Environmental Engineering

Paulina Golinska
Marek Fertsch
Jorge Marx-Gómez *Editors*

Information Technologies in Environmental Engineering

New Trends and Challenges

Springer

Environmental Science and Engineering

Environmental Engineering

Series Editors
Ulrich Förstner
Robert J. Murphy
W. H. Rulkens

For further volumes:
http://www.springer.com/series/7487

Paulina Golinska · Marek Fertsch
Jorge Marx-Gómez
Editors

Information Technologies in Environmental Engineering

New Trends and Challenges

Springer

Paulina Golinska
Poznan University of Technology
Strzelecka 11
60-965 Poznan
Poland
e-mail: paulina.golinska@put.poznan.pl

Marek Fertsch
Poznan University of Technology
Strzelecka 11
60-965 Poznan
Poland
e-mail: marek.fertsch@put.poznan.pl

Jorge Marx-Gómez
Department für Informatik
Universität Oldenburg
Ammerländer Heerstr. 114-118
26129 Oldenburg
Germany
e-mail: marx-gomez@wi-ol.de

ISSN 1863-5520
ISBN 978-3-642-19535-8 e-ISBN 978-3-642-19536-5
DOI 10.1007/978-3-642-19536-5
Springer Heidelberg Dordrecht London New York

Cover design: deblik, Berlin

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

Nowadays every area of human activity leaves a footprint on the natural environment. New legal regulations, shifts in consumption patterns and economic crises force companies and other institutions to change their traditional practices to more environmentally friendly ones. In the "new economy", computing plays an important role in the daily practices of environmental engineers, industrial engineers, economists and social scientists. The complexity of sustainable development requires interdisciplinary approaches where computer science provides the infrastructure for environmental data collection and management, simulations, decision support, documentation and reporting.

The International Symposium on Information Technologies in Environmental Engineering (ITEE) has, for the past 8 years, provided a forum for discussions on state-of-the-art researches and the latest technological trends. Also ITEE 2011 aims to bring researchers from various countries together to present and discuss how Information Technology can support natural resources management, environmental engineering, simulations and integrated assessment studies.

This monograph contains recent studies in eco-informatics, promising ideas and new challenges in information management for supporting sustainability in companies and other organization. The scope of this book includes sets of solutions which show different stakeholders' viewpoints on sustainability.

In individual chapters, authors discuss the role which Environmental Information Systems (EIS) play in the environmental conscious functioning of enterprise. New models, methods and tools supporting sustainability are presented. Emphasis is placed on the innovative approach to eco-friendly organization and coordination of transport, logistics processes and operations management. The information management and decision making in manufacturing and service organizations is highlighted.

The scope of this monograph also encompasses topics related to the modeling and monitoring of climate change.

Paulina Golinska
Jorge Marx Gómez
Marek Fertsch

Information Technologies in Environmental Engineering – New Trends and Challenges

Table of contents

Information management and decision making in sustainable organization

New models and tools for sustainable transports

Part I
Models, Methods and Tools for Information Management Supporting Sustainability

Interactive Technique to Build Fuzzy Rule-Based Systems for Classification

Inti Y. González-Herrera[1], Carlos Pérez Risquet[1],

[1] Universidad Central "Marta Abreu" de las Villas,

inti@uclv.edu.cu, cperez@uclv.edu.cu

Abstract. The construction of classifiers from training data is a current research topic. Most of the techniques involve automatic learning classification models. Models based on machine learning techniques are able to build efficient classifiers, but not always create interpretable models. A visual classifier uses a visual display of data to represent instances of the training set and build, through user interaction with the image, a classification model. This approach has the advantage of providing, to the knowledge engineers, greater understanding of the relationships in the data. This chapter presents a technique for the visual construction of classifiers. The technique uses the parallel coordinate representation to build a set of rules. The membership functions are represented in each coordinate in the traditional way. The flexibility of the technique allows selecting the type of membership functions used and the classification system used by the rules. This chapter presents a group of experimental results that support the validity of the classifiers obtained with this approach. It also presents the dimensions of the sets of rules constructed for multiple datasets. This measure is of great interest in the area of fuzzy rule system to evaluate the interpretability. The experiments were configured to use triangular membership functions and rule systems where the class is selected using a single winner rule.

Keywords: classifiers, visualization, parallel coordinates, fuzzy rule system

1 Introduction

Classification is a common problem in data mining. A wide group of solutions has been proposed. Several methods work as black boxes because users may not explain decisions of classifier. The first challenge to any classification model is to obtain high precision. However, there is not a perfect classifier. This fact is an important motive to develop interpretable classifiers. These allow users to understand correct answers but allow seeing technical limitation too.

A number of interpretable classifiers have been created. These classifiers behave well on many datasets and allow understand knowledge into data. Sometimes users are expert in application domain. Experts may to disagree with classifier decisions. This is because they are not involved in an automatic process of classifier construction.

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_1,

In this chapter, a brief description of classification problem is done first. Next, a specific type of fuzzy rule-based system is presented, these systems are very important for this work due its simplicity. A number of related works are presented later. A technique to build classifiers through user interaction with data, is proposed. The technique allows understanding relation between variables. The built classifiers are fuzzy rule-based systems. Therefore, all advantages of a well-known approach are available. In addition, users are involved in classifier construction, so, they can to add his knowledge to classifier. Finally, the proposed technique is examined through computer simulations. The experiments are done with various datasets. The simulations show than the proposed behaves similar to others classifiers.

2 Data Mining

Current technology allows obtaining a big data volume from multiple application fields [1]. Data sets contain information, but its complex definition and its volume do not allow identify it. Data mining is defined as the process of find patterns into data. The process must be automatic, or more frequently semi automatic. Discovered patterns must be relevant because provide some advantage to his owner, usually an economic advantage. The data volume could vary, from tiny to huge volume [1].

Data mining faces four fundamental problems: cluster analysis, association rules analysis, classification and regression. Cluster analysis and search of association rules are unsupervised learning problems. Classification and regression, which are related, are supervised learning problems [1], [2].

2.1 Classification

Let $U_{1,}U_{2,..},U_n$ and C be sets, with $|C| = c$. A training dataset has the form $T = \{\langle x, y\rangle : x \in U_1 x U_2 x ... x U_n, y \in C\}$ with $|T| = m$. Every pair T is called a training sample. An instance, too called pattern, is a vector $x \in U_1 x U_2 x ... x U_n$. The classification problem is about associate a new instance with a member from C. On classification context, members from C are called classes. A function who assigns classes for a new pattern is called classifier.

A training data set is used to build a classifier through different methods. The most popular methods are based in machine learning.

There is a wide number of classification models. Rules based models, decision tree models, statistical models, neural network models, fuzzy rules based models (FRS) and others could be cited [1], [2], [3].

2.2 Fuzzy Rule Systems

Let T be a training dataset, and suppose fuzzy sets have been defined for every attribute. To classify new patterns, rules with the following format are used:

$$Rule\ R_q : if\ x_1 is\ A_{q1} \wedge ... \wedge x_n is\ A_{qn} then\ C_q with\ CF_q, q = 1,2,..., N_{rules} \quad (1)$$

where R_q is a label for a fuzzy rule, $x = (x_1;...;x_n)$ is a vector, $A_q = (A_{q1};...;A_{qn})$ is the vector containing fuzzy antecedents with linguistic labels (i.e., A_{qi} could be "small" or "huge"), C_q is a consequent class, CF_q is a certainty grade (i.e., rule weight), and N_{rule} is the fuzzy rules number. The rule weight CF_q is used as the strength of rule R_q in fuzzy inference. Although various types of fuzzy rules have been defined, this chapter refers rules as defined in equation 1.

Let S be a set of fuzzy rules as in equation 1. A new pattern x_p is classified for a winner rule R_q wish is selected from S through:

$$\mu_{A_q}(x_p) * CF_w = max\{\mu_{A_q}(x_p) * CF_q ; R_q \in S\}. \quad (2)$$

If there are multiple fuzzy rules with the same product with maximum value but with different classes, classification is rejected. Classification is rejected too, if no rule is compatible with the pattern x_p, this is $\mu_{A_q}(x_p) = 0, \forall R_q \in S$.

In this model, rule consequent and certainty grade are obtained from compatibility grade. To do that, confidence and support are calculated for every single rule.

Let $c(A_q \Rightarrow Class_h)$ be the confidence of rule $R_q : A_q \Rightarrow Class_h$, the consequent C_q of rule R_q is chosen to maximize confidence through:

$$c(A_q \Rightarrow C_q) = max\{c(A_q \Rightarrow Class_h); h = 1,2,\ldots,c\}. \quad (3)$$

Certainty grade could be obtaining through different heuristics [4]:

$$CF_q^I = c(A_q \Rightarrow C_q). \quad (4)$$

Other definitions could improve results:

$$CF_q^{II} = c(A_q \Rightarrow C_q) - c_{avg} , \quad (5)$$

where c_{avg} is the average confidence over fuzzy rules with the same antecedent A_q but with different consequent classes.

$$CF_q^{III} = c\left(A_q \Rightarrow C_q\right) - c_{sec} \quad , \tag{6}$$

where c_{sec} is the second rule with largest confidence value.

$$CF_q^{IV} = c\left(A_q \Rightarrow C_q\right) - s_{\text{sum}} \quad , \tag{7}$$

where C_{sum} is the sum of the confidence over fuzzy rules with the same antecedent A_q but with different consequent classes. An interesting discussion could be found in [4].

An important result of this model is than only antecedent's space need to be explored. Rule consequent and rule certainty grade are automatically obtained. This fact is very important in this chapter.

2.2.1 Interpretability of Fuzzy Rule Systems

On fuzzy rule systems construction there are two goals: maximize classifier performance and decrease system complexity. Systems with low complexity are called interpretable.

A problem arise: these two goals not appear to be compatible, because a common way of increase classifier performance is increase rules number. Many published studies show how to obtain high precision using a small group of rules [5].

2.3 Fuzzy Rules Extraction

This section shows a brief description from different approaches developed to build fuzzy rule systems. Methods based on multiobjective evolutionary search are highlighted.

A lot of work has been done in fuzzy rule extraction for classification. Tools used range from neuro-fuzzy techniques, cluster based methods and evolutionary search. Published solutions use ant colony systems [6], [7], genetic algorithms [5], [8], [9], [10] and others methods [9], [11].

Multiple authors have wrought on FRS extraction through optimization based on ant colony systems. Published experimental results show competitive classifiers precision.

Three paradigms stand out in methods based on genetic algorithms:

1. In Michigan style algorithms each population's member represents a single rule of the system. A fuzzy system is represented by an entire

population. Fuzzy rules compete and cooperate to form an efficient inference system [12], [13].

2. An entire fuzzy system is represented by each member from population in Pittsburgh style algorithms. Genetic operators are applied to produce new generations of fuzzy systems. This approach allows including additional criterions in the objective function. The more important drawback is computational cost, because many fuzzy systems must be evaluated by generation [14].
3. In iterative algorithms, like in Michigan style algorithms, each member code just one rule. An evolutionary algorithm is used to find a single rule. This rule provides a partial solution. This procedure is iterated to find rules. Rules found compose a fuzzy rules system. This approach combines low computational cost of Michigan algorithms with simplicity of Pittsburgh algorithms. Like others incremental methods, these can reach to sub optimal solutions [15], [16].
4. Hybrid solutions have been proposed too [8].

Proposed solutions, based on evolutionary models, allow learning different parameters. The approaches allow learning membership functions to include in rules, the rule consequent and the optimal number of rules [6], [10], [12], [15], [17].

3 Visual Data Mining

Data visualization is crucial on data mining and knowledge discovery. Scientific visualization has been accepted as a useful tool for exploratory data analysis, hypothesis testing and result presentation [18]. A wide number of techniques have been developed to address information visualization. These techniques face the problems of cluster analysis, outliers identification, patterns identification and others.

The paradigm of scientific visualization is exploiting human capacity to detect visual patterns. Images are created from data with this goal, and then they are presented to users. Visualization could be a geometrical, mathematical o physical representation of data, or may be a visual metaphor to highlight some attribute inside data. Visual metaphors are used in specific problems and they can to achieve significant impact. Unfortunately, there is not useful metaphor to an arbitrary data mining problem.

Every visualization technique uses a group of parameters. Selected parameters can have great impact on visualization quality. Although some methods have been proposed, there are not automatic ways to select optimal combination of parameters [19], [20], [21]. Most techniques use an arbitrary parameters combination. To face this drawback, visualization techniques provide user interaction capability.

Visual data mining is based on multi-parametric data visualization, so it must face the same challenges. Information loss is the biggest problem to a technique [22].

A brief description of some popular techniques is presented:

Parallel Coordinates: This technique uses an axis to each dimension from data. Axes are displayed parallel to each other. A polyline, who connect each axis, represents each sample in data. Users can interact with sample color, the order of axes presentation and others parameters. The technique is very popular due its easy implementation and high interpretability. Many modifications have been proposed to it. Some advantages and drawbacks from the technique are discussed [23].

Scatterplot matrix: This technique uses a visual matrix. Each cell contains the scatterplot between a pair of dimensions of data. Users must select which kind of projection to use. The principal diagonal is not used and technique is sensible to order of dimensions. Some applications are presented in [22].

Segment Circles: A circle is used as base image. It is divided in segments, one segment by each dimension. Ordered samples are presented from circle center. The technique allows displaying big data volume due the fact that each sample is represented by a few pixels. It is particularly useful in cluster analysis, but in others fields too [24].

3.1 Visuals Classifiers

Visualization techniques are tools for data mining. Most techniques have been developed as support tools for knowledge procurement to users, not for knowledge extraction. In most cases, users can identify association rules, clusters and classification rules, but they cannot build a model, using the image, to classify new instances. The traditional approach has seen visualization as a complement, but a different approach could increase performance of knowledge engineers.

Methods are presented in [25], [26], [27], [28] to build classifiers through interaction with data. These works use popular techniques as starting point.

An application of segment circles to decision tree construction is presented in [25]. The model allows building trees where dimensions are split in intervals. The approach is very effective in big data volume. Classifier's performance is similar to others well known models and tree size is frequently smaller. Decision conditions are based on intervals.

In [26] experimental results to validate a method to visual decision tree construction are presented. In this case the starting point is the Starplot visualization technique. Decision conditions are based in membership of new instances to regions in projection space. The technique is easy to understand by inexpert users. Precisions shown in experiments are equivalent to other models.

An extension to the previous approach is shown in [27]. The modification allows selecting projection to use. Projection methods evaluate are Starplot and Parallel Coordinates. The cited chapter presents additional advantages of the approach. Classical experiments to validate classifiers are done. The experiments show this new model behaves similar to other approaches to decision trees construction.

A model of visual interaction to classification is proposed in [28]. The model uses the parallel coordinate technique. The first step is project data on image. Next, an optimization based on linear discriminant analysis is done to tunings the visualization. This new visualization allows an easy construction of a decision tree and more accurate classification rules. The approach has the advantage of provide additional information to users and a better understanding of data.

4 The Proposed Technique

The proposed technique is inspired by works discussed in section 3 and in the work presented in [29]. Like in analyzed variants, the proposed allows the user to build a classifier through visual interaction with data. The classifier can be used then with new patterns. In this proposed, the built model is a fuzzy rule system as discussed in section 2.

The proposed technique is based on parallel coordinate and it uses the classical representation of fuzzy membership functions. Users create fuzzy rule-based systems through interaction with data, while they observe wrong classified samples. The technique supports the user backtracking because it presents useful information like confidence, support, certainty grade and consequent for every rule. The technique incorporates data filters to allow real time data selection and data transformation.

To use the technique, users need to understand how infers a fuzzy system. This drawback supports the selection of simple FRS models against other where rule aggregation is complex or rules include other operators.

The construction of FRS is an iterative process, not an algorithm, based on [30]. The diagram is just a guide.

1. Explore classification status. Identify rules that are more used.
2. Identify attribute that separate samples of one class. Define granularity for that attribute.
3. Identify rules who classify samples in a wrong way. Rewrite this rules adding or removing antecedents.
4. Create rule to cover misclassified instances. The misclassified instances may vary, so user must be careful.
5. Check classification status. Is precision reached acceptable? If answer is yes then stop, else go to step 1.

4.1 Technique Description

The proposed technique uses as base image a system of parallel coordinates. Every coordinate represents the membership functions of that fuzzy variable. A fuzzy rule-based system is used to classify training samples. This FRS is empty at the beginning. If one sample is wrong classified for the FRS then it is displayed. A color map is used in order to associate a class with a color.

Created rules are shown in visualization. Every rule may be marked as active or inactive. A rule can be marked as selected. Only the selected rule may be edited. Allowed modifications on rules are to add or to remove antecedents. Consequent of rules is automatically calculated. Support, confidence and its products are shown as information to users.

Although rules used in technique have the structure defined in section 2, other structures are allowed. Others inference models may be used too. However, some limits exist. Antecedents only may contain the operator "and". However, the T-norm to use may vary.

Granularity to use in variables may be edited at any moment. The kind of fuzzy membership functions can be edited too and different variables may select any combination of functions (i.e., trapezoidal, triangular or other may appear in the same linguistic variable). Changes done over these parameters are displayed immediately but some of them may invalidate rules.

Fuzzy rule-based systems with low number of rules have shown to be practical approach to classification in many problems [4], [5]. Due its interpretability, fuzzy rules systems have gained popularity against other data mining methods. The proposed technique is an interactive approach to rules extraction, so built systems will be simples. The tool must provide information to allow fast FRS construction.

The classifier is the FSR built. Like other classifiers, the generalization capability of it may be checked with a testing dataset. Cross validation and other approaches to evaluate classifier quality are available but may be hard to use.

5 Experiment Results

A group of experiments was done to evaluate behavior of visual classifier. A number of datasets was selected to compare visual classifier behavior against other known methods. Single experiments produce quantitative values like classifier precision and area under ROC. Other useful measures were used in order to evaluate FRS interpretability. Variables for comparisons were obtained after applied 10 times a 10 folds cross validation process on datasets.

Parametric test was not practical since the number of datasets used was low. In such cases non parametric test must be applied [31]. So, Wilcoxon signed-rank test [32] was used to compare two algorithms while Friedman [33] and Iman-Davenport was applied to compare several algorithms.

The proposed technique was implemented to take training and testing data from Weka environment. From this environment were taken results to comparisons too.

5.1 Used datasets

Ten datasets from different sources was used to execute the experiments. Datasets only contain numeric predictive attributes. Class number, instance number and attribute number vary. Attributes were normalized in all datasets. Table 1 shows description of datasets.

Breast Cancer Wisconsin dataset was modified to remove missing values. Ying Yan is an artificial dataset. It is random subset of Ying Yang image with three classes, ying, yang and area around symbol. To include credit dataset in the experiments, nominal attributes in the original data were converted to continue attributes on interval $[0,1]$ and missing values were removed.

Table 1. Datasets used in experiments.

Dataset	Attributes	samples	classes
diabetes	8	768	2
breast cancer W	9	683*	2
iris	4	150	3
wine	13	178	3
glass*	9	214	6
sonar	60	208	2
ecoli	7	336	8
Yin Yang	2	6550*	3
credit	15	653*	2
wave	40	5000	3

5.2 Results

In this section, experiment results to validate the proposed technique are presented. To do that, precision from visual classifiers is compared with behavior of other well-known classifiers. C4.5 model, KNN model and Multilayer Perceptron classifier were chosen to contrast behaviors. The performance of new approach is shown on table 2, on the same table other models behavior are presented.

Interpretability of fuzzy systems built through visual technique is compared against automatic approaches to FRS construction [8], [10], [34], [35]. The measures used and its values are presented on tables 4 and 5. Results are shown in some cases because do not exists published experiments for all datasets in table 1.

Membership functions like shown in figure 1 were used for all linguistic variables. Works [4], [35] confirm than rules with simple antecedents could achieve high precision. Certainty grade was calculated with heuristic 6 because published experiments suggest it behaves better than any.

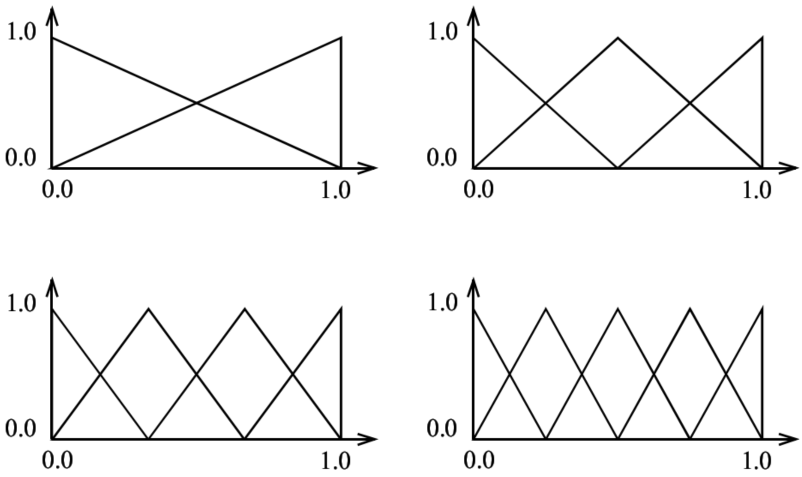


Fig 1. Four fuzzy partitions used in experiments.

Criterions to compare taken from experiments are: classification precision at test data, number of rules in fuzzy system built and the average length of rules. Values taken to compare were the average after ten times ten folds cross validation on each dataset. Criterions were split in two groups, one related to classifier's performance and the other to classifier's interpretability.

Table 2. Classifiers precision in test data, five folds cross validation.

Dataset	C4.5	This work	MLP	KNN
diabetes	71.22	70.31	75.13	73.3
breast cancer W	94.91	96.92	95.29	95.54
iris	96	96	96	94.67
wine	90.44	96.06	97.75	96.07
glass*	66.82	48	65.42	70.09
sonar	71.15	78.84	78.84	87.01
ecoli	84.22	81.25	84.82	85.41
Yin Yang	96.8	85.9	98.03	68.81
credit	85.92	85.6	86.92	84.87
wave	75.25	76	83.82	77.44

A value p = 0.08914 is obtained when apply Iman-Davenport test to data in table 2. So, with $\alpha = 0.05$ there are not differences between classifier behaviors.

Wilcoxon signed-rank test was used to compare visual classifier against C4.5, KNN and MLP. Results are shown on table 3. Visual classifier behaves like C4.5 and KNN. Comparison with MLP is different, with a trust value of $\alpha = 0.05$ the hypothesis h_0 is rejected, visual classifier and MLP behaviors differ.

Table 3. Wilcoxon signed-rank test results.

	This Work vs. C4.5	This Work vs. KNN	This Work vs. MLP
p	0.2402	0.1514	0.0059

System interpretability is contrasted against results obtained with automatic methods to build FRS. Since revised literature do not contains interpretability measures for all datasets used in this work, tables 4 and 5 are not useful to statistical analysis due its low data density. However, is interesting to contrast obtained values.

Rules number has been reported in all cited works for iris and wine datasets while diabetes and breast cancer Wisconsin are partially available. This work behaves similar to others for iris dataset and it behaves worst than others for wine dataset.

Table 4. Rules number.

	Diabetes	Iris	wine	Breast cancer W	sonar	ecoli	wave
This Work	6	4	8	10	23	14	19
Ishibuchi [35]	-	3	3	-	-	-	-
Ishibuchi [36]	-	5	3	-	-	-	-
Wang [17]	-	3	3	2	-	-	-
Abonyi [11]	11.2	3	3.6	-	-	-	-
Chang [10]	3	5	5	3	-	-	-

Number of linguistic terms is a valid measure to evaluate FRS complexity. Although is not possible to do a solid statistical analysis due the low number of published results, is interesting to note a fact: this work is never the worst.

Table 5. Number of linguistic terms used in rules.

	Diabetes	Iris	wine	Breast cancer W	sonar	ecoli	wave
This Work	12	5	11	11	37	15	26
Ishibuchi [35]	-	-	-	-	-	-	-
Ishibuchi [36]	-	7	9	-	-	-	-
Wang [17]	-	11	27	18	-	-	-
Abonyi [11]	40	4	8.8	-	-	-	-
Chang [10]	4	7	13	4	-	-	-

Joining both results, a fact stand out: extracted rules have a length of one or two terms. Those differ from other published results. The conclusion, however, is consistent with the well-known fact than parallel coordinate technique is useful to correlate a few variables, not more. Therefore, fuzzy systems built with this technique will be compound of high number of short rules.

6 Conclusions

Many approaches have been developed to support visual data mining. Some approaches allow creating models to use knowledge. Some of them are used to build classifiers through user interaction with data. Published techniques show competitive classification accuracy. These techniques offer to knowledge engineers all advantages of visualization.

In this chapter, a method to interactive construction of fuzzy rule-based system has been presented. The method is based on parallel coordinates, and it supports visual paradigm in data mining. The technique allows specifying any kind of membership function. The inference model used by systems must be simple in order to be effective. Antecedents of rules are constrained to use only conjunctions. Although this technique is not automatic, is a valid alternative for knowledge extraction, its understanding and use.

The proposed technique has been validated through computer simulations in various datasets. These simulations showed than the visual technique behaves similar to other classification models. Fuzzy systems built in simulations are compound of many rules with short length.

References

1. Witten, I.H., Frank, E.: Data Mining: Practical Machine Learning Tools and Techniques. Morgan Kaufmann, (2005)
2. Ye, N.: The handbook of data mining. Nong Ye (Ed.). Lawrence Erlbaum Associates, (2003)
3. Hand D, Mannila H & Smyth P. Principles of Data Mining. The MIT Press, (2001)
4. Ishibuchi, H., Yamamoto, T.: Comparison of heuristic rule weight specification methods. In: Proc. 11th IEEE Int. Conf. Fuzzy Systems. (2002)
5. Ishibuchi, H., Nojima, Y.: Analysis of interpretability-accuracy tradeoff of fuzzy systems by multiobjective fuzzy genetics-based machine learning. International Journal of Approximate Reasoning. 44, 4--31 (2007)
6. Casillas, J., Cordón, O., Herrera, F.: Learning Fuzzy Rules Using Ant Colony Optimization Algorithms. In: Abstract Proceedings of Ants2000 from Ant Colonies to Arti Ants: a series of international workshops on ant algorithms. (2000)
7. Galea, M., Sheng, Q.: Swarm Intelligence in Data Mining. Abraham, Ajith and Grosan, Crina and Ramos, Vitorino (Ed.). , 2006.
8. Ishibuchi, H., Yamamoto, T., Nakashima, T.: Hybridization of fuzzy GBML approaches for pattern classification problems. IEEE Trans. on Systems, Man, and Cybernetics - Part B. 35, 359--365 (2005)
9. Nomura, T., Miyoshi, T.: An Adaptive Fuzzy Rule Extraction Using Hybrid Model of the Fuzzy Self-Organizing Map and the Genetic Algorithm with Numerical Chromosomes. Journal of Intelligent and Fuzzy Systems. 6(1), 39-52 (1998)
10. Chang, X., Lilly, J.H.: Evolutionary design of a fuzzy classifier from data.. IEEE Trans. Syst, Man, and Cybernetics - Part B. 34, 1894--1906 (2004)
11. Abonyi, J., Roubos, J.A., Szeifert, F.: Data-Driven Generation of Compact, Accurate, and Linguistically-Sound Fuzzy Classifiers Based on a Decision-Tree Initialization. International Journal of Approximate Reasoning. 32, 1--21 (2002)
12. Casillas, J., Carse, B., Bull, L.: Fuzzy-XCS: A Michigan Genetic Fuzzy System. IEEE Transactions on Fuzzy Systems. 15, (2007)
13. Cordón, O., Herrera, F., Hoffmann, F., Magdalena, L.: Genetic Fuzzy Systems: Evolutionary Tuning and Learning of Fuzzy Knowledge Bases. Singapore: World Scientific, (2001)
14. Smith, S.: A Learning System Based on Genetic Adaptive Algorithms. University of Pittsburgh. (1980)

15. Cordon, O., del Jesus, M.J., Herrera, F., Lozano, M.: MOGUL: A Methodology to Obtain Genetic Fuzzy Rule-Based Systems under the Iterative Rule Learning Approach. International Journal of Intelligent Systems. 14, 1123--1153 (1994)
16. González, A., Pérez, R.: SLAVE: A Genetic Learning System Based on an Iterative Approach. IEEE Transactions on Fuzzy Systems. 7, (1999)
17. Wang, J.S., Lee, G.C.S.: Self-adaptive neuro-fuzzy inference system for classification application. IEEE Transaction Fuzzy System. 10, 790--802 (2002)
18. Hansen, C.D., Johnson, C.: The Visualization Handbook. Academic Press, (2004)
19. Peng, W., Ward, M.O., Rundensteiner, E.A.: Clutter Reduction in Multi-Dimensional Data Visualization Using Dimension Reordering. In: Infovis '04: proceedings of the IEEE Symposium on Information Visualization. (2004)
20. Friendly, M., Kwan, E.: Effect ordering for data displays. Comput. Stat. Data Anal. 43, 509--539 (2003)
21. Schneidewind, J., Sips, M., Keim, D.A.: Pixnostics: Towards Measuring the Value of Visualization. In: IEEE Symposium on Visual Analytics Science and Technology. (2006)
22. Soukup, T., Davidson, I.: Visual Data Mining: Techniques and Tools for Data Visualization and Mining. John Wiley & Son, (2002)
23. Siirtola, H., Laivo, T., Heimonen, T., Raiha, K.: Visual Perception of Parallel Coordinate Visualizations. Information Visualisation, International Conference. 0, 3--9. IEEE Computer Society, (2009)
24. Ankerst, M., Keim, D., Kriegel, H.: Circle Segments: A Technique for Visually Exploring Large Multidimensional Data Sets. In Visualization '96, hot topic session. (1996)
25. Ankerst, M., Elsen, C., Ester, M., Kriegel, H.P.: Visual classification: An interactive approach to decision tree construction. In Proc.5th Int.Conf. on Knowledge Discovery and Data Mining (KDD'99). 392–396 (1999)
26. Teoh, S.T, Ma, K.: Starclass: Interactive visual classification using star coordinates. In: SDM. (2003)
27. Teoh, S.T.: Paintingclass: interactive construction, visualization and exploration of decision trees. In: Proceedings of the ninth ACM SIGKDD international conference on Knowledge Discovery and Data Mining. 667--672. ACM Press, (2003)
28. Xu, Y., Hong, W., Chen, N., Li, X., Liu, W., L, Zhang, T.: Parallel filter: A visual classiffier bases on parallel coordinates and multivariate data analysis. Proceedings of the 3rd International Conference on Intelligent Computing: Advanced Intelligent Computing Theories and Applications. With Aspects of Artificial Intelligence, Qingdao, China. 12, 1172--1183. Springer-Verlag, (2007)
29. Berthold, M.R., Hall, L.O.: Visualizing Fuzzy Points in Parallel Coordinates. University of California at Berkeley, (1999)
30. Inselberg, A.: Multidimensional detective. In: Infovis '97: Proceedings of the 1997 IEEE Symposium on Information Visualization (infovis '97). (1997)
31. Demvsar, J.: Statistical Comparisons of Classifiers over Multiple Data Sets. Machine Learning Research. 7, 1--30 (2006)
32. Wilcoxon, F.: Individual comparisons by ranking methods. Biometrics. 1, 80--83 (1945)
33. Friedman, M.: A comparison of alternative test of significance for the problem of m rankings. Annals of Mathematical Statistics. 11, 86--92 (1940)
34. Roubos, H., Setnes, M., Abonyi, J.: Learning fuzzy classification rules from data. Springer, Physica Verlag, (2000)
35. Ishibuchi, H., Yamamoto T.: Fuzzy rule selection by multi-objective genetic local search algorithms and rule evaluation measures in data mining. Fuzzy Sets and Systems. 141(1), 59--88. Genetic Fuzzy Systems: New Developments. (2004)
36. Ishibuchi, H., Nakashima, T., Murata, T.: Three-objective genetic based machine learning for linguistic rule extraction. Inf.Sci. 136, 109--133 (2001)

A Model for Generating Outputs for Multiple Location-based Services

Jiang-Liang Hou[1], Shih-Ting Yang[2], Yu-Hsuan Su[1]

[1]National Tsing Hua University, [2]Nanhua University

adamhou@ie.nthu.edu.tw, stingyang@mail.nhu.edu.tw, g9734544@oz.nthu.edu.tw

Abstract.. This research analyzes the demands from demanders and geographic information from the information provider to define the categories of demands and geographic information. Based on the categories of demands and geographic information, this research generalizes the six basic types of location based-services (LBSs). Based on the characteristics of these LBSs, this research establishes the six sub-modules to generate LBS outputs for these six types of LBSs. In brief, as the demander sends his/her demands to the service provider, the service provider can utilize the demander location, demand specifications, geographic information and the corresponding sub-module to determine the closest target objects that meet the demander requirements. This research also develops a multiple LBS system based on the proposed methodology.

Keywords: Location-based services, Geographic information, Nearest neighbor search

1 Introduction

In the location-based services (LBS), the service provider first acquires the locations and demands (i.e., the LBS inputs) of the service demander via

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_2,

communication technologies. Based on the static and dynamic geographic data maintained in the backend database, the information and services (i.e., the LBS outputs) from the nearest location with respect to the service demander can be determined and provided to the service demander. Traditionally, the LBS-related studies focus mainly on generating appropriate LBS outputs to the service demander under a specific application scenario. That is, the previous models can rarely be applied in various LSB scenarios. In the traditional LBS model, it takes much time for the LBS service providers to filter the appropriate information from the huge and complicated geographical data. In determining the appropriate (or even optimal) outputs for the service demander, the LBS service provider usually employs a single performance indicator (i.e., the shortest path). As a result, the service efficiency of the LBS service provider cannot be guaranteed and the generated outputs cannot meet the various demands of the service demander. The as-is model for the existing LBS services can be revealed in Figure 1.

Concerning the above issues, this research aims at proposing a model for generating outputs for multiple location-based services. The model can be applied to assist the LBS service provider to manage the huge and complicated geographical data and systematically determine the appropriate LBS information and services that can meet the various demands of the service demanders in distinct LBS scenarios. This study first analyzes the characteristics of demands (acquired from the service demander) and geographical data (from the geographical information provider) and establishes their structured representations. After mapping the features of user demands and geographical data, six types of LBS scenarios are established. Based on the characteristics of each type of LBS scenario, algorithms for determining the optimal LBS information or services are also constructed. As a result, by incorporating the demands, geographical data and demander locations, the LBS service provider can determine the appropriate LBS information or services via the corresponding LBS output generation algorithm. The appropriate LBS information or services can be delivered to the demanders to meet their demands from the LBS service provider. The to-be LBS service model can be depicted in Figure 2

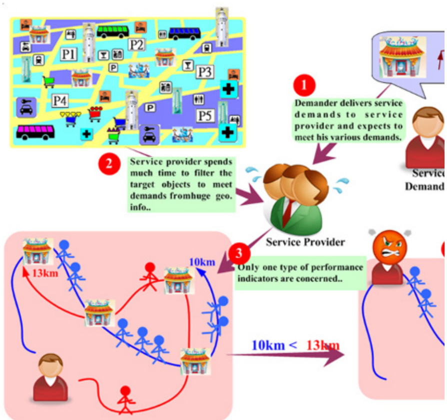


Fig 1. The As-Is LBS model

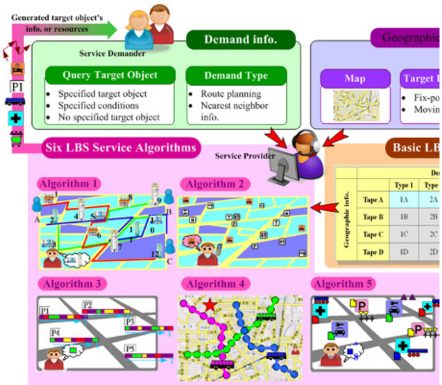


Fig 2. The To-Be LBS model

2 Literature Review

The research topics related to this paper include "LBS demander requirement characteristics analysis", "LBS geographic information extraction", "LBS generation system development" and "LBS output generation". The following is the literature review related to the above research topics.

2.1 LBS demander requirement characteristics analysis

For LBS demander requirement characteristics analysis [14] analyzes the phone call records and Internet browsing records to develop an interactive model of the specific time and location between the mobile phone user and other users. As the target user with mobile device appears in a specific location at a specific time, the service provider can provide the target user with appropriate service suggestions (e.g., calling or sending email messages to another user). With the proliferation of mobile computing technologies, location based services have been identified as one of the most promising target application [12]. Wu and Wu [20] classifies mobile information service domains based on feature characteristics of the information sources and different patterns of mobile information access. In addition, the demander requirement characteristics based on user behaviors is discussed [15]. Huang [5] uses TMSPs (Temporal Mobile Sequential Patterns) is to predict the user behaviors (including position status and required services) to provide corresponding services. Furthermore, Lu and Tseng [16] proposes a novel data mining algorithm for efficiently discovering the Cluster-based Mobile Sequential Patterns (CMSPs) of users in LBS environments.

2.2 LBS geographic information extraction

To generate and provide the target object closer to the service demander in a geographic space, the service provider acquires the geographic information from the geographic information provider [17] and then maintains the static geographic information into the backend database to generate the future position of the moving target as the basis for the LBS outputs. Concerning the static objects, Huang et al. [6] proposes the concept of layer-grid index to improve the efficiency of providing LBS service through organized management of geographic information.

Regarding the prediction of moving target objects [8], Lee et al. [13] develops a model for the prediction of the future location of moving object to accurately predict the target moving path. The research divides the service area into multiple geographic areas and maintains the moving path history of all moving target objects in the backend database. Then, the research analyzes the moving target path history by two dimensions of time and space and summarizes the sequential order of the geographic areas with respect to moving target appearance via sequential pattern mining technology. Moreover, Jula et al. [9] develops a methodology to estimate the truck arrival time at each customer location. The research utilizes the estimated arrival times to propose an approximate solution method based on dynamic programming. The paper finds the best route with minimum expected cost while it guarantees certain levels of service are met.

2.3 LBS generation system development

For LBS generation system development, Kim et al. [11] establishes a location-based guide system integrated with tourist information and LBS. Different from other approaches that analysis data (e.g., locations) needs to be maintained in backend database in advance, Satoh (2007) enables location-aware services to be managed without any database servers, it can be managed by multiple computers, and the research can provide a unified view of the locations of not only physical entities and spaces, including users and objects, but also computing devices and services.

Moreover, Spanoudakis et al. [18] presents a generic platform for delivering location based services (LBS). The platform features a modular architecture, which can be easily extended with additional functionality. Also, in order to solve the problem that present LBS are to a large extent incompatible with each other and unable to interoperate on location semantics, Ibach and Horbank [7] uses Web Services standards for propagation, discovery, and composition of location-based services in mobile environments.

2.4 LBS output generation

With regards to studies related to the object closer to the user [19; 2] proposes a C-PNN (Constrained Probabilistic Nearest-Neighbor Query) model to accurately generate and predict closer object to the user according to the probability distribution of possible service object locations. Regarding the route planning of LBS, sometimes the route has to be adapted not only to current traffic conditions, but also to the physical, geometric and functional attributes of the roads, related to their urban location and environmental characteristics [1]. Hence, Feng et al. [3] takes into consideration of road restrictions and establishes a route planning system to plan routes of higher feasibility for the demander. The research employs the "Turn-constraint matrix" to develop the accessible/inaccessible relationship between any two roads and the spatial index structure (e.g., R-Tree) to construct the conjunctions and roads connected with them. In addition, Flessa [4] proposes an emergency resources distribution model via the linear programming model. Using the method to allocate the emergency relief resources can get the closer relief resources and reduce the harm caused by the disaster.

3 Multiple LBS Output Generation Model

To solve the existing LBS model problems, this paper develops a multiple LBS output generation model to provide users with appropriate services. Before developing the multiple LBS output generation methodology, this paper first analyzes the characteristics of demands (acquired from the service demander) and geographical data (acquired from the geographical information provider) to establish their structured representations. After mapping the features of user demands and geographical data, six types of LBS scenarios are established. Based on the characteristics of each type of LBS scenario, algorithms for determining the optimal LBS information or services are also constructed.

3.1 LBS input data analysis

The services provider utilizes the demander locations, demand specifications and geographic information to determine and deliver the information or services that can meet the demander requirements. The demand information contains the "query target object" and the "demand type". The geographic information provided by the information provider generally contains the "map" in the service scope of the service provider, the "locations" or "corresponding information" of query target object (as shown in Figure 3). After that, six types of LBS scenarios are established including "determine conditional target route planning results (CTRP)", "determine static information corresponding to fixed-point conditional target query results (SIFC)", "determine dynamic information corresponding to fixed-point conditional target query results (DIFC)", "determine moving conditional target information query results (MCTI)", "determine dynamic information corresponding to no-target LBS query results (DINT)" and "determine moving service spots corresponding to no-target LBS query results (MSNT)". The relationships between the features of demand information and geographic information and the LBS types can be depicted in Figure 4.

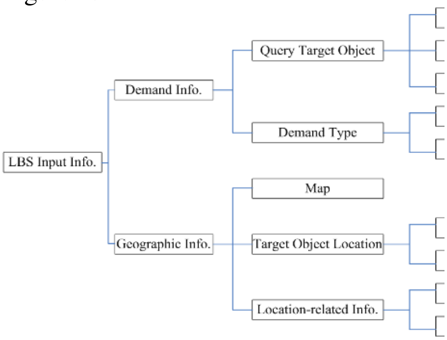


Fig 3. The structured representations of LBS input information

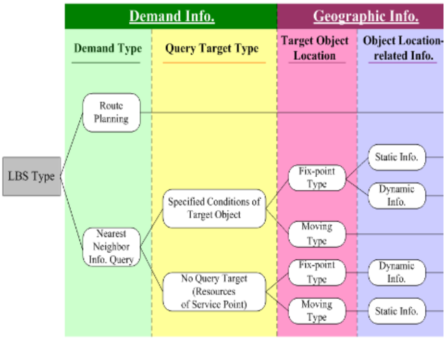


Fig 4. Relationships between the LBS input information features and LBS types

3.2 Multiple LBS output generation algorithm

The service provider maintains the geographic information provided by the data provider in the backend database in advance. Based on the demand information from the user, the service provider acquires the real-time location information of the user and the real-time dynamic geographic information. Then, the service provider compares the locations of the demander and the query target object as well as the attributes of the query target object and attribute values of other target objects to generate the nearest target objects or service points for the demander by using the corresponding algorithm. Finally, the query target objects or service points can be provided to the user or the resources can be allocated for user utilization (as shown in Figure 5). The output generation algorithms of the six LBS scenarios are illustrated as below.

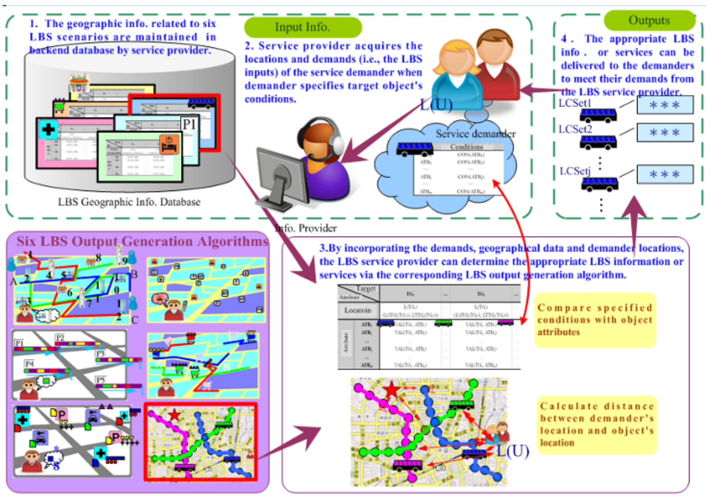


Fig. 5. The architecture of multiple LBS output generation methodology

3.2.1 Determine conditional target route planning results (CTRP) algorithm

This algorithm utilizes attribute values of the target object, the object location, real-time locations of the user, the attribute conditional values specified by the user for route planning based on target object at acceptable distance and avoidance of congestion for the user.

After obtaining the visiting target object conditions and the route planning history data, this algorithm compares the condition values of each attribute provided by the user with the attribute values of all target objects to select the qualified target objects. Then, to ensure the acceptable distance between the recommended target objects and the user and other target objects, this paper measures the degree of visitor willingness by using the distance between qualified target objects and other target objects and the users to include all the target objects in the acceptable distance range in the set of the final target objects. If the impact of a target object on the visiting distance changes insignificantly, the corresponding target object is listed in the final target object set of the user (as shown in Equation (1)).

$$IF\ r(TSet_{q-1}) - r(TSet_q) = \underset{all\ i}{Max}\{r(TSet_{i-1}) - r(TSet_i)\}$$

$$THEN\ RCSet = TSet_q \quad (1)$$

To provide the user a shorter and less-crowded visiting route to save the user's burden of distance and time, this paper calculates the distances between each two final target objects and the distance between the final target object and the user. Then, based on the route planning history of the user earlier demands, the changes of visitor number and time of all final target objects after the user demands are used to determine the congestion of all target objects at each visiting time (as shown in Equation (2) to Equation (5)).

$$IF\ VF(OU_v, DTime) = RCSet_r$$
$$THEN\ Judge(OU_v, DTime, RCSet_r) = 1 \quad (2)$$
$$ELSE\ Judge(OU_v, DTime, RCSet_r) = 0$$

IF **VF**(OU_v, DTime)=$RCSet_r$ **THEN** NP($RCSet_r$, $CHT_{v,1}$)=-1
IF VF(OU_v, $CHT_{v,w}$)=$RCSet_r$ **THEN** NP($RCSet_r$, $CHT_{v,w}$)=1 **AND** NP($RCSet_r$, $CHT_{v,w+1}$)= -1 (3)

$$NU(RCSet_r,\ DTime) = \sum_v Judge(OU_v,\ DTime,\ RCSet_r) \quad (4)$$

$$NU(RCSet_r, RCT_{r,y}) = NU(RCSet_r, RCT_{r,y-1}) + NP(RCSet_r, RCT_{r,y}) \quad (5)$$

Finally, in order to derive the visiting sequences of the final target objects, the distance score (Dscore) can be calculated accordingly (see Equations (6)) based on the obtained distances between each two final target objects. Then, the visitor number and visiting time of all final target objects derived in above steps can be used to calculate the corresponding stream score of the target object (Uscore) (see Equations (7)). Finally, the obtained Dscore and Uscore are integrated into an index value ($Index_r$) to select the next visiting final target object. After that, repeat the above steps until all the final targets are determined to derive the set of ranked final target objects included in the planned route and the remaining final target objects (as shown in Equations (6) to (9)).

$Dscore_r$=DIS(U, $RCSet_r$)/ $\underset{all\ i}{Max}$ (DIS(U, $RCSet_i$)) (6)

$Uscore_r$=NU($RCSet_r$, DTime)/ $\underset{all\ i}{Max}$ (NU($RCSet_i$, DTime)) (7)

$Index_r$＝$Dscore_r$*W(Dscore)+$Uscore_r$*W(Uscore) (8)

IF $Index_s$= $\underset{all\ i}{\min}$ ($Index_i$) **THEN** RR_u=$RMSet_{u-1,s}$ AND $RMSet_u$=$RMSet_{u-1}$-RR_u(9)

3.2.2 Determine static information corresponding to fixed-point conditional target query results (SIFC) algorithm

This algorithm is to assist the service provider to utilize the target object related information, the conditions specified by the user (i.e., user-specified conditions) and the locations to select the nearest target object matching the specified conditions. After obtaining the target object conditions specified by the user, this algorithm compares the condition value of each specified attribute with each attribute value of each target object. If the attribute values of the target object are identical to the attribute values specified from user (i.e., the target object is matching the user-specified conditions), the corresponding target object is classified into the qualified target object set. To provide the user with closer target objects, this algorithm calculates the distances between all qualified target objects and the user. In addition, three principles including "relative ranking principle", "average principle" and the "specified threshold principle" are used to select a number of target objects closer to the user from the qualified target object set (as shown in Equation (10) to Equation (13)).

$$DIS(U,CSet_k)=\sqrt{\{LGT[L(U)]-LGT[L(CSet_k)]\}^2+\{LTT[L(U)]-LTT[L(CSet_k)]\}^2} \quad (10)$$

$$LCSet=\{CSet_k \mid R(CSet_k)<P\} \quad (11)$$

$$LCSet=\{CSet_k \mid DIS(U,CSet_k)<\frac{\sum_{k=1}^{r} DIS(U,CSet_k)}{r}\} \quad (12)$$

$$LCSet=\{CSet_k \mid DIS(U,CSet_k)<Q\} \quad (13)$$

3.2.3 Determine dynamic information corresponding to fixed-point conditional target query results (DIFC) algorithm

This algorithm utilizes the target object locations and history data of target object status, the user locations, the user-specified conditions, the user-specified attribute weight and index weight values for target object selection. The target objects closer to the user with higher matching percentage of user-specified conditions can be selected. Then, the real-time introduction information with respect to the target objects can be provided to the user. First, the status of the specified target object and the history data of each target object status should be acquired. To ensure the target object matching user-specified conditions, this algorithm compares the specified conditions with the history data of each target object and calculates the total time of each target object matching user-specified conditions. Next, the percentage of the total time of qualified target objects to the total time of all target objects with history status is regarded as the probability of target objects matching user specified conditions (as shown in Equation (14) to Equation (16)).

$$\begin{aligned}&IF\ STS(TG_i,ATB_j,t_{ijk})=CON(ATB_j)\ THEN MT(TG_i,ATB_j,k)=T_{ijk+1}-T_{ijk}\\&ELSE MT(TG_i,ATB_j,k)=0 \qquad FOR k=0,1,2\end{aligned} \quad (14)$$

$$SumT(TG_i,ATB_j,CON(ATB_j))=\sum_{k=0} MT(TG_i,ATB_j,k) \quad (15)$$

$$P(TG_i,ATB_j,CON(ATB_j))=SumT(TG_i,ATB_j,CON(ATB_j))/TotalT(TG_i,ATB_j) \quad (16)$$

To solve the problem of limited number of target objects with attributes matching user-specified conditions, this algorithm selects the target objects with higher matching probability. By comparing the specified conditions and the history status data of all target objects and using the frequencies of object attributes matching specified conditions, this algorithm calculates the average cycle time of each target object with all attributes matching the user-specified conditions. Next, the difference between the user demand time and the latest time matching user-specified conditions in terms of target object attributes can be calculated. This is to generate the next time in matching user-specified conditions and obtain the trend of approaching attributes to represent the matching degree with respect to user-specified conditions (as shown in Equation (17) to Equation (18)).

$$ACT(TG_i, ATB_j, CON(ATB_j)) = \frac{TotalT(TG_i, ATB_j)}{Num(TG_i, ATB_j, CON(ATB_j))} \quad (17)$$

$$T(TG_i, ATB_j, CON(ATB_j)) = \frac{DmdT - Max\{T_{ijk} \mid STS(TG_i, ATB_j, CON(ATB_j)) = CON(ATB_j)\}}{ACT(TG_i, ATB_j, CON(ATB_j))} \quad (18)$$

To enable the user to receive the closer services, this algorithm calculates the distance between target object and user. The corresponding distance scores of all target objects should be specified. Finally, above scores are weighted to derive the integrated index score for the target object selection with higher matching degree of user-specified conditions.

3.2.4 Determine moving conditional target query results (MCTI) algorithm

This algorithm utilizes the attribute values of the target objects, the preset route and the user real-time locations, the user- specified condition values corresponding to attributes and location information about the destination and moving target object to select qualified moving target objects with preset route close to the user current location and the user-specified destination. The destination, the conditions of the moving target objects and the current locations of the all moving target objects should be collected in advance. Then, the attribute condition values specified by the user are compared with the attribute values of the all target objects to meet the user demands (as shown in Equation (19) and Equation (20)).

$$IF\ VAL(MTG_i, ATB_j) = CON(ATB_j)\ THEN\ Judge(MTG_i, ATB_j) = 1$$
$$ELSE\ Judge(MTG_i, ATB_j) = 0 \quad (19)$$

$$NC_i = \sum_j Judge(MTG_i, ATB_j) \quad (20)$$

In order to provide the user with the moving target object closer to the user-specified destination (i.e., enable the user to quickly get the destination or the stop), this algorithm calculates the distances between all stops and the user/destination at first and calculates the distances of the stop close to the destination/user to calculate the distance score between the target objects to the user/destination (as shown in Equation (21) to Equation (23))

$$DIS(U,P_{ik}) = \sqrt{\{LGT[L(U)] - LGT[L(P_{ik})]\}^2 + \{LTT[L(U)] - LTT[L(P_{ik})]\}^2} \tag{21}$$

$$UMinDIS(MTG_i) = \underset{all\ k}{Min}\{DIS(U,P_{ik})\} \tag{22}$$

$$Uscore = 1 - \frac{UMinDIS(MTG_i)}{Max\{UMinDIS(MTG_1), UMinDIS(MTG_2), \ldots, UMinDIS(MTG_i), \ldots\}} \tag{23}$$

To provide the user with relatively closer moving target objects for saving waiting time, the distances between all the moving target objects and the user should be calculated and the distance scores can be specified accordingly. Finally, the derived scores are weighted to derive the integrated index value. According to the matching degree of the integrated index values against the conditions, a number of target objects with shorter distances in between the stop, the user, the destination and the moving target objects can be selected for the user.

3.2.5 Determine dynamic information corresponding to no-target LBS query results (DINT) algorithm

First, algorithm utilizes the service point location and user real-time location information, user-specified service type, number of target objects, index weight values, surrounding information of the service points for matching and calculating to provide the user with a number of service points matching the user-specified service types.

First, as the service provider receives the resource type, number, or information type required by the user, the service provider can also simultaneously get the resource type, number and information from all service points. For resource provision, the service provider should provide the user with the closer resources. In addition, with regard to the issue of information provision, the service provider should provide the user with information related to the service points close to the user to present the status of service point locations. Thus, this algorithm calculates the distances in between all service points and the user to determine the distance index values accordingly.

To provide the user with resources matching the user specified type services, this algorithm determines the user demand satisfaction rate of resources from the service point according to the numbers of resources matching the specified service types and user demands. If the number of resources from the qualified service points is greater than the user demanded resources, the redundant resources are not allocated to the user (as shown in Equation (24) and Equation (25)).

$$Srate_i = Num\_SOR(FHD_i, N\_Type) / Num\_N\_SOR \tag{24}$$

$$Sscore_i = Min\{Srate_i, 1\} \tag{25}$$

To provide the user with information related to the user-specified service type, this algorithm determines the satisfaction index value of user demands according to the availability of the information regarding the user-specified service type at each service point (as shown in Equation (26)).

$$\begin{aligned} &IF\ INFO(FHD_i, N\_Type) = Null\ THEN\ Iscore_i = 0 \\ &ELSE\ Iscore_i = 1 \end{aligned} \tag{26}$$

After that, the above three indexes are respectively weighted with the user-specified index weights to obtain an integrated index. The integrated index is regarded as the basis for the qualified target objects selection. Finally, the qualified service points are selected and provided to the user based on the methods of ample resources provision and complete information provision (as shown in Equation (27) and Equation (28)).

$$Sum\_SOR(k, N\_Type) = \sum_{p=1}^{k} Num\_SOR(RF_p, N\_Type) \tag{27}$$

$$\begin{aligned} &IF\ \ Sum\_SOR(k, N\_Type) < Num\_N\_Source \\ &AND\ \ Sum\_SOR(k+1, N\_Type) \geq Num\_N\_Source \\ &THEN\ \ MSet = \{RF_1,\ RF_2,\ \ldots,\ RF_{k+1}\} \end{aligned} \tag{28}$$

3.2.6 Determine moving service spots corresponding to no-target LBS query results (MSNT) algorithm

This algorithm generates the moving service points that can meet the user demands by matching the user-specified service type, the number of demand resources and the number of the resources of the moving service points. Also, this algorithm generates the possible moving direction by using the directional vector formed by the moving service point location, user's demands location and user's earlier locations. Furthermore, the direction of the moving service point and the shortest travelling distance of user can also be calculated. Then, according to the user-specified index weights, the moving service points can be selected. A number of moving service points with ample resources and moving route closer to user can be further provided to the user.

As the service provider obtains resource type and number required by the user, the service provider can receives the resource type, number and information from all service points simultaneously. Secondly, this algorithm determines the user demand satisfaction degree of the moving service points in terms of the specific services (i.e., the index of the user demand satisfaction of the resources). To judge the approximation of the moving service points to the user, this algorithm generates the possible moving direction of the service point by the directional vector formed by the location of the service point, user demands location and previous user demands location. The principle of equal moving time of the moving service point and the user is applied to calculate the meeting node of the user and the moving service point (as shown in Equation (27) and Equation (28)).

$$LGT(L(MFHD_i, DTime+t)) = LGT(L(MFHD_i, DTime)) + \frac{LGT(L(MFHD_i, DTime))-LGT(L(MFHD_i, LSTime_i))}{DTime-LSTime_i} * t \tag{29}$$

$$LTT(L(MFHD_i, DTime+t)) = LTT(L(MFHD_i, DTime)) + \frac{LTT(L(MFHD_i, DTime))-LTT(L(MFHD_i, LSTime_i))}{DTime-LSTime_i} * t \tag{30}$$

$$Node_{i,LGT} = LGT(L(MFHD_i, DTime)) * \left(1 + \frac{T_i}{DTime-LSTime_i}\right) - LGT(L(MFHD_i, LSTime_i)) * \frac{T_i}{DTime-LSTime_i} \tag{31}$$

$$Node_{i,LTT} = LTT(L(MFHD_i, DTime)) * \left(1 + \frac{T_i}{DTime-LSTime_i}\right) - LTT(L(MFHD_i, LSTime_i)) * \frac{T_i}{DTime-LSTime_i} \tag{32}$$

After that, the above two index values are weighted to derive an integrated index. Finally, this algorithm selects a number of moving service points with relatively higher integrated index values for the user and ensures the satisfaction degree of the user demands by resources of moving service points.

4 Multiple LBS Output Generation System (MLBS)

Based on the proposed multiple LBS output generation model, this paper develops a multiple LBS output generation system (MLBS) over Internet enabling service demander to effectively query and access the service information or resource relating to the target object through web browsers (e.g., Internet Explorer, or Google Chrome). Service demanders can log onto the system through web browsers and use the corresponding functions including LBS output generation module, target object selection parameter maintenance module and user profile maintenance module provided by the system. The framework of this system can be illustrated in Figure 6 and the system operation interface is shown in Figure 7.

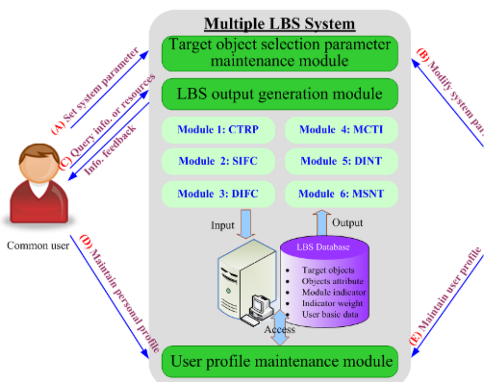


Fig 6. Framework of MLBS

Fig 7. The system operation interface

As shown in Figure 6, common user can set system parameters via the target object selection parameter maintenance module according to their requirements (see Figure 6 (A)); also, system administrator can modify system parameters via this module (see Figure 6 (B)). In addition, common user can query and access the information or resources with respect to the closer target object via LBS output generation module (see Figure 6 (C)). Finally, common users can maintain the their personal profile via user profile maintenance module (see Figure 6 (D)) and the system administrator can manage all the user's basic data and authorities in this module (see Figure 6 (E)).

5 Case Study

In order to demonstrate applicability of the model and system, real cases are used to demonstrate the reasoning performance of the proposed methodology. The system verification including three types of LBS namely SIFC, DIFC and MCTI are introduced.

5.1 Performance evaluation on SIFC

(1) Performance evaluation process

Regarding the performance evaluation of RIFC module, 13 tourist attractions in Hsinchu as the testing target objects are used to demonstrate the reasoning performance of this module. After acquiring the basic information about these target objects (including the location latitude and longitude, type, region and tourist attraction introduction) and the specified demands (different information numbers of target objects) of 20 service demanders at 20 different locations, this module generates and provides the user with appropriate information with respect to the target object. The system performance of this module is evaluated based on two subjective target object selection methods including the intuitive selection (slight impression on the distance) and random selection (no sense on the distance).

(2) Analysis of performance evaluation result

Based on the different requirements of 20 users at different locations (different preferred number of visiting target objects), this system generates the target objects for each user. Furthermore, according to the target objects selected by intuitive selection and random selection methods, the average distance between the target objects and the user, the average improvement distance of target object, the improvement rate of number of accurate target objects can then be calculated. The comparison of system reasoning/generating results and two subjective selection results can be summarized in Table 1 and Figure 8.

Table 1. The comparison of system reasoning/generating results and two subjective selection results

Performance index / Method	Moving distance		Accuracy	
	Avg.	Avg. improvement	Avg.	Avg. improvement
Intuitive selection	37.260 km	28.07%	52%	48.00%
System generation	27.066 km		100%	
Random selection	46.527 km	39.60%	34.64%	65.36%
System generation	27.066 km		100%	

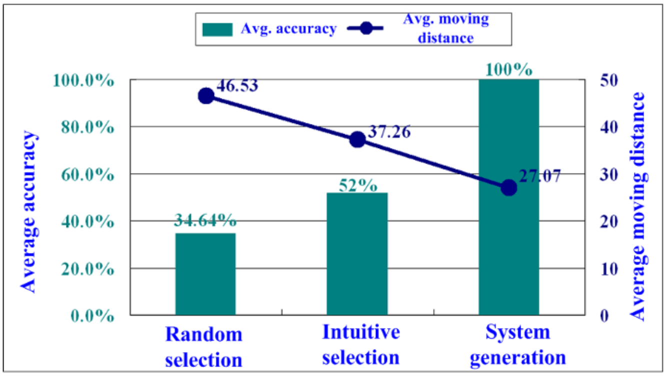


Fig 8. Comparison of accuracy rate and average distance between target object and user

Overall, when the user prefers to visit more than one target object, the system can improve the average distance between the user and the target object as compared with the subjective selection method. Moreover, as the user has no sense in the distances of various tourist attractions (i.e., selection of tourist attractions randomly), the average distance between the target and the user can be significantly reduced.

5.2 Performance evaluation on DIFC

(1) Performance evaluation process

Regarding the performance evaluation of DIFC module, 20 parking spaces in Taipei as the testing target objects are used to demonstrate the reasoning performance of this module. The basic information (including the longitude and latitude and history data of the location) of testing target objects can be collected accordingly. After that, this system generates the demands on parking space for these 20 users at different time and locations.

In addition, this paper takes into consideration the factor of the occupation of the parking space to establish the uniform distribution with 1 to 3 minutes, 1 to 10 minutes and 1 to 20 minutes idle time per hour of the parking spaces. According to above three cases, these 20 users at different time and locations are searching from idle parking space and system generates the parking spaces that are more possible idle and closer to the users.

(2) Analysis of performance evaluation result

The parking spaces with high probability of being idle and nearest to the users are generated and provided to the users. The system reasoning results compared with the subjective selection results in waiting time are summarized in Table 2 and Figure 9 and in moving distances are summarized in Table 3 and Figure 10.

Table 2. The system reasoning results compared with the subjective selection results in waiting time

Performance index / Method	Idle 1 to 3 minutes			Idle 1 to 10 minutes			Idle 1 to 20 minutes		
	Avg. WT	**Avg. Diff.**	**Imp. rate**	**Avg. WT**	**Avg. Diff.**	**Imp. rate**	**Avg. WT**	**Avg. Diff.**	**Imp. rate**
Nearest parking space	25min. 03sec.	14min. 21sec.	57.29%	23min. 57sec.	15min. 06sec.	63.05%	21min. 18sec.	16min. 45sec.	78.64%
System generation	10min. 42sec.			8min. 51sec.			4min. 33sec.		
Nearest idle parking space	13min. 21sec.	2min. 39sec.	19.85%	4min. 30sec.	-4min. 21sec.	-96.67%	0min. 0sec.	-4min. 33sec.	-∞
System generation	10min. 42sec.			8min. 51sec.			4min. 33sec.		

*Note: “WT” denotes “waiting time”, “Diff.” denotes “difference”, “Imp.” denotes “improvement

Table 3. The system reasoning results compared with the subjective selection results in moving distance

Performance Index / Method	Idle 1 to 3 minutes			Idle 1 to 10 minutes			Idle 1 to 20 minutes		
	Avg. MD	**Avg. Diff.**	**Imp. rate**	**Avg. MD**	**Avg. Diff.**	**Imp. rate**	**Avg. MD**	**Avg. Diff.**	**Imp. rate**
Nearest parking space	198.668 m	-94.579 m	-47.60%	198.668 m	-119.886 m	-60.35%	198.668 m	-122.419 m	-61.62%
System generation	293.247 m			318.554 m			321.087 m		
Nearest idle parking space	319.812 m	26.565 m	8.31 %	424.562 m	106.008 m	24.97%	409.328 m	88.241 m	21.56%
System generation	293.247 m			318.554 m			321.087 m		

*Note: "MD" denotes "moving distance", "Diff." denotes "difference", "Imp." denotes "improvement

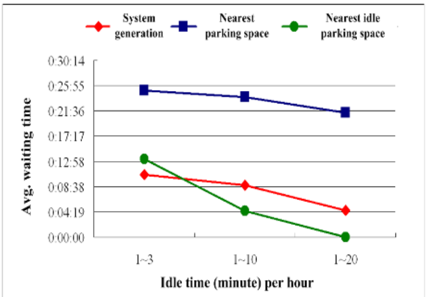


Fig 9. The comparison results of user waiting time

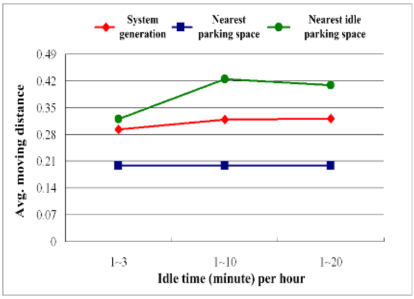


Fig 10. The comparison results of user moving distance

The system reasoning results can shorten the waiting time although the user is unable to get to the target object (parking space) with shortest distance. Also, the target object highly matching the user specified conditions recommended by system can significant reduce waiting time (waiting time reduction percentage increasing from 57.29% to 78.64%). Regarding the user looking for the nearest target objects matching the specified conditions, the system reasoning results can shorten the distance although the user might wait for the target objects. Also, the target object lowly matching the user specified conditions recommended by system can significant reduce moving distance of the user. Moreover, as the degree of a target object matching the specified conditions is extremely low, the system reasoning results can shorten both the moving distance and the waiting time.

5.3 Performance evaluation on MCTI

(1) Performance evaluation process

Regarding the performance evaluation of MCTI module, 10 bus routes, corresponding stops and 10 buses as the testing target objects are selected to demonstrate the reasoning performance of this module. The corresponding information about the buses (e.g., the longitude and latitude of the location, the bus route, the longitude and latitude of the bus stops) can be collected accordingly. Then, the different demands of 10 users at different locations are simulated to generate the buses closer to current location and destination of the user.

The system reasoning performance are evaluated based on two subjective selection methods including selecting buses in the planned route stop nearest to destination method and waiting for bus at the nearest stop method. According to the user's location, the user's destination and the locations of bus stops, the system selects the nearby bus relatively closer to the current location of the user and the user destination.

(2) Analysis of performance evaluation result

With buses in Taipei as an example, this paper simulates the different destinations of 10 users at different locations to generate the buses with planned route closer to the current location and destination of the user. The comparison of the system generation and the subjective selection results are summarized in Table 4 and Figure 11.

Table 4. The system reasoning results compared with the subjective selection results in distance index

Performance index / Method	Distance between target object and user			User moving distance		
	Avg. distance (km)	**Distance difference (km)**	**Average distance improvement rate**	**Avg. distance (km)**	**Distance difference (km)**	**Average distance improvement rate**
The 1st selection method	3.449	0.542	15.73%	3.442	0.596	17.33%
System generation	2.906			2.845		
The 2nd selection method	6.011	3.105	51.65%	4.512	1.667	36.94%
System generation	2.906			2.845		

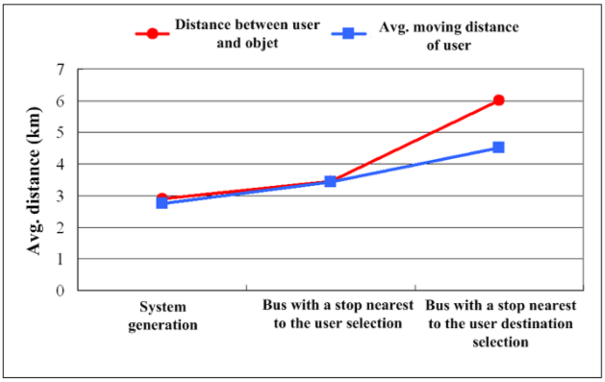


Fig 11. The comparison of the system reasoning results and subjective selection results

As a whole, by taking the buses to the destination, if the user decides to wait for the bus at the nearest bus stop, the burden of moving distance from the bus stop to get off the bus to the destination is increased. On the contrary, if the user takes the bus at the bus stop closer to the moving target object, the burden of moving distance from the current location to the bus stop to get on the bus is increased. To compare with the above two results, the system generation results can effectively shorten the average moving distance of the user. Thus, the user's waiting time for the moving target object can be effectively reduced.

6 Conclusion

As a whole, this model can be applied to assist the LBS service provider to manage the huge and complicated geographical data and systematically determine the appropriate LBS information and services for the various demands of the service demanders. After mapping the features of user demands (acquired from the service demander) and geographical data (from the geographical information provider), six types of LBS scenarios are established; moreover, algorithms for determining the optimal LBS information or services are also constructed. According to the demands, geographical data and demander locations, the LBS service provider can determine the appropriate LBS information or services via the corresponding LBS output generation algorithm and provide to the demanders. Based on the proposed multiple LBS output generation methodology, a multiple LBS system is also developed. Furthermore, three LBS scenarios are used as examples to evaluate the performance of the proposed methodology and system. The verification results show that the developed system is a high-performance multiple LBS provision system for demanders.

References

[1] Avella, P., Boccia, M. and Sforza, A., 2004, "Resource constrained shortest path problems in path planning for fleet management," Mathematical Modeling and Algorithms, Vol. 3, No. 1, pp. 1-17.

[2] Chen, J., Cheng, R., Mokbel, M. and Chow, C. Y., 2009, "Scalable processing of snapshot and continuous nearest-neighbor queries over one-dimensional uncertain data," The VLDB Journal, Vol. 18, No. 5, pp. 1219-1240.

[3] Feng, J., Zhu, Y., Mukai, N. and Watanabe, T., 2007, "Search on transportation networks for location-based service," Applied Intelligence, Vol. 26, pp. 69-79.

[4] Flessa, S., 2000, "A linear programme for the optimal allocation of health care resources in developing countries," Health Care Management Science, Vol. 3, No. 3, pp. 249-267.

[5] Huang, C. H., 2007, "Mining temporal mobile sequential patterns in location-based service environments," Department of Computer Science and Information Engineering, National Cheng Kung University, Master Thesis.

[6] Huang, J. Z., Liu, Y. L., Liu, Y. F., He, J. H. and Chen, D., 2008, "Research and application on network update of land survey spatial data based on embedded GIS and GPS," International Workshop on Geoscience and Remote Sensing, Vol. 1, 532-535.

[7] Ibach, P. and Horbank, M., X., 2005, "Highly available location-based services in mobile environments," Lecture Notes in Computer Science, Vol. 3335, pp. 126-133.

[8] Jin, M.-H., Horng, J.-T., Tsai, M.-F. and Wu, E. H.-K., 2007, "Location query based on moving behaviors," Information Systems, Vol. 32, pp. 385-401.

[9] Jula, H., Dessouky, M. and Ioannou, P. A., 2006, "Truck route planning in nonstationary stochastic networks with time windows at customer locations," Intelligent Transportation Systems, Vol. 7, No. 1, pp. 51-62.

[10] Jula, H., Dessouky, M. and Ioannou, P. A., 2006, "Truck route planning in nonstationary stochastic networks with time windows at customer locations," Intelligent Transportation Systems, Vol. 7, No. 1, pp. 51-62.

[11] Kim, J. W., Kim, C. S., Gautam, A. and Lee, Y., 2005, "Location-based tour guide system using mobile GIS and web crawling," Lecture Notes in Computer Science, Vol. 3428, pp. 52-63.

[12] Küpper, A. and Treu, G., 2006, "Efficient proximity and separation detection among mobile targets for supporting location-based community services," Mobile Computing and Communications Review, Vol. 10, No. 3, pp. 1-12.

[13] Lee, J. W., Paek, O. H. and Ryu, K. H., 2004, "Temporal moving pattern mining for location-based service," Journal of Systems and Software, Vol. 73, No. 3, pp. 481-490.

[14] Lin, R., Zhao, Y., Zou, H. and Yang, F., 2008, "An enhanced location service with social feature," The Forth International Conference on Wireless Communications, Networking and Mobile Computing, pp. 1-4.

[15] Lu, H., Chen, K. and Liu, B., 2007, "Bayesian network based behavior prediction model for intelligent location based services," IEEE Conference on Industrial Electronics and Applications, pp. 703-708.

[16] Lu, H. C. and Tseng, S. V., 2009, "Mining cluster-based mobile sequential patterns

in location-based service environments," International Conference on Mobile Data Management, pp. 273-278.

[17] Sadoun, B. and Al-Bayari, O., 2007, "Location based services using geographical information systems," Computer Communications, Vol. 30, No. 16, pp. 3154-3160.

[18] Spanoudakis, M., Batistakis, A., Priggouris, I., Ioannidis, A., Hadjiefthymiades, S. and Merakos, L., 2003, "Extensible platform for location based services provisioning," The Fourth International Conference on Web Information Systems Engineering Workshops, pp. 72-79.

[19] Tao, Y., Papadias, D. and Shen, Q., 2002, "Continuous nearest neighbor search," Proceedings of the 28th International Conference on Very Large Data Bases Table of Contents, pp. 287-298.

[20] Wu, S.-Y. and Wu, K.-T., 2006, "Effective location based services with dynamic data management in mobile environments," Wireless Networks, Vol. 12, No. 3, pp. 369-381.

Multi-label text categorization forecasting probability problem using support vector machine techniques

Hui-Min Chiang[1], Tai-Yue Wang[2], Yu-Min Chiang[3]

[1]Nan Jeon Institute of Technology,

[2]National Cheng kung University, [3]I-Shou University

hueimin@mail.njtc.edu.tw, tywang@mail.ncku.edu.tw, ymchiang@isu.edu.tw

Abstract. The pervasiveness of information available on the Internet means that increasing numbers of documents must be classified. Text categorization is not only undertaken by domain experts, but also by automatic text categorization systems. Therefore, a text categorization system with a multi-label classifier is necessary to process the large number of documents. In this study, a proposed multi-label text categorization system is developed to classify multi-label documents. Data mapping is performed to transform data from a high-dimensional space to a lower-dimensional space with paired SVM output values, thus lower the complexity of the computation. A pair-wise comparison approach is applied to set the membership function in each predicted class to judge all possible classified classes. Finally, the overlapped area of two classes is obtained from the decision function to determine where a document is classified. A comparative study is performed on multi-label approaches using Reuter's data sets. The results of the empirical experiment indicate that the proposed multi-label text categorization system performs better than other methods in terms of overall performance indices. Additionally, the probability of 0.5 for model membership function is a good criterion to judge between correctly and incorrectly classified documents from the results of the empirical experiment.

Keywords: Multi-label; One-against-one support vector machine; Membership function Gaussian mixture model

1 Introduction

Multi-label text categorization has received considerable attention in recent years [4; 11; 16; 2; 23; 25; 19]. Some methodologies have been proposed by researchers can be found in literatures [11; 16; 6; 21; 18; 13; 10; 24]. Among them, one of the developed approaches is using Support Vector Machines (SVM) to solve the text categorization problem.

SVM can handle multi-class text categorization problems well, and has also been applied successfully to handling multi-label classification problems. Joachims [9] investigated the applications of SVM for text categorization, and observed that SVM

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_3,

is very robust even in the presence of numerous features. He further observed that a multitude of text features is indeed useful for text categorization. Then, Elisseeff and Weston [5] proposed a ranking algorithm for multi-label classification. However, the algorithm does not output a set of labels. Boutell *et al.* [2] adopted SVM as an example classifier to generalize the one-against-all (OAA) approach to multi-label classification, and developed three labeling criteria. Their results indicate that this method is appropriate for scene classification. Wang et al. [23] presented two algorithms, called Parallel Support Vector Machines (PSVMs) and Sequential Support Vector Machines (SSVMs), to manage multi-label classification problems, and applied them to scene classification.

According to above discussions, SVM method can handle multi-label well, but has not been applied to multi-label text categorization problems. Therefore, this study presents a modified one-against-one SVM (MOAO-SVM) classifier to manage the multi-label text categorization problem, which finds all the classes in a document to be assigned simultaneously by examining the SVM's outputs, and the probability (calculated from membership function) of a document belonging to each class is estimated.

Additionally, Metrics such as the Exact Match Ratio, Hamming Loss and overall Precision are used to evaluate the system's performance.

2 The proposed multi-label text categorization system

The proposed multi-label text categorization system has two modules, the processing module and the classifying module. The document processing module includes the processes of document preprocessing, feature selection, document representation and term weighing. After the documents are preprocessed, the documents are gone through the data division process to two portions: training and testing documents for future uses. Then the classifying module is to classify the testing documents into different classes or labels after the system is trained by training documents.

In the training phase, the training data are first processed by the SVM classifier (binary) and the $k*(k-1)/2$ decision functions are obtained. After the decision functions are found, the system goes to the testing phase. In testing phase, the testing data along with the decision functions from training phase are fed into OAO classifier to calculate the decision values. From the decision values, one can find the classes with decision values larger than zero. Finally, the classes that a document is belonged to is decided. The processes the classifying module are discussed in the subsequent sections.

2.1 SVM classifier (binary classifier)

An SVM is a hyperplane that separates a set of positive examples from a set of negative examples with a maximum margin. It is to find the linear separators in order to settle binary classification problems. The simplest model of SVM assumes a set *S* of labeled training points with associated (y_1, x_1)…(y_l, x_l), where each training point $x_i \in R^N$ is given a label $y_i \in \{-1, 1\}$ with i=1,…,l. It works only for data that are linearly separable in the feature space. We use this concept to find the optimum linear hyperplane g(x) = Wt + b =0 for the training data.

At first, all data are assumed to be at a distance of at least 1 from the hyperplane. This classifier is called the maximum margin classifier. The following two constraints are adopted for the training set.

$$\begin{aligned} w^T x_i + b &\geq 1 \text{ if } y_i = 1 \\ w^T x_i + b &\leq 1 \text{ if } y_i = -1 \end{aligned} \tag{1}$$

If the data are nonlinear, then the input space *X* can be mapped into a higher dimensional feature space Φ(x), so that the data in the feature space become linearly separable. The mapping function Φ(*x*) should satisfy Mercer's theorem [8]:

$$K(x_i, x_j) = \Phi(x_i)^t \Phi(x_j) \tag{2}$$

where K (x_i, x_j) denotes the kernel function.

The kernel function can be selected from the polynomial learning machine kernel, radial- basis function network kernel, linear network kernel and two-layer perception functions. By using this nonlinear transformation, the decision function becomes hyperplane g(x)=WΦ (x) +b=0. These decision functions are fed to testing phase for calculating the decision values along with the testing data.

2.2 One-Against-One (OAO) classifier with modified vote strategy

The following procedures are used to obtain the decision value of a testing data, That is, the decision function for the pair of class *i* and *j* is given by:

$$D_{ij}(x) = w^t{}_{ij} x + b_{ij} \text{, where } D_{ij}(x) = -D_{ji}(x) \quad i=1\ldots k, j=1\ldots k. \tag{3}$$

The testing data are then examined for all k *x(k-1)/ 2* decision functions fed from training phase. The vote strategy is employed to classify the examples. The vote score sign (*Dij*) of the *i*th class is added by one if *Dij(x) > 0.* Otherwise, the vote score of

the *j*th class is increased by 1. That is, $\text{sign}\left(D_{ij}\right) = \begin{cases} 1 & D_{ij}(x) > 0 \\ 0 & \text{otherwise} \end{cases}$.

Consequently, the scores of input example *x* for each class can be obtained

by $D_i(x) = \sum_{j \neq i, j=1}^{k} \text{sign}\left(D_{ij}\right)$, and *x* is classified into $\arg \max_{i=1,\ldots,n} D_i(x)$ [7].

Since this procedure could only solve the k-class text categorization problems, one needs to modify the procedure for multi-label text categorization problem. That is, the OAO-SVM must adjust the vote strategy so that it can assign one testing data to more than two classes. According to the assumptions of SVM, all data have at least a distance of 1 from the hyperplane (which creates a maximum margin) to conform to

Eq. (1). Therefore, the modified vote scheme adopts a stricter definition for input example *x*, namely:

$$D_i\left(x\right)=\sum_{j\neq i,\,j=1}^{k}\operatorname{sign}\left(D_{ij}\right)\ \text{ where }\ \operatorname{sign}\left(D_{ij}\right)=\begin{cases}1 & D_{ij}(x)\geq 1\\ 0 & \text{otherwise}\end{cases}. \tag{4}$$

The following steps are then performed to find the classes to which the documents should be assigned.

Step 1: For input example *x*, $D_i\left(x\right)=\sum_{j\neq i,\,j=1}^{k}\operatorname{sign}\left(D_{ij}\right)$ is calculated where $\operatorname{sign}\left(D_{ij}\right)=\begin{cases}1 & D_{ij}(x)\geq 1\\ 0 & \text{otherwise}\end{cases}$

.Step 2: If all D_i (x)=0 for *i=1,...k*, then $D_i\left(x\right)=\sum_{j\neq i,\,j=1}^{k}\operatorname{sign}\left(D_{ij}\right)$ is computed again where $\operatorname{sign}\left(D_{ij}\right)=\begin{cases}1 & D_{ij}(x)>0\\ 0 & \text{otherwise}\end{cases}$ for input example *x*.

Step 3: *x* is classified into the classes with $D_i(x)>0$. The input example *x* is thus classified into one or more classes provided that $D_i(x)>0$.

2.3 Calculate the model membership function

According to the modified vote strategy of the OAO-SVM, input *x* can be assigned to more than one class with the input example that satisfies $D_i(x) > 0$, rather than the plural forms of *i* satisfied for $\arg\max_{i=1,\dots,n} D_i\left(x\right)$ in the original vote strategy. The membership function can then be used to represent the probability of *x* belonging to each class [1; 17; 12; 20; 23]. Thus, the decision functions Dij(x) for the paired class *i* and *j* can then be utilized to compute the membership function orthogonal to the optimal separating hyperplane. Therefore, the membership function $m_{i,\,ij}$ (x) of *x* belonging to class *i* is defined as:

$$m_{i,\,ij}\left(x\right)=\begin{cases}1 & ,\ \text{if } D_{ij}\left(\mathrm{x}\right)\geq 0\\ 1+D_{ij}\left(x\right) & ,\ \text{if } -1<D_{ij}\left(x\right)<0\\ 0 & ,\ \text{if } D_{ij}\leq -1\end{cases} \tag{5}$$

Additionally $m_{i,\,ij}$ (x), the membership function of *x* belonging to class *j*, is defined as:

$$m_{j,\,ij}\left(x\right)=\begin{cases}0 & ,\ \text{if } D_{ij}\left(\mathrm{x}\right)\geq 1\\ 1-D_{ij}\left(x\right) & ,\ \text{if } 0<D_{ij}\left(x\right)<1\\ 1 & ,\ \text{if } D_{ij}\leq 0\end{cases} \tag{6}$$

To describe the degree of input example *x* belonging to class *i*, the average operator m_i (x) is further defined as:

$$m_i(x) = \underset{i,j=1\ldots,k}{\frac{1}{k-1}} \sum_{i=1}^{k} m_{i,ij}(x) \tag{7}$$

3 Numerical Experiment

A numerical experiment using 21,578 Reuter's documents was performed to demonstrate the proposed model.

3.1 Testing data

Documents from Reuters 21,578 in Standard Generalized Markup Language (SGML) format numbered from 1 to 21,578 and with tags TOPIC and BODY were adopted as the empirical data. The content in the tag TOPIC included more than one topic, so each document was assigned to one or more topics. The performance of the proposed model was measured from the 9,401 documents containing the 10 most frequent topics. 9,401 documents contained multiple topics will create over 9,401 unscreened dataset. Therefore, number of dataset of the unscreened dataset is 10,407. A description of the unscreened dataset with the topics and classes in the document set lists in Table1

Table 1. A description of the unscreened dataset

Topic	Earn	Acq	money-fx	Crude	Grain	Trade	Interest	Wheat	Ship	Corn	Total
Class	1	2	3	4	5	6	7	8	9	10	
Number of dataset	3987	2448	801	634	628	551	513	306	305	254	10407

3.2 Processing of the testing data

The content enclosed in <BODY> </BODY> was evaluated as the main content of the documents, and was divided into different words. Insignificant words were screened out. The keywords were located as follows.
Step 1: Count the frequency of the words in every document.
Step 2: Eliminate numbers and punctuation from each document.
Step 3: Eliminate 306 stop words.
Step 4: Select the top 100 words in each class.
Then 751 keywords and 8,559 documents were collected. The dataset was downsized again to 9,553 documents. This value is greater than 8,559, because the data contained multiple topics, as presented in Table 2.

Table 2 A description of the screened dataset after downsizing

Topic	Earn	Acq	money-fx	Crude	Grain	Trade	Interest	Wheat	Ship	Corn	Total
Class	1	2	3	4	5	6	7	8	9	10	
Number of dataset	3776	2209	684	566	574	514	424	287	295	224	9553

The term weight can be defined as $TF\_IDF = n_i \times \log(N / n_i)$ [14].
The input matrix was a collection of n documents and contained the TF_IDF's weights, this corresponds to the input data of the classifiers.

3.3 Parameter settings

The kernel function and its parameters must be set in advance to perform the numerical experiment. The Gaussian kernel $K(x, y) = \exp(-q\|x - x_i\|^2)$ was utilized to perform the experiment, because it provides a tighter enclosing sphere for the data in the original space. The Gaussian kernel parameters were set to q=0.5 and C=100, as in Cawley [3]. The experimental data was processed by MATLAB® 6.5, Visual Basic (VB) 6.0 and Access 2003.

3.4 Performance evaluation

Multi-label text categorization problems need more metrics than those utilized in single-label text categorization problems due to their complexity. The following metrics [15; 16] are applied to evaluate the performance of the proposed system.
(1)Exact Match Ratio
(2) Hamming Loss
(3) Precision
The detailed description and computation on these indices can found the related literature [15; 16].

3.5 Results

To verify the experiment, the dataset was divided into a training dataset and a testing dataset. The performance of the proposed scheme is compared with Binary Naïve Bayes (NB), Multi-label Mixture, and Bp-MLL [24]. We have first compared the proposed multi-label text categorization to NB and Multi-label Mixture methods. The results have shown that the Exact Match Ratio of the proposed multi-label text categorization is 0.9940 compared to 0.7569 of NB model [11] and 0.8392 of the Multi-label mixture model.

The proposed multi-label text categorization is then compared with Bp-MLL. This comparison, however, is not perfectly reliable because it is difficult to have identical settings for them. We have download MATLAB program to do the comparison tasks with same dataset. [25] Due to different settings between different methods, the main purpose of the following comparisons is to provide a method for solving the multi-label classification problems instead of demonstrating which method is better. Both Bp-MLL and the proposed multi-label text categorization are using the same extracted input matrices and these two methods are compared with same metric, dataset and index. Table 3 shows the comparison results.

Table 3 The proposed method and Bp-MLL

Index	Bp-MLL Neural Networks method	The proposed multi-label text categorization method
Precision	0.8076	**0.9947**
Hamming Loss	0.0527	**0.0011**
One-error	0.2714	**0.006**

The probability of the corresponding multi-label documents was then derived. Finally, the distributions of these paired classes were estimated, and the overlapped ranges of SVM's decision values were identified.
Additionally, Table 4 lists the misclassified documents of the testing data. The probability of predicted labels appearing in each class when the document satisfied for plural *i*s was calculated as D_i (x) > 0 for class.

Table 4 The misclassified documents of the testing data

Document number(#)	Actual label	Predicted label
19550	5,8	5,8,9,10
19669	5,8	5,8,9,10
20612	5,8	5,8,9,10
20646	5,8,10	5,8,9,10
20739	5,8	5,8,9,10

The membership function *mi* (*x*) of a misclassified document *x* belonging to class *i* from all possible SVM outputs was derived by Eqs. (5), (6), and (7). Table 5 summarizes the calculation results.

Table 5 The probabilities of misclassified documents

Document number(#)	The probabilities of misclassified documents			
19550	m_5=1.000	m_8=0.6650	m_9=0.3340	m_{10}=0.1225
19669	m_5=1.000	m_8=0.6650	m_9=0.3336	m_{10}=0.1225
20612	m_5=1.000	m_8=0.6650	m_9=0.3340	m_{10}=0.1225
20646	m_5=1.000	m_8=0.6650	m_9=0.0001	m_{10}=0.6250
20739	m_5=1.000	m_8=0.6650	m_9=0.3337	m_{10}=0.1225

The membership function of document *x* correctly classified as belonging to four classes from all possible SVM outputs was computed using equations (5)–(7). Table 6, show the calculation results.

Table 6 The probabilities of correctly classified documents for the four predicted classes

Document number(#)	The probabilities of four correctly classified class documents			
8274	m_5=1.0000	m_6=0.8870	m_8=0.5880	m_{10} =0.5260
17313	m_5=1.0000	m_6=0.8870	m_8=0.5880	m_{10} =0.5260
10269	m_4=0.9802	m_5=1.0000	m_6=0.9660	m_8=0.5000
10407	m_4=0.9802	m_5=1.0000	m_6=0.9660	m_8=0.5000
11886	m_5=1.0000	m_8=0.6740	m_9=0.8370	m_{10} =0.6000
13180	m_5=1.0000	m_8=0.6740	m_9=0.8370	m_{10} =0.6000

Tables 6 reveal that all the probabilities of document numbers 8274, 17313, 10269, 10407, 11886 and 13180 appearing in correctly predicted classes were above 0.5. The membership function of document *x* correctly classified as belongings to three classes from all possible SVM output was then determined by equations (5), (6), and (7), and the results are presented in Table 7.

Table 7 The probabilities of correctly classified documents for the three predicted classes

Document number(#)	The probabilities of three correctly classified class documents		
20512	m_5=0.6460	m_6=0.9597	m_8=0.8678
20650	m_5=0.9000	m_6=0.9597	m_{10}=0.8133
21244	m_5=0.6800	m_8=0.9156	m_{10}=0.4836

Table 7 indicates that all of the probabilities of document numbers 20512, 20650 and 21244 appearing in the correctly predicted classes were greater than 0.5, except the $m10$=0.4836 of document 21244.

4 Concluding remarks

Multi-label classsification is a significant issue in domain text categorization. In many real-world tasks, classes are not independent, and are overlapped in the feature space. The proposed multi-label text categorization provides a framework for exploiting the dependencies between categories to identify label co-occurrences. This method can thus categorize documents into multiple classes according to their contents. Consequently, the probability that a documents belongs to a class can be predicted. Using the same Reuters data, some multi-label text categorization systems from previous studies were compared to the proposed multi-label text categorization system. Analytical results indicate that the proposed multi-label text categorization system performs better than others multi-label text categorization systems.

Further examination of the Reuters 21,578 data set demonstrates that the probabilities of documents appearing in correctly predicted classes were greater than 0.5 and those of documents appearing in the wrongly predicted classes were less than 0.5. Accordingly, the offset to discriminate between correctly and incorrectly classified documents can be set to 0.5.

References

[1] Abe, S., Inoue,T. (2002). Fuzzy support vector machines for multiclass problems. In proceedings of 10th European symposium on artificial neural networks (pp. 113-118). Bruges, Belgium, April.

[2] Boutell, M.R., Luo, J., Shen, X. & Brown, C.M. (2004). Learning multi-label scene classification. Pattern Recognition, 37(9), 1757-1771.

[3] Cawley G. (2000). MATLAB Support Vector Machine Toolbox (svm_v0.54).

[4] Chiang, D. A. & Lin, N. P. (1999). Correlation of fuzzy sets. Fuzzy Set and Systems, 102, 221-226.

[5] Elisseeff, A., & Weston, J. (2002). A kernel method for multi-labelled classification. Advances in Neural Information Processing Systems, 14, 681-687.

[6] Egghe, L. & Michel, C. (2003). Construction of weak and strong similarity measures for ordered sets of documents using fuzzy set techniques. Information Processing and Management, 39, 771-807.

[7] Friedman, J. (1996). Another approach to polychotomus classification, Technical report, Department of Statistics, Stanford University, available at http://www-stat.standford.edu.tw/report/friedman/poly.ps.Z.

[8] Haykin, S., 1999. Neural Networks. New Jersey: Practice-Hall Press.

[9] Joachims, T. (1998). Text categorization with support machines: learning with many features. In proceedings 10th Europen Conference on machine learning (ECML) Chemnitz: Springer-Verlag (pp. 137-142).

[10] Kao, T. H. (2006) Advanced parametric mixture model for multi-label text categorization, a dissertation submitted in partial fulfillment of the requirements for the degree of master of science on national Taiwan University.

[11] McCallum, A. K. (1999). Multi-label text classification with classification with a mixture model trained by EM. In proceedings of the AAAI' 99 Workshop on Text Learning (pp.1-7).

[12] Mill, J. & Inoue, A. (2003). An application of fuzzy support vector machines. Proceeding of the 22nd North American Fuzzy Information Processing Society (pp.302-306). Chicago, Illinois, July 24-26,

[13] Saito, K. (2005). Multiple topic detection by parametric mixture models (PMM)—Automatic web page categorization for browsing. NTT Technical Review, 3(3), 15-18.
[14] Salton, G., & Buckley, C. (1988). Term weighting approaches in automatic text retrieval. Information Processing and Management, 24, 513–523.
[15] Salton, G. (1991). Developments in automatic text retrieval. Science, 30, 974-980.
[16] Schapire, R. & Singer, Y. (2000). BoosTexter : A Boosting-based System for Text Categorization. Machine Learning, 39, 135-168.
[17] Takahashi, F., Abe, S. (2002). Decision-tree-based multiclass support vector machines. Proceedings of the 9th international conference on neural information processing (pp. 1418-1422).
[18] Tanaka, H. ,Sakano, H. & Ohtsuka, S. (2004). Retrieval Method for Multi-category Images. Proceedings of the 17th International Conference on Pattern Recognition (pp. 1051-1054).
[19] Tsoumakas, G. & Katakis, I. (2007). Multi-Label Classification: An Overview. International Journal of Data Warehousing and Mining, 3(3), 1-13.
[20] Tsujinishi, D. & Abe, S. (2003). Fuzzy least squares support vector machines for multiclass problems. Neural Networks, 16(5), 785-792.
[21] Ueda, N. & Saito, K. (2003). Parametric mixture models for multi-labeled text. Advances in Neural Information Processing Systems, 15, 721-728.
[22] Wang, X. & Wu, C. (2004). Using membership functions to improve multiclass SVM. In Proceedings 7th International Conference on Signal Processing (pp.1459-1462).
[23] Wang, L., Chang, M. & Feng, J. (2005). Parallel and sequential support vector machines for multi-label classification. International Journal of Information Technology, 11(9), 11-18.
[24] Zhang, M.L. & Zhou, Z.H. (2006). Multi-label neural networks with applications to
[25] 13
[26] functional genomics and text categorization. IEEE transactions on knowledge and data engineering, 18(10), 1338-1351.
[27] Zhang, M.L. (2006). The MATLAB package source of BPMLL. http://cs.nju.edu.cn/zhouzh/zhouzh.files/publication/annex/BPMLL.htm.

Diatoms classification with weighted averaging fuzzy operators for eutrophication prevention

Andreja Naumoski, Kosta Mitreski

University "Ss. Cyril and Methodius",
Faculty of Electrical Engineering and Information Technologies Skopje

Andrejna@feit.ukim.edu.mk, komit@feit.ukim.edu.mk

Abstract. The level of nutrients determines the triggering point of the eutrophication process, so it is very important to monitor these levels. Diatoms react rapidly on nutrient changes and that makes them ideal eutrophication bio-indicators. In the relevant literature there is known ecological reference for some diatoms, but for many of them these indicator features remain unidentified. In order to fill this gap and deal with disadvantages of the previous used methods, this research chapter aims to a novel fuzzy algorithm for classification of diatoms for eutrophication prevention. By using this algorithm, each diatom will be classified and based on results from the diatom models will be recommended for such objective. The proposed method uses sigmoid distribution to reveal the diatom-indictor relationship. Combined with weighted averaging fuzzy operators the experimental results have verified and discovered several diatom indicators that can be used for prevention. Once the diatom is found in the water sample, the expert looks up in the database and identifies the health state of the ecosystem. This also can be done for metal parameters, not just for nutrients.

Keywords: Diatoms, Trophic State Index Class, Lake Eutrophication, Classification Models, Weighted Averaging Fuzzy Operators

1 Introduction

Diatoms as bio-indicators serve as early indicators of the health state of the ecosystem, and thus they can indicate the level of the eutrophication processes. In this research, we use this property of the diatoms of indicating certain physical-chemical parameters important for the eutrophication processes of the environment in order to classify the appropriate diatom indicator for already recognized and newly discovered diatoms. In this direction, the proposed machine learning methods aims to find this relationship directly from measure data. The TSI classes defined from the ecological point can be interpreted as a classification problem in

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*,
Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_4,

terms of data mining when we build a classification model that correctly classifies the diatom into one of the TSI classes.

In this domain, classical statistical approach are still used, such as canonical correspondence analysis (CCA), detrended correspondence analysis (DCA) and principal component analysis (PCA), are most widely used as a modelling techniques [1]. Although these techniques provide useful insights into data, they are limited in terms of interpretability. Obvious progress in this research area in a direction of interpretability, have been made using data mining techniques, particularly decision trees [2]. The new methods have improved the interpretability and increased the prediction power of the models. The first attempt to model diatom-environment relationship for Lake Prespa, have been made by [3]. Several of the models produced unknown knowledge about the newly discovered diatoms for the first time [3, 4]. Multi-target decision trees later were used, in order to reveal entire set of influencing factors on the diatoms in this lake ecosystem [4]. However, these methods were not robust on data change. This is an important property, because the environmental condition inside of the lake changes rapidly. Also these methods were not used for diatom classification, only for regression analysis of the important influence parameters on the diatoms community.

The robustness of data change and resistant to over-fitting of the fuzzy inducted model trees concept as a classification tool is the main reason of extensive research on fuzzy set based machine learning. Wang and Mendel [5] have presented an algorithm for generating fuzzy rules by learning from examples. Inspired by the classic decision tree induction by Quinlan [2], there are substantial works on fuzzy decision trees. Janikow [6], Olaru and Wehenkel [7] have presented different fuzzy decision tree inductions. Suárez and Lutsko [8], and Wang and Chen, et al. [9] have presented optimizations of fuzzy decision trees. Most of the existing fuzzy rule induction methods including fuzzy decision trees [10] focus on searching for rules, which only use t-norm operators [11] such as the MIN and algebraic MIN. Research has been conducted to resolve this problem. Kóczy, Vámos and Biró [12] have proposed fuzzy signatures to model the complex structures of data points using different aggregation operators including MIN, MAX, average, and etc. The latest survey sums all these advances of fuzzy induction process [13]. The previously investigated methods then are used for classification is based on fuzzy theory approach, so that the problem with data change robust has been overcome.

The main question is: why to use the proposed method in the process of diatom classification? There are several reasons for this. First of all, the proposed method is robust to dataset change because it is based on fuzzy sets, which is not the case with the classical methods and decision trees. Second, the new proposed method obtains a compact structure, which is essential in the process of knowledge obtained from the biological data. Third, these models can achieve high classification accuracy. And the fourth reason is that the proposed method is resistant on over fitting, because he is focusing on entire structures of data samples, which have the same output classes, instead of separating data samples. The accuracy of the fuzzy models depends on both the manner of defining the fuzzy set, (their number, shape and parameters of membership function) and the kind of logical connectivity used. In the previous diatom classification research papers, several different membership functions were applied in order to increase the classification accuracy [14, 15]. In this paper work, we propose to use *WA* and *OWA* aggregation operators with the modified sigmoid (+1) MF, which was not used in the process of fuzzy induced trees [16] and eutrophication diatom classification [14], combined with these fuzzy aggregation operators. Later in the paper the proposed function is compared with the classification accuracy of other MF for diatom eutrophication classification.

The rest of the paper is organized as follows: Section II provides definitions for similarity metrics and the weighted fuzzy aggregation operators. In Section III the evenly distributed sigmoid (+1) MF is presented. Section IV presents the trophic state index diatom datasets as well as the experimental setup. In section V, some models for TSI classes are discussed together with the verification of the model results. Finally, Section VI concludes the paper and gives some future research directions.

2 Similarity metrics and fuzzy aggregation operators

The proposed method generates classification models (CM) made by using similarity metrics and fuzzy aggregation operators, which are presented in this section. The similarity metric that is used in the process of induction classification models is the RMSE metric which is defined with the equation (1):

$$Sim\_RMSE(A;B) = 1 - \sqrt{\frac{\sum_{i=1}^{n} \left(\mu_A(x_i) - \mu_B(x_i)\right)^2}{n}} \tag{1}$$

where x_i, $i = 1, \ldots, n$, are the crisp values discretized in the variable domain, and $\mu_A(x_i)$ and $\mu_B(x_i)$ are the fuzzy membership values of x_i for A and B. In this way the error between the fuzzy membership variables will be much less, and thus we will increase the similarity between these two fuzzy variables. The larger the value of *Sim_RMSE*(*A*,*B*) is, the more similar *A* and *B* are. The $\mu_A(x_i)$, $\mu_B(x_i)$ ∈ [0, 1], 0 *Sim_RMSE*(*A*;*B*) • 1 holds according to (1) and the definition in [11]. Note that the proposed classification method follows the same principle, if an alternative fuzzy set similarity definition such as Jaccard is used [10]. According to the fuzzy logic theory, the fuzzy aggregation operators are logic operators applied to fuzzy membership values or fuzzy sets. There are three sub-categories, namely t-norm, t-conorms, and averaging operators, such as weighted averaging (*WA*) and ordered weighted averaging (*OWA*) [17].

A *WA* operator of dimension n is a mapping $R^n \rightarrow R$, that has an associated n-elements vector $w = (w_1, w_2, \ldots, w_n)^T$, $w_i \in [0, 1]$, $1 \le i \le n$, and that:

$$WA(a_1, a_2, ..., a_n) = \sum_{j=1}^{n} \omega_j a_j, \qquad \sum_{i=1}^{n} \omega_i = 1 \tag{2}$$

An *OWA* operator [17] of dimension n is a mapping $R^n \rightarrow R$, that has an associated n-elements vector $w = (w_1, w_2, \ldots, w_n)^T$, w_i $[0, 1]$, $1 \leq i \leq n$, and

$$OWA(a_1, a_2, ..., a_n) = \sum_{j=1}^{n} \omega_j (f_j(a_1, a_2, ..., a_n)), \qquad \sum_{i=1}^{n} \omega_i = 1 \tag{3}$$

where f_j $(a_1, a_2 \ldots, a_n)$ returns the j-th largest element of the collection $\{a_1, a_2 \ldots, a_n\}$.

A fundamental difference of *OWA* from *WA* aggregation is that the former does not have a particular weight - w_i associated for an element; rather a weight is associated with a particular ordered position of the element. These two operators will be used for generating diatom eutrophication classification models.

3 Proposed sigmoid (+1) membership function

In this section, we define modified evenly distributed sigmoid (+1) membership function, which in general is specified by three parameters, represented with equation (4).

$$f(x; a; b) = \frac{1}{1 + e^{-a*(x-b)}}, \quad a, b, x > 0 \tag{4}$$

In equation 4, the parameter a is positive constant and the b parameter is located at the center of the curve. We propose that the equation (4) be modified, by taking the mean of the given data range into account. In this way, each fuzzy term will reflect the very nature of the tested diatom-indicator relationship. Replacing the b parameter with mean of the given range (μ) and a constant with +1 constant to obtain evenly distributed MF, the equation (5) mathematically represents the sigmoid (+1) MF used for inducing diatom CM as:

$$f(x; \mu; \sigma) = \frac{1}{1 + e^{-\sigma*(x-\mu)}}, x > 0 \tag{5}$$

Because of the smoothness and concise notation, this distribution fits the requirements for specifying fuzzy sets and knowledge discovery using the proposed method for diatom classification. However, this assumption is yet to be proven later in the paper.

4 Data description and experimental setup

The dataset used in the experiments consist from 12 input parameters representing the TOP10 diatoms species (diatom species that exist in Lake Prespa [18]) with their abundance per sample, plus the classes of the two eutrophication parameters that we take into account. One dataset is created for each TSI class as output class.

These measurements were made as a part of the TRABOREMA project [19]. The TSI classes were defined according to the two physical-chemical parameters defined in [20] and they are given in Table 1.

Table 1. TSI classes for two physical-chemical parameters

TSI parameters	Name of the TSI class	Parameter range
Trophic State Index – Total Phosphorus (TSI_TP)	Oligotrophic	TP < 0 - 12 mg/L
	Mesotrophic	12 – 24 mg/L
	Eutrophic	24 – 96 mg/L
	Hypereutrophic	96 – 384+ mg/L
Trophic State Index – Secchi Disk (TSI_SD)	Oligotrophic	SD > 8m – 4m
	Mesotrophic	4m – 2m
	Eutrophic	2m - 0.5m
	Hypereutrophic	0.5m – 0.25m

We will conduct three types of experiments, which are set up as follows:

1) **Train**: A fuzzification method based on the sigmoid (+1) MF, which is used to transform the crisp values into fuzzy values. The same dataset is used as a train and test set;

2) **Exp2**, **Exp3**: The whole data are divided into two parts, namely the odd labelled data and the even labelled data. Two experiments are carried out, with the first (Exp2) using odd labelled data as training set and even labelled data as test set, and the second (Exp3) using even labelled data as training set and odd labelled data as test set. This experimental setup is actually 2-fold cross validation. We will examine the influence of the number of MFs per attribute in more details to compare with the previous used MF.

3) **xVal**: Standard 10-fold cross validation is used for evaluation of the classification accuracy of the algorithm against some classical classification algorithms (C4.5, kNN, Bagging C4.5 and Boosted C4.5).

Evaluation comparison with other crisp classifiers is done with simple (SCM) and general classification models (GCM) with two different depths (5 and 10); named (GCM5 and GCM10). Furthermore, the effect of the MF number per attribute is studied for different number of MFs per attribute (3, 4, 5, 10, 20, 30, 50 and 100). The average value of these experiments for the sigmoid (+1) MF is given in Table 2. Bolded and underlined values are the highest scores for classification accuracy.

Table 2. Average classification accuracy per TSI class (in %)

TSI_TP – Average Classification Accuracy				
MF Type	Triangular	Trapezoidal	Gaussian	Sigmoid (+1)
Train	48.45	50.29	49.25	**50.97**
Exp2	38.88	38.88	**38.99**	37.96
Exp3	37.50	37.27	36.58	**38.65**
TSI_SD – Average Classification Accuracy				
MF Type	Triangular	Trapezoidal	Gaussian	Sigmoid (+1)
Train	84.61	84.87	**84.87**	84.34
Exp2	82.11	81.32	82.37	**82.89**
Exp3	80.92	80.79	81.18	**81.92**

The Table 2 presents the highest prediction accuracy of CM over different combinations of training-test sets, especially in the Exp2 and Exp3 which provide measure for the prediction power of the models. Due to paper constrains we present only the average accuracy for MF per attribute. Concerning the performance evaluation of the sigmoid (+1) MF, this distribution outperformed 2 of the 3 diatom TSI_TP classes compared with other MFs used previously in the process of inducting classification models. The sigmoid (+1) MF achieved highest classification accuracy than compared with all other MF in Exp1 and Exp3, except the Exp2.Regarding the TSI_SD, according to Table 2 the proposed sigmoid (+1) MF outperformed other MFs in two of three experiments, more important in the Exp2 and Exp3.

5 Experimental results

The experiments are conducted with the modified sigmoid (+1) MF with number of MF per attribute equal to 5. For similarity definition, we use *Sim_RMSE* and the new *WA* and *OWA* as a fuzzy aggregation operator. To make the models much easier for interpretation, each Fuzzy Term, which is output for each leaf is labelled according the value of from the set of labels {Bad, Low, Good, Very Good and Excellent Indicator}.

5.1 Classification models for the TSI classes

The proposed method has generated a separate CM for each of these TSI subclasses (oligotrophic, mesotrophic, eutrophic and hypertrophic), which classifies one or several diatoms in the given subclass. Due paper constrains we present only two models. The classification model shown in Fig. 1 – right, states:

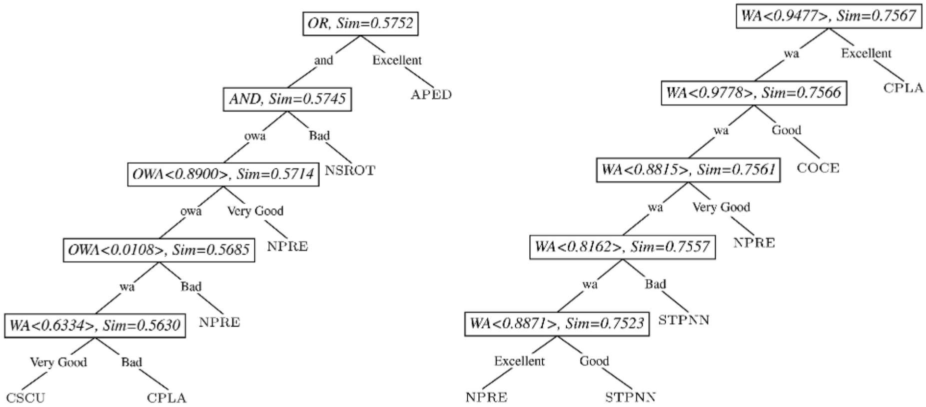


Fig. 1. Classification model for the ***eutrophic*** TSI_SD (left) and ***eutrophic*** TSI_TP class (right)

Rule1: If TSI_SD class is ***eutrophic*** **THEN** ((*Cocconeis placentula* (CSCU) is **Very Good Indicator** with WA (w = (0.63, 0.37); *Cocconeis placentula* (CPLA) is **Bad Indicator** with WA (w = (0.63, 0.37)); *Navicula prespanense* (NPRE) is **Bad Indicator** with OWA (w = (0.01, 0.99); NPRE is **Very Good Indicator** with OWA (w = (0.89, 0.11)) AND *Navicula subrotundata* (NSROT) is **Bad Indicator** AND APED is **Excellent Indicator**). The rule has confidence of 57.52%.

The classification model for ***eutrophic*** class, have shown that the APED diatom is an excellent indicator followed by the CSCU diatom. All the rest of the diatoms (NSROT and CPLA) are marked as bad indicators. Regarding the NPRE diatom, we have a similar situation as the previous model for ***mesotrophic*** class. In this case, the very good indicator property has weighted points of 0.89, which is much higher than the 0.01 points for the bad indicator properties of this diatom. According to this, the NPRE diatom is very good indicator of ***eutrophic*** class.:

Additionally, we will discuss one more classification model, for the TSI class – ***eutrophic*** class using the TP parameter (see Fig.1 - right). Regarding the indicator of the ***eutrophic*** water, the classification model has identified the CPLA diatom as excellent indicator of ***eutrophic*** class. The COCE diatom is good indicator of ***eutrophic*** waters according to the model. In this model, two diatoms (NPRE and STPNN) have to be carefully investigated with their weighed points. According to this model, the NPRE diatom is an excellent indicator (weight = 0.887) and STPNN is good indicator (weight = 0.887). The Rule2 confirmed the former statement.

Rule2: If TSI_TP class is ***eutrophic*** **THEN** (NPRE is **Excellent Indicator** with WA (w = (0.89, 0.11)); *Staurosirella pinnata* (STPNN) is **Good Indicator** with WA (w = (0.89, 0.11))); STPNN is **Bad Indicator** with WA (w = (0.82, 0.18)); NPRE is **Very Good Indicator** with WA (w = (0.88, 0.12)); *Cyclotella ocellata* (COCE) is **Good Indicator** with WA (w = (0.98, 0.02)); CPLA is **Excellent Indicator** with WA (w = (0.95, 0.05)). The rule has confidence of 75.67%.

5.2 Verification of the results from the models

Verification with the model results is done with the ecological references for the TOP10 diatoms from the latest diatom ecology publication [21, 22]. Other publications where these references are used for comparison are given in [3, 4, 14, 15, 18]. Concerning the ecological preferences of the TOP10 dominant diatoms in the Lake Prespa, CJUR and NPRE are newly described taxa (diatoms) with no records for their ecological references in the literature. Some of the results from the classification models are the first known ecological references for certain TSI classes.

In the relevant literature, the APED diatom is known to as ***alkaliphilous***, ***fresh-brackish***, nitrogen-autotrophic (tolerates elevated concentrations of organically bound nitrogen), high oxygen saturation (>75%), ***-mesosaprobic*** and ***eutrophic*** (because of Organic N tolerance) diatom indicator [21, 22]. The classification models have successfully found the indicating properties of the APED diatoms as ***eutrophic*** using TSI_TP. In the relevant literature, CSCU is known as ***alkalibiontic***, ***freshwater*** to ***brakish*** water taxon, being ***oligosaprobic*** indicators with ***eutrophic*** preferences [21, 22]. According to the CMs, the CSCU diatom is a very good indicator for ***eutrophic***. COCE is known as ***meso*** - ***eutrotrophic*** taxon [21, 22]. According to the models, the COCE diatom is a good indicator for the ***eutrophic*** waters. CPLA is a ***eutrophic*** taxon with medium oxygen demand according to the ecological references [20], which are confirmed by the models. Regarding the STPNN diatom, in the literature is known as ***hyper-eutrophic*** (***oligo-eutrophic***; indifferent) taxon frequently found on moist habitats [21, 22], while the models have found that this diatom is a good indicator of ***eutrophic*** waters. Concerning the NPRE, this diatom according to the models is an excellent to very good indicator of ***eutrophic*** waters.

5.3 Comparison with classical classifiers

Most of the classic decision trees - classification algorithms produce very strict interpretable decisions of the acquired knowledge from the environmental data. However, these algorithms are not robust on data change, which is not the case with the proposed method. In order to improve the classification accuracy and maintaining the robustness of the data change which comes by fuzzification of the input data, we have used the proposed method, which perform better according to the evaluation results (see Table 3).

Table 3. 10-fold cross validation classification accuracy of crisp classifiers algorithms against variants of the method with sigmoid (+1) MF (in %)

TSI_TP – Prediction Classification Accuracy				
Algorithm	C 4.5	kNN	Bagging C4.5	Boosted C4.5
xVal	39.91	39.45	**41.28**	41.04
Algorithm	SCM5	SCM10	GCM5	GCM10
xVal	39.68	39.72	38.72	41.08
TSI_SD – Prediction Classification Accuracy				
Algorithm	C 4.5	kNN	Bagging C4.5	Boosted C4.5
xVal	83.16	73.16	83.16	78.42
Algorithm	SCM5	SCM10	GCM5	GCM10
xVal	**83.60**	**83.60**	83.07	83.07

For the evaluation purpose, the classification models were obtained with the number of MF per attribute equal to 5. Most of the cases obtained from 2% to 5% increase of prediction classification power. Increased classification accuracy of the proposed method has been achieved for both TSI classes.

6 Conclusion

The experimental results from the proposed method have shown that the models can be easily compared with the known ecological reference of the diatoms. Because the diatoms are not influenced by the geographical location, but rather the physico-chemical parameters of the environment [23], the proposed method could be used for diatom classification for any ecosystem, not just for Lake Prespa. To best of our knowledge, this is the first time the prosed method to be applied for diatom classification of any ecosystem.

The evaluation results have shown that the modified sigmoid (+1) MF outperformed formerly used MFs in terms of classification accuracy. 10-fold cross validation used to compare the performance of the proposed method with the classical classification algorithms, proofed that the sigmoid (+1) MF exceeded the classification accuracy of the previously classification algorithms. The proposed method which is based on fuzzy logic theory maintained the resistance to data change of the algorithm and the prediction models successfully classified some of the diatoms. For example, we can note that the classification models unmistakably show that the COCE diatom can be used to indicate ***eutrophic*** waters. Verification of the obtained models had successfully confirmed the ecological preference of the known diatoms, and added new ecological knowledge for the unknown diatom references for TSI ***eutrophic*** class. The experimental results showed that this machine learning method can extract valuable knowledge in a relatively comprehensible form, even when the application area is so extremely complex for humans and the data is far from being perfect. From ecological point of view, it is very important that the proposed method had acknowledged ecological references for some of the known diatoms, and thus it can be used for learning a new knowledge for the recently discovered diatoms. If some diatoms exist for the lake ecosystem with high eutrophication class – eutrophic this is the indication that the ecosystem has reached the alarming level of eutrophication.

Further research needs to be the focus on developing more membership function in the process of building classification models. More similarity metrics may be more suitable for diatom dataset and can therefore, lead to higher accuracy of the classification model. The classification of the diatoms can be made not just for TSI classes, but also for water quality and metal parameters classes.

References

[1] Stroemer EF, Smol JP (2010) The diatoms: Applications for the Environmental and Earth Sciences, 2nd edition, Cambridge University Press, Cambridge:46-47

[2] Quinlan RJ (1990) Decision trees and decision making. IEEE Transactions on Systems, Man, and Cybernetics 20(2):339-346

[3] Kocev D, Naumoski A, Mitreski K, Krsti S, Džeroski S (2010) Learning habitat models for the diatom community in Lake Prespa. Journal of Ecological Modelling 221(2):330-337

[4] Naumoski A. Kocev D, Atanasova N, Mitreski K, Krstic S, Dzeroski S (2009) Predicting chemical parameters of the water from diatom abudance in lake Prespa and its tributaries. In: Ioannis N. Athanasiadis, Pericles A. Mitkas, Andrea Emilio Rizzoli, Jorge Marx Gómez, (ed), Information Technologies in Environmental Engineering - ITEE 2009, Proceedings of the 4th International ICSC Symposium, Springer, Heidelberg:264-277, doi: 10.1007/978-3-540-88351-7_20

[5] Wang LX, Mendel JM (1998) Generating fuzzy rules by learning from examples. IEEE Transactions on Systems, Man, and Cybernetics 22(6):1414-1427

[6] Janikow CZ (1998) Fuzzy decision trees: issues and methods. IEEE Transactions on Systems, Man, and Cybernetics 28(1):1-14

[7] Olaru C, Wehenkel L (2003) A complete fuzzy decision tree technique. Fuzzy Sets and Systems 138:221-254

[8] Suárez A, Lutsko JF (1999) Globally optimal fuzzy decision trees for classification and regression. IEEE Transactions on Pattern Analysis and Machine Intelligence 21(12):1297-131

[9] Wang X, Chen B, Olan G, Ye F (2000) On the optimization of fuzzy decision trees. Fuzzy Sets and Systems 112:117-125

[10] Yuan Y, Shaw MJ (1995) Induction of fuzzy decision trees. Fuzzy Sets and Systems 69(2):125-139

[11] Schweizer B, Sklar A (1963) Associative functions and abstract semigroups. Publication Math. Debrecen 10:69-81

[12] Kóczy LT, Vámos T, Biró G (1999) Fuzzy signatures. EUROFUSE-SIC: 210-217

[13] Yi-lai C, Tao W, Ben-sheng W, Zhou-jun L (2009) A survey of fuzzy decision tree classifier. Fuzzy Information and Engineering 1(2), Springer, Heidelberg:149-159, doi: 10.1007/s12543-009-0012-2

[14] Naumoski A, Mitreski K (2011) Diatom classification with novel bell based classification algorithm. In: M. Gusev and P. Mitrevski (ed): ICT Innovations 2010, CCIS 83, Springer, Heidelberg:245-254

[15] Naumoski A, Mitreski K (2010) Classifying diatoms into trophic state index classes with novel classification algorithm. Procedia Environmental Sciences 2(2010):1124-1138

[16] Huang ZH, Gedeon TD, Nikravesh M (2008) Pattern Trees Induction: A New Machine Learning Method. IEEE Transaction on Fuzzy Systems 16(3):958-970
[17] Torra, V, Narukawa Y (2007) Modeling Decisions: Information Fusion and Aggregation Operators, Springer, Heidelberg: 147-175
[18] Levkov Z, Krsti S, Metzeltin D, Nakov T (2006) Diatoms of Lakes Prespa and Ohrid (Macedonia). Iconographia Diatomologica 16:603
[19] TRABOREMA Project WP3 (2005-2007) EC FP6-INCO project no. INCO-CT-2004-509177
[20] Carlson RE, Simpson J (1996) A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society:96
[21] Van Dam H, Martens A, Sinkeldam J (1994) A coded checklist and ecological indicator values of freshwater diatoms from the Netherlands. Netherlands Journal of Aquatic Ecology 28(1):117-133
[22] European Diatom Database (2008) from http://craticula.ncl.ac.uk/Eddi/jsp/index.jsp, Accessed (March 15, 2008),
[23] Gold C, Feurtet-Mazel A, Coste M, Boudou A (2002) Field transfer of periphytic diatom communities to assess short term structural effects of metals (Cd, Zn) in rivers. Water Research 36:3654-3664

Multi-Layer Topic Maps to Support Management-Systems by Structured Information

Hans-Knud Arndt, Stephan Jacob, Sebastian Tietz

Otto-von-Guericke-University Magdeburg-Faculty of Computer Science

hans-knud.arndt@iti.cs.uni-magdeburg.de, stephan-jacob@t-online.de, sebastiantietz@yahoo.de

Abstract. Appropriate information is a challenge for management systems within organizations. These information have to be documented, managed and published to support processes efficiently. Because of complex and heterogeneous information these tasks are not trivial. The required documentation leads to a complex system characterized by hierarchical structures. Beyond this, organizations are faced with several stakes characterized by various levels of influence, which have to be included into the management-system. This chapter introduces a concept for structured capturing, modeling and processing of heterogeneous information and data. For this purpose Topic Maps are used as a concept of knowledge management and semantic networks. Altogether this chapter describes an instrument for hierarchical structuring and processing of information to enhance the efficiency of a management-system.

Keywords: management systems, modeling, topic maps

1 Introduction

Two scenarios in the field of operational and governmental practice will be introduced in the following. Both potentially require knowledge-management-orientated IT-solutions using multi-layer Topic Maps.

Documentation of ecological influences

Organizations are social systems [1] with a huge amount of elements and varied relations of influence. Furthermore they are permanently faced with influences from peripheral systems and internal stakeholders. These influences can be subsumed as stakes [2]. These demands can be restrictive in a way that they constrain special workings or they provide only a restricted amount of alternatives. In the context of organizational management the structured capturing of ecological stakes is a must. For this reason the documentation in an environmental manage-

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_5,

ment-system is appropriate. In this regard the management-system creates a connection between the strategic derived measures for fulfilling the demands and their operational realization [3].

The level of influence of the different internal and external conditions on the processes can vary. Depending on the level of linkage between the organization and its peripheral system the environment can be categorized in general- and task-environment [4]. The task environment is defined by the connection between the company, its market and its competitors [5]. The global environment can be divided into economic, political-legal, cultural, technological and ecological environment [6] which is the source of various ecological stakes. Besides this external stakes, the management of an enterprise often defines visions and sustainability agreements about the way how actions should be performed. The St. Galler Management-Framework [7] arranges these agreements on the level of normative management. By these tools an organization creates certain conditions all actions have to fulfill. The following figure summarizes different sources of ecological stakes[1].

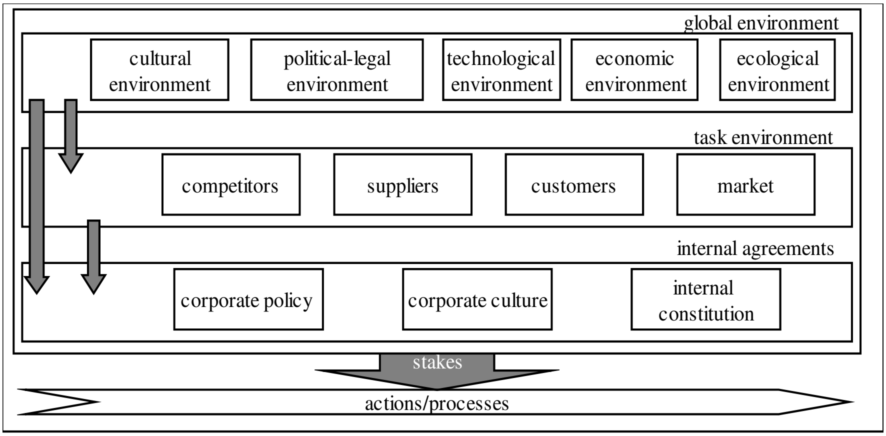


Fig. 1. Different layer of sources of stakes

As presented in Fig. 1 the global environment contains general stakes which influences the task environment on the one hand. On the other hand the internal processes are directly affected by these elements, e. g. by ecological laws. Within the task environment competitors, suppliers, customers and the market create conditions, which the organization has to take into account. The elements of normative management, which describe internal ecological agreements, affect the processes similarly. In this context it has to be considered, that the level of specificity from the view of the organization increases from layer to layer.

[1] The cultural, political, technological and economic environment are visualized for the sake of completeness

In the context of an appropriate documentation and presentation of stakes the different layers of influence have to be taken into account [8]. The Topic Map standard provides a potential tool for this task. That motivates a concept of multi-layer Topic Maps introduced in this chapter. This concept enables the grasping of hierarchies besides the capturing of semantic relations between elements.

Documentation of Occupational Safety and Health Management Systems

In response to demographic shifts and an increasing number of regulations and legislations, occupational safety tends towards a holistic treatment. Therefore companies choose preemptive approaches to ensure occupational safety and health. In analogy to quality and environmental management, occupational safety management systems seem to be a suitable approach. Occupational safety management means applying management techniques in order to improve the ability to meet health and safety obligations in an efficient and methodical manner. [9][10][11] Unlike ISO-standardized quality and environmental management-systems, Occupational Safety and Health Management Systems (OSHMS) were developed later on and the formalization within an ISO-standard was declined [12]. Nevertheless, presented results of this chapter can be applied to quality and environmental management-systems.

OSHMS-concepts define the documentation-structure of OSHMS in different levels of detail. The documentation is typically process-orientated within a handbook describing elements and their relations, using a three-stage documentation hierarchy as illustrated in Fig. 2.

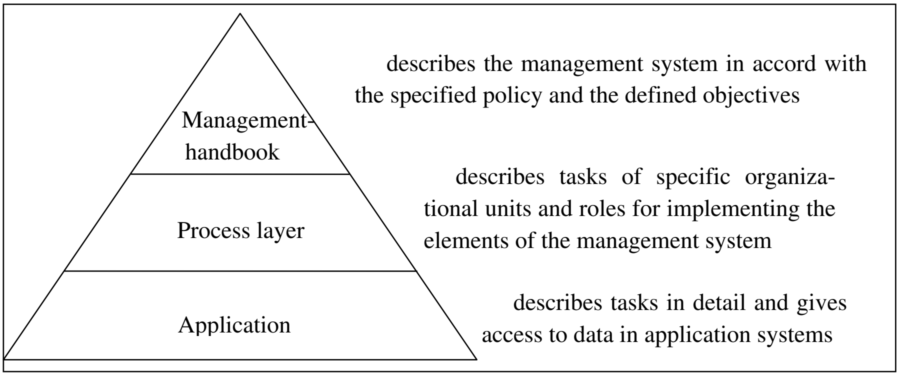


Fig. 2. Typical documentation-hierarchy of a management system [13]

Because of the necessity to compile, to structure and to distribute heterogeneous information, an efficient OSHMS is a challenge for knowledge management as well as for information and communication technology. Thus semantic networks are suggested to represent information and relations in between [14]. To represent a three-stage documentation hierarchy, multi-layer Topic Maps seem to be a suitable approach.

2 Using Topic Maps

2.1 Elements of Topic Maps

Topic Maps are a powerful computer assisted form of semantic networks [15]. The Topic Map standard was published by the ISO. This section briefly introduces main elements which are necessary in the context of multi-layer Topic Maps. These elements are: Topics, Topic Names, Occurrences, Associations, Scopes und Topic Map templates.

A Topic represents a real-world entity [16]. By this it is instance of zero or more types [17]. These types are also modeled as Topics which enables the creation of hierarchies of types. Topics have different characteristics: Topic names, Topic Occurrences and roles the Topic plays within associations [18].

Modeling different names of a Topic is possible by variants of names. The application of the respective variant can be specified by a parameter [19]. By using names it has to be taken into account, that two Topics must not have the same name in the same context [17].

Another characteristic of Topics are their information resources. These are called Occurrences [16]. It is possible to assign a type to each Occurrence at maximum to specify the kind of resource [19]. Also as name variants of Topics, Scopes can be assigned to Occurrences [16].

Besides the linkage of Topics to information resources, they also can be referenced with other Topics. These references are called Associations. In this context the kind of Associations is not restricted [18]. Associations are multi directional references, which are valid in different directions and for an unrestricted amount of members [19]. The participants occupy different roles in an Association, which are specified by Topics [20]. Associations can also be classified by one type at maximum [19]. A special kind of relation is the class-instance-reference. The class-instance-reference can be described by an Association type ‘instance of‘. This type is already predetermined by the standard.

Within a Topic Map it is possible to restrict the validity of characteristics of Topics. This is necessary, because different characteristics do not have to be fulfilled at any time. Scopes describe the context a characteristic is valid in. Scopes are modeled by Topics. [21]

The Topic Map concept supports creation and usage of Topic Map templates. These are Topic Maps, which can be included into a complex Topic Map document to support modularization. Typically these modules contain Topics, which are used as types in a class of Topic Maps. Usually these Topics describe types, Association types and roles. [20]

2.2 Implementation Strategies

This section analyses, which Topic Map-concept supports a multi-layer Topic Map for the purposes described in the first section. Owing to the flexibility of the Topic Map standard there are different options for creating multi-layer Topic Maps. In principle the membership of each Topic to its layer has to be modeled. As a precondition the layers have to be defined before-hand. The layers are represented by Topics, which should be denoted as Layertopics hereafter. A meaningful and universal name is assigned to each Layertopic.

Fig. 3 visualizes modeling a Layertopic as a XML Topic Map (XTM) fragment. Besides a universal name, a German denotation is assigned to the layer.

```
<topic id="Layer_1">
 <baseName>
  <baseNameString>Layer 1</baseNameString>
 </baseName>
 <baseName>
  <scope><topicRef xlink:href="#German"/></scope>
  <baseNameString>Ebene 1</baseNameString>
 </baseName>
</topic>
```

Fig. 3. Modelling a Layer as a Topic

Wu/Tian/Yang [22] describe the usage of layer Topic Maps in the field of annotating documents. An ontology of keywords, which characterize the contents of the documents, is build up by different layers. This hierarchical structure eases the search within documents. This propose uses Topics as a representation of documents and keywords. Thus Association types are restricted to support search-tasks. The authors define only three types of relations, where two types (‘is super-topic of‘ and ’is sub-topic of‘) are used to describe the relation of layers. Only the third type is used for modeling relations between keywords.

The concept of multi-layer Topic Maps presented in this chapter is primary not focused on annotation of documents. Furthermore complex relations, like relations between stakes of an organization, should be modeled hierarchically. In the context of management systems the documentation of hierarchical relations is necessary as discussed in the first section. On the one hand the objective of the introduced concept is to capture hierarchical relations as good as possible. In this context the existing structure between elements has to be modeled by appropriate relations. On the other hand this concept extends the structure by hierarchical information. To assign Topics to a corresponding layer the Topic Map concepts of class-instance-relations, Associations, Scopes and Occurrences could be appropriate. In the following it will be analyzed how these concepts can be used to create multi-layer Topic Maps.

Class-instance-relations

Basically it is possible to use the type attribute of a Topic. By this an assignment of Topics to a class, which represents the corresponding layer, is realized. Modeling of classes is described in Fig. 3 in general. These classes can be provided as Topic Map templates to the author of a multi-layer Topic Map. The semantic of this instantiation of a Layertopic is that the corresponding Topic inherits all attributes of the Layertopic. By using the class-instance-relation the Topics can be filtered and arranged in groups according to their layer very easily.

Associations

According to the first strategy, a further possibility to annotate Topics with their corresponding layer will be introduced: While the predefined relation type 'instance of' is used in the first strategy, the possibility of defining a special Association type also exists. This type references each Topic with its Layertopic and should only be used for assigning a layer to a Topic within a multi-layer Topic Map. The relation type used for this purpose should have a meaningful and uniform name like 'is referenced to layer'.

Fig. 4 visualizes a possible implementation of this relation type. Hereby a universal name for this association is created first. Also two names, whose validity is scoped by the roles of the participants, are defined. The role of the implemented Associations, which have to be created afterwards, are on the one hand the layer and on the other the element assigned to the corresponding layer. Thereby the general characteristics of Associations within a Topic Map become apparent, because the new relation type is undirected. The semantic of the Association is equal from both point of views, e. g. 'Topic A is connected to layer 1' and 'layer 1 contains Topic A'. The Topic Map standard defines relations as n-ary connections. In the analyzed context, only binary connections should be created and every element should separately be connected with the corresponding layer. Otherwise the clarity of the model is getting lost.

```
<topic id=" is_referenced_to_layer _type">
 <baseName>
  <baseNameString>
   is referenced to layer
  </baseNameString>
 </baseName>
 <baseName>
  <scope><topicRef xlink:href="#Layer" /></scope>
  <baseNameString>Layer of element</baseNameString>
 </baseName>
 <baseName>
  <scope><topicRef xlink:href="#Element" /></scope>
  <baseNameString>Element of layer</baseNameString>
 </baseName>
</topic>
```

Fig. 4. Association Type for assigning a Topic to a layer

Scopes

Another method of assigning Topics to their layer is the restriction of Topic characteristics to the validity of the layer. A closer look to the Topic Maps standard shows, that the validity of a Topic itself cannot be restricted, because there is no corresponding Scope-element [23]. To restrict all characteristics of an element to the context of the corresponding layer, all Scope-attributes have to reference the appropriate Layertopic. In conclusion there should be no characteristic of universal validity. For reasons of clarity the Topic Map processing software should visualize the Topic only in the context of the corresponding layer.

Occurrences

Furthermore Occurrences enable the representation of layers within a Topic Map. According to the Topic Map standard the Occurrences describe information resources respectively sources of the subject represented by the Topic. In the concept of multi-layer Topic Maps the layers are the sources of the elements. In a semantic sense the layers describe the information resource, in which the subject, represented by the corresponding Topic, exists. Within an Occurrence it is not possible to reference another Topic. Because of this the representation of layers is realized by pure text information. This information is captured directly in the Topic Map as a date.

Fig. 5 visualizes this method for the Topic ‘Element A‘. An Occurrence of the type ‘Layer’ is assigned to this Topic. The content of this Occurrence is the layer associated to the corresponding element. In the example it is ‘Layer 1’. The usage of a separate type for the Occurrence, which contains the information about the layer, eases the evaluation and processing of the Topic Map. The layer is modeled as an internal Occurrence, so that the corresponding information is in the Topic Map document.

```
<topic id="Element_A">
 <baseName>
  <baseNameString>Element A</baseNameString>
 </baseName>
 <occurrence>
  <instanceOf>
   <topicRef xlink:href="#Layer" />
  </instanceOf>
  <resourceData>Layer 1</resourceData>
 </occurrence>
</topic>
```

Fig. 5. Connecting an element with a layer by an Occurrence

2.3 Evaluation of Alternatives and Proposal of Solution

The concept of Occurrences is not appropriated in the considered application, because this method represents a layer as a pure date, which is problematical; the layer does not become an element of the Topic Map, which can lead to ambiguity, because no explicit representative of the layer is created.

The usage of Scopes relates a Topic with one or more other Topics, which define the area of validity. The necessary typing of relations to support navigation along hierarchical dependencies is missing in this procedure. Syntactically this construct of modeling is not appropriated to restrict the validity of a Topic to the context of a layer. Furthermore an increased effort is necessary to connect all characteristics of a Topic with the corresponding Scope of the layer. Because of this the usage of Scope is declined.

Using Associations has to be evaluated as advantageous as possible in the presented context. In particular the usage of the predefined 'instance of'-relation can be deemed as the proposal of solution to be as appropriate as possible. This method has the advantage that no new association type has to be created. On the one hand this increases the clarity of the model, on the other hand binary relation between elements and layers are guaranteed by definition.

3 Draft of Implementation

In the application of a multi-layer Topic Map, a single Topic Map which contains all layers, can be used on the one hand. On the other it is possible to create separate Topic Maps for each layer. These Topic Maps can be connected by merging mechanisms to achieve an entire Topic Map. Depending on objectives and the kind of approach, separated capturing of layers in several Topic Maps can support the construction by initially reducing the complexity. In this case the corresponding Topics and their associated elements are modeled. Such layers could be provided as templates. This eases the reutilization in various fields of application. It has to be taken into account, that merging of separated layers is an additional task which has to be performed. Within this process possible inconsistencies have to be identified and solved. This task is not necessary as one entire Topic Map is created from the first step on - but the complexity is increased by examining all elements. Using separate Topic Maps eases the realization of a layer-based concept of permissions and roles, which can be an advantage in some kind of application. In both approaches the entire Topic Map is used in actual applications. So questions about the performance are less important for the actual usage. Therefore choosing an alternative of realization depends on concrete tasks and organizational objectives, which have to be fulfilled.

Using visualization libraries eases the presentation of Topic Maps as graphs. The Java library JGraph is such a tool. This library is available open source. Because of its flexibility it is appropriate to create a first prototype of the concept of layer Topic Maps. JGraph is implemented in Swing and compatible to Java since version 1.4 [24]. JGraph supports presentation (adding of nodes and edges) and interaction (zooming, grouping, editing of elements etc.) of graphs, whereby all necessary functions are already implemented [24]. Application specific data can be inserted into the library through defined interfaces. For this purpose a mapping between the visualization library and the Topic Map has to be implemented. By extending corresponding JGraph components the presentation and the behavior of the graph at user interactions can be adjusted to preset criteria. For this, preimplemented layouts [24], like the hierarchical alignment of elements, can be used as templates.

In the context of Topic Maps-usage in general and for a textual presentation in particular the Layertopics, introduced in this chapter, can be used as navigational aid to inform the user about the layer, which contains special connected Topics. Furthermore search functions can be enhanced by providing the function of reducing the results to a certain layer. After all the explicit definition of layers supports the masking of internal information at the reporting to external stakeholders like customers, suppliers etc.

Fig. 6 features a simplified example of linked elements of an OSHMS. Hereby Topics are linked hierarchical and every Topic belongs to a documentation-hierarchy-level. Though a multi-level based knowledge management solution is necessary to structure and represent information relevant for occupational health and safety.

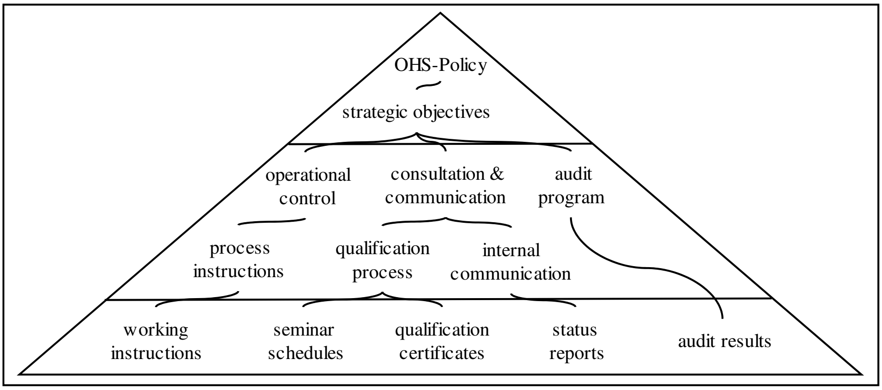


Fig. 6. Simplified Example of hierarchical dependencies

4 Outlook

The application of the discussed concept of multi-layer Topic Maps is not restricted to the presented functional fields in the first section. Because of its generic character it can be applied on other fields of application of similar type. Beyond the theoretical explanation, experience data of usability and performance have to be captured for application. The publishment of repositories of Layertopics could enable an efficient reutilization and a simplified exchange of information. Secondary this chapter pointed out that layer Topic Map templates could ease implementation.

One-dimensional hierarchies, that mean hierarchical dependent layers, have been analyzed in the underlying example. As an outlook it has to be pointed out, that an extension of the presented proposal to multidimensional assignments is possible. By this a Topic can not only be located in a one layer-hierarchy, but it also can be structured by other dimensions. For this application only the Layertopics, presented in the second section, have to be typed corresponding to their dimensional affiliation. Fig. 7 visualizes multidimensional assignments graphically.

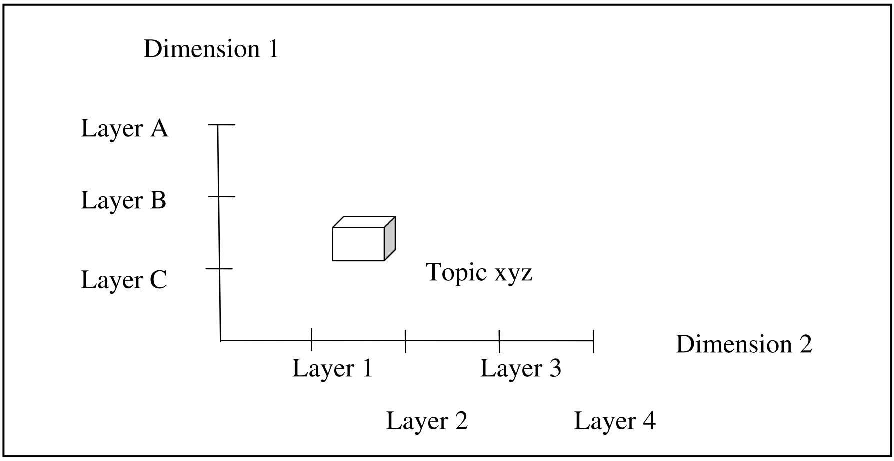


Fig. 7. Multidimensional Topic Maps

References

[1] Hofmann-Kamensky M (2001) Grundelemente, Gestaltungsregeln und Nutzen von Managementsystemen. In: Ahrens V, Hofmann-Kamensky M (Eds.) Integration von Managementsystemen: Ansätze für die Praxis. Vahlen Verlag, München

[2] Ahrens V (2001) Allgemeine und ethische Grundlagen von Managementsystemen. In: Ahrens V, Hofmann-Kamensky M (Eds.) Integration von Managementsystemen: Ansätze für die Praxis. Vahlen Verlag, München

[3] Pischon A (1999) Integrierte Managementsysteme für Qualität, Umweltschutz und Arbeitssicherheit. Springer Verlag, Berlin, Heidelberg, New York

[4] Bea FX, Haas J (2005) Strategisches Management. 4th edn. Lucius und Lucius Verlag, Stuttgart

[5] Welge M, Al-Laham A (1999) Strategisches Management – Grundlagen – Prozess – Implementierungen. 2nd edn. Gabler Verlag, Wiesbaden

[6] Macharzina K, Wolf J (2005) Unternehmensführung – Das Internationale Managementwissen – Konzepte – Methoden – Praxis. 5th edn. Gabler Verlag, Wiesbaden

[7] Bleicher K (1996) Das Konzept integriertes Management. 4th edn. Campus Verlag, Frankfurt am Main, New York

[8] Arndt H-K, Jacob S (2010) Ein Konzept zur Steuerung von Organisationen bei unklaren Zieldefinitionen unter Berücksichtigung von ökologischen Forderungen mit Hilfe von semantischen Netzen. In: Greve K, Cremers AB. (Eds.) Integration of Environmental Information in Europe (24th International Conference on Informatics for Environmental Protection in Cooperation with Intergeo2010. Shaker Verlag, Aachen

[9] Schliephacke J (2003) Führungswissen Arbeitssicherheit: Aufgaben – Verantwortung – Organisation. 2nd edn. Erich Schmidt Verlag, Berlin

[10] Universum Verlagsanstalt (UV) (Ed.) (2000) Wörterbuch Arbeitssicherheit und Gesundheitsschutz. 9th edn. Universum Verlagsanstalt, Wiesbaden

[11] Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA) (Ed.) (2002) Leitfaden für Arbeitsschutzmanagementsysteme des Bundesministeriums für Wirtschaft und Arbeit (BMWA), der obersten Arbeitsschutzbehörden der Länder, der Träger der gesetzlichen Unfallversicherung und der Sozialpartner. Dortmund

[12] Lehder G (2005) Taschenbuch Arbeitssicherheit, 11th edn. Erich Schmidt Verlag, Berlin

[13] Deutsches Institut für Normung e. V. (DIN) (Ed.) (1996) DIN ISO 10013 – Leitfaden für das Erstellen von Qualitätsmanagement-Handbüchern. Beuth Verlag, Berlin

[14] Arndt H-K, Günther O, Pluskat H (2001) Verwaltung von umweltmanagementbezogenen Wissensinhalten mit dem EcoExplorer. In: Hilty LM, Gilgen PW (Eds.) Sustainabity in the Information Society (15th International Symposium Informatics for Environmental Protection, Zurich, 10.10.-12.10.2001). Marburg

[15] Sowa JF (1991) Principles of Semantic Networks – Explorations in the Representation of Knowledge. Morgan Kaufmann Publishers, San Mateo

[16] ISO (2008) Topic Maps — Data Model. http ://www.isotopicmaps.org/sam/sam-model/
2008-06-03/ Accessed 01.12.2010

[17] Rath HH, Pepper S (2000) Topic Maps: Introduction and Allegro.
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.103.2288&rep=rep1&type=pdf Accessed 01.12.2010

[18] Widhalm R, Mück T (2002) Topic Maps – Semantische Suche im Internet. Springer Verlag, Berlin, Heidelberg

[19] Rath HH (2003) The Topic Maps Handbook. http://www.sts.tu-harburg.de/~r.f.moeller/
lectures/anatomie-i-und-k-system/empolistopicmapswhitepaper_eng.pdf Accessed 01.12.2010

[20] Smolnik S (2005) Wissensmanagement mit Topic Maps in kollaborativen Umgebungen – Identifikation, Explikation und Visualisierung von semantischen Netzwerken in organisationalen Gedächtnissen. Shaker Verlag, Aachen

[21] Pepper S, Gronmo GO (2002) Towards a General Theory of Scope. http://www.ontopia.net/topicmaps/materials/scope.htm Accessed 01.12.2010

[22] Wu J, Tian H, Yang G (2006) A Multilayer Topic-Map-Based Model Used for Document Resources Organization. In: Huang D, Li K, Irwin GW (ED) Intelligent Control and Automation - International Conference on Intelligent Computing ICIC 2006 Kunming, China, August 16–19, 2006. Springer Verlag. Berlin, Heidelberg

[23] XML Topic Maps (XTM) 1.0(2001) http://www.topicmaps.org/xtm/ Accessed 10.12.2010

[24] JGraph Ltd. (2009) JGraph User Manual. http://www.jgraph.com/downloads/jgraph/
jgraphmanual.pdf Accessed 01.12.2010

Application of Bio-Inspired Optimization Techniques in Power Distribution Systems

Saumel Enriquez-Caro[1], Victor S. Ocaña-Guevara[1], Maybel Anido-Bada[2]

[1] Universidad Central "Marta Abreu"de Las Villas
[2] Universidad de Ciencias Informáticas

senrique@uclv.edu.cu , victors@uclv.edu.cu , mab@uclv.edu.cu

Abstract. In a world where the climate has begun to change and the resources are limited, it's imperative to optimize the amount of energy used in any system. The distribution system of electrical energy in any country must be the leader providing the exact infrastructure to give to his clients a service at low cost, trustable, and most important without affecting their environment. In this chapter we present the model of a system to provide electrical energy, heat and in some cases cool services using bio-inspired algorithms to optimize several objectives. The model designed must be able to predict changes in the future based on the growing or decreasing of the system. This model has been implemented using Wolfram Mathematical and the optimization method used were Genetic Algorithms and Ant Colony Optimization, to find the Pareto's Front in a multi-objective, multi-step system to distribute electrical energy and heat to the city of Santa Clara, Cuba.

Keywords: Life Cycle Assessment, Environmental Impact, Optimization techniques.

1 Introduction

The biggest part of the real world optimization problems is naturally multi-objective. Multi-Objective Optimization Problems (MOOP) deal with two or more objective functions simultaneously and more often these functions are in conflict. To solve this kind of systems many researchers have applied bio- inspired algorithms to find out the Pareto's Front, which contain all non-dominated solutions of the problem. There are some aspects to bring into account when you are searching these solutions. The main decision is to find which meta-heuristic is correct for the problem; stochastic tests can play an important role deciding this. The other important task is the parameters configuration of each meta-heuristic, if this is not well done a good method for certain problem can show a bad behavior. This approach has been widely used to solve environmental problems, mainly because the objectives of the sustainable development are, in fact, in conflict. The three pillows of the sustainable development are economic, social and environmental development, and being focused only in the first, have brought us to a world in danger of extinction. On this chapter we describe two bio-inspired algorithms used to solve MOOP for the generation of electrical energy with the aim of minimizing the cost, the environmental impact and

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*,
Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_6,

maximizing the feasibility. Section 2 describe power generation problem, its objectives and constrains, section 3 and 4 are dedicated to the implementation of two famous meta-heuristics to solve this MOOP. In section 5 are described the results of this implementations.

2 Power Distribution System

The power distribution systems have a great importance in the economy of a country [18]. It is the part of the electrical system that extends from distribution substations to the processing centers (primary network), and to final consumers (secondary network). These end-users show a behavior in its application electricity, in most cases, significantly increasing, eventually approaching the limits of supply distribution network. For that, frequently, is necessary to expand these distribution systems, specifying the construction or expansion of substations, installation and reconfiguration of new lines, among other measures. This requires planning modifications to perform properly. Planning distribution systems is a decision process that requires the study of the needs of electrical power and seeks to identify the best plan to improve the network thus achieving a higher quality of supply at the lowest cost. On this chapter we present the model for a distribution system in the city of Santa Clara. Several objectives are taken into account, the cost of the system, the feasibility and the impact on the environment it causes.

2.1 Model Description

The optimization model described below is designed to present the optimal combination of technologies to be installed and decide when and how much each technology should be operated. The annual costs for each year of the planning horizon are summarized and optimized with a multi-objective approach.

2.1.1 Objective functions

In order to structure the model and to facilitate the understanding of it, the total cost is divided into two parts, fixed cost (FC), variable cost (VC)

$$\mathrm{TC} = \mathrm{FC} + \mathrm{VC} \tag{1}$$

The FC is a cost that exists whether a technology is in operation or not. This cost has been divided into three parts, investment cost (IC), stripping cost (SC) and fixed O&M costs (FOMC). The FC doesn't necessarily have to be fixed over time; it can vary with interest rate, salary levels and other variations.

$$FC = IC + SC + FOMC \tag{2}$$

Investment cost is a cost that can't be avoided and obviously has to be represented in the model. This cost is calculated by first divide the cost into equal annuities and the summed them over the technology's lifetime as seen in the equation below:

$$IC = \sum_{t=1}^{N_t} \sum_{i=1}^{N_i} UIC_{i,t} \cdot IAF_{i,t} \cdot X_{i,t} \tag{3}$$

Where $UIC_{i,t}$ is the investment cost of the *i-th* unit at year t and $X_{i,t}$ is number of units i to be installed at year t and $IAF_{i,t}$ is the investment cost annualization factor:

$$IAF_{i,t} = \frac{IR_t}{1 - (1 + IR_t)^{-Z_i}} \tag{4}$$

Where IR_t is the interest rate at year t and Z_i is the lifetime of the i-th technology. The striping cost is handled in a similar way as IC but with one important difference. Since this cost occurs after the lifetime of the technology it should be treated as a saving and not as a loan and thus the interest rate is working in "favor" of the investor.

$$SC = \sum_{t=1}^{N_t} \sum_{i=1}^{N_i} USC_{i,t} \cdot SAF_{i,t} \cdot X_{i,t} \tag{5}$$

Where $USC_{i,t}$ the stripping cost of the i-th unit at year t and $SAF_{i,t}$ is the stripping cost annualization factor seen below:

$$SAF_{i,j,t} = \frac{IR_t}{(1 + IR_t)^{Z_i} - 1} \tag{6}$$

The FOMC is hard to estimate, it can be e.g. labor costs, land rent and insurance. These costs don't just depend on the technology but also on where the technology will be located. The annual fixed O&M cost is here chosen to be calculated as a percentage of the unit investment cost and then the annual costs are summed over the lifetime of the unit and assumes the following expression:

$$FOMC = \sum_{t=1}^{N_t} \sum_{i=1}^{N_i} UIC_{i,t} \cdot FCF_{i,t} \cdot X_{i,t} \tag{7}$$

where $FCF_{i,t}$ is the fixed O&M cost factor for the i-th unit the t-th year. The VCs are costs that only depend on the operation of a technology; if a technology is not operating the VCs will be equal to zero. In this model the VC is divided into fuel cost (FUC), water cost (WC) and variable O&M cost (VOMC).

$$VC = FUC + WC + VOMC \tag{8}$$

The FUC is calculated with the following equation:

$$\mathrm{FUC} = \sum_{t=1}^{N_t} \sum_{j=1}^{N_i} \mathrm{FP}_{j,t} \sum_{i=1}^{N_i} \mathrm{Fcon}_{i,j} \sum_{p=1}^{N_p} \mathrm{EPP}_{i,t,p} \cdot \mathrm{T}_{t,p} \quad (9)$$

Where $\mathrm{FP}_{j,t}$ is the fuel price of the j-th fuel the t-th year and $\mathrm{Fcon}_{i,j}$ is the fuel consumption of the i-th unit consuming the j-th fuel. $\mathrm{EPP}_{i,t,p}$ is the electrical power production of the i-th during the p-th interval of the t-th year and T_p represents the time of period p. The water cost may in many parts of the world be a negligibly small cost compared to the fuel cost but in some parts of the world water is a scares commodity (reference) and will thus be taken into account in this model and is calculated as following:

$$\mathrm{WC} = \sum_{t=1}^{N_t} \mathrm{WP}_t \sum_{i=1}^{N_i} \mathrm{Wcon}_i \sum_{p=1}^{N_p} \mathrm{EPP}_{i,t,p} \cdot \mathrm{T}_{t,p} \quad (10)$$

Where WP_t is the water price year t and $Wcon_{i,j}$ the water consumption of the i-th unit. VOMC is a cost related to the operation of the unit due to e.g. wearing, lubricant oil etc. This cost is hard to calculate and will thus be taken from reference material or be assumed.

In equation (11) below equation (1) to (10) is summarized into one expression.

$$\begin{aligned}\mathrm{TC} = \sum_{t=1}^{N_t} \{ \sum_{i=1}^{N_i} [UIC_{i,t} \cdot (\frac{IR_t}{1-(1+IR_t)^{-Z_i}} + FCF_{i,t}) + \mathrm{USC}_{i,t} \cdot \frac{IR_t}{(1+IR_t)^{Z_i}-1}] \cdot X_{i,t} \\ + [\sum_{i}^{N_i} Fcon_i (\sum_{j}^{N_j} \mathrm{FP}_{j,t})] \sum_{p}^{N_p} EPP_{i,t,p} \cdot \mathrm{T}_{t,p} + [\sum_{i}^{N_i} \mathrm{WP}_t \cdot Wcon_i \\ + \sum_{i}^{N_i} VOMC_i] \cdot \sum_{p}^{N_p} EPP_{i,t,p} \cdot \mathrm{T}_{t,p} \}\end{aligned} \quad (11)$$

The environmental impact of electricity generation creates a conflict about planning decisions and operation of electrical system. Initially, this conflict did not exist, because the only aspect considered in the decisions of the electricity sector was the cost of the system. Recently, environmental criteria were added, as a result of the aforementioned social concern about the impact electricity and environmental convinced that this is a cost impact for society, which must be internalized. In a general view the environmental impact of the generation system can be represented as follow:

$$\mathrm{EI} = \mathrm{COE} + \mathrm{SOE} + \mathrm{NOE} + \mathrm{RRE} \quad (12)$$

Where COE, SOE, NOE, RRE are the emission rates of $\mathrm{CO_2}$, $\mathrm{SO_2}$, $\mathrm{NO_x}$ and radioactive waste. These values can be calculated for a specific technology and resource:

$$EI = \sum_{p=1}^{P} d_P \sum_{t=1}^{T} \sum_{r=1}^{R} (RR_{r,t,p} + NO_{r,t,p} + SO_{r,t,p} + CO_{r,t,p}) X_{i,t} \quad (13)$$

The feasibility is another aspect to be considered, for that reason the third equation of the system is:

$$FE = \sum_{t=1}^{T} \sum_{i=1}^{I} \gamma_{i,t} X_{i,t} \quad (14)$$

Where $\gamma_{i,t}$ is the failure rate associated to each technology. This has meant that, as mentioned above, the vast majority of plans cited energy as its main objective is to guarantee electricity supply affordable, reliable and environmentally friendly. But these three objectives are contradictory.

2.1.2 Constrains

There are two types of constraints, equality and inequality constraints. All the constraints have to be fulfilled in order to consider a solution feasible.

Positivity constraint

These constraints make sure that the decision variables don't assume any negative value.

$$X_{i,t} \geq 0 \quad (15)$$

$$EPP_{i,t,p} \geq 0 \quad (16)$$

Load satisfaction

The installed capacity has to cover the demand peak plus a chosen reserve margin. The annual peak load corresponds to the first time step in every forecasted LDC for each year.

$$\sum_{i=1}^{N_i} EPC_i \cdot X_{i,t} \geq EPD_{t,1} \cdot PRM \quad (17)$$

Energy balance

The electricity produced has to equal the electric power demand.

$$\sum_{i=1}^{N_p} EPP_{i,t,p} = EPD_{t,p} \quad (18)$$

Operation limit

The installed capacity can't be exceeded by the power production

$$\mathrm{EPP_{i,t,p}} \leq \mathrm{EPC_i} \cdot \mathrm{X_{i,t}} \tag{19}$$

Availability limit

$$\sum_{p=1}^{N_p} \mathrm{EPP_{i,t,p}} \cdot \mathrm{T_{t,p}} \leq \mathrm{AVF_i} \cdot \mathrm{EPC_i} \cdot \mathrm{X_{i,t}} \tag{20}$$

In order to solve this MOOP the Theory of Pareto's Front is used to find the set of solution that optimize the model. Special attention must be taken the emission of contaminants to the environment and the ecosystem where the technology is going to be installed. This constrains are going to be included in the next version of the model.

3 Multi-Objective Optimization Problems

The goal of Multi-Objective Optimization Problems is to find one or many solutions that minimize o maximize two or more objective functions. A general problem of this kind includes n decision variables into a set of objective functions and a set of restriction functions. Mathematically it can be defined as follow:

Find $\overrightarrow{X^*} = [x_1{}^*, x_2{}^*, \dots x_n{}^*]$ that satisfy m constrains $G_{i(\vec{X})} \geq 0$ *i=1..m* and that optimize n objective functions $F_{(\vec{X})} = [f_{1(\vec{X})}, f_{2(\vec{X})}, \dots f_{n(\vec{X})}]$(cita)

To solve these problems, the Theory of Pareto has been widely accepted. Some algorithms take into account the concept of Pareto dominance allowing to compare two solutions considering several objectives simultaneously.

3.1 Pareto Optimality

A solution $\overrightarrow{X^*} \in \varphi$ is a Pareto Optimum if to every $\vec{X} \in \varphi\ e\ I = \{1, 2, .. k\}$ it is true that $\forall\, i \in I\ (f_{i(\vec{X})} = f_{i(\overrightarrow{X^*})})$ or exist at least an $i \in I$ that makes $(f_{i(\vec{X})} > f_{i(\overrightarrow{X^*})})$. Then, according to Pareto, a vector $\vec{u} = [u_1, u_2, \dots u_n]$ dominate to another vector $\vec{v} = [v_1, v_2, \dots v_n]$ if and only if $\vec{u}$ is partially less than $\vec{v}$, $\forall\, i \in \{1,2, .. k\}\ \vec{v} \geq \vec{u}$ and exist at least an that $i \in \{1, 2,\ .. k\}\ \vec{v} > \vec{u}$. To a MOOP the set of Optimums of Pareto is defined as $P^* = \{x \in \varphi \mid \neg\ \ x' \in \varphi\, \vec{f}_{(x')} \leq \vec{f}_{(x)}\}$. Then to a MOOP and a set of Pareto Optimums, a front of Pareto is defined as follows:

$$PF^* = \{\vec{f} = (\ (f_{1(x)}, f_{2(x)}, .. f_{k(x)})\mid x \in P^*\} \tag{21}$$

In this chapter a three objective Pareto's Front is presented to find the best solution that allow the sustainable development in the power distribution system presented.

3.2 Genetic Algorithms

Genetic Algorithms (GA) are inspired by the evolutionist theory explaining the origin of the species. Each operator in this kind of implementation is based on the behavior of organisms interacting with their environment. Chromosomes usually represent the solutions in this approach and the chromosomes are made of genes. Each gene represents an aspect of the solution. A mapping mechanism is necessary to translate chromosomes and genes into the solution space, this is called encoding.

Genetic Algorithms work with collection of chromosomes, called population. In a general approach they work over a population randomly initialized and applying two operators to generate new solutions from the existing ones, these operators are crossover and mutation.

The ability of GA to simultaneously search different region of the solution space make it possible to find a diverse set of solutions in a multi-objective approach. The crossover operator is able to find good solutions respecting to different objectives to create new non-dominated solutions in unexplored regions of the Pareto-Front.

There are many implementations of genetic algorithms, mainly because their uses on Multi-Objective Optimization have been widely spread. The first multi-objective GA, called vector evaluated GA (or VEGA), was proposed by Schaffer. Afterwards, several multi-objective evolutionary algorithms were developed including Multi-objective Genetic Algorithm (MOGA) [1], Niched Pareto Genetic Algorithm (NPGA) [2], Weight-based Genetic Algorithm (WBGA) [3], Random Weighted Genetic Algorithm (RWGA)[4], Non dominated Sorting Genetic Algorithm (NSGA) [5], Strength Pareto Evolutionary Algorithm (SPEA) [6], improved SPEA (SPEA2) [7], Pareto-Archived Evolution Strategy (PAES) [8], Pareto Envelope-based Selection Algorithm (PESA) [9], Region-based Selection in Evolutionary Multi-objective Optimization (PESA-II) [10], Fast Non dominated Sorting Genetic Algorithm (NSGA-II) [11], Multi-objective Evolutionary Algorithm (MEA) [12], Micro-GA [13], Rank-Density Based Genetic Algorithm (RDGA) [14], and Dynamic Multi-Objective Evolutionary Algorithm (DMOEA) [15].

This chapter presents an implementation of the problem described above using GA. The solution is represented using a two dimension vector that shows the amount of each technology that should be used in a determinate period. The operator of recombination is defined as the non dominated solutions and the mutation operator is applied to solutions that show a better behavior in an objective but a bad one in the other two. The initial population was made of 300 solutions the crossover factor 0.4 and the mutation factor 0.02. The results of this implementation are discussed in the next section.

3.3 Ant Colony Optimization

Other popular bio-inspired model applied to MOOP is ACO. There have been lately a lot of efforts to use this techniques and the number of applications have arise strongly in the past few years [16]. The idea of ACO is quite simple, inspired in the real ants and the pheromone trail on their path. It's a general-purpose stochastic local search method [17] and its behavior is strongly dependent of their parameters. The parameters configuration can be very important implementing this heuristic, especially definition of pheromone and heuristic information, the aggregation of specific information for each objective, different ways of selecting solutions for the pheromone update and the use of multiple ant colonies to specialize on specific areas of the Pareto-Front [18]. - - - -experimental setup considers three components: the search strategy that can be of class D, S(all) or S(one); iteration-best versus best-so-far pheromone update; and one or multiple colonies. In addition, each algorithm was run with and without local search. The total number of ants (m) was equal to the instance size and we used 5 colonies in the multiple colony approach, where each colony had m=5 ants. For the management of the pheromones, we followed the rules of *MMax* with µ= 0:9 for the pheromone evaporation; Pbest = 0:05 to derive the factor between the lower and upper pheromone trail limits; and £max was set to the theoretically largest value [19]. Each solution is also represented as a two dimension vector that contains each period and technologies to be used on it.

4 Result Analysis

The implementation of both algorithms was made over a Core 2 Dou CPU and 4 Gb of RAM. The Algorithms were coded using Wolfram Matehematica. Each implementation was tested 10 times using 3 different power generation systems scenarios for the city of Santa Clara. This is the first implementation of this model and we hope to integrate it with transmission and distribution model to supply for the Electrical Energy Enterprise of Santa Clara a tool to assist their directives in decision making regarding to the expansion of electrical network and service to the Industrial and residential areas.

In the case of ACO implementations, this analysis clearly showed that for unstructured as well as structured instances any algorithm that uses local search outperforms all algorithms that do not use local search. Interestingly, the second phase of our analysis, also suggested that the best ACO configurations that do not use local search are very different from the best configurations that do make use of local search procedures. Anyway the implementation of genetic Algorithms showed to be a better option in this problem.

In Fig. 1 is showed the Pareto-front obtained from the implementation of MOOP using ACO. The measures have been mapped from the original model. The cost is measured in millions of dollars, the feasibility in terms of number of energy not supplied and the environmental impact in the amount of grams of population per kilowatt supplied to the network of the power generation system.

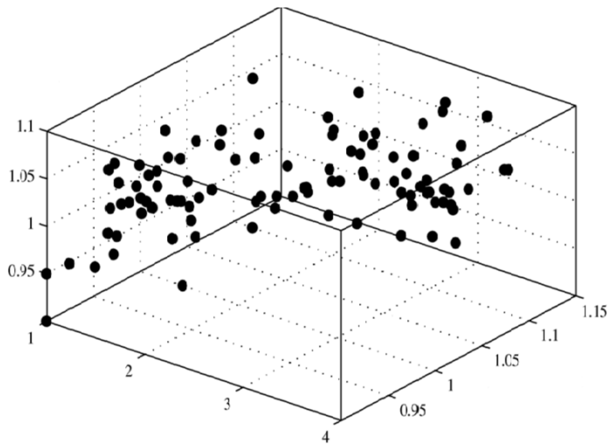


Fig 1. Pareto-Front using ACO

The Pareto-Front in Fig. 2 was obtained from the implementation of a general purpose Genetic Algorithms.

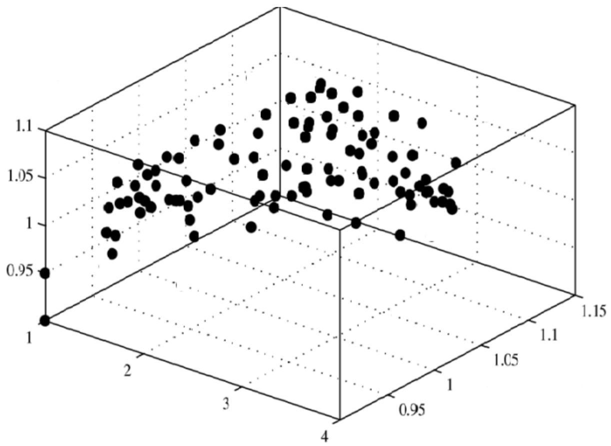


Fig 2. Pareto-Front using GA

It's important to say that both implementations show better behavior that general multi-objective optimization solutions. The final decision of which solution is the best among all the non-dominated solutions is a difficult task. Several theories have been exposed to solve this problem, but regarding to sustainable development the wisest decision is allow to experts to choose which objective is most important in each scenario.

Genetic Algorithms have proved to be a most efficient method in this problem, but there are many configuration issues to be handle that may ACO an alternative to be considered.

5 Conclusions

In this chapter, we have presented a new model to describe the power generation systems of a mayor city. The objectives of sustainability development have guided this investigation and two bio-inspired algorithms have been implemented to solve this multi-objective optimization problem. Once again Artificial Intelligence Methods have proved to be very efficient solving this kind of problems; also configuration parameters came up as a very important issue to be handled carefully. The model presented can be extended in many ways and simulation algorithms can be applied to show how it should work under certain circumstances.

References

[1] Fonseca CM, Fleming PJ. Multiobjective genetic algorithms. In: IEE colloquium on 'Genetic Algorithms for Control Systems Engineering' (Digest No. 1993/130), 28 May 1993. London, UK: IEE; (1993).
[2] Horn J, Nafpliotis N, Goldberg DE. A niched Pareto genetic algorithm for multiobjective optimization. In: Proceedings of the first IEEE conference on evolutionary computation. IEEE world congress on computational intelligence, 27–29 June, 1994. Orlando, FL, USA: IEEE; (1994).
[3] Hajela P, lin C-y. Genetic search strategies in multicriterion optimal design. Struct Optimization;4(2):99–107(1992).
[4] Murata T, Ishibuchi H. MOGA: multi-objective genetic algorithms. In: Proceedings of the 1995 IEEE international conference on evolutionary computation, 29 November–1 December, 1995. Perth, WA, Australia: IEEE; (1995).
[5] Srinivas N, Deb K. Multiobjective optimization using nondominated sorting in genetic algorithms. J Evol Comput;2(3):221–48. (1994)
[6] Zitzler E, Thiele L. Multiobjective evolutionary algorithms: a comparative case study and the strength Pareto approach. IEEE Trans Evol Comput 1999;3(4):257–71. A. Konak et al. / Reliability Engineering and System Safety 91 (2006) 992–1007 1005 TICLE IN PRESS
[7] Zitzler E, Laumanns M, Thiele L. SPEA2: improving the strength Pareto evolutionary algorithm. Swiss Federal Institute Techonology: Zurich, Switzerland; (2001).
[8] Knowles JD, Corne DW. Approximating the nondominated front using the Pareto archived evolution strategy. Evol Comput;8(2):149–72. (2000)
[9] Corne DW, Knowles JD, Oates MJ. The Pareto envelope-based selection algorithm for multiobjective optimization. In: Proceedings of sixth international conference on parallel problem solving from Nature, 18–20 September, 2000. Paris, France: Springer; (2000).
[10] Corne D, Jerram NR, Knowles J, Oates J. PESA-II: region-based selection in evolutionary multiobjective optimization. In: Proceedings of the genetic and evolutionary computation conference (GECCO-2001), San Francisco, CA, (2001).
[11] Deb K, Pratap A, Agarwal S, Meyarivan T. A fast and elitist multiobjective genetic algorithm: NSGA-II. IEEE Trans EvolComput;6(2):182–97. (2002).

[12] Sarker R, Liang K-H, Newton C. A new multi-objective evolutionary algorithm. Eur J Oper Res;140(1):12–23. (2002)
[13] Coello CAC, Pulido GT. A micro-genetic algorithm for multiobjective optimization. In: Evolutionary multi-criterion optimization. First international conference, EMO 2001, 7–9 March, 2001. Zurich, Switzerland: Springer;(2001)
[14] Lu H, Yen GG. Rank-density-based multiobjective genetic algorithm and benchmark test function study. IEEE Trans Evol Comput;7(4):325–43. (2003)
[15] Yen GG, Lu H. Dynamic multiobjective evolutionary algorithm: adaptive cell-based rank and density estimation. IEEE Trans EvolComput;7(3):253–74.(2003)
[16] Dorigo, M., St¨utzle, T.: Ant Colony Optimization. MIT Press, Cambridge (2004)
[17] An Analysis of Algorithmic Components for Multiobjective Ant Colony Optimization: A Case Study on the Biobjective TSP. P. Collet et al. (Eds.): EA 2009, LNCS 5975, pp. 134–145, (2010)
[18] Khodr, H. "Curso Tutorial: Optimización Aplicada a la Planificación de Sistemas de Distribución de Energía Eléctrica". IV Congreso Venezolano de Ingeniería Eléctrica. Universidad Simón Bolivar. Sep. (2004).
[19] T. Stutzle, and H. Hoos.: "MAX-MIN Ant System." Future Generation Computer Systems (2000)

Data Defects in Material Flow Networks

Nashida Barakat[1], Alexandra Pehlken[2]

[1]Carl von Ossietzky University, [2]University of Bremen

Barakat@wi-ol.de, pehlken@uni-bremen.de

Abstract. Eco-balance is the basis for the assessing production impact on the environment. Eco-balancing is divided into four phases: goal and scope definition, inventory analysis, impact assessment, interpretation. However, during the creation and evaluation of material flow networks some defects appear which inhibit or make it more difficult to establish realistic statements towards the environmental impact. In order to make a reliable statement about the environmental impact with the help of eco-balance it is necessary to consider all material and energy flows. This chapter gives an overview of the classification of defects in material flow networks. After the classification of data defects the causes of these defects are discussed. In order to resolve the causes of defects some solutions will be presented using the advantages of Petri nets and the application of Fuzzy sets and Rough sets to the Petri nets.

Keywords: Eco-balance, Fuzzy set, Rough set, Petri nets, Material flow networks.

1 Introduction

Eco-balances are the basis for assessing the production impacts on the environment and the creation of environmental reports. According to DIN EN ISO 14040 eco-balances are divided into four categories: goal and scope definition inventory analysis, impact assessment and interpretation [1].

Creation of an eco-balance is supported by software tools, like Umberto for example. In Umberto material and energy flows required for the production of inventory analysis will be designed by means of material flow networks.

Material flow networks are based on Petri Nets which consist of knots (transition, places) and edges (arrows). Transitions symbolize transformation processes of material and energy. They are specified by input –output –equations. Within the places the distribution of material flows are defined. Raw materials, supply materials, preliminary products, semi- finished products, and by products like waste and emissions are considered as materials. Arrows between places and transition illustrate material flows.

Information about the process structure (including sub-processes) is necessary in order to create material flow networks [1]. To make reliable statements about environmental impacts with help of eco-balance it is evident to consider all ma-

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_7,

terial and energy flows [2]. However, during the creation and evaluation of material flow networks data defects can occur which inhibit or make it more difficult to establish realistic statements towards environmental impacts. Therefore, in the following chapters these defects will be discussed.

2 Defects types

The defects in material flow networks can be roughly divided into missing data and incorrect data [2].

2.1 Missing Data

Modeling a material flow network requires information about the structure of the modeled (sub-) processes and corresponding material including their quantities resp. calculation rules. If this information is not available or only partly available, it is said that data is missing. Missing data can be classified more precisely in:

- missing process data,
- missing process steps and
- missing pre-chains resp. post-chains.

With missing process data the structure of the approached (sub-) process is well known, but there is a lack of some (or all) relevant materials or their quantities resp. calculation rules. The structure of the material flow network can be modeled, although, the specification of places, transition or arrows, which is necessary for the material flow network calculations, is not available
(see Figure 1).

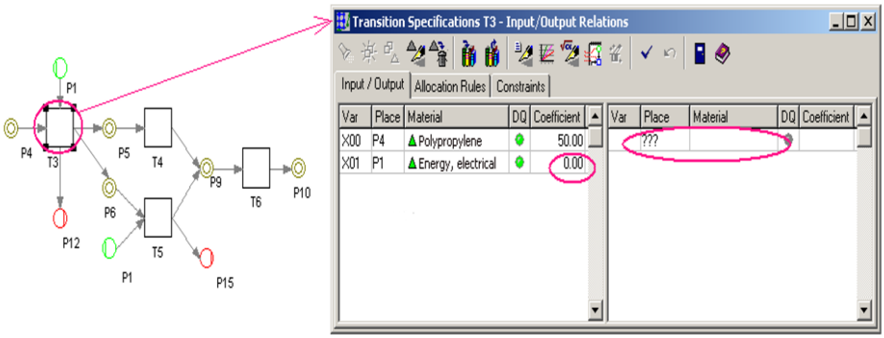


Fig 1. Missing Process Data , *Source: [3]*

Information about process structure of a (sub-) process is missing when we identify missing process steps. A detailed modeling of the process as a subnet (see Figure 2) is therefore not possible and only a representation as a “black box” in form of a transition can be modeled. (See Figure 2). If a material flow network contains incomplete information about the production of a used material (production of raw materials resp.preliminary products and also by-products, wastes and emissions), it is said that pre-chain is missing. Similarly missing post-chain indicates that there is no information regarding future usage of a material. In a material flow network knots and edges that are connected directly or indirectly with the help of transition in the pre-area (post-area) are classified as pre-chain (post-chain) (see Figure 3). The case when partial chains are missing in the middle of the material flow network they will be classified as missing process steps.

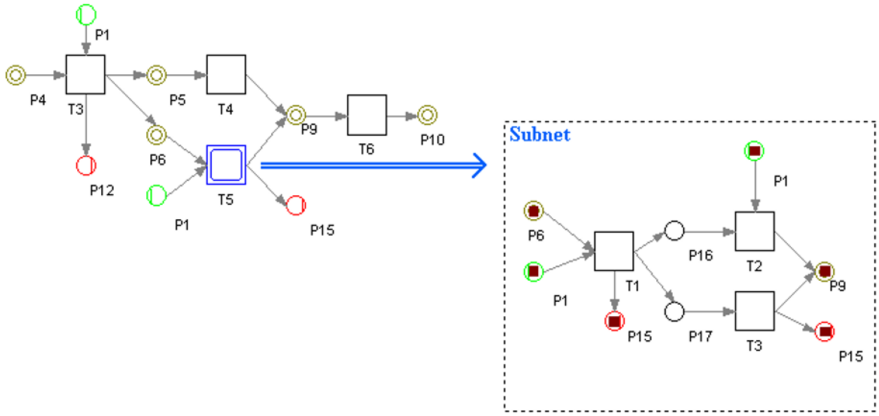


Fig. 2. Detailing by Means of a Subnet , *Source:[3]*

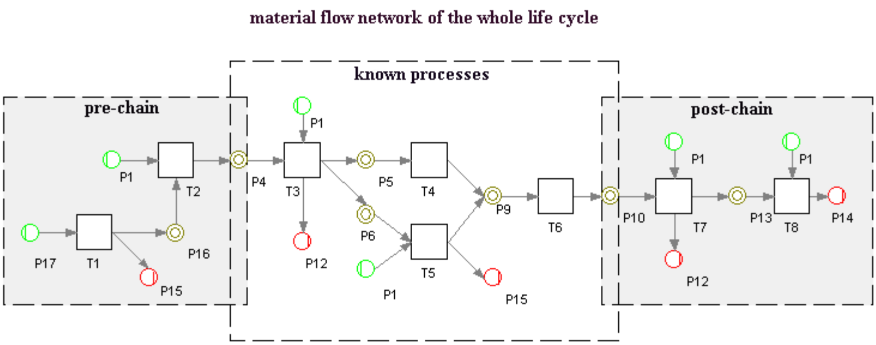


Fig. 3. pre-chain and post-chain, *Source:[3]*

2.2 Incorrect Data

Errors during acquisition, calculation or aggregation of data lead to incorrect data. Measurement errors can occur during data acquisition. They are an outcome of negative outside influences and can be subdivided in gross, systematic and random errors [4]. Gross errors appear because of reading errors, transfer errors or improper working measuring instruments for example. These errors are avoidable. Inaccurate measuring methods or incorrect measuring instruments lead to systematic errors.

Thereby the measured values are falsified in the same way. Random errors are based on non-controllable negative outside influences like slight variation in temperature or air pressure.

Wrong or incorrect calculation formulas can cause incorrect data during the calculation of data. Furthermore, incorrect data can be a result of over-simplification. This is the case if instead of a real value a reference value from a library or a (public) database is used. Estimated values and aggregated data like median or mean values also belong to this category. Over-simplified data deviate partly or considerably from the original data and are therefore incorrect.

After the calculation of the material flow network incorrect data entail a faulty inventory analysis. Based on this, the impact assessment does not correspond to reality but looks correct or is "plausibly" reasonable. As a result the problem is to detect incorrect data. The appearance of unrealistic results or existence of big value variations in data of different periods are potential indicators for data defects. Nevertheless, if the eco-balance is created the first time, this method cannot be used because the possibilities of comparison are missing.

2.3 Possible Defect Combinations

Various defect types and defects of one type can occur in a material flow network simultaneously. The occurrence of one defect type does not exclude the occurrence of other defect types and also has no influence on their characteristics.

Besides, there exists a ranking between the defect types: incorrect data are preferred to missing data. In contrast to missing data, incorrect data allows making statements about environmental impacts, even though the data differ from reality [2].

3 Solution attempts

There are various possible solutions for data defects:

- To integrate input –output data into supply chain management in order to enable an improvement of data availability for eco-balance production [5].
- To estimate values using fuzzy logic, but is inapplicable because it would mean inaccurate calculation rather than data gaps removing [2].
- To use knowledge acquisition and information fusion form [6].
- To use machine learning in order to find out the values for missing data from known transition specification.
- To use neural networks and Petri nets [1].

- Hybrid system: with this system we can design neural network starting from Petri net to model a specific material flow network application. This system combines neural network with cased based reasoning module [7].
- To use preventive measures.
- To compare measured data and data from independent measurements [1].
- To increase density of measuring points in conjunction with sample calculations.
- If aggregate data are used it is necessary to control aggregate criteria. The assumption should be managed if statistical methods are used. [2].
- To remove data gaps due to missing data is the use of available databases.
- The environmental management standards include basis that force a publication of data, in order to know about external process steps, pre- or post-chain and acquisition of data by the eco-balance originator.

4 A possible solution using Petri nets, Fuzzy set theory, Rough set theory

Petri Nets (PNs) are alternative tools for the study of non-deterministic, concurrent, parallel, distributed or stochastic systems.
They can model system in any easy and natural way. Furthermore, the Petri Nets approach can be easily combined with other techniques and theories such as Fuzzy theory, neural networks, Rough set theory etc [8],[9]. These modified PNs are widely used in computer; manufacturing, robotic, knowledge based systems, process control, as well as other kinds of engineering application.
Since the Petri Nets (PNs) offer the advantages to model systems and are able to interact with other techniques, it would be beneficial to model Petri nets with Fuzzy set.

We can define Fuzzy Petri nets as classical Petri Nets that have a structure $N=<, S\ T, F>$ where S is a set of places, T is a set of transitions and F is defined as $F \subseteq (SxT) \cup (TxS)$, where $(\forall t \in T)\ (\exists p,q \in S),(p,t),(T,P) \in F$

Graphical representation is set up by following symbols:

- Places- circle
- Transitions- rectangle
- Relations - arrows between transitions and places or places and transitions.

For more information about Petri nets we recommend Literature [12], [13]. In classical Petri Nets a token placed if the expression is true (1) and no token is placed if it is false (0).

Now we create such a Petri net that will work with vague values ("small", "big", etc.). We use tools of fuzzy logic for working with such values especially IF THEN rules.

Token represent fuzzy sets in this case, edges will be evaluated by linguistic expression from IF THEN rules and own transition represent basically fuzzy relation according to the IF THEN rule. Fuzzy IF THEN rule is a concept used for describing logical dependence between variables of the following form:

IF X_1 is A_1 AND……….. AND Xn is A_n THEN Y is B

where A_1; : : : ;A_n and B are certain predicates characterizing the variables X_1; : : : ;X_n and Y . They are often specified linguistically.

We will work with specific kind of linguistic expressions as defined in [5]. For more information about logical structure of Fuzzy IF-THEN rules see [6].

The part before THEN is called the antecedent and the part after it the succedent. The variables X_1; : : ; X_n are called input, or independent variables. The variable Y (in general, there may be more of them, but we will limit oneself to only one) is called output, or dependent variable.

The fuzzy IF-THEN rules are usually put together to form the linguistic description.

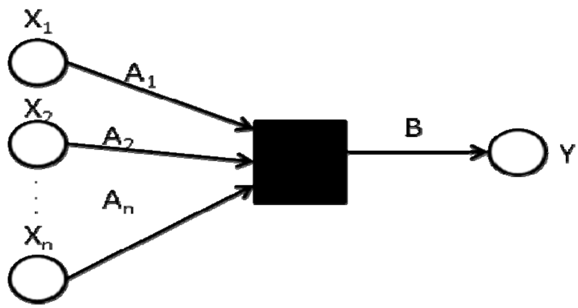
R_1: = IF X_1 is A_{11} AND……….. AND X_n is A_{1n} THEN Y is B_1
. . . .…
R_m: = IF X_1 is A_{m1} AND ………. AND X_n is A_{mn} THEN Y is B_m

Now we model IF THEN rules by Fuzzy Petri Nets (PNs):

Any IF THEN rules of this form:

IF X_1 is A_1 AND……….. AND X_n is A_1n THEN Y is B

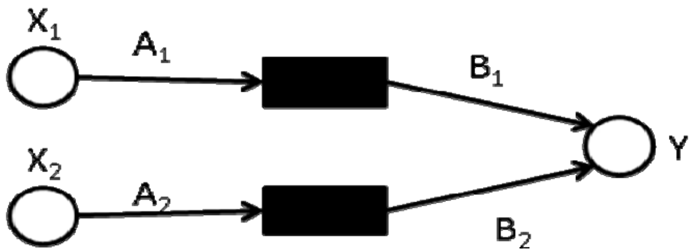
can be expressed by the following Petri Net (PNs):



The set of IF THEN rules which forms linguistic description can be modeled the same way.

R_1:= IF X_1 is A_{11} AND……….. AND X_n is A_{1n} THEN Y is B_1
. . . . …
R_m: = IF X_1 is A_{m1} AND ………. AND X_n is A_{mn} THEN Y is B_m

Each transition of result fuzzy Petri net corresponds to one rule of linguistic description.
Fuzzy Petri Nets (FPNs) may look differently if we have to deal with the situations: What will happen when some of the edges are missing?



In this case two corresponding IF THEN rules are:

R_1:= IF X_1 is A_1 THEN Y is B_1
R_2:= IF X_2 is A_2 THEN Y is B_2

To create linguistic description for one output variables Y and two input variables X_1, X_2 we extended the set of predicates characterizing input variables by "UNDEF" linguistic expression which means that the values of the variables is undefined. So the linguistic description in this case will be:

R_1:= IF X_1 is A_1 AND X_2 is UNDEF THEN Y is B_1
R_2:= IF X_1 is UNDEF AND X_2 is A_2 THEN Y is B_2

If there is more than one output variable the corresponding linguistic descriptions could look like this:

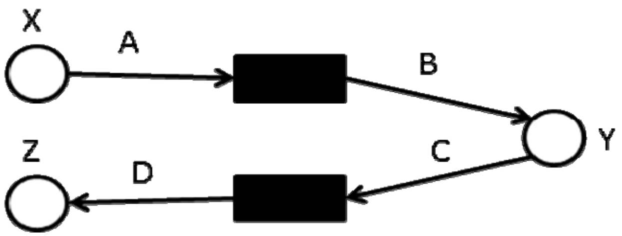
R: = IF X_1 is A_1 THEN Y_1 is B_1 AND Y_2 is B_2

But as we said we will limit only to one output variable. In this case we will create several linguistic descriptions, one for each output variable:

R: = IF X1 is A1 THEN Y1 is B1
For the first output variable

R: = IF X1 is A1 THEN Y2 is B2
For the second output variable.

In general for k output variables k linguistic description with only one output variables in each of them will be constructed.
At the situation when an output place of a transition is the input place for another transition we can create the linguistic description using also Fuzzy Petri Net:



This Fuzzy Petri net leads to two linguistic descriptions:

R: = IF X is A THEN Y is B

and

R: = IF Y is C THEN Z is D

The number of linguistic description is equal to the number of output places.

In the application of Rough set theory to the Petri Nets we have applied Rough set theory just for the OR-split and we have defined: rough places, rough token and rough transition. In this case we can just detect the defect but we cannot treat it. For more information we recommend [10]. The next step will be the application of this idea to material flow networks, using some transformation idea that other authors have been used. First attempts are presented in [2], [11].

In our research we concentrate on recycling processes that generate material flows in various qualities. A complete separation of waste material components is not possible but quality standards can be met through defining separation grades as categories (high, medium, low). Therefore, material flow networks are useful to describe the correlation of material properties. Please note that the visualisation of material flows in recycling processes is not related to specific data (numbers) but rather to data ranges (or quality issues). The material flow network can help in decision making processes if the uncertainty of the model has an acceptable level. The acceptable level depends on the aim of the modeler and the model user. We are presenting first attempts in another publication [11] and are still in the process of researching the best available methods.

5 Conclusion

In this chapter we presented some ideas according the material flow networks, Petri Nets, and the use of Fuzzy set theory. It can be summarized as followed:

- Material flow networks based on Petri Nets.
- Petri Nets are a tool to design any systems.
- All the information about the process in Eco-balance is necessary.
- The defects in material flow networks are presented.
- The application of Fuzzy set to Petri nets is presented.

We are still working on this topic, and the next step will be applying Fuzzy rough set to the material flow network to detect the defect in it.

References

[1] Marx Gómez, J., Prötysch, S., Rautenstrauch, C.: Data Defects in Material Flow Networks-Classification and Approach; cybernetics and Systems: An international Journal (CBS), pp. 549-558. Vol. 35, No 5-6, July – September 2004

[2] Arco, L., Bonte, I., Marx Gómez, J., Rautenstrauch, C.: A new Approach to Solve Data Defects in Material Flow Networks. In: 19th EnviroInfo International Symposiurn on Environmental Informatics, Brno, Czech Republic (2005)

[3] Marx-Gómez, J., 2004, Automatisierung der Umweltberichterstattung mit Stoffstrom-managementsystemen, Habilitationsschrift Universität Magdeburg

[4] Papula, L., Mathematik für Ingenieure und Naturwissenschaftler, Band 3, 2nd ed. Vieweg, Braunschweig/Wiesbaden. (1997)

[5] Seuring, S. MANAGEMENT WISSEN - Stoffstrommanagement und Supply Chain Management. In: Umwelt Vol. 30, 6, pp. 30-31. (2000)

[6] Kunze, M., Rösner, D. Eine xml-basierte Werkbank für das Document Mining. In: Lobin, H. (Hrsg.) (2001): Proceedings der GLDV-Frühjahrstagung 2001, Universität Gießen, pp. 131-140

[7] Allam, N., Development of methods for reducing the defect in Material Flow Networks Master thesis October 2005

[8] W, Yu , X. Li, Some New Results on System Identification with Dynamic Neural Networks, IEEE Trans. Neural Networks, Vol.12, No.2, 412-417, 2001

[9] Wen Yu and Xiaoou Li, Some Stability Properties of Dynamic Neural Networks, IEEE Trans: Circuits and Systems, Part I, Vol. 48, No. 1, 256-259, 2001

[10] Barakat, N., Detecting Data Defects in material flow networks based on a Fuzzy rough set (Fuzzy set, rough set), Proceedings of the International Society for Ecological Economics (ISEE) : 11th Biennial Conference: Advancing Sustainability in a Time of Crisis, Oldenburg and Bremen, Germany, August (2010).

[11] Pehlken, A., Gómez, J., Barakat, N.; Modelling solid waste recycling processes under the consideration of data defects; International Symposium on Information Technologies in Environmental Engineering ITEE 2011, Poznan, Poland, July 2011

[12] Brauer ,W., Royenberg, G., Salomaa, A. Reisig W; Petri Nets - An Introduction , Springer Verlag, Berlin Heidelberg (1985)

[13] Reisig, W.; Petrinetze Modellierungstechnik , Analysemethoden, Fallstudien(2010)

Modelling solid waste recycling processes under the consideration of data defects

Alexandra Pehlken[1], Jorge Marx Gómez[2], Nashida Barakat[2]

[1]University of Bremen, Institute for Integrated Product Development, Germany
[2]Carl von Ossietzky University, Very Large Business Applications, Oldenburg, Germany

Abstract. Secondary resources are not derived from mining or chemical processes compared to primary resources. They are resources that had been already in use and are processed afterwards. Some secondary resources may be waste material in their original application but they might be useful in other applications. The goal of each recycling process should be to generate material streams with a quality that ensures further usage in any way. Since it is not possible to achieve this goal for all life cycles the goal has to be to maintain specific material properties as long as possible. It is desirable to forecast specific material properties for choosing processes with the best performance. A rough prediction on material flows, costs and environmental impacts can be assessed through combining the methods Material Flow Assessment (MFA) and Life Cycle Assessment (LCA). But these methods lack of the description of material properties and their variations and uncertainties respectively. Uncertainties are related to data defects. The presented chapter will demonstrate a strategy for developing a recycling model that is able to handle data defects. Future prospects of the quality of secondary resources, including their input and output properties may be helpful to assess their potential to substitute primary resource for example.

Keywords: material flow assessments, data defects, recycling, modelling

1 Introduction

Modelling recycling processes offers the potential of identifying the processing steps with regard to the main material flows and emissions to reduce the environmental impact and improve the economics. Simulation has to be made available for further investigations. The major problems are uncertainties on the material composition within the material flows, and in the recycled products; especially regarding their characteristics like size, material combination and distribution. Furthermore, data defects may become a hindrance to perform a reliable simulation. Data defects are roughly divided into missing data or incorrect data.

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_8,

Solid waste recycling can be found in various ways:

a) direct recycling - material is used "as is" in further applications (no recycling process involved)
b) down-cycling - material is used for products that are of minor quality as the source (for example passenger tires into construction materials)
c) up-cycling - material is used for products that are of better or equal quality as the source (for example aluminium or glass recycling)

The goal of each recycling process should be to generate material streams with a quality that ensures up-cycling in any way. Since it is not possible to achieve this goal for all life cycles the goal has to be to maintain processing of materials as long as possible to guarantee specific material properties. The material properties are as important as the variation of quality attributes as impurities for example. Excellent material properties cannot be managed if they underlie extreme variations and are not reliable and reproducible respectively. Substance values are reproducible if – when repeating the sampling procedure – the new set of one or more substance values is statistically indistinguishable from the original one (i.e. the statistics of interest (e.g. means) do not differ significantly). The reproducibility must be guaranteed over the whole processing time to obtain a material stream with constant properties and therefore ensures the process capability.

2 Methods and Materials

2.1 Life Cycle and Material Flow Assessment

To assess a sustainable resource management the following conditions for a reasonable recycling process have to be achieved:

- Adequate material mass for the recycling process;
- Adequate material mass for further product manufacturing;
- Defined material properties;
- Very little variation of material properties.

It is desirable to forecast the above mentioned conditions for choosing the processes with the best performance. A rough prediction on material flows, costs and environmental impacts can be assessed through combining the methods Material Flow Assessment (MFA) and Life Cycle Assessment (LCA). But these methods lack of the description of material properties and their variations and uncertainties respectively.

Life Cycle Assessment (LCA) covers the entire lifecycle of a product, process or activity. According to the International Organization for Standardization (ISO), an environmental lifecycle assessment is analyzing the environmental interventions and potential impacts throughout the life (from cradle to grave) from raw material acquisition through production, use and disposal [1]. During the whole life cycle of products and materials the amounts of materials involved, the inputs of energy and water resources along the life cycle, the amounts of waste materials and the associated environmental impacts all along the product chain have to be assessed. Material Flow Assessment (MFA) clearly is useful here, but it can be only a part of the whole equation. MFA can illuminate the amounts of materials involved and the amount of material waste, but it does not include all the information necessary to assess potential impacts on the environment. With regard to material management MFA must be used in conjunction with other types of data [2].

According to Finnveden [3] the interest in LCA grew rapidly during the 1990s, also when the first scientific publication emerged [4]. Since then a strong development and harmonization has occurred resulting in an international standard [1]. Since there are still open questions while performing LCAs there are several international initiatives to provide recommendations, including the Life Cycle Initiative of the United Nations Environment Program (UNEP) and the Society of Environmental Toxicological and Chemistry [5], the European Platform for LCA of the European Commission [6], and the emerging International Reference Life Cycle Data System.

LCA helps decision makers taking into account environmental contribution on the basis of material and energy flows. Material Flow Analysis (MFA) is a systematic assessment of the flows and stocks of materials within a system defined in space and time [7]. It connects the sources, the pathways, and the final sinks of a material. An MFA delivers a complete and consistent set of information about all stocks and flows of a particular material within a system. The MFA can be regarded as a method to establish the inventory for an LCA.

A short history of MFA and can be found in Binder [8] and is going back to the roots of the 1960's to studies on material balances. The publication of Brunner and Rechberger [7] is now established as a textbook in the application of Material Flow Assessment.

Material Flow Assessment can be easily applied to recycling processes because is takes into account all material flows entering and leaving the recycling process (system boarder). Since the input in recycling processes is often a mixture of various material streams the exact composition is never known. There is often a lack of information due to unknown parameters in material composition or processing steps [9]. Due to the high potential of recycling processes contributing to a sustainable management of resources (e.g. energy savings and material efficiency) it is necessary to assess the material flows with the regard to their environmental impact [10], [11]. Assessing the material flows involves the characterization of materials and their properties. According to secondary (recycling) materials this is only possible in determining a range of properties values.

Material properties and material flows in recycling processes are strong connected with uncertainties since their origin lack of information. Materials entering a recycling process are products that have already been in use and are at their end-of-life. Therefore, information on their production process and especially their components cannot be provided as reliable data. Often assumptions are made that are based on human's knowledge and experiences.

2.2. Data Defects

In this chapter the missing data and incorrect or uncertain data represent data defects. Data defects in material flow networks can be roughly divided into missing data and incorrect data.

Missing Data: Modeling a material flow network requires information about the structure of the modeled (sub-) processes and corresponding material including their quantities resp. calculation rules. If this information is not available or only partly available, it is said that data are missing [12].

Missing data can be classified more precisely in:

- missing process data,
- missing process steps and
- missing pre-chains and post-chains respectively.

With missing process data the structure of the (sub-) process, which should be modeled, is well known (e.g. technical flow diagram), but there is a lack of some (or all) relevant materials or their quantities resp. calculation rules. The structure of the material flow network can be modeled, although, the specification of places, transition or arrows, which is necessary for the material flow network calculations, is not available.

Missing process steps means that information about process structure of a process or sub process is missing. A detailed modeling of the process as a subnet is, therefore, not possible, only a representation as a "black box" in form of a transition can be modeled.

If a material flow network contains incomplete information about the production of a used material (production of raw materials resp. preliminary products and also by-products, wastes and emissions), it is said that pre-chain is missing. In the same way missing post-chain results in the availability of no information regarding future usage of a material. In a material flow network knots and edges that are connected directly or indirectly with the help of transition in the pre-area (post-area) are classified as pre-chain (post-chain). The case when in the middle of the material flow net-work partial chains are missing will be classified as missing process steps.

On the one hand the reason for missing data is company's secrets. Publication of such data endangers the existence of an enterprise. On the other hand the measurability of data often is problematic. While calculating material flow network and inventory analysis, missing data cannot be taken into consideration. This results in the fact that only a limited assessment of the inventory analysis data concerning the environmental burdens is possible. The influence of the missing data can be only guessed. In this case a precision of the eco-balance will be pretended such that it does not actually exist. Mistakes in inventory analysis will be carried over to the impact assessment and interpretation [13].

Incorrect Data: Mistakes during acquisition, calculation or aggregation of data lead to incorrect data. It is valid for both: in-house acquired and supplied from outside data.

Measurement errors can occur during data acquisition. They are an outcome of negative outside influences and can be subdivided in gross, systematic and random errors [14]. Gross errors appear because of, for example, reading errors, transfer errors or improper working measuring instruments. These errors are avoidable. Inaccurate measuring methods or incorrect measuring instruments lead to systematic errors. Thereby the measured values are falsified in the same way. Random errors are based on non-controllable negative outside influences like slight variation in temperature or air pressure.

During the calculation of data, wrong or incorrect calculation formulas can cause incorrect data. Furthermore, incorrect data can be a result of over-simplification. After the calculation of the material flow network incorrect data entail a faulty inventory analysis. Based on this, the impact assessment does not correspond to reality but looks correct or is "plausibly" reasonable. As a result the problem is to detect incorrect data.

Possible Defect Combinations: Various defect types and defects of one type can occur in a material flow network simultaneously. The occurrence of one defect type does not exclude the occurrence of other defect types and also has no influence on their characteristics.

2.3. Material and Material Properties

Recycling processes generate material flows in various qualities. A complete separation of waste material components is not possible but quality standards can be met through defining separation grades as categories (high, medium, low). Therefore, modeling is useful to describe the correlation of material properties. Please note that the modeling in recycling processes is not related to specific data (numbers) but rather to data ranges (or quality issues). The modeling can help in decision making processes if the uncertainty of the model has an acceptable level. The acceptable level depends on the aim of the modeler and the model user.

For developing new products most input materials are primary resources and can be described in their properties since nearly all suppliers of resources participate in a quality management system and provide all their details on material streams. In most cases material streams generated from recycling processes (secondary resources) cannot compete with primary materials because secondary resources are often a mixture of various components. There is a chance that secondary resources are able to substitute primary resources if the information on their properties is complete and provided through an information system [15]. A parameter of high influence for the process performance is the homogeneity of material streams which is dependent on the sorting and separation success of recycling plants. An example gives the recycling of scrap tires. At the end-of-life of a tire there is information available on the brand, life time, kind of seasonal tire (winter, summer or all season), passenger or truck tire and much more. Besides this information it is never possible to get to know the exact tire composition (because of company secrets) that represents the input of a recycling plant.

According to scrap tires there is a strong relation between the liberation of materials and the particle size. Figure 1 shows three different particle sizes of a crushed scrap tire. The coarse particle demonstrates that there is no mechanical processing technology to separate the main materials fibre, steel and rubber from each other. The medium particle indicates that fibre particles are still connected to rubber particles, whereas the fine fraction shows the liberated rubber particle. For further applications it is necessary to know the "liberation grade" of particles to evaluate the material properties. Most recycling processes do not separate material flows by 100 percent. Therefore the impurities in material flows are essential to know.

Fig. 1. Relation of particle size and liberation grade of scrap tires

3 Model Structure and Solution Attempt

Developing a model that is able to cope with data ranges, missing data, incorrect data it is essential to follow some rules to make the model reliable. First of all information on the considered recycling stream and process has to be gathered and evaluated. It is very important that the model is able to tolerate uncertainties since this is a major parameter to look at. Second, the data has to be processed and statistical properties can be identified for example. At last a knowledge-based decision support system (see Figure 2) uses mainly the information generated by processing steps resulting in an abstract combination of the elements of the model and its linkages. Instead of specific data it processes the information of a process (e.g. dismantling of waste products into components of different shapes and compositions)[16].

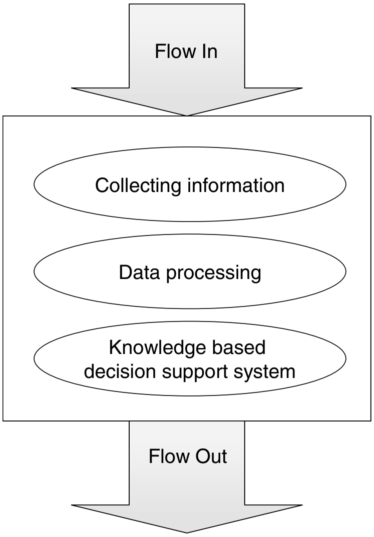


Fig. 2. Model architecture

The case study of scrap tire recycling delivers the information on the material flow properties as particle sizes and liberation grades during the process. This information is needed for further use of material flows in succeeding applications. The demand on material properties of rubber particles for use in automotive parts differ from the one for use on playgrounds for example. The model has to cope with information like coarse, medium and fine particles and quality issues like contamination of rubber with textile particles, steel with rubber particles, and further more. The variation of material properties is an issue and the model has to cope with it to deliver a reliable result. Processing of information and data has a major influence on the model output.

The model is based on Petri Nets. Petri Nets are alternative tools for the study of non-deterministic, concurrent, parallel, asynchronous, distributed or stochastic systems. They can model systems in a natural way. Furthermore, the Petri Nets approach can be easily combined with other techniques and theories such as object-oriented programming, fuzzy theory, neural networks, etc. [13]. Since Petri Nets offer advantages to model systems and can interact with other techniques easily this approach is the base for our model. We are using the Life Cycle Assessment Software Umberto which is based on a modified Petri Net. Figure 3 shows the structure of an example for the model which is focused on scrap tire recycling.

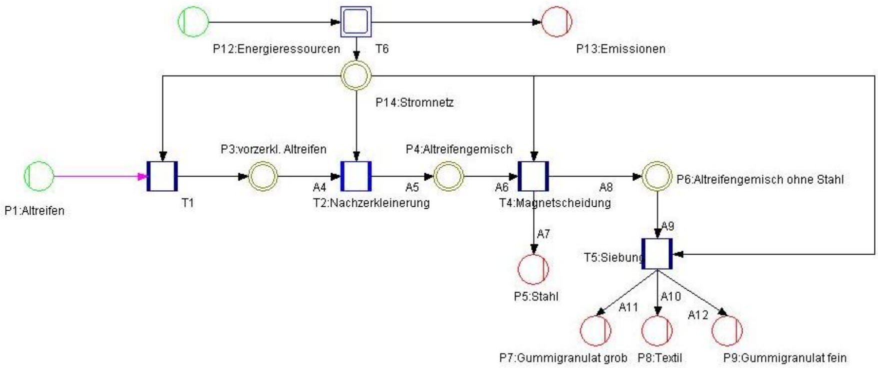


Fig. 3. Modified Petri Net of a scrap tire recycling process

To cope with data ranges and information with high uncertainties we are using artificial intelligence techniques. Neural networks, Petri nets, and hybrid systems that combine the above mentioned techniques with case based reasoning may be useful here. Whereas neural networks are learning systems the Petri nets follow given algorithms. With a hybrid system we can design a neural network starting from Petri net to model a specific material flow network application. It is necessary to combine neural networks with a case base reasoning module when there is missing process data. An alternative is to recover the cases similar to the problem and estimate the possible values of non-valued features. The recovery of similar cases can be done using near-neighbor algorithm, decision tress or associative memory methods [13].

Since the Petri Nets (PNs) offer the advantages to model systems and are able to interact with other techniques, it would be beneficial to model Petri nets with Fuzzy set.

We can define Fuzzy Petri nets as classical Petri Nets that have a structure
N=<, S T, F>
where S is a set of places, T is a set of transitions and F is defined as
$F \subseteq (SxT) \cup (TxS)$
where $(\forall t \in T)$ $(\exists p,q \in S),(p,t),(T,P) \in F$

Graphical representation is set up by following symbols:
- Places – circle
- Transitions – rectangle
- Relations - arrows between transitions and places or places and transitions.

In classical Petri Nets a token placed if the expression is true (1) and no token is placed if it is false (0).

A Petri net that will work with vague values ("small", "big", etc.) is created by using tools of fuzzy logic for working with such values especially IF THEN rules.

Token represent fuzzy sets in this case, edges will be evaluated by linguistic expression from IF THEN rules, and transition by itself represent basically fuzzy relation according to the IF THEN rule. Fuzzy IF THEN rules is a concept used for describing logical dependence between variables of the following form:

IF X_1 is A_1 AND……….. AND X_n is A_n THEN Y is B

where A_1; …. ;A_n and B are certain predicates characterizing the variables X_1; .... ;X_n and Y. They are often specified linguistically.

For the development of our model we are using specific kind of linguistic expressions as defined in [13]. For more information about logical structure of Fuzzy IF-THEN rules see [12].

The part before THEN is called the antecedent and the part after it the succedent. The variables X_1; …. ; X_n are called input, or independent variables. The variable Y (in general, there may be more of them, but we will limit oneself to only one) is called output, or dependent variable.

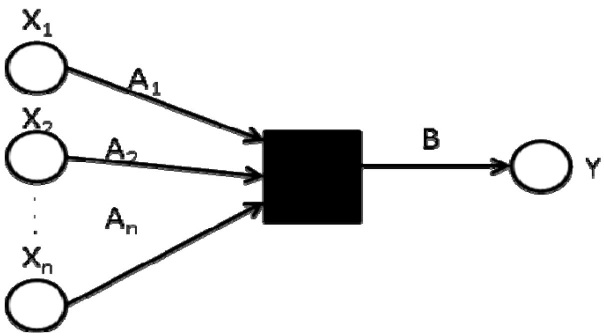
The fuzzy IF-THEN rules are usually joining each other to form the linguistic description.

R_1: = IF X_1 is A_{11} AND……….. AND X_n is A_{1n} THEN Y is B_1
. . . . …
R_m: = IF X_1 is A_{m1} AND ………. AND X_n is A_{mn} THEN Y is B_m

Followed by IF THEN rules by Fuzzy Petri Nets (PNs):

IF X_1 is A_1 AND……….. AND X_n is A_1n THEN Y is B.

This rule is represented by the following Petri Net (PNs):



In this Petri Net each transition of result fuzzy Petri net corresponds to one rule of linguistic description. If some edges are missing we extended the set of predicates characterizing input variables by “UNDEF” linguistic expression which means that the values of the variables is undefined. Accordingly the linguistic description in this case refers to:

R_1:= IF X_1 is A_1 AND X_2 is UNDEF THEN Y is B_1
R_2:= IF X_1 is UNDEF AND X_2 is A_2 THEN Y is B_2

At this stage of our research we limited our work to only one output variables. We are still in the process of developing the model [17].

4 Conclusion and Outlook

Data defects in recycling processes are commonly described as uncertainties. If an uncertainty assessment is performed and a decent result has occurred the user is satisfied. It is questionable how uncertainties are processed. In case of incorrect data a data range might help while performing statistical performances. Missing data are processed as either no value at all or data numbers are based on expert interviews. Since this approach is very subjective and may cause an error that makes the whole assessment questionable it is necessary to develop new procedures to handle data defects in material flow networks. Especially in recycling processes the evidence of data defects is high and it is a challenge to develop a model for solid waste recycling processes that considers data defects.

Still, we are at the beginning of our research and the intention is to provide a model that is based on own research results and already available information from recycling stock exchanges or international data bases.

References

[1] ISO 14040 International Standard (2006). In: Environmental Management – Life Cycle Assessment – Principles and Framework, International Organization for Standardization, Geneva, Switzerland
[2] Allen, F.W., Halloran, P. A., Leith, A.H., Lindsay, M.C. (2009); Using material flow analysis for sustainable materials management; Journal of Industrial Ecology Vol 13 No 5, pp. 662-665
[3] Finnveden, G., Hauschild, M.Z., Ekvall, T., Guinée, J., Heijungs, R., Hellweg, S., Koehler, A., Pennington, D., Suh, S. (2009); Recent Developments in Life Cycle Assessment, Journal of Environmental Management 91, pp. 1-21
[4] Guinée, J.B., Heijungs, R. (1993); A proposal for the classification of toxic substances within the framework of Life Cycle Assessment of products; Chemoshere 26(10), pp. 1925-1945
[5] United Nations Environment Programme (2002); Life Cycle Initiative Homepage; http://www.uneptie.org/pc/sustain/lcinitiative/home.htm
[6] European Commission (2007); Directorate General Joint Research Centre (JRC), European Reference Life Cycle Database (ELCD); http://lca.jrc.ec.europa.eu/lcainfohub/

[7] Brunner, P., Rechberger, H. (2003); Practical Handbook of of material flow analysis. Advanced methods in resource and waste management; Boca Raton; USA; Lewis Publishers
[8] Binder, C.R., van der Voet, E., Rosselot, K.S. (2009); Implementing the results of material flow analysis; of Industrial Ecology Vol 13 No 5; pp. 643-649
[9] Pehlken, A., Müller, D.H. (2009); Using information of the separation process of recycling scrap tires for process modelling, Resources, Conservation and Recycling (54) 2009; pp. 140-148; http://dx.doi.org/10.1016/j.resconrec.2009.07.008
[10] Bringezu, S., Bleischwitz, R. (2009); Sustainable resource management: global trends, visions and policies; Sheffield, UK, Greenleaf Publishing Ltd
[11] Salhofer S., Wassermann G., Binner E. (2004); Strategic Environmental Assessment as a Participatory Approach Environmental Planning: Experiences from a Case Study in Waste Management. In: Pahl-Wostl C., Schmidt S., Jakeman T. (Hrsg.): Complexity and Integrated Resources Management. iEMSs 2004 International Congress, 14. – 17. Juni 2004, Osnabrueck, Germany. Proceedings on CD and on the internet: http://www.iemss.org/iemss2004/; International Environmental Modelling and Software Society, Osnabrück, Germany
[12] Marx Gómez, J., Prötzsch, S., Rautenstrauch, C.(2004): Data Defects in Material Flow Networks - Classification and Approaches; Cybernetics and Systems: An International Journal (CBS), Volume 35, Numbers 5 - 6, pp. 549-558
[13] Arco, L., Bonet, I., Marx Gómez, J., Rautenstrauch, R.(2005): A new Approach to Solve Data Defects in Material Flow Networks; in: Hrebizek, J. (ed.): Proceedings of 19th International Symposium on Environmental Informatics – Networking Environmental Information – EnviroInfo 2005, Brno, (Czech Republic), pp. 724-731
[14] Papula, L. (1997), Mathematik für Ingenieure und Naturwissenschaftler, Band 3, 2nd Edition Vieweg, Braunschweig/Wiesbaden
[15] van Schaik, A., Reuter, M.A., (2010); Dynamic modelling of E-waste recycling system performance based on product design; Minerals Engineering (23) 3 pp.192-210
[16] Pehlken, A., Thoben, K.-D.; (2011) Contribution of Recycling Processes to Sustainable Resource Management, Life Cycle Engineering Conference 2011, Braunschweig, Germany
[17] Barakat, N.,Pehlken, A., Marx-Gómez, J.; Data Defects in Material Flow networks; International Symposium on Information Technologies in Environmental Engineering ITEE 2011, Poznan, Poland, July 2011

A Model-Driven Approach to Uncertainty Reduction in Environmental Data

Marina G. Erechtchoukova and Peter A. Khaiter

Faculty of Liberal Arts and Professional Studies, York University

Abstract. Environmental simulation modeling is inherently linked to observation data on the status of the environment. Data are a limiting factor in the selection of a model suitable for sustainable decision making. Models transform observation data into information by extracting aggregate values from raw data, projecting values of selected environmental indicators and detecting trends to track changes in environmental conditions. The chapter describes the framework for a model-driven development of sampling programs on the quality of the aquatic environment. Monitoring designs are determined as solutions of the operation research models articulated based on the cost-effectiveness analysis. The uncertainty of the estimates derived from monitoring data is used as a measure of the effectiveness of a monitoring design. Since data collected for one set of objectives can be used for the purposes which were not even considered at the planning stage, simple random designs are preferable. The proposed approach takes into account existing sampling procedures, models used for data analysis and uncertainty associated with the collected data. The approach has been used to develop efficient simple random designs common for all water quality parameters which are detected from the same water sample. The designs were built using linear regression models which improved the observation programs by reducing the numbers of required samples.

Keywords: water quality monitoring system; operation research model; monitoring design; uncertainty

1 Introduction

Environmental simulation modeling is inherently linked to observation data on the status of the environment. The status is described by the quality of the environment which reflects the suitability of an environmental resource for a designated use (e.g., recreation, drinking water supply, etc.). The quality of the environment is usually determined by comparing a set of values of selected indicators with existing standards. As a rule, environmental indicators are

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_9,

quantifiable variables reflecting physical, chemical or biological characteristics of natural ecosystems at a given moment of time and point in space. These variables are parameters representing environmental quality including various indices which provide aggregate values for a scientifically grounded assessment. With respect to the aquatic environment, its quality refers to physical conditions, such as the temperature and the presence of particulate matter, and to chemical conditions described by concentrations of dissolved constituents. Values of environmental indicators must be obtained by direct observations and measurements implemented under a certain program or calculated using appropriate formulae and observation data. Long-term standardized measurement, observation, evaluation and reporting of the aquatic environment in order to define status and trends of a water body are called monitoring [14].

Monitoring systems are the most systematic sources of environmental data. They perform such processes as collection and analysis of physical, chemical and biological data as well as quality assurance and control programs to ensure that the data are scientifically valid. While all these aspects are important for monitoring system functioning, the current study deals only with those requiring mathematical tools. Although automatic samplers are able to determine values of water quality parameters with high frequencies, they cannot replace routine water sample collection followed by a laboratory analysis due to the following reasons. First, these automatic tools can determine values for a limited set of water quality parameters. Second, limited budgets of monitoring systems cannot afford a large number of such devices, thus leaving many monitoring sites to operate under routing sampling programs. For an efficient assessment of water quality, EPA recommends an integrated approach incorporating several techniques [27]. These techniques include sampling programs supplying data for a statistically valid assessment along with watershed and water quality models used to transform collected data into information.

Uncertainty is one of the intrinsic characteristics of information supplied by a monitoring system [13]. This uncertainty significantly affects various steps of environmental assessment fed by monitoring data [25]. According to the Quality Assurance Plan [27], it is important to understand and quantify the uncertainty and incorporate its estimates into environmental assessment. In general, the uncertainty of an environmental indicator depends on the applied estimator and its mathematical properties, the variability of an investigated environmental parameters and an available data set [5]. The larger the set, the lesser the uncertainty of values calculated based on the set. However, for the majority of important water quality indicators and many sampling sites, extensive observations are not attainable due to logistic and financial constraints. For example [22], issued recommendations to collect as few as 4 – 6 observations per year at some monitoring sites or 6 – 12 samples over a three-year period. Water Framework Directive [10] prescribes sampling intervals of three months for all physico-chemical water quality parameters with the exception for priority constituents which must be observed on a monthly basis. Estimates derived from such data sets carry a high level of uncertainty. At the same time, the systems are expected to provide sufficient data for a wide range of scientifically valid conclusions with the level of errors not exceeding 10%.

Models can significantly improve the reliability of obtained information by reducing uncertainty of model outcomes provided that data sets are sufficient for model application. Strictly speaking, the quality of generated information depends on the model used [6]. Investigation of model properties can suggest the ways to reduce the uncertainty of the information and to develop monitoring designs improving estimates of environmental indicators [24], [26].

Formal approaches to the development of efficient temporal monitoring designs for a single water quality parameter have been already investigated in [5], [6], [7]. It has been shown that stratified monitoring designs or designs which prescribe specific calendar dates for water sampling result in a lesser total number of required observations compared to simple random designs. Nevertheless, former designs produce recommendations which are hard to follow due to the human factor and/or technical constraints. At the same time [21], recommended simple random designs since they generate data set suitable for a wide range of statistical procedures.

The study focuses on the role of models in routine water quality monitoring. It describes an approach to the development of an efficient temporal monitoring design for data collection at a given site for several water constituents. The approach assumes random distribution of water samples over an investigated period of time and takes into account existing sampling procedures, models used for data analysis and uncertainty associated with the collected data.

2 Monitoring systems

Monitoring systems provide broad sets of data collected in accordance with a program designed for specific scientific, environmental or managerial objectives. Although monitoring objectives differ for various monitoring systems, in general, they include such common tasks as determination of water quality standards to be attained, attainment of the standards, identification of impaired waters, as well as causes and sources of water quality impairments and detection of long-term trends [27]. Monitoring objectives dictate important characteristics of selected water quality indicators required for decision making and constraints imposed on sampling programs. For example, implementing the total maximum daily load process, it is important to know not only concentrations of water quality constituents and violations of water quality standards, but also the duration and magnitude of the violation [21]. Trend detection requires sampling of selected water quality indicators with a fixed frequency at the same location and at the reference site for a long period of time [17]. Attainment of water quality standards can be confirmed using different schemes, including fixed frequency, sequential or Markov sampling where the number of observations is determined based on the outcome of previous observations [28]. For mass transport estimation, simple random sampling or stratified random sampling are preferable [20], [6]. The designs supporting environmental assessment are project specific. They must be compliant with the type of analysis of the effects in an investigated project. In all the cases, the designs are supposed to provide reliable estimates of selected environmental indicators.

The extent, to which collected data represent actual state of the aquatic environment, depends on a chosen spatial and temporal monitoring design. That is why its selection is important for many tasks of environmental assessment. There are several approaches to a monitoring design. A fixed station approach, a short-term monitoring, a rotating-basin approach, a probability-based approach, an exhaustive approach and a tiered approach are among commonly adopted [27]. It is worth noting that values of concentrations of several water constituents are determined from the same water sample imposing that monitoring designs must be common for all these water quality parameters. Obviously, no single monitoring approach is sufficient to provide the data for all information needs. To meet the objectives, monitoring systems integrate several designs or programs of observations. Thus, the fixed station approach along with tiered monitoring design coupled with sampling programs reflecting environmental heterogeneity is useful for long-term trend detection, for assessment of critical reaches on large streams and, at the same time, provides site-specific water quality data.

The development of a monitoring system in general or a monitoring design, in particular, unavoidably includes the cost-effectiveness analysis as one of the important stages of the process. The effectiveness of a monitoring program should quantitatively express the extent to which monitoring results meet the objectives. Although monitoring systems generate series of data, the main outcome of a monitoring program is information needed for decision making in accordance with the monitoring objectives. This information is usually obtained through the processing of monitoring data using simple or complex models. Hence, the evaluation of the effectiveness of a monitoring program should include mathematical models transforming observation data into information.

Since monitoring systems operate under financial constraints, cost estimates of a monitoring system are important. They allow for straightforward comparison with available budget and between different monitoring programs. Although [12] considered the process of deriving the financial estimates simply as a technical exercise, absolute values of the estimates or their components are not always available. At the same time, the cost of a monitoring program definitely depends on the number of collected samples.

If the effectiveness of a monitoring program can be expressed in the monetary form, the cost-effectiveness analysis can be done as a direct comparison. However, such estimates are usually not available. In this case, the comparison can be replaced by constrained optimization techniques which do not require the goal function and constraints to be expressed in the same measuring units, although both the goal function and constraints must have common variables.

3 Role of models in monitoring designs

Observation data supplied by monitoring systems are a mandatory component of any environmental decision making process, but this component can be useful only if the data are synthetized into information. Ideally, information has to be comprehensive and complete to meet multiple relevant needs. Environmental indicators convert extensive monitoring data into scientifically valid information which represents the state of the environment in a concise form [4]. The conversion is implemented by means of selected statistics or mathematical formulae generating aggregate values. This is the moment when models come into play. These models are denoted as group 2 in Figure 1. In many cases of environmental decision making, understanding of interactions of key environmental processes is vital. It cannot be achieved by observations along or even via simple summaries of observation data. More sophisticated process-based models are required (group 3 in Figure 1).

Environmental models form a diversified set of techniques based on different mathematical and computational methods [16], [23]. Models transform observation data into information by extracting aggregate values from raw data, projecting values of selected environmental indicators and detecting trends to track changes in water quality. In order to be applied, models impose additional requirements on the way the data are acquired. A data set available for the analysis must satisfy the assumptions that underlie mathematical techniques (group 3 in Figure1) employed for data analysis, namely, for obtaining values of environmental indicators (models from group 2) and their further transformation into information for decision making (models from group 3). Formal representation of these assumptions can be used to construct models from group 1. The latter can help to determine frequencies of observations sufficient for deriving statistically meaningful results.

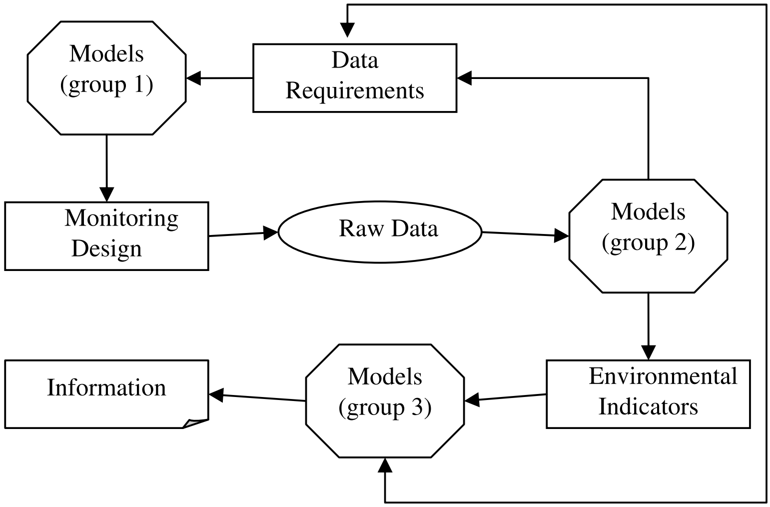


Fig. 1. Model application in monitoring systems

Strictly speaking, frequencies of observations conditioned by models from group 1 reflect variability of the model results rather than the natural environmental heterogeneity. Information extraction from observation data heavily depends on models chosen for environmental indicators and further analysis. At the same time, model selection is significantly limited by available observation data and, hence, data collection must fit the entire modelling process [19]. This interdependency of data and models calls for the necessity to design sampling programs based on specific statistical or mathematical assumptions consistent with the ways collected raw data are analyzed and the type of models used for this purpose.

4 Optimization of a monitoring design

Optimization algorithms require to formulate an objective function which reflects the goal of optimization and, at the same time, allows for quantitative comparison of different monitoring designs. Mathematical properties of the objective function restrict or even determine computational algorithms to be applied to derive monitoring designs which are at least satisficing. The cost-effectiveness analysis implies two possible articulations of the problem of an efficient monitoring system: (1) to maximize the effectiveness of the design under limited budget and (2) to minimize the cost of the design within an acceptable level of effectiveness. In each case, it is necessary to provide quantitative estimates of the cost and the effectiveness of a monitoring design.

Although the cost of a monitoring network comprises various components which may not be independent, it is reasonable to assume that this cost increases monotonically with the number of samples collected at the monitoring sites and the number of sites. This assumption validates the replacement of a cost estimate by the total number of samples in an operation research model for the development of a monitoring design. This assumption also leads to an articulation of the problem of an efficient water quality monitoring design in the form (2), since articulation in the form (1) requires explicit estimates of the cost of a monitoring design.

Monitoring objectives impose additional requirements on data sets used for data analysis. These requirements can be formulated using models from group 1 (Fig. 1). These models describe environmental indicators selected for preprocessing of raw observation data, e.g. the mean or the stratified mean of a selected indicator. Since many process-based water quality models are derived from balance equations, estimates of the average concentration of a water constituent over a period of time in a certain compartment of a water body are important.

The effectiveness of a monitoring program should quantitatively express the extent, to which monitoring results meet the objectives. At the same time, this criterion should demonstrate to what extent one monitoring design outperforms another. Although monitoring systems generate series of data, the main outcome of a monitoring program is information which supports decision making in accordance with the monitoring objectives. This information is usually obtained via processing monitoring data, applying simple or complex models and deriving reliable estimates. Reliability of the estimates of an environmental indicator depends on the available data sets and monitoring designs used for data collection or, in other words, on the total number of observations and their distribution over an investigated period of time. Therefore, the effectiveness of a design can be considered as an increasing function of the total number of observations. Assuming that observations are implemented randomly during an investigated period, the operation research model for the developing of an efficient design can be written as:

$$\min n \ \text{ subject to} \tag{1}$$

$$E(n) \geq E_{\min}, \tag{2}$$

where n is the total number of observations in the design, E is the effectiveness criterion, and E_{min} is the lowest acceptable level of effectiveness.

In general, the estimates derived from monitoring data are considered reliable when their uncertainty does not exceed an established level. The articulations of the effectiveness in terms of uncertainty has been discussed earlier [5].

4.1 Uncertainty in water quality monitoring data

There are various classifications of uncertainty in observation data [13], [3]. In the present paper, uncertainty of observation data is classified into two types: observational artifact and the uncertainty introduced by temporal and spatial resolution of a monitoring system, particularly by selecting sampling sites and frequencies of observation. Model utilization for evaluating environmental indicators and generating conclusions makes model uncertainty an important factor for overall assessment of water quality monitoring uncertainty.

Observational artifact is produced by measurement tools and analytical methods used in the laboratories in order to obtain values of environmental indicators of interest. The type of uncertainty was defined in [15], which suggests the ways for evaluation of standard and expanded uncertainty. Although the proposed methods have given a rise to some concerns regarding their statistical validity among statisticians [11], the methods provide formulae for approximation of measurement uncertainty in a consistent way. The current study does not investigate this type of uncertainty admitting that although some improvements of the results are attainable, this type of errors in monitoring data is unavoidable.

The very idea of the monitoring to describe continuous fields of concentrations of chemical constituents or physical parameters by discrete samples collected from time to time implies the uncertainty since it is based on the assumption that values of observed water quality parameters remain steady in a neighbourhood of a sampling site for some period of time which is not always valid. This type of uncertainty can be reduced by optimizing spatial and temporal monitoring design and most likely by introducing additional sampling sites with higher frequencies of observations, but can hardly be eliminated entirely. Usually, monitoring guidelines recommend keeping both types of uncertainty below a 10% level.

Model uncertainty plays an important role not only in the evaluation of environmental indicators, analysis and interpretation of monitoring data, but also in the identification of an appropriate temporal and spatial resolution of a monitoring system. Frequencies of observation are derived from model properties and seem to contain an error. Being a simplified representation of reality, no model can fully duplicate real system behaviour and, thus, introduces an error which is also referred to as model uncertainty. Model uncertainty, in its turn, transforms into the errors in recommended frequencies of observations. These errors can be minimized by selecting a model which, under given assumptions, describes an investigated system better than others. Models receive the uncertainty from previous monitoring phases and convert it into uncertainty of information required for decision making. The resulting uncertainty must be understood, quantified, and limited to a reasonable extent with respect to the cost of possible consequences of decision errors.

A commonly accepted definition of model uncertainty describes it as deviations of simulated system variables from their known or observed values [1]. It allows to evaluate the uncertainty as the variance of an estimate which has been obtained on data collected according to a monitoring design and a model used for the estimate. Model uncertainty undoubtedly influences the process of conversion of monitoring data into information.

4.2 Temporal monitoring design

Formal definition of the effectiveness of a monitoring design requires to select an indicator of interest. Since the presence and amount of various constituents in a water column are determined based on their concentrations, the current study used the average concentration of a substance over an investigated period of time as a primary indicator of water quality. The variance of this estimator can be directly obtained from the variance of concentrations of selected constituents. The effectiveness of a monitoring design monotonously decreases with the increasing uncertainty of the estimate. Assuming that the maximum effectiveness is achieved when the accurate estimate is available, the constraint function (2) can be reformulated as:

$$\left|\frac{D(I(n))}{I(n)}\right| \cdot 100\% \leq V, \tag{3}$$

where I is the selected estimator, $I(n)$ is its estimate on a set of n observations, $D^2(I)$ is the variance of the estimator I, and V is the acceptable level of the uncertainty in I.

The investigation of monitoring designs developed using various criteria of effectiveness and indicators for a single water quality parameter has been done earlier [6]. It has been shown that the total number of observations required to achieve an established level of uncertainty in the estimate varies significantly for different parameters. Since modern analytical methods determine concentrations of several water quality parameters from the same water sample, it is necessary to compromise monitoring designs for individual constituents so, that estimates of all these water constituents meet monitoring objectives. For this purpose, the constraint function (3) must be replaced by a set of constraints for each investigated parameter:

$$\left|\frac{D(I_k(n))}{I_k(n)}\right| \cdot 100\% \leq V_k, k = 1,..., K, \tag{4}$$

where I_k is the estimator of the k-th constituent, V_k is the acceptable level of uncertainty in this estimate, and K is the total number of constituents of interest.

An obvious advantage of the models in the form of either (1) and (3) or (1) and (4) is that they do not require site specific parameterization. The constraint functions (4) are evaluated based on the time series of concentrations of the selected water quality parameters collected at the investigated sites. The solution of the model (1) and (4) has been obtained using non-gradient constrained optimization method implemented in MATLAB 7.1 [2].

4.2.1 Case study

The proposed approach to the development of efficient monitoring designs has been applied to the series of concentrations of water constituents observed at the cross-section Vyatskiye Polyany of the Vyatka River. The data sets had been collected by the routine monitoring systems with the objectives outlined in section 2 of this chapter. The Vyatka River is a large Eastern-European river with a length of 1,370 km and a watershed area of 129,000 km^2. The selected cross section is characterized by the average annual water discharge of about 22.6 km^3. Two years with different hydrological characteristics has been chosen. Year 1 has a unimodal type of hydrograph and sharp rising and falling limbs for spring-summer high flow events. The hydrograph in Year 2 is bimodal: high flow events took place in spring-summer and late fall. Both hydrographs exhibit distinct hydrological seasons with sharp rising and falling limbs for spring-summer high flow events.

Table 1. Basic characteristics of the selected water constituents

Water constituent	Year 1		Year 2	
	Mean, *mg/L*	Variation coefficient	Mean, *mg/L*	Variation coefficient
TDS	263.2	0.240	245.8	0.337
HCO_3	161.6	0.269	148.1	0.342
Cl	4.2	0.341	3.8	0.514

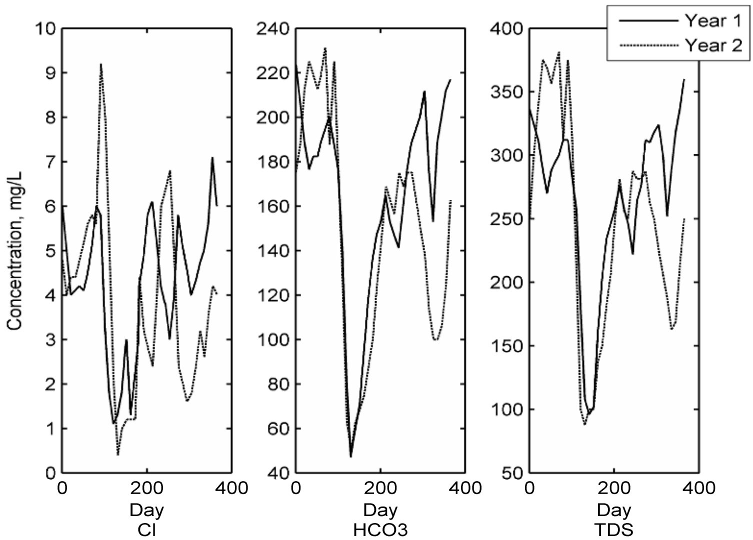


Fig. 2. Chemographs of water quality parameters

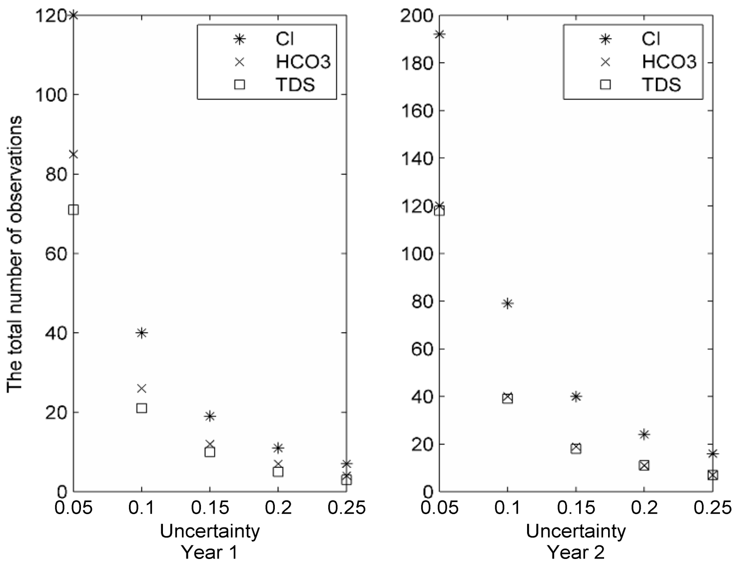


Fig. 3. The total number of observation vs. uncertainty in the estimates

The approach has been applied to a series of concentrations of major ions. The chloride ions, hydrocarbonate ions and total dissolved solids (TDS) were selected as water quality parameters of the interest mainly due to the availability of long series of data. Their chemographs are presented in Figure 2.

The total number of required observations has been determined for individual water constituents using model (1) and (3) for different levels of uncertainty in the estimate of the average concentrations of the TDS, hydrocarbonate and chloride ions (see Figure 3).

On the next step, the total number of observations required to achieve the established level of uncertainty has been recalculated using model (1) and (4). The results for the Years 1 and 2 are presented in Table 2.

Table 2. The total number of required observations to estimate all investigated water quality parameters vs. uncertainty level

Year	Uncertainty level, %				
	5	10	15	20	25
Year 1	120	40	19	11	7
Year 2	192	79	40	24	16

4.2.2 Adding the model to improve the monitoring designs

Simultaneous satisfaction of the constraints in the form of (4) produces the annual number of observations in the designs which are sufficient to estimate the most variable investigated constituent. Following this recommendation, the two other water quality parameters would be observed with the frequency exceeding the required one by 60%. It can be explained by the fact that the fitness function is linear. Even adding the weights to the constraint did not change this outcome.

It has been noticed that the investigated series are correlated to a great extent. Thus, the correlation coefficient between TDS and HCO3 ions was 0.98 and the same coefficient between TDS and chloride ions was about 0.76. Such correlation among a set of water quality parameters observed at the same sampling site is expected. The presence and level of concentrations of different water constituents are affected by waterbody processes as well as anthropogenic and natural factors which are typical for a sampling site and common for all or some water constituents observed at this site. At the very minimum, common hydrological conditions contribute to the dynamics of all observed parameters. At the same time, due to specific biochemical properties and external factors, the investigated water constituents exhibit different variability which explains the distinctions in monitoring designs when each of them was considered separately. It suggests to develop a regression function to restore the values of more variable water quality parameters based on the values of the parameter with the lesser variability. The high values of the correlation coefficients justify the application of the linear regression equation to model concentrations of a water quality parameter. Assume that the concentration C of a water quality parameter is estimated as:

$$C = a \cdot C_{CMV} + b, \tag{5}$$

where C_{CMV} is the concentration of the base water constituent which has the minimal variability, a and b are regression coefficients which are identified based on the least squares fitting. Then, the variance of the estimator I_C can be evaluated using the series of the constituent with the minimal variability in the following way:

$$D(I_C) = a^2 \cdot D(I_{CMV}). \tag{6}$$

Formulae (5) and (6) has been used in the constraint expression (4) to obtain monitoring designs sufficient to estimate the average concentrations of all three water constituents for a given level of uncertainty. The suggested designs for Year 1 and Year 2 are presented in Table 3.

Table 3. The total number of observations required for evaluation of all investigated water quality parameters with different levels of uncertainty

Year	Uncertainty level, %				
	5	10	15	20	25
Year 1	83	40	12	7	4
Year 2	127	43	21	12	8

5 Discussion and conclusions

The linear regression models introduced to describe concentrations of water quality parameters with the higher variability help to reduce the total number of water samples for evaluation of the average concentrations of all three water quality parameters by 37% in Year 1 and by 45% in Year 2. Although these numbers exceeded the numbers of required observations for total dissolved solids, the absolute values of the increments are relatively small. Overall, the results support the application of the linear model for the estimation of the missing concentrations of more variable water constituents.

In the current case study, the less variable water quality parameter (concentration of TDS) has the largest mean value. That is why the coefficient a from (5) is less than 1.0 and the variance of the estimate based on regression function is less than the variance of the mean for both hydrocarbonate ions and chloride ions. The aggregate nature of TDS allows for assumption, that the same pattern will be observed on many other monitoring sites and water bodies. If the constituent with the highest variability would also have the largest mean value of concentrations, the approach may not necessarily reduce the number of required observations. The choice of an appropriate water constituent for a base parameter will be investigated in the future. Since the total dissolved solids reflects the cumulative contents of several water quality parameters, the mean value of this water quality parameter will always be higher than the mean values of other parameters determined from the same water sample. That is why TDS can be considered as a parameter which determines the sampling design.

Suggested monitoring designs are obviously model-dependent. Linear regression functions have been chosen as the first step in the development of the model-driven approach to an efficient monitoring design. The investigation of regression functions in various forms for developing an efficient monitoring design is a subject of further research. The present application of linear models was justified by high correlation of the investigated water quality parameters. These relationships can vary from one site to another and over time. In general, it is necessary to determine the appropriate form of the regression function, which would be waterbody and site specific. It is worth noting that monitoring designs are developed for future use based on observations conducted in the past. The relationships between constituents in a water column are conditioned by the factors typical for a site. These factors may vary slowly and can be considered as static. Nevertheless, it is necessary to check periodically the validity of the parameters of the selected models.

The numbers of required samples obtained from the models (1), (5) and (6) for Years 1 and 2 are different due to the natural variability of the selected water constituents. The designs common for both years and ensuring the estimates with the desired levels of uncertainty are those corresponding to Year 2 with the higher numbers of required samples (see Table 3).

The developed monitoring designs depend on the selected estimators of environmental indicators. On the same data set, values of estimator's variance vary significantly for different mathematical expressions. The estimators should be built on the same mathematical assumptions as those that determine an appropriate monitoring design. However, numerous examples demonstrate that objectives may change between the time a monitoring design was developed and the time it is applied for data collection. Moreover, data collected for one set of objectives can be used for the purposes which were not even considered at the planning stage. Following [18], utilization of monitoring data for various types of data analysis requires simple sampling designs. The latter explains the choice of the average concentration as an estimator and the variance of the estimator as a measure of uncertainty which implies simple random designs.

The total numbers of observations in the designs common for all investigated water quality parameters are sufficiently higher than numbers prescribed by existing monitoring recommendations for archiving the declared 10% uncertainty in information. When uncertainty of 15% or higher is acceptable for at least some of the water constituents due to a site specific or project specific needs, the different acceptable levels of uncertainty can be recommended for water quality parameters according to their importance for a task at hand. The proposed approach can generate simple random designs with reduced numbers of required observations.

Acknowledgments. The authors are grateful to anonymous reviewers for their thoughtful suggestions and helpful comments on the manuscript. Part of the research was done based on the data sets prepared in Hydrochemical Institute, the Russian Federation.

References

[1] Campolongo F, Saltelli A., Sørensen T, Tarantola S (2000) Hitchhiker's guide to sensitivity analysis. In: Saltelli A, Chan K, Scott EM (eds) Sensitivity Analysis, Chichester: Wiley

[2] Conn AR, Gould NIM, Toint PL (1997) A globally convergent augmented Lagrangian algorithm for optimization with general constraints and simple bounds. Mathematics of Computation 66(217): 261 – 288

[3] Cuadros-Rodriguez L, Hernandez Torres ME, Almansa Lopez E, Egea Gonzalez FJ, Arrebola Liebanas FJ, Martinez Vidal JL (2002) Assessment of uncertainty in pesticide multiresidue analytical methods: main sources and estimation. Analytica Chimica Acta 454:297-314

[4] Environment Canada (2005) Knowledge Integration Strategic Division National Environmental Indicator Series. Online URL http://www.ec.gc.ca/soer-ree/English/Indicators.

[5] Erechtchoukova MG, Khaiter PA. (2010) Efficiency Criteria for Water Quality Monitoring. In: Swayne DA, Yang W, Voinov AA, Rizzoli AE, Filatova T (eds) 2010 International Congress on Environmental Modelling and Software Modelling for Environment's Sake, Fifth Biennial Meeting, 5 – July 2010, Ottawa, Canada

[6] Erechtchoukova MG, Khaiter PA. (2009) Investigation of Monitoring Designs for Water Quality Assessment In: Anderssen, B. et al. (Eds.),18th IMACS World Congress - MODSIM09 International Congress on Modelling and Simulation, 13-17 July 2009, Cairns, Australia,

[7] Erechtchoukova MG, Khaiter PA. (2008) Role of models for building an efficient monitoring design. In: Sànchez-Marrè M, Béjar J, Comas J, Rizzoli AE, Guariso G (eds) iEMSs2008: International Congress on Environmental Modelling and Software. Integrating Sciences and Information Technology for Environmental Assessment and Decision Making, July 2008.

[8] Erechtchoukova MG & Khaiter PA. (2007) Data-model issues in environmental impact assessment The International Journal of Environmental, Cultural, Economic and Social Sustainability 3 (6): 149-156

[9] Erechtchoukova MG, Chen SY, Khaiter PA (2009) Application of Optimization Algorithms for the Improvement of Water Quality Monitoring Systems. In: Athanasiadis IN, Mitkas PA, Rizzoli AE, Marx Gomez J. (eds) Information Technologies in Environmental Engineering Proc. of the 4th International ICSC Symposium Thessaloniki, Greece, May 28-29, 2009. Springer.

[10] EU (2000) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.
[11] Gleser LJ (1998) Assessing Uncertainty in Measurement. Statistical Science 13(3): 277-290
[12] Groot S, Schilperoort T (1983) Optimization of water quality monitoring networks. Water Science and Technology 16: 275-287
[13] Harmel RD, Cooper RJ, Slade RM, Haney R., Arnold JG (2006) Cumulative uncertainty in measured streamflow and water quality data for small watersheds. Transactions of the ASABE 49(3): 689-701
[14] Helmer R (1993) Water quality monitoring: national and international approaches. In: Int. Symp. Proc. Hydrochemistry 1993. Rostov-on-Don, Russia: IAHS Publ., 219: 3-17
[15] ISO, 1993. Guide to Expression of Uncertainty in Measurement, 1st ed. International Standard Organization, Switzerland.
[16] Jørgensen SE, Bendoricchio G (2001) Fundamentals of ecological modelling. Elsevier, Amsterdam
[17] Lettenmaier DP (1978) Design considerations for ambient stream quality monitoring. Water Resources Bulletin 14:884–902
[18] Overton WS, Stehman SV (1995) Design implications of anticipated data uses for comprehensive environmental monitoring programmes. Environmental and Ecological Statistics 2:287-303
[19] Richardson JR, Berish CW (2003) Data and information issues in modelling for resource management decision making: communication is the key. In: Dale VH (ed) Ecological modelling for resource management. Springer, New York
[20] Robertson DM, Roerish ED (1999) Influence of various water quality sampling strategies on load estimates for small streams. Water Resources Research 35(12): 3747–3759
[21] Shabman L, Smith E (2003) Implications of applying statistically based procedures for water quality assessment. Journal of Water Resources Planning and Management 129(4)
[22] Statistics Canada (2008) Canadian environmental sustainability indicators 2007: Freshwater quality indicator. Data sources and methods. (Cat. N 16-256-X) Online URL http://www.statcan.gc.ca/pub/16-256-x/16-256-x2008000-eng.pdf
[23] Straškraba M, Gnauck AH (1985) Freshwater ecosystems: modelling and simulation. Elsevier, Amsterdam
[24] Strobol RO, Robillard PD, Shannon RD, Day RL, McDonnell A.J (2006) A water quality monitoring network design methodology for the selection of critical sampling points: Part I. Environmental Monitoring and Assessment 112:137-158
[25] Ullrich, A., Volk, M., Schmidt, G., 2008. Influence of the uncertainty of monitoring data on model calibration and evaluation. In: Sànchez-Marrè M, Béjar J, Comas J, Rizzoli AE, Guariso G (eds) Proceedings of the iEMSs Fourth Biennial Meeting: International Congress on Environmental Modelling and Software (iEMSs 2008). International Environmental Modelling and Software Society, Barcelona, Catalonia, July 2008.
[26] Urban D (2000) Using model analysis to design monitoring programs for landscape management and impact assessment. Ecological Applications 10(6):1820-1832
[27] US Environmental Protection Agency (USEPA) (2003) Elements of a state water monitoring and assessment program (EPA 841-B-03-003), online URL http://www.epa.gov/owow/monitoring/elements/index.html,
[28] Whitfield PH (1988) Goals and data collection designs for water quality monitoring Water Resources Bulletin 24(4):775–780

Participatory Environmental Sensing for Quality of Life Information Services

Kostas D. Karatzas[1]

[1]Aristotle University

kkara@eng.auth.gr

Abstract. The chapter evolves Participatory Environmental Sensing (PES) as the new model of access, exchange and utilization of environmental information, resulting in the creation and adoption of sophisticated services that can lead to Quality of Life (QoL) support. The chapter addresses PES for QoL environmental information services, defines next steps for making PES for QoL part of the environmental monitoring and decision making process, and presents related developments in Thessaloniki, Greece. The environmental domain addressed is the quality of the atmospheric environment (air quality, pollen, and urban meteorology), as it affects the quality of life in various countries, especially in urban regions.

Keywords: participatory environmental sensing, quality of life, air quality, pollen, biological weather, information services.

1 Introduction

Participatory environmental sensing for quality of life (PESQoL) may be defined as the participation of citizens in the monitoring of the quality of the environment they live in, with the aid of (a) mobile devices of everyday utility, (b) specialized environmental sensors, (c) general purpose sensors and (d) personal, subjective recordings, information annotation and exchange methods, coming from social media or other similar platforms and technologies. The concept of PES has been proposed in the last years (Burke et al. 2006, Goldman et al. 2009, Karatzas 2005) and related projects have appeared especially in the USA (e.g. PEIR [27], Living Environments [31], Citysense[28], Common Sense[29]) and in Europe (e.g. Envitori[25], Message [24] and MIMAQ [26]). In addition, citizen participation in environmental monitoring has been introduced in the Eye on Earth project [30] of the European Environment Agency that has created the first "official" environmental portal that includes citizens' observatory on air and bathing water quality. On this basis, it is expected that PES will have an increasing importance in QoL services and applications in the next years.

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering,*
Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_10,

2 Environmental Information and QoL

Environmental Information is nowadays being made available mostly with the aid of electronic media and the internet. On the other hand: (i) human-centric, sustainable development requires solutions that are new in comparison to existing ones, (ii) providing access to data sources and making information available and exchangeable is expected to accelerate the development of new applications and services, (iii) new sensing concepts and technologies and sensor networking are needed to enhance environmental monitoring, (iv) developments in ICT will make environmental data & services ubiquitous [15], while (v) computational intelligence methods are particularly suitable for environmental modelling, knowledge extraction and generation of knowledge intensive e-services content [14].

Air pollution comprises one of the most important parameters of environmental information that impacts citizens' quality of life. Following the international environmental legislation and the established community directives by the EU Council, it is evident the need to ensure free and direct access, availability and dissemination of environmental information to citizens, through on-line sustainable environmental information systems. Evolving the concept of Participatory Environmental Sensing (PES) is considered to be the new model of access, exchange and utilization of environmental information, resulting in the creation and adoption of personalized, society oriented services, leading to information systems for quality of life reassurance.

It has already been suggested that the usage of telecommunication networks and modern mobile devices can help in the "transformation" of the citizen from a passive receiver (and "consumer") of information to an actor [9]. This has been linked with the possibility for the citizen to electronically annotate (tag) information related to the quality of the environment, and post it to a digital community, for others to use, thus generating the content of an environmental information service [10]. These ideas have independently been pushed much further in the frame of various research projects, like the PEIR project, which is based on participatory or citizen-initiated sensing, and data commons [3]. The Personal Environmental Impact Report (PEIR) project has developed an online tool that allows people to use their mobile phones in order to explore and share their impact towards the environment and the way that the environment has an impact on them [32]. The aspect of the digital city and sustainability information services has been extended and enriched via the Ubiquitous Sustainability concept [17] and its relationship to environmental quality, that also incorporates the usage of micro-sensors, together with mobile phones, for advanced environmental quality monitoring [6]. The aforementioned projects and concepts have already been tested for the air quality domain, and are expected to act as paradigms for future environmental information services. Such services will be digital, yet working on an ambient environment, making use of Human-Computer Interaction developments, and allowing for participatory environmental surveillance and actions, especially in the way that social media are able to support. In addition, small, mobile sensors are already available to monitor environmental pressures in the vicinity of patterns of urban living and mobility [24]. In this respect, biological weather information (i.e. information on meteorology, air pollution and airborne pollen, [14]) is expected to play an important role for the personalization of environmental information services on the fly, taking into account (i) georeferencing, and (ii) the needs for adaptation to individual environmental pressures and health problems. Personalised exposure and "dosage" estimations may be supported by biological weather services and devices attached to mobile phones, thus quantifying quality of life on an individual level, while also providing with information of alternatives for urban living and mobility patterns. Such services may thus support quality of life and may also have a quantitative effect on life expectancy, if they are able to result in the reduction in exposure to ambient air pollution (like in the case of fine particulates, which greatly affect human health, [19]).

3 Participatory Environmental Sensing

The idea of a "digital city" that provides sustainable green e-services for citizens, through PES and available ICT, web 2.0, social media technologies, wireless sensors and mobile devices is the innovative transition from existing environmental information systems to PES systems, as suggested by the current paper. Services that would allow citizens to develop a personal opinion, according to their own interests, on environmental pressures and conditions in relation to their everyday life, are considered to be of importance for people that live especially in urban environments. In addition, technologies and services that enhance environmental awareness and participation in decision making in order to improve QoL may very well complement the aforementioned personalized services. . Thus, PES systems suggested in this chapter enable participatory or citizen-initiated sensing and transform the role of the citizenship from a passive receiver of information to an active agent participating in the elaboration of that information.

Through rapid technological developments, phone devices have become mobile computing, sensing and communication platforms, enabling ubiquitous capture and dissemination of data of all types: text, image, video, audio, location, etc (Lane et. al., 2010). There is also a great advancement in the area of ad-hoc sensors' design, able to record and distinguish levels of different types of air pollutants, while sensor web enablement has already entered the standardization phase, supported by the OGC [33]). The interconnection of devices and the bidirectional data transfer between users, through a system for collecting, processing and routing data to different means of communication, may allow for the operation of a disperse air quality monitoring network that will record, map and process data of particular importance. Thus, it is possible to include and to communicate people of all backgrounds, located everywhere in the world, to record sources of pollution in any spatio-temporal level and to benefit from personalized services, available on-demand or real-time.

The idea of PESQoL services is to record, collect and access data about the environment's status and quality, at the individual user and business level, through the use of participatory environmental sensing (PES), and available ICT, web 2.X and social media technologies. These can include direct raw data like actual sensor readings (such as those found in official air quality and meteorology monitoring networks but also those operated by individuals, amateurs, research groups), as well as “indirect sensor data” gathered through the subjective sensory perception of the general populace, which can be determined by examining personal remarks and comments about their personal status and the status of their present environment. Regarding the latter, such data is often recorded and shared automatically and/or voluntarily, on various social networking media, and can be enriched with the aid of digital, georeferenced, time stamped recordings, made with mobile devices (photos taken with smart phones, mobility patterns, etc). Such indirect data can be mined e.g. from social networking sites, blogs, forums, or personal tracking applications like twitter. While lacking the rigor of an actual sensor read, they can be used to extrapolate useful data or provide an extra set of parameters to use during modeling.

At the same time, sustainable development, environmental decision-making, and business operation optimization services can be supported by mapping the extrapolated knowledge into suitable entities. Furthermore, the analysis and modeling that takes place will allow for participatory decision-making by part of citizens and officials, potentially interacting with the environment and working towards improving it.

4 The PESQoL system

The idea of a PESQoL system for information services provision may be materialized with the aid of an information system that will be developed, tested and validated under real world conditions. The concept of “sensory presence” will be the basis of such a system, since it defines the status of a user based on his or her activities (e.g. walking, sitting, meeting with friends), mood (e.g. happy, sad, “ok”), habits (e.g. gym, café, work) and surrounding environment (e.g. noisy, warm, moist, cold, dim, high levels of pollution etc.). Such a system is planned to be developed for the city of Thessaloniki, Greece. The system aims to integrate sensory presence with popular social networking application, thus allowing unprecedented levels of connection between people belonging to the same groups within those networks. The system is based upon the belief that creating a framework which would allow collecting, organizing, presenting and sharing the personal sensory present and daily habit and status data of the user and his/her activity environment, will be of service to a large number of citizens as well as tackling the challenge of making people-centric environmental sensing a reality [18].

In addition, and in order to support personalization, early information provision and decision-making processes, it is of great importance to develop knowledge intensive e-services for QoL support. For this reason, Computational Intelligence methods should be employed, as they have been proven to be of importance for environmental information and air quality in particular [1; 11; 12; 21; 22]. Moreover, the design and development of personalized, electronic information services for the atmospheric environment has already been the subject of relevant research, thus providing with the necessary input towards a PESQoL service bundle [13; 14; 23; 20; 8; 7].

5 Materials and methods

The PES for QoL is planned to make use of available as well as new technological know-how, with the final goal being the design of a complete system which will collect, combine, prognose and transmit personalized information to the individual citizen. For the materialization of such a system the following subjects need to be addressed:

- Methods for evaluating biological weather (air quality, meteorology and airborne pollen) classified according to type, measurement method and the different conventions used to determine alert and tolerance levels for each one.
- Use of existing IT infrastructure in order to continuously monitor and record the level of biological weather
- Develop advanced methods of combining and merging the measured data in order to create new space-time simulation models for evaluating pollution.
- Develop methods for the dynamic and reliable gathering and processing of the data in order to ensure a constant renewal of the available information, prognoses and conclusions about biological weather.
- Take advantage of sensory and wireless data communication technologies in order to design and develop a complete, continuous pollution data streaming system for the general public.
- Develop a series of personalized “quality life support” applications, aimed at informing the citizenry about the environmental hazards it’s exposed to, but also about the expected pollution levels at the time and place of their choosing.

In order to address and handle these subjects, the proposed PESQoL services bundle will be based on PES to create a new environmental information system and develop new, innovative “life quality” services. The success of the proposed approach will depend upon it reaching certain milestones, which can be henceforth summed up:

- Data collection (for what regards individual mobile users): certain types of environmental data can be gathered by a suitably equipped mobile phone or similar portable device (PDA, netbook, etc.). Certain types of functionality can be added/ extended by using specialized software. Typically, the data will be textual comments, remarks etc. (like “Tweets”) but it can also consist of light and noise levels, geopositioning data, acceleration data or actual photographs depending on the type of application and hardware capabilities.
- Data transfers, to be performed through mobile telephony and wireless networks. Specialized software can take care of this task for the user, including delayed and error-tolerant data transmission/ reception.

- Access, to be regulated by a set of regulations, especially for what regards the ever-important aspects of user privacy and data security.
- Security: it's common for users of social networking sites to restrict access to certain select information only to trusted members of their network. Those same access control rules should be applied to PESQoL services, especially since the data that may be exposed through it can be particularly sensitive or compromising, as they may well include the photograph of a family member or the precise geolocation of a certain person's activity. Therefore, it's extremely important that participants understand the risks and regulate the type and quantity of published sensitive and personal data, as well as enforce access control and visibility restrictions using the provided functionality. Beyond that, certain technologies may provide some degree of "default" automated privacy control by limiting the quality and clarity of published data e.g. making geolocation "fuzzy" to a degree by limiting its accuracy to a postal area code, or using automated face detection in order to blur or erase faces from uploaded photographs.
- Analysis includes a broad spectrum of data processing methodologies, ranging from simple grouping of available data and projecting them to participants, all the way up to sophisticated data oriented analysis techniques which will allow classifying user's activity and status (e.g. walking, riding a bike, moving on a bus, etc.). Analysis also includes the computation of statistical data of participant groups, as well as their inclusion in artificial intelligence computational models which can be used to individuate patterns in the time and space domains.
- Allowing for user feedback should also be included, in order to activate an automated or manual event. The system could use gathered data and send out SMS text messages in order to provide information during such occurrences. As a practical example, when a user is located near an interest point, he/she could receive a notification via SMS, prompting him/her to take action with messages such as "Please acquire and send a photograph of this location". The procedure could be automated to a degree e.g. activate sound recording when the user stops moving.
- Creating forecasts of critical biological weather parameters through the use of suitable computational models, able to describe their spatial and temporal variations, with emphasis on their effect over daily citizenry activities.
- The visual presentation of the produced information is directly linked to their analysis and knowledge extrapolation, and will also be part of the developed services.

6 The application in Thessaloniki

The PESQoL system that is under development is based on a Data Management Framework (DMF) from the server side, while the client side provides with the User Application (UA). An observation is the main type of data object that the DMF recognizes. An observation can contain actual measurements such as air temperature, humidity (numeric values), citizen's categorisation on the quality of the environment like poor, adequate, good (nominal values), recordings on events (like the existence of local noise sources, i.e. binary values), short text messages generated by the citizen, and multimedia files consisting of recordings, photos, etc. Within the DMF, observations are organized into data objects, each one having a unique ID, accompanied by a time stamp and a location stamp, thus allowing for time related and/or location aware service generation. The arrival of new data cause notifications to be generated, with a notification containing no actual data, but including all the available metadata such as the time range of the new observations, their type, etc; (enough information to retrieve the actual data from the system). These notifications are placed on the event bus that manages them and routes them to their appropriate destinations. Appropriate software entities (listeners) register on the event bus their interest on notifications by the way of a filter, which decides whether the registered listener will receive notifications based on the characteristics of the data object, i.e. its actual content categories and types. A listener may, on arrival of a notification, fetch the relevant data object from the data store, compute something (f.e. the maximum value, the frequency – popularity of the observation), and send the results to the data store as a new data category of a new data object, possibly causing a cascade when another listener has expressed interest in the data object. On the basis of this mechanism, an event-based architecture is being implemented at the server side of the system, on top of the OSGi framework [34], which is a module system and service platform for the Java programming language that implements a complete and dynamic component model. The system's architecture is utilizing the event bus and plug-in architecture of OSGi to ensure extensibility. The event bus is being implemented via the EventAdmin service of OSGi, where the notifications are Events with multiple properties, and the listeners are registered EventHandlers with filters on those properties. The data store is currently implemented with a PostgreSQL database.

The UA currently consists of a client that runs on Android. The client reads information from a set of mini sensors of atmospheric conditions (currently temperature and relative humidity, provided by [35], via Bluetooth, and the values are then passed over the smart phone. The application manages the connection with the sensors as well as the data flow, and makes use of these observations to calculate the Discomfort Index (DI), which is an integer denoting the level of discomfort felt by humans. The actual information is being presented to the user in an intuitive way, with the aid of a colour code, as well as a graphical representation of the DI that is of a speedometer type. A screen shot of the application as well as of the sensor being used is provided in Figure 1

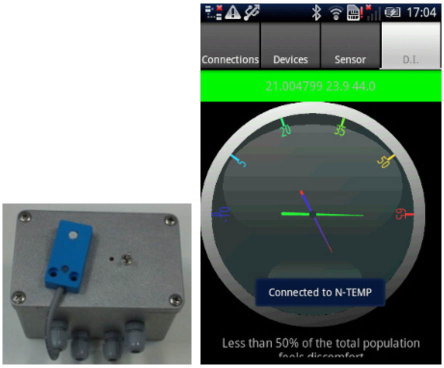


Fig 1. The environmental sensor (left) and a screenshot of the user application (client side, right) that have been implemented for the PESQoL system in Thessaloniki, Greece

The second client side application, that would allow for the collection and exchange of the citizens observations on the urban environment is currently under development. In order to collect personalised, subjective information by the users, a simple list of predefined terms will be applied, like the following:

- Personal health status
  - Asthma, Respiratory problems, Cardiovascular diseases
  - Allergies associated to specific plants (tick box list to include local flora like: cypress, grasses, goosefoot, wall pellitory, pine, ragweed, plane, plantain, hazel, poplar, oak, olive tree, etc)
- User’s observations:
  - Type of observation (meteorological parameters, sources of air pollution, emergencies, etc)
  - Quality of observation, observation area, time of observation
- Alerts defined by the user
- Texts and multimedia files generated by the user

The idea of the Thessaloniki application is to have a field trial that would allow for the development of citizens profiles, and will also help in the estimation of personal exposure per citizen category (commuter, urban area worker, etc). In addition, user feedbacks as well as changes in behavior and everyday habits will be monitored, the latter being among the most important parameters in the use of the so called persuasive technologies [4]. The second client side applications will allow for the quick interaction between the system and the users, and will have a simple interface (Figure 1, left: mockup currently based on EnviObserver, [25]). The system will provide information with the aid of appropriate graphs and symbols, taking into account the perception, understanding and interpretation of environmental pressures (Figure 2, right)

Fig 2. A PES application mockup for Thessaloniki, Greece (right). The use of graphs and symbols for the communication and exchange of environmental information and sensory presence conditions (right)

7 Conclusions

In the frame of the proposed PESQoL services system a number of interesting results may be produced:

A new type of information system for monitoring, storing, accessing, exchanging and utilizing environmental information based on PES, to be used as an open platform for the development of innovative information services.

The promotion of a new applied research area and of an integrated, shared environmental information space, to support a new "e-services model" that will increase citizens' participation on environmental decision making and will advance green entrepreneurship, in a sustainable way.

The creation of a new paradigm concerning the way that citizens perceive and interpret the quality of environment they live in and take action.

References

[1] Athanasiadis IN, Karatzas K and Mitkas P (2006). Classification techniques for air quality forecasting. Proceeding of the 5th ECAI Workshop on Binding Environmental Sciences and Artificial Intelligence, Riva del Garda, Italy

[2] Burke J, Estrin D, Hansen M, Parker A, Ramanathan N, Reddy S and Srivastava B (2006). Participatory Sensing. WSW'06 at SenSys '06, Boulder, Colorado, USA (http://www.sensorplanet.org/wsw2006/6_Burke_wsw06_ucla_final.pdf)

[3] Cuff D, Hansen M and Kang J (2008). Urban Sensing: out of the woods. Communications of the ACM 51(3), pp 24-33

[4] Fogg BJ and Ecklers D (2007). Mobile Persuasion: 20 Perspectives of the Future of Behavior Change, Stanford Captology Media; 1st edition.

[5] Goldman J, Shilton K, Burke J, Estrin D, Hansen M, Ramanathan N, Reddy S, SamantaV, Srivastava M and West R (2009) Participatory Sensing: A Citizen-

powered Approach to Illuminating the Patterns that shape our world. Wilson International Center for Scholars (http://wilsoncenter.org/topics/docs/participatory_sensing.pdf)
[6] IEEE Spectrum (2009) Cell phones for Science. Issue Feb., p 12
[7] Karatzas K and Moussiopoulos N (2000). Urban air quality management and information systems in Europe: legal framework and information access. Journal of Environmental Assessment Policy and Management 2, No. 2, pp 263-272
[8] Karatzas K, Dioudi E and Moussiopoulos N (2003). Identification of major components for integrated urban air quality management and information systems via user requirements prioritization. Environmental Modelling and Software 18, pp 173-178
[9] Karatzas K (2005). A quality-of-urban-life ontology for human centric, environmental information services. Presentation at the COST C21- Towntology meeting on WG1: Ontologies and Information Systems and Information Systems (available via http://www.towntology.net/Meetings/0512-BXL/presentations/C21_towntology_karatzas_brussels.pdf), Brussels, 12-13 Dec. 2005 (accessed 30.12.2010)
[10] Karatzas K. (2006). Environmental Information Service Web. Meeting on Information and Communication Technologies for the Management of Natural Resources and Environmental Risks, 21.03.2006, available via ftp://ftp.cordis.europa.eu/pub/ist/docs/environment/karatzas_en.pdf (accessed 30.12.2010)
[11] Karatzas , Bassoukos ., Voukantsis D., Tzima F., Nikolaou K. and Karathanasis S. (2008a) ICT technologies and computational intelligence methods for the creation of an early warning air pollution information system, Proceedings of the EnviroInfo 2008 (Environmental Informatics and Industrial Ecology) Int. Conference, A. Moehler, B. Page and M. Schreiber, eds. pp. 482-489. ISBN:978-3-8322-7313-2, Shaker Verlag, Aachen, 2008
[12] Karatzas K, Papadourakis G and Kyriakidis I. (2008b) Understanding and forecasting atmospheric quality parameters with the aid of ANNs. IEEE World Congress on Computational Intelligence, vols. 1-8, pp 2580-2587, Hong Kong
[13] Karatzas K (2009) Informing the public about atmospheric quality: air pollution and pollen. Allergo Journal 18, Issue 3/09, pp 212-217
[14] Karatzas K and Kukkonen J (editors) (2009). COST Action ES0602: Quality of life information services towards a sustainable society for the atmospheric environment. Sofia Publishers, Thessaloniki, Greece, pp 118, ISBN: 978-960-6706-20-2 (available via http://www.chemicalweather.eu/material/COST.Action.ES0602.Quality.of.life.info.services.Karatzas.Kukkonen.eds.2009.pdf).
[15] Kotovirta V. and Turtiainen H. (2010) From measurement to service: Environmental information into use. Presentation at SHOK Summit 20.4.2010, http://www.vtt.fi/ files/download/shok_summit_2010/shok_summit_2010_heikki_turtiainen.pdf
[16] Lane N, Miluzzo E, Lu H, Peebles D, Choudhury T and Campbell AT (2010). A survey of mobile phone sensing, IEEE Communications Magazine 48(9), pp. 140-150
[17] Paulos E, Foth M, Satchell Ch, Kim Y, Dourish P Hee-jeong Choi J (2008. Ubiquitous Sustainability: Citizen Science & Activism. Workshop at UbiComp, September 2008, paper available via http://www.paulos.net/papers/2008/Ubiquitous%20Sustainability%20%28UbiComp%202008%29.pdf (accessed 30.12.2010)
[18] Miluzzo E, Lane ND, Eisenman SB and Campbell AT (2007). CenceMe - Injecting Sensing Presence into Social Networking Applications, In Proc. of Second

European Conference on Smart Sensing and Context (EuroSSC 2007) , Lake District, UK, October 23-25, 2007, LNCS 4793, pp 1-28. http://www.cs.dartmouth.edu/~miluzzo/papers/cenceme_EuroSSC07.pdf, (last accessed: 30.12.2010)
[19] Pope CA 3rd, Ezzati M, Dockery DW. (2009). Fine-particulate air pollution and life expectancy in the United States. N Engl J Med. Jan 22; 360(4):413-5
[20] Trausan-Matu S, Karatzas K. and Chiru C. (2007) Environmental information perception, analysis and communication with the aid of natural language processing. Proceedings of the 21st International Conference on Informatics for Environmental Protection - EnviroInfo2007, (Hryniewicz O., Studzi ski J. and Romaniuk M., eds.), vol. 1, pp 299-306, Shaker Verlag, Aachen, 2007, ISBN 978-3-8322-6397-3
[21] Tzima FA, Karatzas KD, Mitkas PA and Karathanasis S (2007). Using data-mining techniques for PM10 forecasting in the metropolitan area of Thessaloniki, Greece. International Joint Conference on Neural Networks, pp. 2752-2757
[22] Voukantsis D, Niska H, Karatzas K, Riga M, Damialis A and Vokou D (2010) Forecasting daily pollen concentrations using data-driven modeling methods in Thessaloniki, Greece. Atmospheric Environment, vol. 44, issue 39, pp. 5101-5111
[23] Zhu L, Karatzas K and Lee J (2009). Urban environmental information perception and multimodal communication: the air quality example, Multimodal Signals: Cognitive and Algorithmic Issues (Anna Esposito, Amir Hussain, Maria Marinaro, Raffaele Martone, eds.), Lecture Notes in Artificial Intelligence 5398, Springer-Verlag Berlin Heidelberg, pp 288–299
[24] http://bioinf.ncl.ac.uk/message/
[25] http://knowledge.vtt.fi/
[26] http://mimaq.org/
[27] http://peir.cens.ucla.edu
[28] http://www.citysense.net
[29] http://www.communitysensing.org/
[30] http://www.eyeonearth.eu
[31] http://www.living-environments.net/
[32] http://peir.cens.ucla.edu/
[33] http://www.opengeospatial.org/projects/groups/ sensorweb
[34] www.osgi.org
[35] www.neuronica.polito.it

Sketch Technology Roadmap by Using a Novel Vision-oriented Service Innovation Approach: Environmental-Technology Roadmap for Designing Sustainable City as an Example

Yu-Tso Chen

Department of Information Management National United University, Taiwan R.O.C.

yutso.chen@gmail.com

Abstract. In order to overcome the challenges due to rapid urbanization, forward-thinking governments are attaching great importance to smart living services. Smart living services leveraging ICT-enabled intelligence to improve urban systems are able to not only enhance quality of life for people but also create new opportunities for economic growth. In particular, emerging technologies like greentech are increasingly introduced to arrange smarter living services capable of city sustainability. However, emerging technologies are in essence high-impact and high-uncertain forces of changing the future world, they are matters of course to be concerned carefully when being adopted to design sustainable cities. To solve this problem, we propose a Vision-oriented Service Innovation (VioSIn) approach sufficient to sketch technology roadmap for service innovation. Next, by means of the VioSIn process, we demonstrate an environmental-technology roadmap for designing sustainable city as an exemplary practice. From a practical point of view, the VioSIn provides a systematic method beneficial to blueprint the emerging technologies and services, and further indicate strategic initiatives of promoting those services.

Keywords: Technology Roadmap Environmental Technology, Smart Living Sustainable City

1 Introduction

Cities are in general composed of several essentials central to their developments and operations. Dirks and Keeling [5] decompose a city into seven units: city services, citizens, business, transport, communication, water and energy. The facilities of transport, communication, water, and energy are commonly perceived as city infrastructure, both citizens and business are classified as the user domain

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_11,

of a city. Based on city infrastructure in conjunction with appropriate city governance and policies, systems such as education, sanitation, transportation, healthcare, public safety and etc are operated to provide city services to achieve operational goals of user domain; i.e., quality of life for citizens and industrial benefits for business.

1.1 A global trend of Rapid Urbanization

Rapid urbanization is an ongoing trend which implicates that cities are getting out of control over their existing development. According to a 2009 to 2010 United Nations World Urbanization Prospects study [15], world population in urban is more than that in non-urban since 2010 and will reach up to 60% in 2050; the population living in urban areas is projected to gain 2.9 billion, passing from 3.4 billion in 2009 to 6.3 billion in 2050. As urban areas grow in population, they expand outward as well as upward, thus cause several emerging living challenges regarding overcrowded housing, depraved sanitation, inefficient transportation, inadequate healthcare, unsatisfactory public safety and so on [7]. These challenges are threatening city services meanwhile overwhelming natural environment and people-centered urban ecosystem (as indicated in Fig. 1).

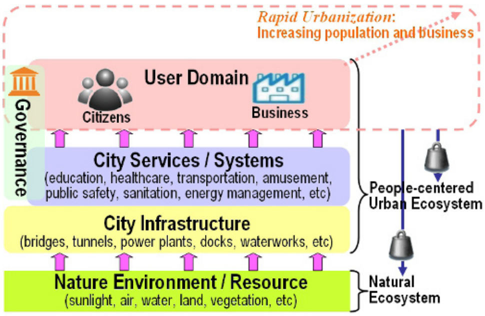


Fig. 1. Rapid urbanization is overwhelming people-centered and natural ecosystems

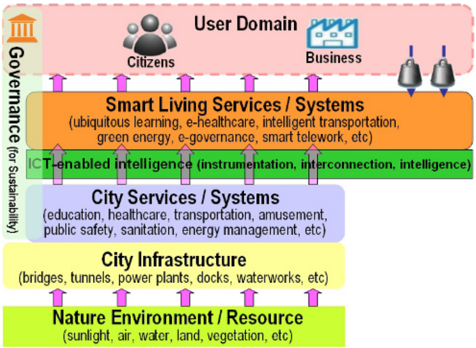


Fig. 2. ICT-enabled intelligence innovate smart living services to overcome challenges due to rapid urbanization

As cities are facing a range of challenges and threats to their core services, they need to become "smarter" to build sustainable prosperity. At this juncture, Information and Communications Technology (ICT) plays a decisive role of enhancing the understanding development, operation and control of urban systems for their enhancement. Washburn and Sindhu [17] expounded their conceptual thoughts of Smart City initiatives for CIOs, "cities are becoming smarter, as governments, businesses, and communities increasingly rely on Smart Computing to overcome the challenges from rapid urbanization." They further defined Smart Computing as a new generation of integrated hardware, software, and network technologies that may provide ICT-based systems able to real-time awareness of physical world and further advance analytics to help people make more intelligent decisions about alternatives and actions. In addition, Dirks, Keeling, and Dencik [6] introduced IBM Smarter City as a cohesive system within many interconnecting and interdependent sub-systems. They highlight the realization of from instrumentation, interconnection to intelligence is the activator of making city services smarter. That is to say, modern smart services for living could be built by applying ICT-enabled intelligence on the basis of instrumentation and interconnection, so that upgrade and innovate existing urban systems to conquer emerging living challenges (as illustrated in Fig. 2). These ICT-enhanced city services will fulfill overall quality of life for citizens as well as benefit commercial opportunities for business, and finally sustain city ecosystems.

In recent years, forward-thinking governments are attaching great importance to ICT-based smart living services. In Europe, Denmark is promoting Smart Healthcare services in Copenhagen; Sweden is operating an Intelligent Transportation system in Stockholm; Germany is deploying RFID-based Intelligent Logistics applications in its core cities; Russia is performing an Ubiquitous Information Access project emphasis on Cloud Computing technology in Moscow. In USA, smart living services such as Renewable Energy and Green Energy Usage, Total Public Safety, Ubiquitous Education, Smart Telework and etc are progressively implemented in cities like Chicago, Seattle, San Francisco and several regions in Silicon Valley. Meanwhile in Asia, Japan is planning various smart living services in Tokyo, Kurashiki, Uruma, and Yokosuka; South Korea is developing different intelligent applications in Seoul and Songdo International Business District. In Taiwan, the Ministry of Economic Affairs (MoEA) has launched a Smart Living Technology Application Project, also called i236 Project [14] since 2009, to seek ideal smart living services in specific cities or regions.

1.2 ICT-enabled Environmental Technology takes the lead of innovating Smart Living Services

There is no hiding the fact that global warming and energy depletion are two critical issues in terms of far-reaching problems which are endangering all the people in the world. So far, energy saving and emission reduction are thought as priority principles for constructing sustainable civil and industrial developments. Various national projects with their purpose of depicting future technologies, such as “FinnSight 2015” of Finland, “Strategy for Science, Technology and Innovation” of Ireland, “Making Sweden an Oil-free Society” of Sweden, ”Australia 2020” of Australia, “Innovation 25”/“2050 Low-Carbon Society” of Japan, and so on all indicate the importance of environmental technology to be adopted for energy efficiency and environment sustainability. In addition, a report of “Industrial Technology Foresight for Taiwan 2020” published by MoEA Taiwan stressed that the management of energy relying on ICT-enabled environmental technology is highly suggested as the first and foremost strategic policy of designing and innovating all living services in smart cities.

Environmental technology (abbreviated as envirotech, greentech, or cleantech) is the realization of environmental science to conserve natural environments and resources, as well as to curb the negative impacts of human involvement. In fact, as more people migrate to urban areas, the mass population will significantly strain cities' already limited energy and other resources. Furthermore, not only are these resources limited in supply, they are often poorly managed. That is, there are inconsistencies in how limited energy are distributed and contained [17]. For solving this problem, it is imperative to implement smarter ways in which energy can thus be conserved, delivered, and managed. For example according to [18], Cities around the world are nowadays deploying "smart grids." A smart grid system that is cooperated with Internet Protocol enabled sensors, supervisory control and data acquisition devices, heating ventilation and air conditioning equipments, distribution apparatus, transformers, and metering technologies. The purpose of smart grid system is to install thousands of interactive meters and intelligent sensors to monitor electricity use in real time, therefore to better energy management. Another example is as [16] reported, the US Green Building Council promoting the Leadership in Energy and Environmental Design (LEED) certification encourages the ICT-based Smart Computing technology to be adopted into building energy management systems. The LEED-certified buildings can automate heating/cooling equipments and different sensors to for instance power down lights when not in use, accordingly stand out with 26% less energy consumption, 13% lower maintenance costs, 27% higher occupant satisfaction, and 33% less greenhouse gas emissions. As a result, ICT-enabled environmental technology with the considerations of energy management is leading the development of smarter living services and is highly expected to deliver a myriad of financial and environmental benefits.

However in essence, greentech is often considered a high-impact meanwhile high-uncertain force of changing the future world; i.e., a small discrepancy of its application may lead to a great impact or fault. Although forward-thinking governments and industrial companies are making much efforts on the development of greentech systems, some of their application trials are inspired unfortunately some are abortive. For all practical purposes, there are several issues to be concerned toward greentech R&Ds and greentech service promotion, they are including: (1) What the convincible blueprint of future city which applies greentech look like? (2) How to select priority greentech science and products beneficial to sustaining urban environments? (3) What principles or key performance indicators (KPIs) would be helpful to evaluate the engineering performance of the greentech-led smarter urban systems? (4) What strategic actions are valuable to promote greentech industries? To answer these difficult questions, we refer to three practical Foresight and Innovation methodologies, and accordingly design a Vision-oriented Service Innovation (VioSIn) approach capable of sketching technology roadmap, particularly for emerging technologies full of uncertainty. By means of the proposed VioSIn, we generate a vision network (VN) with three scenario kernels to demonstrate an exemplary practice of sketching environmental-technology roadmap for designing sustainable city.

In the next section, we focus on Foresight methodologies for Technology Roadmap. Three sub-sections include an introduction of the concept of Foresight and Technology Roadmap, a brief review on three practical Foresight and Innovation methodologies, and an exposition of our VioSIn scheme which is on the advantage of the reviewed approaches. In Section 3, we demonstrate a case practice of sketching greentech roadmap for future city by adopting our VioSIn process. Next, the VioSIn pros and cons are addressed in Section 4. Finally, the last section concludes this chapter with future works.

2 Foresight Methodologies for Technology Roadmap

"Foresight" is already a term widely used by academic researchers, policy-makers, industrialists, consultants, and others round the world. Coates [2] defined Foresight as a process by which one comes to a fuller understanding of the forces shaping the long-term future which should be taken into account in policy formulation, planning, and decision-making. Also as Martin [10] introduced, Foresight is a process involved in systematically attempting to look into the longer-term future of science and technology, the economic and society with the aim of identifying the areas of strategic research, and the emerging generic technologies likely to yield the greatest economic and social benefits. In practice, Foresight is a process containing conscious and iterative activities to recognize the future by ensuring feedback to and from relevant actors. It can systematically work out the direction of the planning services and technologies in an engineering manner.

By applying the concept of Foresight, the Technology Foresight (TF) utilizes prediction engineering to determine the most likely technological developments in the future. Up to now, there have been different TF methods announced in academic and industrial circles. Detailed introduction and associated discussions regarding to the development of TF can be found in a review article by Miles [11]. In recent years, the state-of-the-art TF methods almost emphasize the importance of bringing the producers and users together to generate a specific vision for their future development of using the innovating technology with a timeframe ranging between 10 and 30 years. Such vision-guided TF scheme is usually good at blueprinting a technology roadmap with an appropriate timeframe. Technology roadmap (TRM) means a plan that indicates short-term and long-term goals aiming at the conceived vision with specific technology solutions. Kostoff and Schaller [9] reviewed the fundamentals of TRM. Phaal, Farrukh, and Probert [12] analyzed the types of TRM methodology. Albright and Kappel [1] highlighted the use of TRM to link TF to business strategy, the TRM can thus reasonably help making decisions in planning, acquiring, and utilizing technological assets which have become an important element in determining how best to use today's limited resources in business. Coming back to the subject, TF is a candidate tool in tackling sustainable development for future[4]. Besides, TRM is a practical TF product beneficial to envisioning emerging technology-dependent services.

2.1 Three practical approaches: SRI-SP, Siemens PoF, and IBM IoFT

Generally speaking, the value of TF is to realistically think about on-going trends, discover emerging issues, watch potential events, and accordingly arranges stepwise goals aiming at a preferable future. The fact implies that the practicability of a TF approach is much crucial than the theoretical contention of it. For this reason, we prefer to believe existing practical TF methodologies rather than theoretical models. In this chapter, we recommend three popular TF methods which have already been proven in practice. They are Scenario Planning, Siemens Pictures of the Future(PoF), and IBM Impact of Future Technology(IoFT).

Scenario Planning (SP) is a method of creating strategic options for technology and business innovations based on considerable future scenarios. As Ringland[13] emphasized, scenario analysis plays a key role of strategic foresight because of its feature of providing well-understood description that permits exploration of the future. The power of SP was originally established by Royal Dutch/Shell which has used scenario analysis since the early 1970s as part of a process for generating and evaluating its strategic options. After that, the Stanford Research Institute (SRI) enhanced and glorified such SP approach (so called SRI-SP) to offer long-term planning facilities for education, governance, and of course business innovations. The steps of SRI-SP are (1) define focus, (2) define critical decision factors, (3) find and analyze drivers, (4) decide uncertainties, (5) select and depict scenarios, and (6) analyze scenario implication. In brief, the main feature of SRI-SP is to build candidate futures in a scenario manner composed of prioritized uncertainties.

Siemens PoF is a widely used strategic planning methodology for service innovation and technology roadmapping in industrial circles. The steps of PoF are (1) survey current business, (2) analyze trends, (3) extrapolate the selected trends, (4) depict scenarios, (5) evaluate scenarios, and (6) establish action plans. The attribute of PoF is to describe the futures in the light of on-going trends and experts' opinions.

In principle, PoF and SRI-SP are both classified as forward thinking schemes primarily consider key trends and associated uncertainties to conduct possible futures. In contrast, backward thinking approaches applying a different logic from the forward thinking ones emphasize the procedure of from envisioning back to defining practical stepwise goals. In 2005, IBM researchers developed a Foresight and Innovation model called Impact of Future Technology (IoFT) [8] to provide on-demand innovation services to their Global Business Services customers. The IoFT can explore technology landscape, identify strategic actions, and other disruptors or game changers that may signal new business opportunities or threats on innovation analysis. The characteristic activities of IoFT process are including (1) ideation, (2) envisioning, (3) generate vision-map, (4) technology deep dive, (5) describe futures, and (6) arrange strategic signposts . In one world, the distinguishing feature of IoFT due to its backward thinking functionality helps to generate preferable future in view of expected visions, so that the IoFT could address more ideal options for TRM than that by forward thinking approaches.

In summary, the backward thinking approaches like IoFT initially aiming to deeper future can address desirable directions containing creativeness for developing a TRM. However, the forward thinking schemes like SRI-SP and PoF are skilled in forecasting possible futures tending to on-going status as usual. An ideal TRM should be made as a set of actionable goals created by integrating forward forecasting process and backward envisioning actions.

2.2 The proposed VioSIn methodology

As mentioned above, PoF is able to draw reasonable futures by analyzing on-going STEEP trends. Besides, the strength of SRI-SP is to generate alternative futures through dealing with uncertainties, and IoFT provides an iterative model passing from incasting, backcasting and prioritizing visionary ideas into well-understood strategic results. Based on the advantages of these approaches, we accordingly propose a novel Vision-oriented Service Innovation (VioSIn) method. The conceptual process of VioSIn as depicted in Fig. 3 is mainly on the basis of IoFT, i.e., ideation, envisioning, and technology deep dive. It also combines some modules from PoF and SRI-SP for example, trend extrapolation and analysis, cross-impact analysis, decide uncertainties, and so on. The VioSIn is detailed as the follows:

(1) Ideation: Ideation, also known as idea generation, is a process of creating new ideas. The ideation in VioSIn is to widespreadly gather preferable ideas without much concern of trends or uncertainties in this initial stage. After that, the associated ideas are clustered into a group named vision.

(2) Trends analysis: This is to analyze current business, application, and market data by considering different aspects like society, technology, environment, economy, and politics (STEEP) to extrapolate a baseline situation by trends.

(3) Cross-impact analysis: Based on the result of trends analysis and extrapolation, a process of cross-impact analysis is operated to determine the influence on the on-going trends, further to explore major uncertainties according to key trends.

(4) Envisioning: The envisioning defined in VioSIn is composed of vision incasting and vision backcasting. Vision incasting is meant to expand the details of a target vision. Differently, the purpose of vision backcasting is to find out more related intermediate visions between two selected visions. Although these two skills have distinct logics, they usually work together to perform an iterative operation capable of divergence and convergence.

(5) Technology deep dive: Technology deep dive is to discover existing technologies which would be helpful to realize the aimed vision or to seek emerging technologies which will benefit from the aimed vision if being realized. The prod-

uct of technology deep dive is a visual blueprint, called vision network (VN), composed of visions, technologies, uncertainties, and their influence links.

(6) Scenario generation: This part of VioSIn is to depict future scenarios by combining the VN and the comments from domain experts.

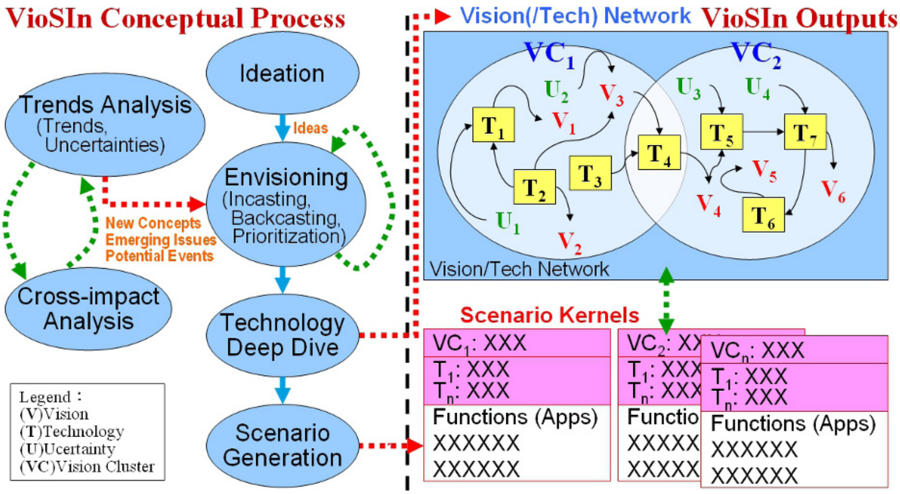


Fig. 3. Conceptual process and outputs of the VioSIn

As shown in Fig. 3, the outputs of VioSIn are finally formed as vision network and vision-clustered scenario kernels.

(1)Vision network (VN): Through envisioning iteratively, a large number of noticeable ideas are clustered into visions. In addition, some forces of changing the on-going trends are also highlighted as key uncertainties. Next, technologies associated with respective visions are thoroughly ascertained. Furthermore, relationships among visions, uncertainties, and technologies are represented as influence links. In consequent, a vision network composed of visions, uncertainties, technologies, and influence links is thus constructed.

(2)Vision-clustered Scenario kernel: To clearly describe the introduced futures, the associated visions with their related uncertainties and technologies are gathered as a vision cluster(VC). Each VC containing specific functions/applications is therefore provided as a scenario kernel useful to compose a fully-structured story about the future.

3 A Case Practice Adopting VioSIn

The purpose of this chapter is mainly to present a novel service innovation approach, the VioSIn. To estimate the usability of the VioSIn, we coworked with researchers from Industrial Technology Research Institute (ITRI), which is the most important non-profit R&D organization engaging in applied research and technical service in Taiwan, to launch a VioSIn practice targeted to sketching a greentech TRM for sustainable city. The operations of this practice and the results of it are concisely interpreted in Section 3.1 and figured in Section 3.2 respectively.

3.1 The operations

(1) Ideation: We collected around three hundreds of ideas towards greentech applications by web-searching, reviewing literatures, brainstorming, and interviewing experts who are from ITRI, National Chiao Tung University, and National Central University in Taiwan.

(2) Trends analysis: We referred to fourteen global trends summarized from a report of "Industrial Technology Foresight for Taiwan 2020" by MoEA. The surveyed trends are such as the increasing of senior popular, the decreasing of birthrate, the raise of recycling consensus, and etc.

(3) Cross-impact analysis: Further, we sought uncertainties implied as new ideas, potential events or emerging issues which might change these trends by convening several brainstorming meetings.

(4) Envisioning: The inputs from ideation and trends analysis were reasonably abandoned, expanded, clustered, and converged depending on their circumstances, and were consequently transformed into classified visions according to the feedbacks from the domain expertise. In practice through several rounds of internal discussions and external focus meetings in conjunction with Delphi operation, the visions were iteratively incasted, prioritized and backcasted. As a result, a pure VN without technologies addressed was thus produced.

(5) Technology deep dive: We detailed the key visions by means of discovering their related technologies. Furthermore, we pointed out the influence links among visions, critical uncertainties and their related technologies as the curves with arrow on the VN.

(6) Scenario generation: We reviewed all the materials in this case and summarized useful ideas to generate desirable functions or expected applications for the visions. Compared with the relevance among visions, uncertainties, technologies, and functions, three VCs are thus resulted. Finally, we compose scenario kernel for each VC. The VC scenario kernels and the final VN are mutually referenced to introduce an overall greentech TRM (a blueprint) for designing a sustainable city.

3.2 The Results: a VN and three VC scenario kernels

The main result of this study is a VN composed of greentech-associated visions, uncertainties, technologies, and the influence links among them. In the beginning, the phased achievement of the Ideation stage is 18 visions related to designing sustainable cities. After that, through the iterative Envisioning operations, we seriously considered the potential uncertainties and checked possible influences among these 18 visions, and then produced our final VN consisting of 10 visions and 7 uncertainties. As shown in Fig. 4, two axes Impact and Time are noted. For any vision or uncertainty, the score of Impact reflects its effects upon the governmental missions, commercial benefits, and living quality of people if the vision was achieved or the uncertainty was happened; at the same time, the score of Time means the possibility of realizing the vision or the risk of the uncertainty; i.e., more Impact scores more importance and more Time scores more risks. Moreover, a curve with arrow represents an influence link, for example a curve with arrow from bubble A to bubble B in a VN means the item A will significantly affect the developments of item B.

Since we consider the relationships among the items in the VN in accordance with influence links, it's rational to draw an influence path from one item through some other items to a final vision, therefore introduce a development roadmap. For instance referring to Fig. 4, the vision number 12 will affect the development of the vision number 3, and the vision number 3 will help the achievement of the vision number 7, so that a stepwise path from vision 12 to vision 7 through vision 3 is marked. That is, according to Fig. 4, we can find that the visions numbered 5 and 7 are both significantly aimed by other visions; they play the role of leading greentech implementations of arranging a sustainable city. In order to make more specific results for this study, we considered the missions and policies of Taiwan's greentech development, and then select the number 7 as our priority vision. The accompany VCs based on the selected vision are accordingly produced, Details of the three VCs are depicted as Figs. 5, 6, and 7.

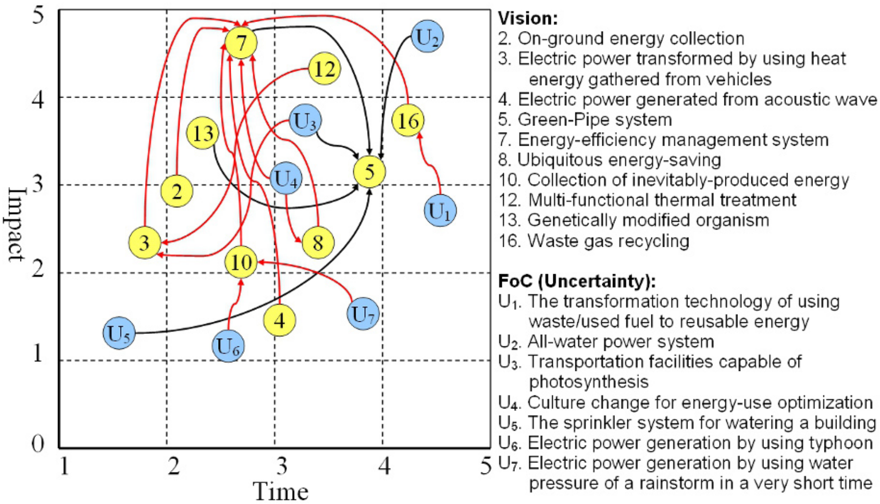


Fig. 4. The Greentech VN

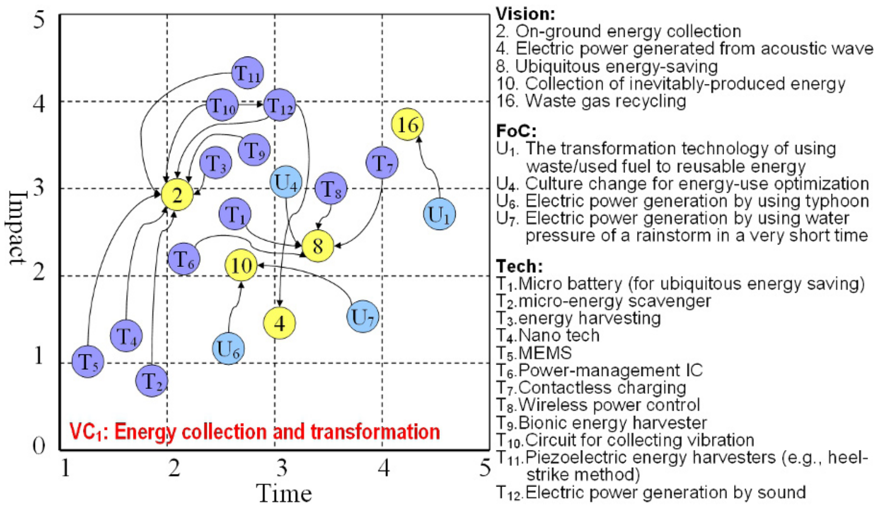


Fig. 5. VC_1 with its related technologies

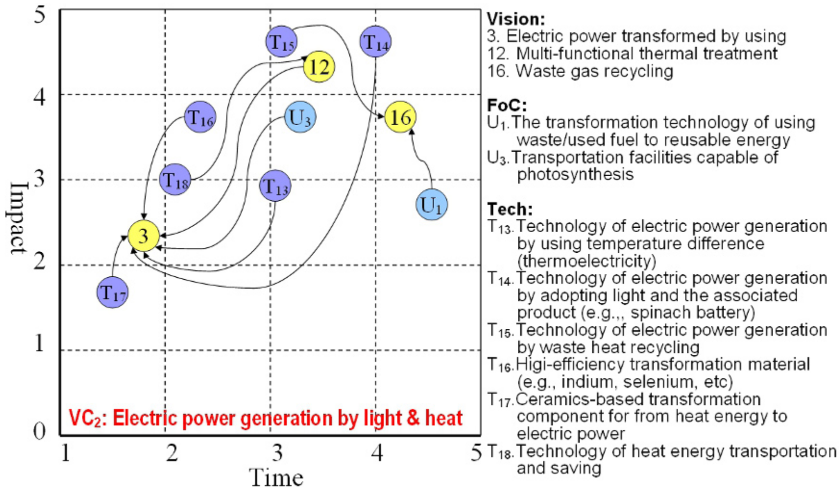


Fig. 6: VC_2 with its related technologies

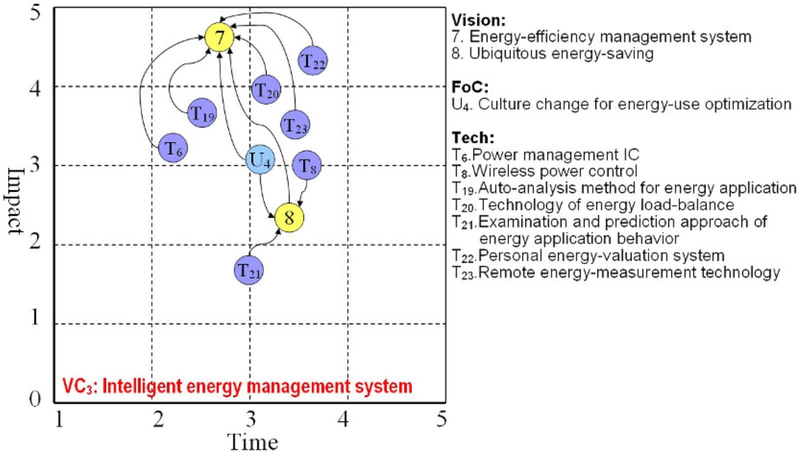


Fig. 7: VC_3 with its related technologies

Coupled with the key functions introduced in Table 1, the contents of VCs are sufficient to be adopted as scenario kernels for composing stories toward the greentech futures of sustainable cities.

Table 1. Key functions of respective VCs

VC Title	***VC$_1$***: Energy collection and transformation	***VC$_2$***: Electricity generated by light and heat energy	***VC$_3$***: Intelligent energy management system
Key Functions (Apps)	■One-minute walk can generate sufficient energy for daily use of ten-minutes phone calls. ■The stamping-impact to the floor by crowd stampede is converted to electricity for lighting or other purpose. ■The vibration issued by the car drove off the road is collected for power generation or other energy applications. ■The energy produced by people walking will be saved in the shoes, underwear, or portable device. ■The noise or sound is incorporated and converted to electrical energy.	■Thermal-to-power generation by using waste heat from car exhaust and car engine provides auxiliary power for vehicle. ■Using the heat from garbage incinerator or steel mills to generate electricity (AMTEC) ■Paint or car paint capable of photosynthesis. ■Spinach battery is widely adopted as green energy for cell phones and PDAs. ■Biomass-power generation by driving engine generators through using high temperature waste heat (more than 600 degrees).	■The fare for a vehicle ride is accurately calculated according to energy use. ■The city/town as a region, a household as a unit, a client-server energy management system is used to manage all energy use (cars, public transport-through personal portable record, scooters, etc) and also to record the logs of energy generation and applications. ■Sensing and prediction of behavior (adopting situation-awareness tech) is widely used to help pre-allocation strategy for energy-use optimization.

4 Discussions

The objective of VioSIn is aiming at solutions of sketching TRM of emerging technologies like greentech. We here review the VioSIn pros and cons as the issues worthy of discussion.

Pros.

- Unlike most of the theoretical TF methodologies, the VioSIn on the strength of SRI-SP, PoF, and IoFT provides a practical service innovation model which would be beneficial to generating reliable TRMs for emerging technologies.
- Since the VN is built by analyzing objective literatures as well as comments from domain experts through an iterative process, it offers conceptual visions in both considerations of technological trends and human demands which are essential to construct desirable service systems.
- The influence links in a VN are sufficiently provided as the materials for arranging strategic actions.
- The VC scenario kernel is a well-formed outcome useful to compose the stories readily for general public reading.

Cons.

- The proposed VioSIn combines the advantages of several existing TF and business innovation schemes; unfortunately it doesn't cover the items of system implementation and service commercialization. That is to say, the VioSIn provides a way of depicting conceptual TRM-oriented visions in a VN manner, but exposes its poverty of proof of system as well as proof of service. For the same reason, the VioSIn can not guarantee the success of designing new products or deploying new service systems, of course including the new greentech ones.
- The operation of VioSIn leverages the ideas and knowledge from reading literatures, interviewing domain experts, and inviting other extensive involvement of human factors. Because of this, the human bias is certainly inevitable in the VioSIn process. Except of relying on skills of project management and facilitation, we believe that the Bibliometrics[3] could be a potential discipline which would be able to ease this imperfection off.

5 Conclusion and Future Works

In this chapter, we present a novel VioSIn approach capable of sketching technology roadmap for emerging technology full of uncertainty. To further estimate the usability of the proposed VioSIn, we made a practice through the VioSIn conceptual process consisting of six working phases to compose an environmental-technology roadmap for designing sustainable city. From a practical point of view, the VioSIn provides a systematic method beneficial to blueprint the emerging technologies and services, and further indicate strategic initiatives of promoting those services. Next, we would like to highlight more issues which may merit further investigations:

- To build a trial of ICT-enabled greentech services: We intend to cowork with some of our partner research organizations to arrange one or more ICT-enabled greentech systems in planned physical areas. The systems in planning will be consisting of various primary greentech applications suggested in this chapter.
- The study of evaluation schemes for service innovation: Although the proposed VioSIn is helpful to indicate major directions of designing smarter services, how the innovated services can effectively be estimated is less considered. For this reason, existing KPI approaches and artificial intelligence methods will be considered to build appropriate schemes for estimating the levels of innovation.
- Further research of Knowledge Management for service innovation: Undeniably, Knowledge Management (KM) plays an essential role of service innovation. As Foresight methods are getting widely used for business/service innovations, KM for Foresight is also becoming a key component of services maintenance and sustainability. We are taking account of context-awareness and situation-awareness technologies as the primary means to achieving KM in future works.

Acknowledgement. The author thanks researchers and professors, too numerous to be listed here, specialize in energy science and environmental engineering from Industrial Technology Research Institute, National Chiao Tung University, and National Central University in Taiwan for their contributions during the development of various ideas and concepts presented in this chapter.

References

[1] Albright, R.E. and Kappel, T.A., 2003, “Roadmapping the Corporation”, *Research Technology Management*, Vol. 46, No. 2, pp.31-40
[2] Coates, J.F., 1985, “Foresight in Federal Government Policymaking”, *Futures Research Quarterly*, pp. 29-53
[3] Daim, T.U., Rueda, G., Martin, H., and Gerdsri, P., 2006, “Forecasting emerging technologies: Use of bibliometrics and patent analysis”, *Technological Forecasting & Social Change*, Vol. 73, No.8, pp.981-1012
[4] Destatte, P., 2010, “Foresight: A major tool in tackling sustainable development”, *Technological Forecasting & Social Change*, Vol. 77, No. 9, pp.1575-1587
[5] Dirks, S., and Keeling, M., 2009, “A vision of smarter cities: How cities can lead the way into a prosperous and sustainable future”, *IBM Institute for Business Value*.
http://www-03.ibm.com/press/attachments/IBV_Smarter_Cities_-_Final.pdf
[6] Dirks, S., Keeling, M., and Dencik, J., 2009, “How Smart is your city? Helping cities measure progress”, *IBM Institute for Business Value*.http://www-05.ibm.com/pl/public/pdf/How_smart_is_your_city.pdf

[7] Hinrichsen, D., Salem, R., and Blackburn, R., 2002, “Meeting the Urban Challenge”, *Population Reports*, Series M, No. 16, Baltimore, The Johns Hopkins Bloomberg School of Public Health, Population Information Program.
[8] Impact of Future Technology, *IBM*. http://www.almaden.ibm.com/asr/projects/ioft/
[9] Kostoff, R.N., and Schaller, R.R., 2001, “Science and Technology Roadmaps”, *IEEE Transactions on Engineering Management*, Vol. 48, No. 2, pp.132-143.
[10] Martin, B.R., 1995, “Foresight in Science and Technology”, *Technology Analysis & Strategic Management*, Vol. 7, No. 2, pp. 139-168.
[11] Miles, I., 2010, “The development of technology foresight: A review”, *Technological Forecasting & Social Change*, Vol. 77, No. 9, pp.1448-1456.
[12] Phaal R., Farrukh C.J.P., and Probert D.R., 2004, “Technology roadmapping-A planning framework for evolution and revolution”, *Technological Forecasting & Social Change*, Vol. 71, No. 1, pp.5-26.
[13] Ringland, G., 2010, “The role of scenarios in strategic foresight”, *Technological Forecasting & Social Change*, Vol. 77, No. 9, pp. 1493-1498
[14] Taiwan i236 Project. http://www.i236.org.tw
[15] United Nations, 2010, *World Urbanization Prospects: The 2009 Revision*.
[16] US Green Building Council, 2009, *Green Building Facts*, http://www.usgbc.org/ShowFile.aspx?DocumentID=5961
[17] Washburn, D. and Sindhu, U., 2010, “Helping CIOs Understand Smart City Initiatives”, *Forrester Research*.
[18] Wildeman, R.C., Gilpin, M., and Knoll, A., 2009, “Smart Grid Technologies: Coming To A Utility Near You”, *Forrester Research*.

Part II
Environmental Information Systems

Problems of practical CEMIS (Corporate Environment Information Management Systems) usage

Horst Junker[1], Corinna V. Lang[2]

[1] IMBC GmbH
[2] Hochschule Anhalt

horst.junker@imbc.de, c.lang@wi.hs-anhalt.de

Abstract. Up to now environmental oriented activities has been sufficiently efficient neither in politics nor in administration to gain essential improvements of the global or national environmental situation. Consequently laws and regulations have been enacted, which influenced significantly the economical oriented actions of companies. Companies, which intend to meet these challenges, are forced to consider the complete value chain from procurement over production to distribution regarding the aspects of saving resources and the minimization of waste and emissions. Despite of the fact, that the responsibility for environment protection are fixed in mission statements of many companies CEMIS are seldom in use. In a noteworthy amount just systems to fulfil legal compliance are expanded in companies. Within the last decade we have performed or supervised more then 40 projects to implement CEMIS in SME. In these projects one has to detect, that management is not interested in an implementation of comprehensive holistic CEMIS. They are mainly interested in systems to fulfil legal regulations and the connected burden of proof. The following chapter shows, in which corporate application areas the use of CEMIS is demanded in business practise. It should be possible to derive categories of application areas from the empirical findings and to find out for which reasons the management of SME didn't spend the desirable attention to CEMIS.

Keywords: Corporate Environmental Management Information Systems SME, Empirical study

1 Introduction

Since about two decades CEMIS are a topic of scientific research. The results of this research seem to be anyhow insufficient. CEMIS is defined as an application-oriented science – a so called hyphen informatics. Consequently, the results of the academic work on and of CEMIS should be relevant for the practitioners within companies. But up to now, having a first glance it is to be observed that environment protection activities are not sufficiently efficient to gain essential contribution to improve (e. g.) the national environmental situation. The objective of

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_12,

CEMIS is to support the idea of corporate environment protection by the provision of adequate methods of informatics.

As a result, obviously the efforts of the academic CEMIS to support corporate environment protection are anyhow very modest. At least one of the reasons for the inefficiency of CEMIS concerning corporate environment protection seem to consist mainly in the fact, that academic researcher do not and possibly will not notice the urgent problems to be solved in companies. The suspicion is not to dismiss that the scientific research interests are not ruled by corporate necessities with the result that there is a big gap between the actual research work and the practical requirements of companies.

The purpose of an application-oriented science should be to focus its work on such topics the companies need. However, precondition is an intimate knowledge of companies. In the last decade we realised about 40 CEMIS-oriented projects with (mostly SME) companies. On the basis of this rather comprehensive experience it should be possible to demonstrate the gap between theoretical interests and practical requirements. For this reason, first, the state of the actual scientific discussion of CEMIS will be presented. Thereafter, a comprehensive and aggregated overview and characterization of the above mentioned projects will be given. And, as a conclusion the gap between theoretical and practical situation will be described.

2 Traditional framework of CEMIS

As far as so called hyphen informatics are concerned, information systems shall principally support the solution of problems of concrete application areas. Therefore, the objective of CEMIS consists in an explanation of corporate environmental phenomena. Furthermore, information systems are dealing with the management of data and processes. They consist of men and machines, which execute their tasks in a cooperative manner, which are connected by cooperative relations to use them for collecting, storage, processing and transmission of information. Such a description of information systems provides an indication of a principally complex and comprehensive application background. IT-systems to support singular, less complex tasks can not be called to be an information system. Consequently it is impossible that there will be a CEMIS on the basis of EXCEL.

In the history of companies activities to protect environment came very late in the focus of corporate interests – about in the eighties last century. The integration of environmental activities into the corporate range of tasks was forced on the one hand by the beginning environmental legislation, which obliges the companies. Legislation was not any longer willing to offer the possibility to the companies to externalize the costs for the disposal of environmental damages caused by the production processes. On the other hand by ISO 14.001 and EMAS two norms for environmental management was published, which companies could accept, if they want. In any case the initiation of corporate examination of environmental phenomena was widely external initiated.

The idea of the environmental management systems as an instrument of an environmental policy was to strengthen the ecologic responsibility. Topic of environmental management systems is the natural environment, in the end the nature. It "is the entity of all factors in the form of air, water, soil, renewable and not renewable raw materials, weather, climate and ecological processes, which effect companies or which are effected by companies [7].

The objective of the realization of environmental management systems shall contribute an ecological improvement of resource efficiency, especially in the areas of the input of energy, water and raw material and the output emissions and waste. It is assumed that the economic benefits of environmental management systems consist in cost savings and internal and external benefits. Internal benefits can be for example an improvement of legal security, transparency or an improved staff motivation. External benefits are reflected in better relationships to customer and groups of stakeholder on the market [3].

However, empirical surveys demonstrate that environmental management measures in the corporate practise are concentrated of the operative layer that means they are directed inward. Corporate optimizations and the utilization of cost reducing potentials are predominant. Environmental management systems are seldom used for market-orients strategies and ecological product innovations. The question stays open, whether a realization of environmental management systems leads to a formulization of ambitious environmental objectives [3].

Concerning the existing reality of companies it is to state that the intension is failed to a large extent to integrate objectives of environment protection into the common corporate target system. The influence in the strategic business objectives by environmental department or environmental officers is conceivable small.

One of the reasons for this issue is the unsatisfactory construction of the norm for environmental management systems. E. g. ISO 14.001 provides the following procedure for its corporate implementation:

- Environmetal policy definition,
- Planning,
- Implementation and processing,
- Control and correction measures,
- Assessment by the top management [1].

Especially, there are no guidelines to transform business objectives into the planning phase with the result that planning, control, processing and monitoring of environmental activities are largely assigned to the operative management layer. The amount of laws and regulation of the last three decades impose extensive restriction and burdens of proof. Thereby decentralized requirements arise which are covered by It-systems of very different levels of success and quality. As a result often applications e. g. for waste, waste water, emissions hazardous materials etc. has been developed by using existing standard software systems or by consultation of local software developer. Such software solutions could satisfy the requirements directly, but from an intercompany or scientific point of view they are afflicted with all disadvantages of local stand-alone solution [6]. Such island solution requires a less comfortable data management, but causes very often timely and costly extra work.

3 Existing definitions of CEMIS

Altogether is to accept that CEMIS has failed to offer support for a mitigation of deficits in the early implementation phases, although business informatics offer for quite some time procedures for the way from a defined policy to the implementation of measures by a multi-level strategy. Heinrich [11] by the usage of the process model of information management it would be possible to define term and content of CEMIS in a much precise manner. By missing that, in theory and practise manifold application systems are identified as CEMIS without a persistent and generally binding has been achieved. [10, p.2] Mostly any employment of information technology to process environmental relevant data is said to be a CEMIS.

Subsequently some definitions of CEMIS in the German speaking literature will be presented:

- CEMIS are a summary of all information systems, which serve the corporate environmental management [5],
- CEMIS serve the information technical support of corporate environmental protection [4],
- […] are systems to administer environmental information within the enterprise [2],
- CEMIS are organizational-technical systems for systematically obtaining, processing and making environmental relevant information available in companies [8].

All definitions convey the impression of a high degree of fussiness and to a certain degree of ambiguity. This is owed to the fact that the authors try to attempt to catch in their definition the characteristics of all possible theoretically thinkable environmental-oriented software systems. This assumption will be confirmed by the following attempt of a definition: “In analogy to business information systems CEMIS is an information system, which is used to collect, document, plan and control corporate environmental impacts and supports the envir0nmental management activities. Further, as information systems are understood systems of different complexity. According to this a CEMIS can be either a spread sheet to calculate environmental indices or a specific software to analyse material flows or to balance environmental impacts within the scope of a ecobalance.” [12, p. 4)

This high amount of fussiness results in a morphological box as a classification schema for CEMIS. Originally a morphological box has been a creativity technique, which serves the creation of ideas. A problem or a fact has to be characterizes in its different characteristics (in a vertical manner). Following, for each of these characteristics it is necessary to find all possible characteristic values (in a horizontal manner). An ides – in this case a (new) CEMIS – will be identified by any user-defined vertical run through the characteristic values. By variation of the considered characteristic values per run through it will be possible to generate and to define any number of CEMIS which are able to cover very different scopes of problems. Thus it will be possible to denote software systems as CEMIS, which will not fulfil the criterions which have by definition to be fulfilled by information systems. Thus it becomes visible that up now CEMIS has failed to acquire a precise theoretical and scientific fundament. This serious deficit has extensive consequences in particular concerning the development and the implementation of CEMIS in the corporate practise.

	characteristic	value							
environmental organization	strategy	preventive	end of pipe						
	business objectives	EMAS/ISO-certification	environmental optimizational eco efficiency	legal compliance	presentation of environmental record				
	time horizon	strategic – long-term	tactical – medium-term	operative – short-term					
	organization unit	management	department	environmental representative	local responsibility				
	application area	waste manage-ment	water protection	emission protection	energy manage-ment	hazardous substance manage-ment	material data adminis-tration	resource adminis-tration	material flow manage-ment
CEMIS specific aspects	tasks	report generation	process planning support	process control support	process monitoring support	procedural support/gui deline	information interface	organiza-tional support	environ-mental balancing
	functionality	analysis	modeling	simulation	realtime monitoring	document management	report generator	work flow component	
	system border	department / corporation	process	product / LCA					
IT	degree of integration	stand-alone	add-on	integrated system					
	operating system	Windows	Unix	Mainframe	others				
	formats	HTML	ODBC	Office formats	others				

Fig 1. Morphological box for CEMIS, *Source:* [9]

4 Survey of CEMIS projects

From the above mentioned about 40 projects realised within the last seven years by IMBC are 30 included in the survey, because some of the IMBC projects has rather been feasibility studies or something like that.

The following overview tries to characterize the CEMIS projects by the items given by the morphological box.

	industry	problem area	strategy	business objectives	time horizon	organisation unit	application area	tasks	functionality	system border	degree of integration
1.	traffic (LSE[1])	information flow	preventive	eco-efficiency	tactical	environmental representative		organisational support	analysis	department	stand alone
2.	traffic (LSE)	management of environmental measures	end of pipe	legal compliance	operative	environmental representative	resource administration	report generation	report generator	process	stand alone
3.	automative (LSE)	energy flow	preventive	eco-efficiency	tactical	environmental representative	energy management	process control support	analysis	process	stand alone
4.	automative (LSE)	material flow	end of pipe	legal compliance	operative	environmental representative	emission protection	process monitoring support	analysis	process	stand alone
5.	print shop (SME)	information flow	preventive	ISO-Certification	tactical	management	resource administration	process monitoring support	analysis	company	stand alone
6.	print shop (SME)	monitoring of indices	preventive	EMAS-Certification	strategy	environmental representative	resource administration	report generation	modeling	company	
7.	print shop (SME)		preventive	presentation of environmental record	tactical	management	resource administration	report generation	report generator	inter-company	stand alone
8.	print shop (SME)	environmental data base	preventive	presentation of environmental record	tactical	management	resource administration	report generation	document management	inter-company	stand alone
9.	consulting (SME)	hazardous substances	end of pipe	legal compliance	operative	environmental representative	hazardous substance management	report generation	modeling	company	stand alone
10.	consulting (SME)	measures management	end of pipe	legal compliance	operative	environmental representative	resource administration	report generation	modeling	company	stand alone
11.	consulting (SME)	ERP-interface	preventive	presentation of environmental record	tactical	environmental representative	material data administration	information interface	modeling	process	integration system
12.	consulting (SME)	waste management	end of pipe	legal compliance	operative	environmental representative	waste management	report generation	modeling	process	stand alone
13.	plastics production (LSE)	environmental indices	preventive	eco-efficiency	tactical	environmental representative	resource administration	report generation	report generator	department	stand alone
14.	plastics production (LSE)	energy management	preventive	eco-efficiency	tactical	environmental representative	energy management	process control support	analysis	department	
15.	raw material (SME)	facility management	preventive	eco-efficiency	tactical	management	resource administration	process monitoring support	modeling	company	stand alone

1) Large Scale Enterprise

	industry	problem area	strategy	business objectives	time horizon	organisation unit	application area	tasks	functionality	system border	degree of integration
16.	plastics production (SME)	environmental indices system	preventive	ISO-Certification	tactical	environmental representative	resource administration	report generation	report generator	process	stand alone
17.	public utilities (LSE)	process optimization	preventive	eco-efficiency	tactical	environmental representative	material flow management	process control support	modeling	process	stand alone
18.	public utilities (LSE)	environmental reporting	end of pipe	legal compliance	operative	environmental representative	resource administration	report generation	report generator	company	stand alone
19.	public utilities (LSE)	environmental law date base	preventive	legal compliance	operative	environmental representative				company	stand alone
20.	mechanical engineering (SME)	noise register	end of pipe	legal compliance	operative	environmental representative	emission protection	report generation	report generator	company	stand alone
21.	traffic (LSE)	eco-balance	preventive	environmental optimization	tactical	environmental representative		environmental balancing	analysis	LCA	stand alone
22.	mechanical engineering (SME)	input-output balances	preventive	environmental optimization	tactical	environmental representative	material data administration	environmental balancing	analysis	process	stand alone
23.	environmental services (LSE)	hazardous substances information system	end of pipe	legal compliance	operative	department	hazardous substance management	report generation	analysis	process	stand alone
24.	consulting (SME)	environmental risk management	preventive	eco-efficiency	tactical	environmental representative	resource administration	process control support	modeling	process	stand alone
25.	waste management (LSE)	environmental indices management	preventive	eco-efficiency	tactical	environmental representative	resource administration	report generation	modeling	company	stand alone
26.	waste management (LSE)	waste distribution	end of pipe	presentation of environmental record	tactical	department	material flow management	report generation	modeling	department	stand alone
27.	mechanical engineering (SME)	environmental indices management	end of pipe	eco-efficiency	tactical	environmental representative	resource administration	organisational support	modeling	company	stand alone
28.	raw material (SME)	energy and material flow	end of pipe	eco-efficiency	tactical	environmental representative	material flow management	process monitoring support	modeling	company	stand alone
29.	raw material (SME)	material flow	end of pipe	eco-efficiency	tactical	department	material flow management	process planning support	analysis	department	stand alone
30.	public administration (LSE)	process analytics	end of pipe	legal compliance	operative	environmental representative	material flow management	report generation	analysis	department	stand alone

1) Large Scale Enterprise

Fig 2. Characterization of CEMIS projects

All these projects are summarized in the following figure to demonstrate the different areas, which are focussed by the projects.

	characteristic	value							
environmental organization	strategy	preventive	end of pipe						
	business objectives	EMAS/ISO-certification	environmental optimization / eco efficiency	legal compliance	presentation of environmental record				
	time horizon	strategic – long-term	tactical – medium-term	operative – short-term					
	organization unit	management	department	environmental representative	local responsibility				
	application area	waste manage-ment	water protection	emission protection	energy manage-ment	hazardous substance manage-ment	material data adminis-tration	resource adminis-tration	material flow manage-ment
CEMIS specific aspects	tasks	report generation	process planning support	process control support	process monitoring support	procedural support / guideline	information interface	organiza-tional support	environ-mental balancing
	functionality	analysis	modeling	simulation	realtime monitoring	document management	report generator	work flow component	
	system border	department / corporation	process	product / LCA					
IT	degree of integration	stand-alone	add-on	integrated system					

Fig 3. Morphological box of realised CEMIS

The above figure is to interpret as follow: the darker the background of the single cells of the morphological box is, the more frequently the content of the projects meet this feature.

In a more intensive examination of the figure, first it will be surprised that the number of projects which have a preventive character exceeds the end-of-pipe projects. Generally it will be expected that companies – in the course of performing legal compliance – will rather provide for passive environment protection. However, in this case it becomes apparent that relative many projects are processed, which will shall enable at least a rudimental environmental controlling by development and provision of indices.

Concerning the business objectives it is recognizable that neither the EMAS or ISO 14.001 certification nor the presentation of environmental record plays a major role in the projects. Rather the eco efficiency and the environmental optimization as well as the achievement of legal compliance are the decisive objectives. In all projects these two objectives are tried to achieve equally often. Also in this case it can be observed that legal compliance was expected before to be the dominant objective. By the in many projects developed indicators and indicator systems the target is pursued to achieve controlling components for influencing the corporate environmental situation in a positive manner.

The time horizon of the project result efficiency is mainly medium-term and therefore assigned to the middle management field of responsibility, in principal. In this context it will be remarkable that there are nearly no project, which has a long-term character. Obviously no project is initialized by the top management. This fact seems to be a distinct indicator that the top management will turn its attention to corporate environment protection to a very small amount.

This becomes apparent by the fact that the results of most projects will affect the environmental officer's area of responsibility. Furthermore, there is no project, which is initiated in local responsibility. Very seldom projects have been performed, whose results will be used the entire company or a concrete department.

Concerning the application area of CEMIS no clear classification are possible. As well projects aiming legal compliance as such for developing and providing indicators and indicator systems are not precisely assignable to singular application areas. At best it can be noticed that there are no projects assigned to the areas of waste management and water protection. With reference to the other application areas the project are rather equally distributed.

Concerning the tasks covered by the realised projects report generation is clearly outnumbered. This fact is less surprising, because CEMIS serving legal compliance have to verify that by reports. Similarly indicators for promoting environmental optimization or eco efficiency will provide the management in form of reports. Just some project pursued the target to support process control or process monitoring. It is further remarkable that there was just one project with the task to perform a – anyway natured – eco balance. Overall the assignment of project contents to the different application areas makes clear that only a few projects can be assumed to support typical tasks of the middle or higher management layer.

Regarding the different functionalities principally covered by CEMIS it is noteworthy to mention that the project will cover just a small amount of areas. None of the realised systems touches relatively challenging functionalities as simulation, real-time monitoring or workflow management. Primarily, in the project are addressed – and mainly equally distributed over all projects – the functionalities of analysis, modelling and generation of reports that means functionalities which belong to the traditional tasks of information processing.

Concerning the system border one can (negatively) notice that none of the realised systems will exceed the company borders as product eco balances or life cycle analysis will require. The systems are mostly oriented to the entire company or a single department, while the treatment of (single) processes has been done just in a few projects. If it is suggested that processes will rather indicate corporate dynamic it will be clear that the provided systems will have a rather – conservative–static character.

Finally, in conclusion it can be said that –with the exception of one –all projects have so called stand-alone systems as a result. Efforts to integrate the realised CEMIS into the existing landscape of business information systems will not take place.

A comprehensive consideration of all realised CEMIS makes clear that the existing reality covers the possibilities of the scientific discussion just to a relatively small amount.

5 Conclusion

The imperfect stepwise development of corporate environmental strategies derived from an environmental policy leads to the result that there is no or a very small identification of the top management with the objective of environment protection. For this reason in the corporate practise the implementation of environmental measures will be assigned to the operative layer.

- The corporate strategic management can close their mind furthermore to the tasks of environmental management and can obviously keep on to be convinced that environmental measures are exclusively a cost factor. The economic efficiency of such measures is very often consequently denied. By that investments in the development and implementation of complex and efficient CEMIS are made at least considerably more difficult.
- The assignment (also of IT-supported) environmental activities to the operative management layer leads because of the missing strategic orientation to fact that usually rather small and little complex solutions of environmental tasks will be aspired and be approached.
- Because of the small strategic importance of the required solutions of tasks and the operative management insufficient possibilities of enforcement environmental-oriented software development projects are very low priori-

tized in the project portfolio of corporate IT departments with the result that their chance to be realized is very small.

- The missing classification of intended IT-solutions in a comprehensive strategic concept implicates that mostly so called island solutions are strived, that a self-contained software system will be developed for every single (sub) problem.
- In their day-to-day business – often characterized by ad hoc-measures – the operative (environmental) management see themselves committed to the idea of the so called passive environment protection, by which it is mainly important to comply practical constraints resulting from the requirements of legal compliance by avoidance, at least reduction of environmental damages. Software systems stimulated by that realise mostly the aspect of output-orientation e. g. by emission reduction which in turn prefer the so called end-of-pipe technologies. These measures obtain the desires results without to be forced to change anything of the production processes. As one result additional efforts have to be done to fulfil the (legal) environmental specification, which naturally causes additional costs. Presumptively especially the passive corporate environmental activities will be the root of the top management assumption that the corporate environment protection will be (nearly) exclusively a cost factor.
- This operative approach, which is rather typical in the business practise, may lead to efficient IT-supported solutions of environmental problems. But without their classification in a previous developed comprehensive strategic concept, which pursues the idea of so called active environment protection, it will not be possible to develop and implement highly effective systems. Effective CEMIS do not serve the function, “anyhow” to mitigate or at best to eliminate already in companies arisen environmental damages, but ensure to reconfigure corporate activities and processes that environmental damages will not arise.

To achieve an adequate significance for CEMIS in the business practise and, especially, to take into account the effectiveness point of view in a comprehensive manner, the discussion about CEMIS has to be promoted at least in two directions:

- An enlargement of corporate target systems by (partly) consideration of the results of the sustainability discussion achieved up to now
- Closing the strategic gap between environmental policy and environmental activities (ISO 14.001) by a (strategic) environmental information management.

References

[1] Gastl, R. (2005): Kontinuierliche Verbesserung im Umweltmanagement, Zürich
[2] Günther, O. (1998): Environmental Information Systems, Berlin et al.

[3] Hamschmidt, J. (2001): Wirksamkeit von Umweltmanagementsystemen – Stand der Praxis und Entwicklungsperspektiven, (Diss.) St. Gallen
[4] Hilty, L. (1997): Umweltbezogene Informationsverarbeitung – Beiträge der Informatik zu einer nachhaltigen Entwicklung, (Habil.) Hamburg
[5] Kramer, M. (1993): Betrieblicher Umweltschutz, Wiesbaden
[6] Kürzl, H. (1999): BUIS der 2. Generation – von funktionalen Lösungen zur Praxisintegration, in: Rautenstrauch, C.; Schenk, M. (Hrsg.): Umweltinformatik 99: Umweltinformatik zwischen Theorie und Industrieanwendung, Marburg
[7] Müller-Christ, G. (2001): Umweltmanagement, Umweltschutz und nachhaltige Entwicklung, München
[8] Rautenstrauch, C. (1999): Betriebliche Umweltinformationssysteme: Grundlagen, Konzepte und Systeme, Berlin, New York.
[9] Rey, U., Schnapperelle, D. (1999): Transferplattform zur Darstellung IT-gestützter Werkzeuge im betrieblichen Umweltschutz; in: Dade C., Schulz B. (Hrsg.) Management von Umweltinformationen. in vernetzten Umgebungen, Marburg, 1999, S. 146 - 150. 1.
[10] Schlatter, A. (2000): Der ökonomische Nutzen Betrieblicher Umweltinformationssysteme – Eine Evaluationsmethode, in: Hilty, L.; Schulthess, D. Ruddy, T. (Hrsg.) Strategische und betriebsübergreifende Anwendungen betrieblicher Umweltinformationssysteme, Marburg
[11] Heinrich, L.; Lehner, F. (2005): Informationsmanagement, 8. Auflage, München, Wien
[12] Beucker, S. et al. (2002): Betriebliche Umweltinformationssysteme und ihre Funktion für die Ressourceneffizienzrechnung. Ergebnisbericht 2.3 des Forschungsprojekts CARE, Stuttgart

Sustainable Online Reporting Model – a Web Based Sustainability Reporting Software

Andreas Solsbach, Daniel Süpke, Benjamin Wagner vom Berg, Jorge Marx Gómez

University of Oldenburg

solsbach@wi-ol.de, suepke@wi-ol.de, wagnervomberg@wi-ol.de, jorge.marx.gomez@uni-oldenburg.de

Abstract. The chapter presents the main motivation and achieved goals of the project "Sustainable Online Reporting Model" (STORM) and successive research based on the developed prototype. STORM was established in September 2009 and ended in September 2010 with the aim of developing a web based sustainability reporting software based on dialog-based communication, efficiency, expandability and adaptability. The chapter will give a short introduction to the project group and the project STORM which was performed in an interdisciplinary approach at the University of Oldenburg by combining a business informatics project group and economic project group called "Sustainability and Management in Web2.0". The chapter will present furthermore the reference architecture of dialogue-based sustainability reporting system. Further information is available on the project website of STORM (2010) including a Live-Demo of the system. The chapter will present an outlook on ongoing research in our faculty e.g. for inter-organizational sustainability reporting.

Keywords: Sustainability Reporting Software, Environmental Information System, Web 2.0 Sustainability Reporting

1 Introduction

In recent years, the idea of sustainability has become one major point of interest for companies and an emerging research field with new ideas and problems to be solved by companies and universities [6], [9]. Companies as well as researchers are discussing the impact of the demand for environmental information of the public and the current state of sustainability reporting done by companies lacks to support a dialogue between companies and stakeholders. The companies are transferring the chapter sustainability reports into the internet and using technologies such as a basket of goods [in our case sustainability information], the portable document format and an email form for a single-sided dialogue. All these technologies or measurements are not supporting the idea to involve the stakeholders and

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_13,

bonding them to the company by sustainable oriented dialogue which will be a benefit from our perspective.

A thesis conducted [3] identified a gap within sustainability reporting software systems, with only one available open source sustainability reporting software called “Corporate Environmental Reporting for Business Related AffiLates” (cerebral) developed in 2006 to 2007 in our faculty. The architecture and technologies used for STORM differ strongly from the cerebral architecture, mainly by introducing dialog-orientation, automation, expandability and adaptability.

The motivation of the project group STORM was to develop an open source sustainability reporting system based on current state-of-the-art technologies supporting web 2.0 functionalities. These were used to establish a continuous dialog between reporting companies and interested stakeholders, designing adaptable software by using software modules and defining interfaces to extend the current software with new functionalities. Such software could be especially interesting (but not limited) for small and medium-sized enterprises, which need a sustainability reporting software to support structuring, generating and delivering of sustainability reports to interested stakeholders, such as organizations, enterprises, public, finance analysts or any other interested group. Furthermore, also internal reporting and environmental management can be strongly improved using this tool, helping companies to assess their environmental impact.

The project group STORM started in September 2009 together with a project group of the economic science as a trans-disciplinary approach to design and realize a web-based sustainability reporting software and ended September 2010 with a prototype which has been published under the open source Berkeley Software Distribution license on the 25th of October 2010. The project enlarges the soft skills and software engineering know how of the students by involving them in a one year project under assistance of the business informatics section I of the university of Oldenburg.

2 Motivation

Sustainability reporting is increasingly used by large companies. In a ranking from 2007 none of the 30 biggest German companies (DAX30) were listed as “non-reporter” any more [2]. However, the same is not true for Small and Medium Enterprises (SMEs). In a market study of 2008 nine software systems for sustainability reporting have been analyzed [3], with the only free one being cerebral. Considering that one of the issues of SMEs not reporting is found within the lack of resources [1], the high costs of available sustainability reporting systems can be seen as one of the main points for a lack of participation.

Another issue is the presentation of sustainability reports; even though the content has improved with the development of standards like GRI G3 and a shifting focus from print media to web media, the potentials of the new, social and community-based way the web is used, is not even closely used to its potential [8]. Related, most reports are still delivered in terms of a monologue, dialogue is rarely going beyond preliminary stakeholder round tables. Thus, the second main point being dealt with in this chapter is the question, how the benefits of the web 2.0 can be used to enable a truly dialogue-driven sustainability reporting.

3 Reference Architecture

The reference architecture presented here is an updated version of [9]. This view presents the interaction of different components in a clearer way.

The goals of the reference architecture are twofold: For one, it needs to serve as a template for different companies and different IT-environments.[1] Within this, the focus of the architecture should be put on efficiency (in order to reduce resource amount required for comprehensive reporting), effectiveness (by supporting accepted standards and provide structured, comprehensible reports), and exchangeability (in order to allow sub companies, ministries etc. to easily access and compute data). The second goal is to utilize the advantages of the web 2.0, providing true and continuous stakeholder dialog, and to use network effects and user data to improve and tailor content for specific readers.

To demonstrate how the reference architecture aims to achieve the first goal, we will present it in Fig. 1 and afterwards talk about the different modules and how they interact to provide efficiency, effectiveness and exchangeability.

The item within the middle rectangle represent the components directly under company control, the upper part is the visible web site for the general public, while the lower part contains external entities. The central component for all data exchange is the schema.

A schema is an abstract representation or definition of all content and guidelines a report has to follow, if it should be valid against certain standards. Such a schema could be G3. Therefore, all indicators such as water consumptions are described along with their units of measurement, methodology for data retrieval and a unique identifier to ensure comparability and support date exchange.

[1] As mentioned, the regards of SMEs and first time reporters should be considered, providing an easy to use, guided reporting system based on standards. However, there is no special focus, the architecture should provide new terms of efficient reporting (and dialogue) for all reporting organizations.

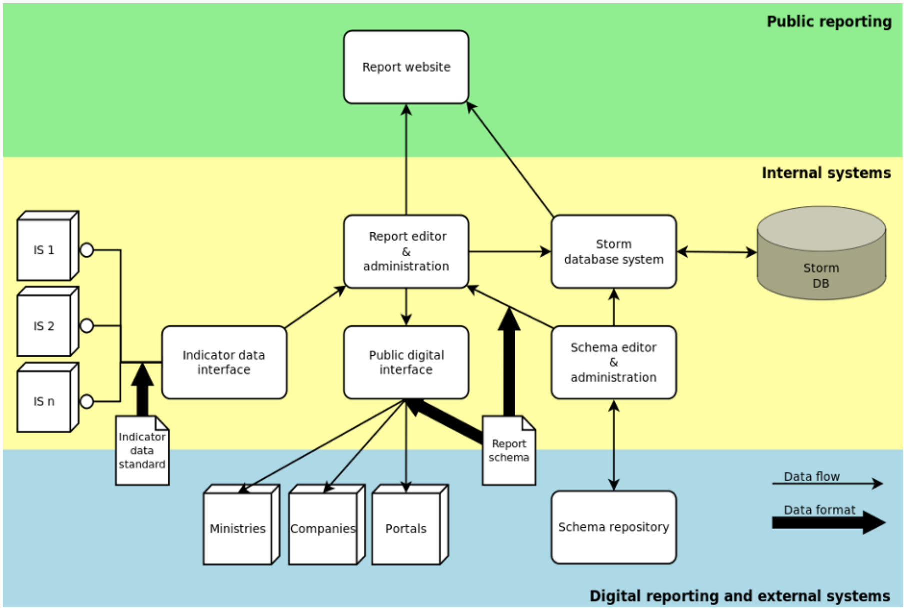


Fig. 1: Reference architecture for sustainability reporting (without dialogue modules)

For every report, a schema has to be defined in the schema editor. To avoid every company having to define their own standard from scratch, common standards such as GRI or EMAS could be retrieved from a central repository and extended within the company's schema editor as fit.

When a new report is being started, a schema is chosen and the indicator templates copied to a specific report. Now, all the editor has to do in the first step is to use the computer guided web-editor to fill out the indicators and articles step by step, based on the descriptions given in the schema. To support efficiency and to fulfill demands for integration in environmental management information systems [4], data interfaces can be defined for indicators. This can be done in two ways: Either a direct data connection is established (e.g. accessing a mysql database directly) or a service interface is defined, where the available information systems can connect to. This way, existing EMIS and ERP (Enterprise Resource Planning) systems can automatically provide data to the report, theoretically even enabling a daily actualized reporting system.

Providing a public digital interface for automated and easily computable retrieval can enable companies to easily include data from sub companies or export data to them, e.g. to establish reporting along a supply chain. Furthermore, ministries environmental portals, investors etc. can easily retrieve data and compute that automatically.

All data is stored and retrieved internally using a data access layer, here named as *Storm database system* (naming explained later within this paper). Of course, finally the report will be presented in a suitable fashion on the company's web site and be accessible to all stakeholders. However, in this generic architecture, while allowing efficient, effective, and exchangeable sustainability reporting, stakeholder dialogue has not been included. Not all companies may yet be ready to allow open stakeholder communication, this is way the architectures are separated.

In Fig. 2, stakeholder dialogue is supported by the introduction of web 2.0 modules and a central feedback component. The actual functionalities of these modules may vary and will be demonstrated in the prototype chapter. These functionalities are introduced as optional modules, because they may be critical to the company in two ways: If open dialogue is possible, it may be used to provide critical comments and ratings by users. A company not ready for this should not use such functionalities yet and wait until they are ready to embrace stakeholders fully. Second, if stakeholders participate, the company needs to react and talk to stakeholders, which means providing time and personnel. When resources are low (e.g. in SMEs), such modules don't need to be activated, while still providing a fully functional (yet not dialogue-based) sustainability reporting. If enabled, using a central user feedback module will help to respond to the various communication methods on the company's web site as well as on external web sites (such as facebook or twitter) in a concerted fashion. Finally, a central module will vastly help web mining to improve the report on the fly, as well as prepare for the next report cycle.

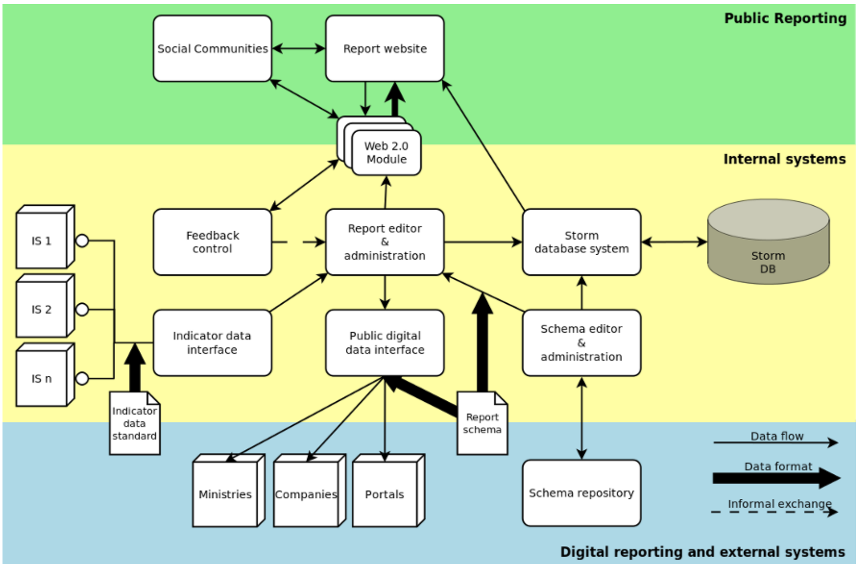


Fig. 2: Reference architecture for sustainability reporting with web 2.0 support and stakeholder dialogue

4 Prototype

In the following we will describe the prototype. The prototype is completed and full functional. The prototype provides different functions and user interfaces depending on the role of the user. There are three general user groups:

- Administrator
- Editor
- Public user/Reader

The prototype also includes several web 2.0 features that are integrated in the application. The application is multilingual. Actually STORM provides German and English language. The prototype is especially applicable for SMEs because it provides all functions for creating a sustainability report in an easy to use interface with no need for a deep knowledge in sustainability reporting of the editor.

4.1 System Administration

The system administration offers the administration of modules and users. STORM is an adaptable application and allows activating and deactivating single modules according to the individual requirements of the company that uses the application. A module contains a certain comprehension of functions and is technical a controller. Every module has its own user rights and parameters. The module concept allows an easy extensibility of the application by adding new modules e.g. for web 2.0 features. A new module contains at least one controller.

The user administration is based on a role concept for an easy and efficient administration. Every right is connected to a certain module. A user right can allow the use of a certain action within a module (controller-action-combination) or the use of the whole module (user right: controller-*). One user can be attached to multiple roles and one role can contain an arbitrary set of rights. Roles can be created individually according the companies requirements. There are four roles provided in the standard delivery condition:

- Anonymous – This role gets every visitor of the website initially.
- User – Registered users.
- Editors – Editors can create reports, edit articles and administrate the media library. Also this user can release reports and create and administrate schema.
- Administrator – This role contains all available rights.

A special feature is the follower-function. The follower-function allows the user to follow others users he is interested in. The follower-function affects the recommender engine and the user gets articles that were read by a follower as suggestions. A scenario would be that a student adds his professor as a follower.

4.2 Public Area /Readers Area

The public area provides all information for stakeholders and other readers of the sustainability report of the company/university. On the starting page (Fig. 3) the recipient gets some general information and already several dialog-oriented and web 2.0 features that give additional information and can actively used to communicate with the company or other users. The application can be used personalized or anonymous. The personalized version requires a username and a password that the user needs for sign-in at the starting page. The personalized version provides additional features for personalization compared with the anonymous version like e.g. a comment function.

The main menu bar on the left side has several items for navigation. In the report item are shown all published sustainability reports ordered by the year of publishing. The main chapters of every report can be directly opened from the menu bar. The report contains both indicators and articles (e.g. mission statement). By a very easy to use function the user has the chance to rate every single article. Also it is possible to export the article in PDF- or a structured xml-format. With another item it is possible to add an article to the info cart. The info cart is a feature similar to a shopping cart in web shops, where the user can collect interesting articles and save them. The info cart option is available for registered and anonymous users. The info cart can contain an arbitrary number of articles and the user can create multiple info carts. Articles for the actual info cart are shown at the info cart item. If articles are selected only from one report, they are ordered according the report schema. If articles are selected by different reports they are ordered by time of selection. There are more personalization options for info carts like modifying the content or the name of the info cart. It is also possible to publish public info carts for different groups of stakeholders, e.g. staff. These info carts can be selected from the main menu. The content of the info cart is used by the recommender engine as well (see section recommender engine).

The comment function allows the registered user to comment on articles or other user comments. The comment function is available about the “add comment” button.

Registered users can also tag single articles. The tagging effects the recommender engine and the tag cloud. The tag cloud is also integrated in the starting page (Fig. 3) and shows the most important tags in different font size analyzed by relevance and frequency.

Fig. 3. STORM – starting page of public area

4.3 Editorial Area

The editorial area contains functions for creating and modifying reports, articles and schemas. This area has to essential editor functions, the schema editor and the report/article editor.

4.3.1 Schema Editor

The schema editor provides a basic schema that is build according the reporting framework (G3) of the Global Reporting Initiative (GRI). In sustainability reporting the G3 framework has become a worldwide standard. It is possible to create any other schema based on different guidelines or an individual schema. Within a schema it is possible to mark single guidelines as optional or as required. The content is divided in qualitative (report text) and quantitative (indicators) content. The schema editor provides a graphical user interface (Fig. 4) that shows the schema structure and details and allows editing a schema in an easy way.

The editor mask is divided in a menu and a workspace. It is possible to create, edit and delete schema. Also it is possible to import schema as a new schema or importing a schema in an existing schema. Schemas are divided in levels. Levels can be added, deleted or moved inside a schema. Categories can be created arbitrary and allow to group indicators.

Fig. 4. STORM – schema editor4.3.2 Report- and Article-Editor

The editor for reports and articles is the main component to create and edit sustainability reports. Every report has one of the following statuses according its processing stage:

- new,
- in progress,
- closed,
- published.

Some statuses are set automatically or are connected to a workflow. E.g. the status "published" to publish a report on the website can only be set when all articles of the report have the status "approved".

The editor for articles is based on the Tiny MCE-Editor (Fig. 5) and it is integrated in the application. This editor provides multiple functions like changing font size, font color, listing and the integration of multimedia content.

Multimedia content like pictures and videos is stored in a special library within a file system and the files are linked with an article. Indicators of an article can be filled manually or by the import from external systems like SAP. The user gets values of an external system as a suggestion and can decide if he accepts the value or rejects it.

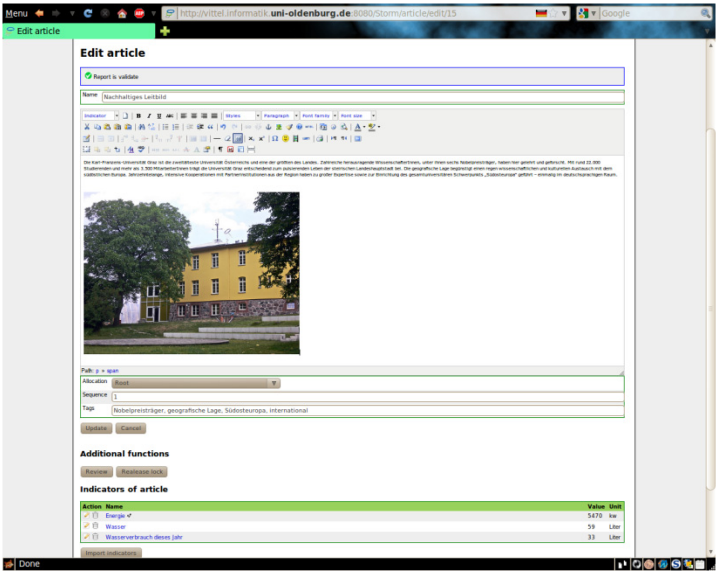


Fig. 5. Tiny MCE-Editor integrated in STORM4.4 Recommender Engine

The recommender engine is one important module of the application. The recommender engine is providing suggestions for articles to the user that might be interesting for him. Suggestions can be based on various ideas like e.g. the most read articles or articles that are interesting for certain groups.

For every function the recommender engine provides an offline- and an online-algorithm. The offline-algorithm collects the data for a function and is running on the server. The online-algorithm is working on runtime and selects the user specific suggestions from the data of the offline-algorithm. The following article selections are supported by the recommender engine and are shown at the starting page of the public area individual for every user:

– most viewed articles,
– last viewed articles,
– similar articles,
– articles viewed by followers,
– articles for your interest group.

4.5 Additional Features

The application provides a range of further features partial related to web 2.0 and dialog-orientation that should be shortly described:

– Auto-complete: The auto-complete function supports the user when he makes entries in the search form. The function is using the RichUI-plugin.

- Language selection: STORM is available in different languages and can be easily adapted for further languages. Language variables can be set for label text of buttons, menus and the help function but not for articles. For switching the language the starting page includes a selection box.
- Template selection: The system provides different templates for the look of the application. The template is activated in the administration menu.
- RSS-Import: To integrate external RSS-feeds in the application they can be imported about the administration menu with different options and parameters.
- Newsletter: For a newsletter function that allows registering for a newsletter in the public area and sending newsletters there can be integrated an external newsletter tool.
- Question system: The question system allows the user to ask questions, to comment on questions and to read the answers. The system is following the idea of "ask the president". Answers can be administrated in the administration menu by authorized users.
- Help system: STORM provides a help function for supporting the user in working with the application. Help texts can be added/edited by the administrator.
- News: STORM provides a news section in the public area.
- Social Bookmarks/Networks: The application provides buttons to add the site to social bookmarks like e.g. Delicious or Mister Wong. Also he can add single articles or reports on social network sites like Facebook and to rate them.
- Twitter: Twitter is specially integrated in STORM that allows editing tweets directly in the application. This service is based on JTwitter and provides all basic functions.

5 Conclusion and Outlook

The paper presents the results of the project group STORM, the reference architecture for dialogue-based sustainability reporting and the STORM prototype. The benefits of dialogue-based sustainability reporting are based on direct linkage between the public (such as costumers) and the reporting company, yielding increased value of user-enriched report content and feedback mechanisms.

The paper describes in a short summary the trans-disciplinary approach at University of Oldenburg by the teamwork of two project groups (one from economic science and one from business informatics) which are focusing on analyzing and generating a list of requirements for a dialogue-based sustainability reporting to be a first step for a later sustainability report of the University of Oldenburg.

Furthermore the reference architecture of dialogue-based sustainability reporting is described and presented in this paper. This identifies several components necessary for a reporting system enriched with dialogue between stakeholders and the reporting company to generate added-values and to increase the connection between stakeholders and the reporting company. The reference architecture uses web 2.0 modules to allow stakeholders to be involved in the process of generating a sustainability report or to increase the value of reports. As an outlook this reference architecture can be extended to the idea of inter-organizational sustainability reporting:

The approach of inter-organizational sustainability reporting has the aim to consider the information from suppliers and customers for a sustainability report by extended current sustainability guidelines and standards. Currently reporting standards are not able to include not-wholly owned subsidiaries or any other kind of supplier for their sustainability report. The guidelines lack support for companies to involve the data of theses partners due to a missing guideline on how to handle these data. Exemplary, the GRI guidelines G3 mentions that companies should involve information from other companies which have an influence on the environmental impact but the guidelines are still missing on how to handle this information. They are not suggesting that non-qualitative indicators as scope of involvement, duration and similar should be included.

The third presented aim of this paper was to present the STORM prototype which allows generating sustainability reports in a web browser. The paper shows an open source sustainability reporting software which is highly configurable due to a modular approach, where certain functionalities are optional to use. Exemplary, an assistant system which helps companies to do the first steps to introducing sustainability reporting systems or an extension to support the eXtensible Business Reporting Language to introduce a semantic layer for the presented information could be an extension of STORM in following up web 2.0 modules or new components.

References

[1] Coope, R. (2004): Seeing the “Net potential” of online CSR communications - Learning from the best and worst on the Web. Corporate Responsibility Management, 2004, pp. 20-25

[2] Gebauer, J. and Westermann, U. (2007): Nachhaltigkeitsberichterstattung in Deutschland - Ergebnisse und Trends im Ranking 2007. Berlin, Münster: Institut für ökologische Wirtschaftsforschung (IÖW) und future e.V.

[3] Stammel, H. (2008) Software-Werkzeuge zur Nachhaltigkeitsberichterstattung von Unternehmen - Marktanalysee und Benchmarking. Individual project, University of Oldenburg

[4] Junker, H.; Marx Gómez, J. Lang, C. (2010): Betriebliche Umweltinformationssysteme. In Schumann, Matthias et al. (Hrsg.): MKWI 2010.

Track Betriebliches Umwelt- und Nachhaltigkeitsmanagement. Universitätsverlag Göttingen, 2010, pp. 1045-1062
[5] Solsbach A.; Marx Gómez J. and Isenmann R. (2010) Network publicity – An approach to Sustainability Reporting from a Network View. In Proceedings: ISEE 2010 - International Society for Ecological Economics 11th Biennial Conference (Conference paper)
[6] Solsbach A. and Schubert A. (2010). Anforderungen an die IKT zur unternehmensübergreifenden Nachhaltigkeitsberichterstattung. In: Wittmann J. and Maretis D. K. (Eds.) Simulation in Umwelt- und Geowissenschaften, Workshop Osnabrück 2010, Aachen Verlag 35-43
[7] Sustainable Online Reporting Model (STORM) (2010) Project website of STORM. http://www.storm.uni-oldenburg.de/. Accessed 17 December 2010
[8] Süpke, D.; Marx Gómez, J. and Isenmann, R. (2009): Stakeholder Interaction in Sustainability Reporting with Web 2.0. In: Marx Gómez, J.; Rizzoli, A.E.; Mitkas, P.A.; Athanasiadis, I.N. (Hrsg.): Information Technologies in Environmental Engineering (ITEE 2009) - Proceedings of the 4th International ICSC Symposium Thessaloniki, Greece; Springer, Berlin. pp. 387-398
[9] Süpke, D. (2010). Reference Architecture for Dialogue-Based Sustainability Reporting In: Greve, K.; Cremers, A. B. (Eds.). EnviroInfo 2010 - Integration of Environmental Information in Europe; Shaker, Aachen, 480-487

Web Service-enabled Collaborative Corporate Environmental Management Information Systems

Nabil Allam[1], Tariq Mahmoud[1], Jorge Marx Gómez[1]

[1]Carl von Ossietzky University of Oldenburg

nabil.allam@uni-oldenburg.de, mahmoud@wi-ol.de, marx-gomez@wi-ol.de

Abstract. In this chapter authors present the Web Service-enabled CCEMIS solution that is mainly relying on the idea of supplying Web Services from different CEMISs to handle corporate environmental issues. This solution reduces the efforts to achieve a legal compliance environmental management. It proposes an environmental collaboration between companies via summing up all the required information from different involved players in form of Web Services. In this solution, the companies will act as consumers and providers at the same time. They are both requesting and supplying environmental data. They maintain their identities by not revealing the information regarding their resource details.

Keywords: CEMIS, collaborative CEMIS, web-services.

1 Introduction

Corporate environmental management information systems are organizational-technical systems for collection, processing and making the data relevant to environment available [1]. For more than two decades theoretical and practical researches on CEMIS took place. Based on results of these research projects, there are many different CEMIS in the market that are providing several approaches to solve environmental issues in companies. However, these systems are rarely used in the day-to-day work in the German enterprises [5; 7; 4]. In Germany, around 0.18% of the taxpayer companies are ISO 14001 certified and much less are EMAS[1] certified (Table. 1). In an empirical research, Perl [5] stated that the reasons for this insufficient situation are:

- High costs to supply these systems;
- High expenses to install and maintain such systems and
- Particular absence of necessitated information.

[1] Eco-Management and Audit Scheme

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_14,

Table 1. Certified companies in Germany

	Quantity	**Percentage**
Taxpayer companies (2007)	3,140,509	100%
ISO 14001 certified (2007)	5,800	0.18%
EMAS certified (2007)	1,979	0.06%

Source: based on [11; 12]

In scientific discussion, environmental activities are separated in proactive and reactive measures. Reactive handling of environmental issues means that the companies comply with legal and achieve industrial standard [2]. Especially small and medium-sized companies often don't have enough resources for proactive environment management. Proactive environmentalism is found mainly in big companies where resources are available to use new technologies. If so, proactive environment efforts support production oriented environment protection. This allows utilizing environmentalism as a competitive advantage [6].

In order to apply proactive environmentalism in small and medium-sized businesses it is at least necessary to manage internal environmental issues such as legal compliance and environmental certifications in a simpler manner. For this reason, only compliance issues will be discussed in this article to open new options for proactive environment management. To support these proactive efforts, one possibility is the approach of collaborative corporate environmental information systems. C CEMIS should be understood as systems at inter-company level.

You can differ between vertical, horizontal and diagonal cooperation. Vertical cooperation refers to successive value-added steps alongside of the supply chain [8]. Horizontal cooperation is networks of companies that work with each other on the same level of enterprise in the same industry [8]. The companies of diagonal cooperation are from different industries and work together in variable value-added steps. There is some scientific research about vertical cooperation in the academic discussion for environmental issues. Environmental horizontal cooperation is rarely presented but there are some projects in Asia (e. g. India) and North America [16]. However, diagonal forms of cooperation are till now not discussed, even though there are many suitable industry parks where such cooperation is possible. It refers to collaboration among geographically proximate individual firms to physically exchange by products, share in the management of utilities, and share ancillary services[2]. This kind of cooperation networks brings synergistic effects for all participants of such collaborations. Furthermore such systems would simplify environmental management. This means that it:

- Allows to use CEMIS for low cost;

[2] Theoretically, firms can share ancillary services, such as transportation, landscaping, waste disposal/collection, and share the management of their utilities, such as energy, wastewater treatment or water… It is also possible to build common organizational infrastructure such as buying syndicate.

- Reduces the overall costs of environmental protection;
- Reduces the investment to use such systems;
- Supports increasing material and energy efficiency;
- Supports Emission reduction,
- Enables exchange of information between companies and
- Permits the increasing of the competitive advantages by realizing economic and environmental benefits simultaneously.

Pressure by governments and societies will increase in the next years in this direction. Companies are forced to handle with it in a sustainable manner. This will have a direct impact on the individual companies. The implementation of successful CCEMIS will help to deal with it. The inter-company approach reduces the investments to fulfill environmental legal compliance and eliminates existing barriers for proactive environmentalism. Actors engaging in CCEMIS are thought to be motivated by potential economic and environmental benefits.

1.1 Inter-Company cooperation

Cooperations between companies are growing based on the drive of globalization from marketplaces and the internationalization of competition consequentially[3]. Collaborations today are presented along supply chains preserving the market position to get advantages in competition. Thus, consideration focuses on business shift more and more from the individual enterprise to the complete Supply Chain (SC). To effectively handle such production structures, Supply Chain Management (SCM) concepts are used. They provide tools to plan, control and monitor the business processes in a SC to meet customers' and the involved parties' expectations.

An Environmental Supply Chain (ESC) uses the given possibilities on a SC [9]. The enterprise borders here are no more the frame of action for environmental efforts. The application of such inter-plant cooperations can be different. For example, if the physical flows are focused in the collaboration, the vertical material flow management can be applied[4].

SC gives and limits possibilities of inter-company cooperations at the same time. With the focus on a SC, the cooperation is dependent on all of its participants. On the one hand, if one of the companies in the cooperation doesn't want to work on environmental issues, the whole sustainable efforts are endangered consequentially. On the other hand, many of the existing environmental efforts in network are initiated from an influential company such as car manufacturer. Subcontractor or suppliers works in the network under constraint with the focus dic-

[3] The reduction of the real net output ratio: the depth of added value is the result of globalization. The real net output ratio presents the part of additionally bought services/products in relation to in-house efforts [9]. At 1981, the real net output ratio was 71% and today it is nearby 43% [10].

[4] The material flow between different companies represents the focus of such collaboration.

tated from influential company. One’s own initiative is very important in sustainable development and such cooperation is not ideal.

Horizontal cooperations are not widely-used in common business. Companies from the same industry on the same production level are normally in competition. It is very difficult to convince them to share data, information and activities to save environment.

An approach that is rarely discussed till now is the diagonal cooperation. Normally you have geographical concentrations of companies spanning various classes of business and on different value-added steps in industry parks. These companies do not have a lot in common except the location nearness. But especially this situation allows the use of synergistic effects. Most firms are not in competition in the market and there is no limit of business classes or SC. The cooperation doesn't depend so deeply on individual company. The participants work with each other because of the advantages through synergistic effects of such cooperations.
Another term that is implicated in this context is the industrial symbiosis[5]. The industrial symbiosis has been used to describe the physical exchange and shared management of input and output materials by geographically proximate firms. Most studies have focused on the technical aspects of symbiosis rather than organizational, social facets or the use of information systems to support the cooperation [18].

1.2 Synergistic effects through collaboration

Companies that have been actively working towards saving the environment often find it increasingly difficult over time to further improve their environmental efforts. Sooner or later the environmental activities within the firm borders become expensive. Collaborations open new ways for environmentalism. Also companies that don't have a lot of work on environmental management can be animated to introduce an environmental management system to increase their environmental efforts.

Based on the achievement of Perl's empirical research [5], the synergistic effects will be separated in three categories[6]:

- Costs reduction;
- Expenses reduction and
- Increasing necessitated information.

---

[5] In the industrial ecology field, the term industrial symbiosis was first used to describe the high level of resource cycling among separate firms in Denmark. Industrial symbiosis describes cooperations among firms in a region to physically exchange and share the management of resources such as raw materials, energy and any input and output materials [17].

[6] Most of the advantages influence all the three categories but the categorization helps to structure them.

Sharing a software system is cheaper than developing or buying one. Using a system that serves collaboration functionality allows planning and executing activities in common. For example, it is possible to arrange employee training or use consulting services for energy efficiency in a community or manage the disposal of hazardous material together. Companies can build buying syndicates or use a product transport in common. These few examples give an overview about the ways to reduce costs in collaboration.

Independent of the type of enterprise, the appropriate regulations, conditions, and documentations are basically the same [13]:

- Licenses and conditions: Are a collection of legal regulations for facilities and machines. Technical facilities such as waste utilizing and sewage disposal are affected in particular.
- Training: Above a certain size of an enterprise, legislation requires staff to take part in training regularly including environmental education. The management of such training is difficult to handle.
- Register of Laws: All laws and regulations that are relevant for the enterprise have to be accessible to the staff are collected in a so-called register of laws.
- Hazardous Materials Management: If hazardous materials are used by an enterprise, a register of hazardous materials is required by law. Important data are: place of storage, place of utilization, quantities, and classification of danger for human and environment.
- Facilities and Machines Management: In addition to the register of hazardous materials, operating instructions are also required for machines and dangerous facilities.

This gives different options to reduce expenses when companies work with each other like using the same register of law from the same database. If a law is changed, only one database must be updated. Also material safety data sheets for hazardous materials should be checked once a year. The materials that are the same in different companies must not be checked by everyone. They can be separated so that every participant manages a few of the hazardous material information.

A CCEMIS must provide a platform where exchange of experiences is possible and where environmental problems can be discussed. This helps to increase necessitated information and reduce the fears to implement environmental management.

1.3 Requirements for CCEMIS

Based on the investigation done by Elke Perl [5] and the theoretical concepts of CEMIS in the literature, all the requirements for CCEMIS can be defined as follows:

Equal Rights for all participants

First of all, the participants of such collaboration must be strongly involved in the network for a successful CCEMIS. The additional values from the cooperation must be available for all. The companies' attitude towards such collaboration is essential. Also it is important that in each company a defined work group manages the implementation of a CCEMIS because of the complexity of such system. Furthermore, an environmental management system must be integrated in the whole organization of a company and the CCEMIS software system that supports this effort must be available for all employees in a company regardless of their location.

Expandable and intuitive use

A system that allows such cooperation must be built in a modular manner. Gradualist policy[7] helps to avoid the problems of megalomania where projects try to achieve all the aims in one single step. This is the reason of many project failures [15]. Many companies don't engage in information systems to solve environmental issues and don't care about sustainable development [5]. Comprehensive changes here will scare firms to participate in such cooperation[8]. The incremental approach also helps to keep the financial investments low[9].

Guaranteed Data Privacy and Data Security

Data privacy protection and data security (integrity) are essential conditions for any business information system that also targets the avoidance of redundant data. Taking into consideration that communication and trust among actors must be recognized as very important. Especially for a system that supports collaboration, it is very difficult to create trust because there are organizational elements that can't be controlled by software in addition to the technical requirements. A CCEMIS must provide the possibility for any participant to decide which data can be used in a network i.e. which data can be seen by the other members. In some cases data anonymization helps so that it is possible to cooperate without information of the source. However, it is mostly necessary that participants are prepared to invest some of their "data" for a successful network. This can be the biggest barrier for CCEMIS implementation in the praxis.

Further requirement is the availability of interfaces to other company information systems. Ideally data input must be done one time from an employee and the data are available in all the other company information systems. Also it is good when a CCEMIS provides import and export functionality to standard software tools in a company like word processing software (e.g. MS Word, Excel or Open Office Writer, Calc) or PDF [5].

Non-functional requirements that have to be taken into consideration while defining the requirements are efficiency, performance, scalability, reliability so that

---

[7] Gradualist policy is the implementation of an information system in an organization step by step.

[8] Complexity scares companies to use software for the environmental management ([5] page 250). Modular software system allows companies to pick up the functionality that they need. The software for the environmental management can be expanded later with different modules. Individual adjustment is an important requirement for CCEMIS implementation.

[9] Based on the investigation of Elke Perl, financial aspects are one of the reasons why firms don't use software to increase environmental efforts.

the system can be always available in high performance, and issues like load balancing can be seen as future requirement of realization.

These requirements are more theoretical in nature and are not complete. It is also impossible to fall back on experiences of other software systems that are used in other business to business networks. Most of the networks in Germany and Austria don't use information systems to manage their cooperation [5]. To achieve significant results for CCEMIS it is helpful to develop a prototype that can be used in existing networks. The investigation of such a prototype will deliver detailed and practical oriented requirements that can't be fetched from theoretical investigations.

2 CCEMIS approach

With the requirements mentioned above, a CCEMIS approach is exemplary built to manage the use of hazardous materials. Based on European and German law on chemical substances, enterprises that handle with hazardous materials must provide up-to-date information about the materials and preventive measures [14]. A register of hazardous materials is required. Important data are:

- Place and quantity of storage;
- Place of utilization;
- Instruction for use[10];
- Risk assessment[11] and
- Classification of danger for human, animals and environment.

The storage and utilization information are normally regulated by a company but the other data are company independent. This can be managed by a network. For example, there are three companies that work with hazardous materials. Most of the substances are the same in the different firms. Instead of making every company updates its data alone, using central data storage helps to reduce the efforts to manage the data that must be updated yearly. And it gives the possibilities to exchange information like to substitute a material through another one.

2.1 Abstract Model for CCEMIS

To realize the CCEMIS concept, one possible solution is to expose all its functionalities in form of Web Services and put these services together as actions in form of workflows. One system that is fulfilling such prerequisites is the lightweight Semantic-enabled Enterprise Service Oriented Architecture (SESOA)

---

[10] Instruction for use is a document. It is created based on the information of a substance like the classification of it. This should be checked once a year.

[11] Risk assessment is normally combined in a work sheet (document). Also this should be checked once a year.

[19]. SESOA is an enterprise solution that links businesses to external systems based on Web Services. All the functionalities that are exposed using Web Services can be invoked by SESOA framework. This means that this framework can deliver traditional Web Services supplied by various service vendors, validate them following businesses' criteria, evaluate them and annotate them with semantics.

The main idea behind SESOA framework is to have an architecture that has the role of dealing with semantic annotations of services relations as well as representing the whole aspects of Web Services. In this way we can see the services as black box and both traditional and semantic Web Services can be used.

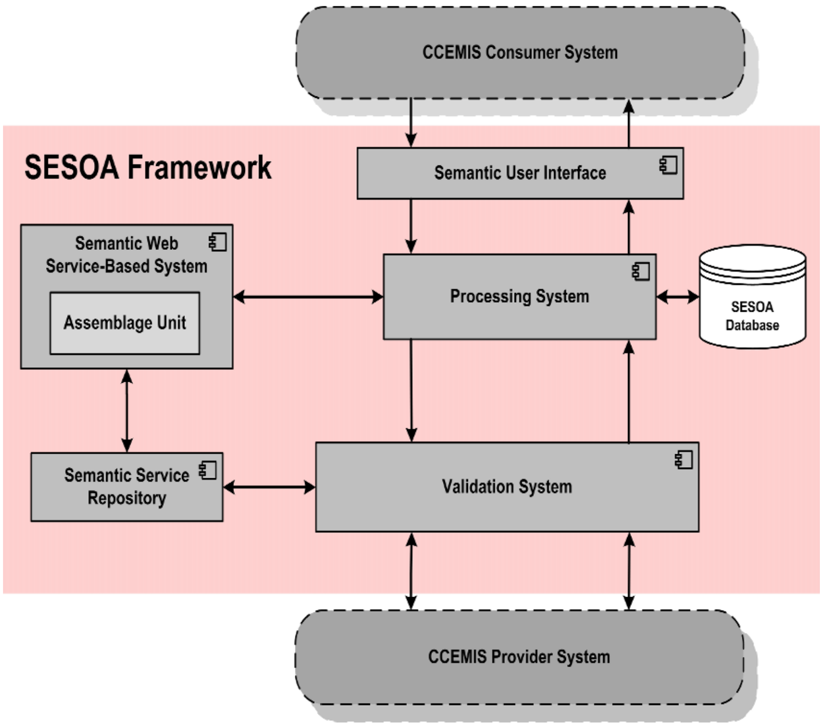


Fig 1. CCEMIS Realization Using SESOA Framework

Figure 1 represents the realization of CCEMIS using SESOA framework. The main and centric component in this framework is its processing system. It is workflow-based system from which all the business processes can be initiated. By relying on the workflow system, we can use the market best practices by storing workflows in an internal database named SESOA database. It is linked to CCEMIS consumer and provider systems using semantic user interface and validation system respectively. The semantic user interface has the responsibility of annotating the CCESMIS consumer systems requests' objects with semantics using RDFS schema. The validation system is validating the CCEMIS provider sys-

tems' services and annotates them with similar annotation used in the consumer side. The requests' and services' objects are related by assemblages in the semantic Web Service-based system. These assemblages are having the CCEMIS services as members and linking those services to the consumers' requests and storing it in the semantic service repository.
By using SESOA framework as realization for CCEMIS approach, all the aforementioned requirements can be fulfilled and the CCEMIS participants can easily provide their environmental relevant- data and consume it. Bigger amount of data can be shared using SESOA framework as a medium in the CCEMIS environment where all the players can hide their identity or reveal it depending on the data value and their policies.

3 Conclusions

The researches of diagonal cooperations represent new research direction. Refining the requirements of CCEMIS is the next step of the researches in this area. The processes of handling environmental issues should investigate how it is possible to handle it in a network and what the synergistic effects of collaborations in the different area of legal compliance are.

The proposed CCEMIS approach based on an abstract example of managing hazardous materials, how collaboration can help to reduce company's efforts for legal compliance. This can be a way to animate companies to manage environmental issues actively. It also gives reasons for enterprises to use software for the environmental management systems. The implementation of CCEMIS using SESOA framework is a way to fulfill its requirements. It is fully Web Service-based system where all the players can offer and ask for CCEMIS services. This approach allows reducing costs and financial expenses for introducing a new corporate environmental management information system. Also, it increases the information availability and helps to overcome the resistance to new technologies because other firms respectively a network of firms demonstrate its applicability.

References

[1] Marx Gómez, J.: Encyclopedia Business Informatics: http://www.enzyklopaedie-der-wirtschaftsinformatik.de/wi-enzyklopaedie/lexikon/informationssysteme/Sektorspezifische-Anwendungssysteme/Umweltinformationssystem%2C-betriebliches/index.html/?searchterm=BUIS, Oldenburg 2009
[2] Braun, B.: Unternehmen zwischen ökologischen und ökonomischen Zielen: Konzepte, Akteure und Chancen des industriellen Umweltmanagements aus wirtschaftsgeographischer Sicht, LIT Verlag Berlin, Hamburg - Münster 2003

[3] Funk, B., Möller, A., Niemeyer, P.: Integration of Environmental Management Information Systems and ERP systems using Integration Platforms. Springer Verlag 2009
[4] Lang, C., Gunnar, J.: Aufgaben betrieblicher Umweltinformationssysteme. Brauweiler, Jana; Helling, Klaus (Hrsg.): Internationales Umweltmanagement; Band II, Umweltmanagementinstrumente und –systeme pp. 77--¬100. Wiesbaden (2003)
[5] Perl, E.: Implementierung von Umweltinformationssystemen. Industrieller Umweltschutz und die Kommunikation von Umweltinformationen in Unternehmen und in Netzwerken. Wiesbaden: DUV (2006)
[6] Rebe, B., Schlitt, M.: Umweltverträgliches Wirtschaften: Wettbewerbsvorteile, Marktchancen, Wohlstandssicherung. Georg Olms Verlag 1993
[7] Wohlgemuth, V., Niebuhr, C., Lang, C.: Exchanging Environmental Relevant Data between ERP Systems and Industrial Environmental Management Information Systems Using PAS 1025. In: 18th Conference Informatics for Environmental Protection, pp. 183¬--193. Genf (2004)
[8] Pfohl, H.-C.: Logistiksysteme: Betriebswirtschaftliche Grundlagen. 7., korr. und akt. Aufl., Berlin: Springer Verlag (2004)
[9] Bleis, C., Helling, K.: Was kostet die Welt?: Moderne Kostenrechnung und Umweltkostenrechnung. Bd. 1, pp. 81. Berlin: P-und-H-Verlag (2002)
[10] Wildemann, H.: Wertschöpfung und Wettbewerb: Haben Unternehmen eine Heimat?, S. 11-92, München: TCW-Verlag (2005).
[11] http://www.umweltbundesamt.de/umweltoekonomie/ums-welt.htm (on 22-03-2010)
[12] Statestisches Jahresbuch 2009 (German statistics agency annual register 2009) S. 489 (http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/SharedContent/Oeffentlich/AI/IC/Publikationen/Jahrbuch/Unternehmen.psml)
[13] Allam, N.: Industrial Environmental Information Systems to solve Environmental Issues, Proceedings of ICTTA'08 IEEE, Damascus, Syria, 2008.
[14] Chemikaliengesetz (German hazardous material law) paragraph 14 – 3 – b (2008)
[15] Pieler, D.: Neue Wege zur lernenden Organisation. Bildungsmanagement - Wissensmanagement - Change Management - Culture Management, p. 30 (2003)
[16] Center of Industrial Ecology, YALE SCHOOL OF FORESTY AND ENVRIONMENTAL STUDIES, http://cie.research.yale.edu/industrial-ecology.html, 28 April 2010
[17] Chetrow, M. R., Ashton, W. S., and Espinosa, J. C. 2008: Industrial symbiosis in Puerto Rico: Environmentally-related agglomeration economies. Regional Studies. Forthcoming.
[18] Jacobsen, N 2005: Industrial symbiosis in the making: Bridging social and technical explanations-the case of Klaundborg, Denmark. Paper presented at 11th Annual International Sustainable Development Research Conference 6-8 June, Helsinki Finland.
[19] Mahmoud T, Marx Gómez, J. (2011) "Functional Components Specification in the Semantic SOA-based Model," in Semantic Technologies for Business and Information Systems Engineering: Concepts and Applications, IGI Global.

Classification of CEMIS Standard Software available on the German Market

Nabil Allam[1], Horst Junker[1], Manuel Christel

[1]IMBC GmbH Berlin

nabil.allam@imbc.de, horst.junker@imbc.de, manuel.christel@imbc.de

Abstract. During the last two decades different software products were developed to help companies managing environmental issues. At the same time the scientific discussion continued. Different approaches are developed to fulfill the needs of the market. Up to now, there is no empirical study to investigate the environmental standard software market about an impression of offered software systems and their functionalities, which can be used by companies. Within the project “IT for Green” we conduct such a study and start investigations to describe the actual standard software systems that are available on the German market. The project will present a simplified classification of CEMIS products on the German software market which makes the information accessibility for interested companies. This should help to remove barriers, that impede the use of these systems.

Keywords: Information systems, corporate environmental management information systems, software

1 Introduction

On the German market there are a lot of corporate environmental management information systems (CEMIS) that handle environmental issues in companies. Even so, such systems are rarely used in companies [9]. The market penetration of CEMIS is comparably small. Approximately 70% of the industry are using programs for spreadsheet analysis only such as MS Excel to handle environmental information. Most of the companies doesn't have an access to information about the use of CEMIS [10]. Removing this barriers helps avoiding this suboptimal situation.

Although, the CEMIS on the market provide different approaches for solving environmental problems and environmental protection in companies. Otherwise there are a lot of scientific research and discussions about CEMIS with the result

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_15,

of many suggestions, prototypes and proposals for CEMIS developments within the last two decades. The gap between scientific approaches and practical realizations in companies is huge and seems still raising. For example, nowadays some scientists are thinking about a CEMIS 2.0 even though there is no realization of a production integrated CEMIS in companies, which seemed to be required by the early beginning of the scientific CEMIS discussion twenty years ago.

The investigation of the range of CEMIS should help to downsize the gap between the scientific researches/discussion and the practical realizations. On the other hand it supports the penetration of these software systems in companies to advance the handling of environmental issues. Easy access to information can remove the barriers of rarely using CEMIS in companies.

2 Corporate Environmental Management Information Systems

Today, environmental issues are dealing on corporate management level. This is based on the late 1980s where companies were exposed to increasing pressure from national and international politics to internalize their impacts on the environment. The emergence of systems for voluntary eco-management, as e.g. EMAS or ISO 14001, expands the environmental efforts of the companies. A special category of information systems (IS) was created known as Corporate Environmental Management Information Systems (CEMIS) originated from the pressure to comply with environmental goals [6]. Such systems were originally developed to meet a limited number of external environmental requirements. Nowadays, a large variety of highly specific, heterogeneous solutions for different environmental issues exist in the market. Even so, no truly integrative approach to the topic has been taken to date. In almost all cases where CEMIS contribute to the solution of large-scale problems, this happens on an operational level only. The introduction of environmental management can be financially beneficial (e.g. higher efficiency, waste avoidance, reduction of resource consumption or winning new customer groups). However, it is questionable whether the scientific discussion/definition and the available CEMIS on the market are able to meet the complex environmental goals. Thus, to get an overview of the CEMIS market in Germany, it is advisable to understand what CEMISs are, as defined from a scientific point of view.

2.1 CEMIS definitions

There are different traditional definitions of CEMIS in scientific discussion. The most used definitions are (sorted by date):

1. CEMIS are a summary of all information systems, which serve the corporate environmental management [8].
2. CEMIS serve the IT support of corporate environmental protection [7].

3. CEMIS are organizational-technical systems for systematically obtaining, processing and making environmental relevant information available in companies [13, pp. 11].
4. [A CEMIS] is a corporate instrument for anticipatory, […], strategic and innovative acting, which detects environmental opportunities and risks. Such a system is not only for documentation, it is also for planing, monitoring and controlling [11].

The third definition from Rautenstrauch is most used in the scientific community. Based on this, there is also a definition from Marx Gomez [6] that provide a roughly classification of CEMISs from the operative point of view (Table 1). All of the presented definitions are not longer state of the art. They don't reflect the developments of information management and ignore the previous changes and experiences of business informatics. The traditional definitions have somehow operative point of view and don't recognize the holistic approach of information management. A strategic orientation is missing.

Table 1. CEMIS classification

<table>
<tr><th colspan="7">Corporate Environmental Management Information Systems (CEMIS)</th></tr>
<tr><td colspan="2">Reporting Systems</td><td colspan="2">Ecocontrolling Systems</td><td colspan="3">Systems for production-integrated environmental protection</td></tr>
<tr><td>Government</td><td>Society</td><td>Indicator Systems</td><td>Eco-balancing Systems</td><td>Input-oriented Systems</td><td>Process-oriented Systems</td><td>Output-oriented Systems</td></tr>
<tr><td colspan="3">Inter-organizational Sustainability Reporting</td><td colspan="4">Environmental Information Management</td></tr>
</table>

Source: [6]

Independent of the mentioned definitions, considering the increasing public debate about a sustainable society the expectations of industry are also growing. Instead of pure legal compliance, there is a growing demand on companies to reduce actively there environmental impacts. Companies shall work on an active environment protection. This does not only involve avoiding unnecessary waste, improving risk assessment or reducing resource consumption, but also inclusion environmentalism in companies' long-term strategic goals of being effectively beneficial. This means integrating the environmental protection in companies' decision-making and improving the general efficiency of production processes in terms of production-integrated environmental protection. To achieve this, a more complex CEMIS is needed than programs for spreadsheet analysis or a simple application that manages appointments. It is questionable whether individual CEMIS that exist only at operational level are able to meet the mentioned complex environmental goals. Additionally, such isolated solutions usually come with all the problems that business informatics experts try to prevent by constructing integrated systems, as e.g. data redundancy, heterogenous user interfaces inefficient communication etc. Considering this fact, it is even more surprising that the mistakes of business informatics of the early 1960 and 1970s are still being repeated, leaving companies with the high costs of integrating separate, outdated legacy systems.

2.2 Approach for a new CEMIS Definition

One of the problems of the CEMIS definitions is their arbitrarity. This leads to say that every thing can be a CEMIS, an Excel sheet or an environmental management book [10]. Comparatively with other computer science sector, it is unique to describe an information system as an system in paper mold. Nobody would describe an Excel sheet as a supply chain management system in a scientific publication. Only CEMISs are information systems which can be everything. A concentration of essential requirements for a CEMIS reduce the complexity of a definition of such a system.

CEMIS are information systems, which serve and support the ideas of sustainable development within an enterprise, on the strategic point of view. On a tactical point of view CEMIS are information systems, which deal in a holistic manner with:

- material/energy efficiency,
- emissions/waste minimization/reduction,
- disposal,
- stakeholder support,
- legal compliance.

CEMIS are corporate organizational-technical systems for forward-looking, strategic, innovative and operative acting, which helps to detect environmental opportunities and risks. It allows the systematically planning, processing, monitoring, documentation of (relevant) environmental information and makes this available for external and internal stakeholder. Such a system uses a centralized data base, provides a user authentication and user verification approach. It is not a program for spreadsheet analysis.

Basically a CEMIS is a company information system (CIS). The definition of such a system in the Gabler encyclopedia achieve the presented requirements mainly. Based on it:

1. A CEMIS is a collective term for environmental management software systems which allows the detecting environmental opportunities and risks.
2. It is a general approach for computer based planing, processing, monitoring, analysis, documentation of (relevant) environmental information and makes it available for external and internal stakeholder (to the different target groups).
3. The components of a modern CEMIS are:

a. a central data base to avoid issues of data consistency and data actuality and defined security approach for data privacy and data integrity,

b. with methods (algorithms) and
c. and a graphical user interface to handle the system with a user authentication and authorization.

3 Methodology and Basics of the Research

Considering the increasing number of possibilities to search for software products (in search engines, software catalogs, technical magazines and papers), it is essential to use a systematic methodology for this investigation. Therefore we adapted an analytical framework to analyze literature for our research from [3]. Instead of reviewing literature we use it to review software products. Such a framework describes the structure of a set of objects (papers, software etc) within a predefined domain and the relationships among those objects. It helps to clearly delineate the domain, organize knowledge transparent, highlight opportunities and organize the research procedure comprehensible. The five-step procedure we execute (Figure 1).

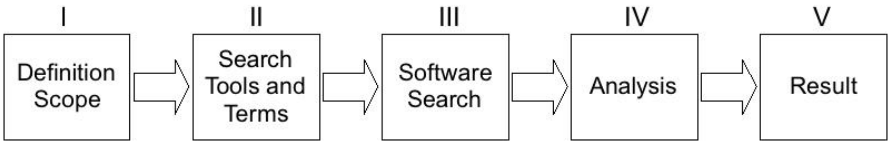


Fig 1. Framework procedure

3.1 Definition and Scope

This step contains the topic conceptualization and the definition of the investigation scope: The CEMIS discussion in the previous chapters covers the scope of the research and marks out the topic. Additionally, we limit the investigation of standard software products on the German market. The investigated tools should be industry-independent.

3.2 Determination of Search Tools and Used Terms

The search was focused on the Internet. You can essentially assume that a software provider use the internet for marketing. Used search tools are:

- German chamber of commerce and industry (CCI): It provides a data base with software products and services for the industry.
- Software-marktplatz.de: It is a supply of “isi Medien GmbH ISIS Medien”. It provides a software products catalog.

- Softguide.de: It is a software catalog.
- Asking software provider about known competitors.
- Different search engines: google, bing, yahoo, altavista.

The used search keys were concentrated on known legal compliance issues in companies and scientific discussion. All following criteria was combined with the term “software” and “system” (in German):

- Material Flow Management
- Emission
- Emission avoiding
- Recycling: Related to this term, we get a lot of software product for waste management enterprise. This type of software is not a standard software product and can't be recognized in the investigation.
- Electronic Scrap
- Eco
- Eco Design
- Waste Management
- Waste Avoiding
- Waste Reduction
- Environment
- Environment Management
- Hazardous Material
- Legal Compliance
- ISO 14001
- DIN 16001
- DIN 15232
- EMAS
- Material Efficiency
- Energy

3.3 Software Products Search

Building on the previous steps the search for relevant software products were conducted as showed in Figure 2.

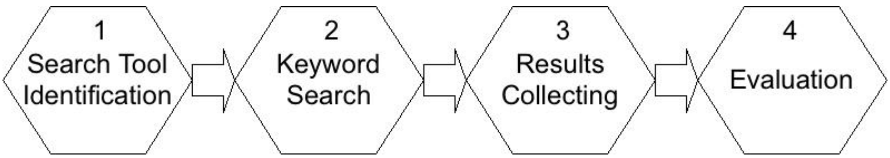


Fig 2. Search process

After identification of the search tools the pre-defined key words were applied to the search engines of each one. The results were collected in a sheet (name and URL). In the 4th step the websites of each product was visited and software description was analyzed. The functionalities of detected software (CEMIS) stood superficially.

4 Analysis

At the beginning of our investigation, we made two assumptions:

1. The most CEMIS is developed from companies which provide consulting services in environmental issues for companies.
2. We suppose also, that most of the software products are handling problems of legal compliance in the industry.

An Entity Relationship Diagram was build which allows describing a software product. It makes saving metadata of each software (technical characteristics, software provider etc.) possible and it describes the functionalities of each product. It simplifies building ratios.

During this step software data sheets and descriptions were analyzed by means of a systematic review of the functionalities that were presented on the websites of the software provider. For this purpose the morphological box from Marx Gómez (see chapter "CEMIS definitions") was simplified and adapted. Four classes were built to structure the results:

- Legal Compliance [2]: e.g. managing hazardous material or employment protection and industry safety
- Management / Controlling: e.g. creating ratios for more transparency about the environmental situation of a company
- Material Flow Management: building and calculation material flow netzworks
- Environmental Software (not CEMIS): e.g. energy management for buildings

4.1 Outcome and Classification

One of the objectives of this investigation is to make information about CEMIS and their use accessible for the industry. Therefore, we are trying to structure the classification as simple as possible.

The first supposition (most companies provide consulting services) is disproved:

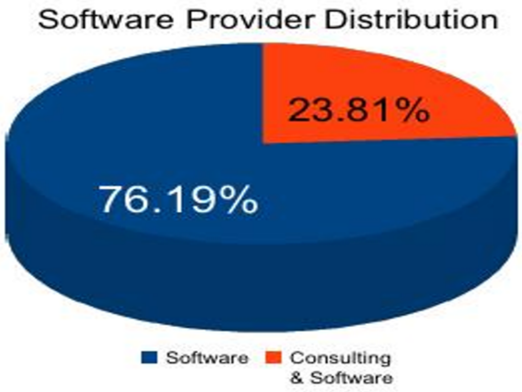


Fig 3. Provider distribution

Until now, we found 63 CEMIS providers in Germany. 76.19% of them are providing only software. All others are providing a composition of software and environmental consulting (e.g. ISO 14001 certification preparing etc.). The outcome of this is:

- the market needs such software tools,
- the software is professionally developed but
- you can't see any relation between origin of CEMIS and consulting in environmental issues.

Based on the history of CEMIS origins, you can clearly see, that the need of such software tools was not initiated by consulting companies.

The investigated 63 companies provide today 156 software products today. Based on the described functionalities on their webpages and data sheets, they are distributed to mentioned classes:

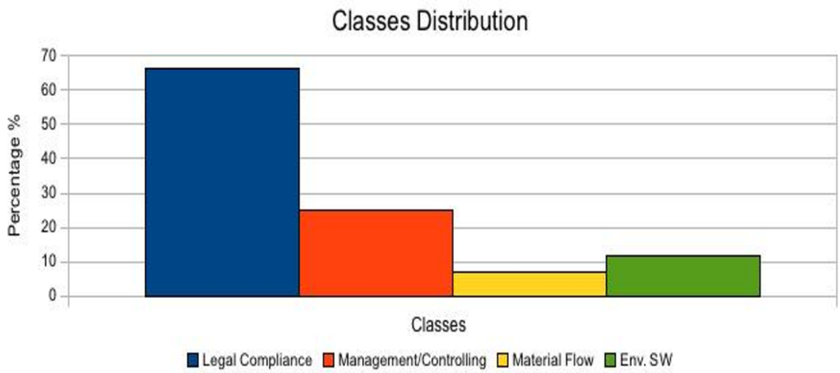


Fig 4. CEMIS distribution to the four classes

Figure 4[1]. approves the second supposition (most of the CEMIS are to manage legal compliance issues). This verifies the frequently-used statement, that the most companies are handling environmental issues in reactive measures[2]. [2]

4.2 Summary and Outlook

The software market in Germany provides a variety of functionalities. But we didn't found software tools which make an integration in a heterogeneous software environment possible. All the software products that are investigated appear very simple. The fewest are able to be used in a web-environment (have an access by a web browser). Many of them are software applications that have to be installed on a personal computer to be employed. Web services or similar technologies don't seems to be used in this domain. Only one of the 153 products provides such services.

The collected data will be prepared and provided on a webpage[3], where interested companies have the possibility to search a software product based on functionality requirements. This allows a problem-oriented search for a software product. It will not increase the proactive environmental efforts in the companies, but it helps to reduce the environmental issues in the industry and shows new ways to handle / improve environmental situation in an organization.

Preparing a form to interview CEMIS providers to get more information about the background of the software and their application. For example on till now, no software provider gives information about technical aspects of the software systems. Also, it was not possible to get clear proposition about offered interfaces to other systems (e.g. ERP systems).

The project has just started to investigate the corporate environmental management information systems in Germany. Next step will be refining and improving the results so the classification can be upgraded. The project is not about recognizing non functional requirements of the considered software products. This fact is very important to apply software products in companies. This must be integrated in next project phase. Another approach for the investigation is to survey companies that are already using CEMIS. Here is to ask:

- which software tools are used,
- which software tools are known at the market,

---

1 Percentage summation of the classes exceeds 100% because a CEMIS can be classified in different classes in the same time.

2 Reactive handling of environmental issues means companies comply with legal and achieve industry standard. Especially small and medium-sized companies often don't have enough resources for proactive environment management. Proactive environmentalism is found mainly in big companies where resources are available to use new technologies, if so proactive environment efforts support production oriented environment protection.

3 See www.it4green.de

- which are the decisive reasons for implementing those systems,
- which demands were made for a CEMIS product.

This will help to get new considerations of those software systems and give companies an understanding of CEMIS.

References

[1] Allam et.al. 2010: Allam, N.; Junker, H.; Marx Gómez, J. collaborative corporate environmental management information systems. Proceedings: 24th International Conference on Informatics for Environmental Protection (Cologne / Bonn) Germany. 197-204; Shaker Verlag

[2] Allam N 2008: Industrial Environmental Information Systems to solve Environmental Issues, Proceedings of ICTTA'08 IEEE, Damascus, Syria (2008)

[3] Fettke P 2006: State-of-the-Art des State-of-the-Art – Eine Untersuchung der Forschungsmethode „Review" innerhalb der Wirtschaftsinformatik. Wirtschaftsinformatik 48(2006)4, S. 257-266

[4] Gabler 2010: http://wirtschaftslexikon.gabler.de/Definition/betriebliches-informa tions system.html; from 04.01.2010

[5] Marx Gómez 2009: http://www.oldenbourg.de:8080/wi-enzyklopaedie/lexikon /informationssysteme/SektorspezifischeAnwendungssysteme/Umweltinformationss ystem%2C-betriebliches/index.html/?searchterm=buis

[6] Marx Gómez, Teuteberg 2005: Towards the Next Generation of Corporate Environmental Management Information Systems: What is there and what is Missing? In: Corporate Environmental Management Information Systems; Frank Teuteberg; Jorge Marx Gomez; IGI Global 2010

[7] Hilty L 1997: Umweltbezogene Informationsvorbereitung – Beiträge der Informatik zu einer nachhaltigen Entwicklung, (Habil.) Hamburg

[8] Kramer J 1996: Erfahrnugen mit der Entwicklung Betrieblicher Umweltinformationssysteme, in: Schimmelpfeng, L.; Machner, D. (Hrsg.): Öko-Audit und Öko-Controlling, Taunusstein

[9] Perl E, Vorbach, (2005): Development of an Implementation Concept for Environmental Information Systems on an Industrial and Intercompany Level. In: Hrebícek, J. / Rácek, J. (Eds.): Networking Environmental Information. Proceedings of the International Conference Informatics for Environmental Protection, EnviroInfo 2005 Brno. 36-40. Brno: Masaryk University.

[10] Perl 2006: Implementierung von Umweltinformationssystemen. Industrieller Umweltschutz und die Kommunikation von Umweltinformationen in Unternehmen und in Netzwerken. Wiesbaden: DUV (2006)

[11] Schulze et. al. 2001: Schulz W F, Burschel C, Weigert M, et al.: Lexikon Nachhaltigen Wirtschaften, München

[12] Rautenstrauch, C. (1999): Betriebliche Umweltinformationssysteme: Grundlagen, Konzepte und Systeme, Berlin, Heidelberg, New York u.a.

Green Software and Green IT: An End Users Perspective

Eva Kern[1], Markus Dick[1], Timo Johann[1], Stefan Naumann[1]

[1]Institute for Software Systems, University of Applied Sciences Trier, Umwelt-Campus Birkenfeld

e.kern@umwelt-campus.de, m.dick@umwelt-campus.de, t.johann@umwelt-campus.de, s.naumann@umwelt-campus.de

Abstract. Caused by the movement to a sustainable development, Green IT is still a big trend and more than just a buzz phrase. Especially data centers are working on their own energy efficiency. Additionally, Green IT needs to involve end users as the ones who play a decisive role in the utilization phase of ICT[1] devices as well as software products according to the idea of Life Cycle Thinking. In our chapter, we describe some typical end user software usage scenarios and take measurements to ascertain the energy consumption induced by these. We compare the energy consumption of word processors as well as the energy consumption induced by web browsers. In regard to sustainable development, the user has to be involved in the movements of Green IT.

Keywords Green IT, Sustainable Software Engineering, Green Software, Energy consumption of ICT devices, Energy Efficiency

1 Introduction

Greenhouse gas effects, global warming and the climate change cannot be ignored in our daily lives. That is reason enough for changing to a sustainable development in a way described in the Brundtland report [1].

The discussion about renewable energies is becoming more and more interesting for the IT Sector, since ICT is responsible for approximately two percent of global CO_2 emissions [2]. In November 2008 the EU published a *Code of Conduct for Data Center Efficiency* [3], which is just one example for the movement in Green IT. The reaction to this is positive: the number of green data centers is getting bigger[2] and the development of energy efficient hardware is moving forward (e.g. [4]).

---

[1] ICT: information and communication technology

[2] List of participants of the Code of Conduct for Data Center Efficiency: http://re.jrc.ec.europa.eu/energyefficiency/html/standby_initiative.htm

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_16,

Indeed all these movements do not pay much attention to the end users themselves. The influence of Green IT on private users could be high, since they are independent in their choice of IT tools and software. According to Heng [5], the topic is also interesting for companies. Both, management and the individual employee need to be involved in the movement of Green IT. If the head of a company is positive about sustainable workflows, the staff is nearly as independent as private users [5]. The agreement of Green IT influences the environmental report and carbon footprint of a company, which is getting more and more important in economics.

One should use these trends by promoting green and sustainable IT for the end user. In this chapter we present an approach to this topic, by pointing out requirements of a Green-IT-Model for end users and present first steps on how to realize it.

Below, we will describe some typical end user scenarios and take measurements to ascertain the energy consumption induced by these. In doing so, we want to show the chance for the user to influence his consumption of resources by the selection and configuration of software.

2 Related Work

There are many publications available regarding energy efficiency of data centers and thus ecological sustainability [3]. The end user will find more and more guidelines for Green IT, e.g. "Recommendations for the eco-friendly procurement of desktop PCs", published by *BITKOM*[3] [9] or "Sustainable procurement guidelines for office IT equipment", published by *UNEP*[4] [10]. Unfortunately these publications are focusing mainly on hardware aspects of ICT. Software aspects (applications and data) are, even if mentioned, not discussed in detail.

However, Capra et al. [11] measure and discuss the impact of several implementations of enterprise resource planning systems, customer relationship management systems, and database management systems on IT energy consumption. They found that power consumption induced by software depends on the implementation of the operation systems, the runtime environment, and the software product itself. This means that a product, which performs better than its competitors on one operating system may perform poorer on the other operating system. Possibly, this leads to metrics that can be used as energy efficiency criteria in purchasing processes for software products.

Walton [12] compared the energy efficiency of several web browsers on different notebooks, which lead to a ranking of web browsers ordered by battery life.

---

[3] Bundesverband Informationswirtschaft Telekommunikation und neue Medien e. V. (German Association for Information Technology, Telecommunications and New Media)

[4] United Nations Environment Programme

Beside these measurements, it is not possible for end users to get to know the energy consumption and hence the environmental impact caused by using his ICT device. For desktop PCs, there are similar possibilities: Amsel and Tomlinson [13] introduced Green Tracker, a software tool for estimating the energy consumption of software installed on a personal computer. Its objective is to enable users to make informed decisions about the software they use. Unfortunately, the tool only gives users indications of energy efficiency via the average CPU usage of software that results from performing automated benchmarks. *Granola* [24] is a power management system that allows software to regulate the speed and power usage of the CPU by using build in "dynamic voltage and frequency scaling". The users are informed about his yearly savings of energy (kWh), CO_2 emission, money, and the number of trees the Granola community offset so far. The intention of *Greentrac* [25] goes further. The system measures the energy and paper consumption of a company referring to individual staff members. The resulting data can be analyzed and the consumption might be reduced by individual activities in the long run [26].

Dick et al. [14] introduced a reference model for Green and Sustainable Software. This model contains a process and lifecycle model, as well as guidelines and checklists. The objective of the model is to classify all activities in the field of green, energy efficient, and/or sustainable software.

These works can be subsumed in a new research field called "Sustainability Informatics" [15].

3 Typical End User Scenarios

There are three aspects of the relations between end users and Green IT activities. First of all, there is the common definition of Green IT, which basically focuses on hardware. Secondly, the selection and configuration of software also influences the resulting energy consumption and thus the environmental impact. The users need process models of how to use software in a sustainable way. Apart from this, they want to be informed about their products [16], as well as the services they use. In order to access the third aspect, adequate information systems, e.g. in the Internet or included directly in the software product, seem to be required to get more transparency for users.

3.1 Green IT on the Hardware Side

By now, there are many checklists for users on how to save energy and natural resources. Advice like using energy-saving modes or printing duplex (more examples see: [17], [18], [9]) should be well known to users, who are interested in controlling the energy consumption of their ICT devices. The advantages for users are obvious: using IT in an ecological (resource-efficient) and economic (saving money) sustainable way. According to the German Federal Environmental Agency, one can reduce the energy consumption of the PC from 80 to four watt by setting it on standby [17] while the PC is not in use.

3.2 Software Selection and Configuration

Even though the energy management of operating systems is probably the predominant driver for the resulting energy consumption, software usage has an influence on the consumption, as well.

The software, end users select, also influences the resulting energy consumption and thus energy costs and environmental impact by using hardware resources indifferent ways [19].

To get an impression of the dimensions, we set up the following test scenario. The results can be used to give recommendations to the end user on how to influence the energy efficiency of their software. Thus, the user gets objective information to support the sustainable utilization phase of ICT devices.

3.2.1 Test scenarios

To find out how much users can directly reduce their IT-induced energy consumption, we set up different end user scenarios. Statistics show that the private user but also the business user uses the PC mainly for word processing, browsing the web, and communication [20].

For all of these cases, users have the choice between different software. Furthermore, they are free to use energy management and follow different suggestions to reduce power consumption, e. g. by configuring their web browser as described by Dick [21].

In the following, we describe the test scenarios we set up, to take measures of the energy consumption of different end user's applications.

3.2.1.1 Test Scenarios for Internet Browsers

In each case, the browser is already started. The measurements of the energy consumption start with loading the website. All scenarios are laid out for a 10 minutes test run.

Since the energy consumption is related to the shown content of a website [12], we chose websites with three different kinds of content: one video streaming website, one knowledge base with simple text and images as content and one geographical information system, which is realized with JavaScript.

a) Video Streaming:
   - Search for the video

- Choose the first entry out of the search results
- Play the video completely and reload it after its end
- Start a new search by repeating the steps

b) Knowledgebase:
- Search for a definite article
- Read the information text by scrolling down until a specified keyword and stopping for two minutes
- Follow a link to another article and read it in the same way
- Start a new search by repeating the steps

c) Geographical Information System:
- Search for a particular city
- Interact in the map by zooming and moving to the left
- Search for a route from the current location to the focused city
- Print the map by following the corresponding link and close the print dialogue afterwards
- Start a new search by repeating the steps

The described settings are typical end user scenarios at home but also in the office. By choosing exemplary websites, empirical values may easily be projected onto other websites. In this case, the kind of content is important.

Table 1. Websites, the measurements are based on

Website	main content	category
http://www.youtube.com	video files	Video Streaming
http://en.wikipedia.org	text, images	Knowledgebase
http://maps.google.com/	JavaScript, images	Geographical Information System

According to different statistics, the chosen websites are the most popular websites in their different categories [27], [28]. We took the measurements on the two most popular browsers *Internet Explorer 8.0.7600.16385* and *Mozilla Firefox 3.6.12* [29].

3.2.1.2 Test Scenarios for the Word Processing Programs

In each case, we used an existing five-page document (10,658 characters excluding spacing) with one image. In order to have the possibility to use the test results for an expansion of a 60-minute user scenario, the file is already loaded by start of the measurements.

The following actions are performed, while the measurements are being taken:

– Go to a specified part of the document and type in a predefined text of 36 words (19 CWpM[5]),

[5] CWpM: Corrected Words per Minute

–Reformat an existing heading,
–Insert an image and scale it,
–Add an image legend and a cross reference to the image in the text,
–Type in a predefined text of 105 words (19 CWpM),
–Update the content table and the list of Figures,
–Save, print and close the document.

The described scenario stands for a typical end user scenario in a word processing program. In most cases, these software products are used to insert text and images. In contrast to Hilty [22], we used a small file (fife pages, 575 KB) instead of a 150-page document. This appears more suitable for the typical end user.

We took the measurements on the word processor application *Microsoft Word 12.0.6545.5000* and the open-source application *OpenOffice Writer 3.2.0* as the two most popular word processors [30].

3.2.2 Description of the Experimental Settings

For testing, we used a desktop PC with the hardware specification shown in Table 2. The energy consumption of the computer during idle mode is 129W. The operation system of the computer is *Windows 7 Professional* (v. 6.1.7600 Build 7600). We used *Mouse Robot 2.0.0.1199* [31] to automate the tests, which does not influence the energy consumption significantly.

Table 2. Hardware specification of the testing PC

Parameter	
Processor	Intel, Core 2 Quad Q8200 / 4x 2.33GHz
Main board	Foxconn, G45M / Intel G45 chip set
Main memory	Samsung, 4x 2Rx8-PC2 DDR2 / 2Gbyte
Hard disk	Seagate, ST3500418AS / 500Gbyte
Monitor	Iiyama, ProLite B2409HDS
Graphics board	Nvidia, Geforce 9800GT / 1Gbyte Ram
Power supply	FSP Group, FSP350-60-HHN / 350Watt
Optical drive	Samsung, Super Writemaster SHS223C SATA

3.2.3 Results of the Tests

Each test has been repeated ten times and the results have been averaged to eliminate random influences by the operating system as far as possible. Hence, all given values are arithmetic averages of the tests. The time of each action during the different simulation, e.g. mouse clicks, is constant for all tests.

The results show the coherency between the total CPU utilization and the CPU utilization of the particular process. Overall, it is shown that there is a dependency of the selection of software and electrical power consumption. This comes into notice for the internet browsers as well as for the word processing applications. Capra [11] demonstrated the relation with measurements of different MIS[6]. Since end users software has an influence on the resulting energy consumption of the software we tested, the results might also be transferable to other types of software.

3.2.3.1 Testing of the Internet Browsers

Comparing the two browsers, different values of the energy consumption can be detected. In the following, we will describe some parts of the results in detail and show the differences between the two browsers.

Figure 1 shows the overall CPU utilization vs. the CPU utilization of the browser. The graphs only show the results of 1:10 minutes for reasons of clarity and readability, since the following actions are repeated afterwards: the website is loaded until 0:06 min, afterwards the search takes place (until 0:13 min.). The video is shown in the browser between time 0:14 - 0:29 min and 0:31 - 0:46 min. After the video ran two times, the user started the search again and played the first video of the results.

Over the total period of the test (10 minutes) *Firefox* induced 16,655 Wh of energy consumption, *Internet Explorer* induced 16,523 Wh. The standard variance is 0,02 Wh for *Firefox* and 0,04 Wh for *Internet Explorer*.

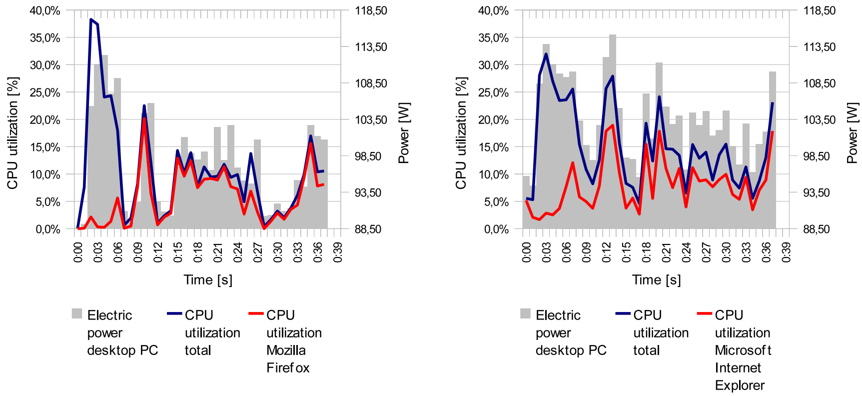


Fig. 1. Consumption of resources for the video streaming website

During the measurements of the browser's energy consumption while using the online knowledgebase (Fig. 2), the following actions were performed: The search started at time 0:06 min. We simulated the reading operation by scrolling through the article and doing nothing ("reading") for two minutes, starting at 0:13 min.

[6] MIS: Management information system

Even though the user is inactive, the graphs show that the process is consuming energy. The results show that the CPU utilization of both browsers is quite different during the testing period.

Overall *Firefox* consumed 15,220 Wh, while *Internet Explorer* needed 16,034 Wh during the ten minute scenario. The standard variance is 0,05 Wh for *Firefox* and 0,04 Wh for *Internet Explorer*.

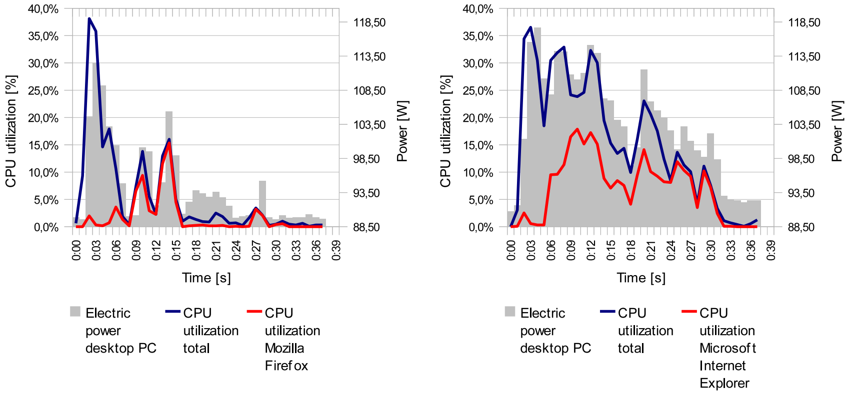


Fig. 2. Consumption of resources for the knowledgebase website

The graphs in Figure 3 show the consumption of resources during the testing of the Geographical Information System. The following actions were performed: The website is loaded for six seconds, afterwards the search needs three seconds. Until the time 0:20 min. the user navigates through the map and afterwards, searches for the direction to the current place (until 0:29 min.). The print dialog is opened by using the corresponding link. After the print process is done, a new search is started at 0:36 min. The described process takes 42 seconds.

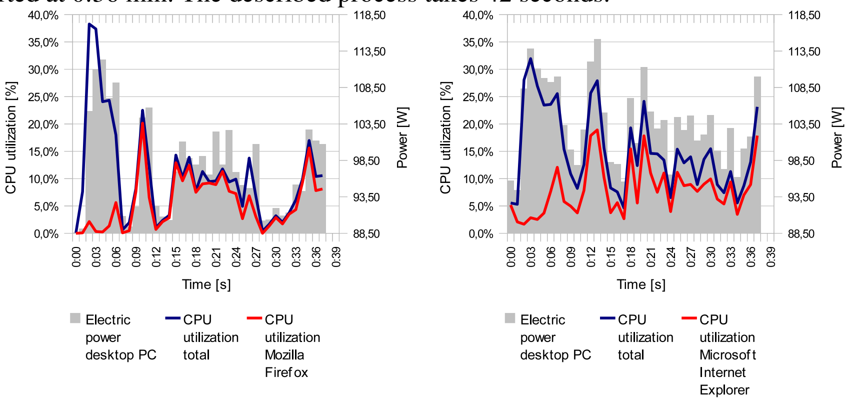


Fig. 3. Consumption of resources for the Geographical Information System

Over the total period of the test (10 minutes), *Firefox* induced 16,086 Wh of energy consumption, *Internet Explorer* induced 17,082 Wh. The standard variance is 0,03 Wh for *Firefox* and 0,05 Wh for *Internet Explorer*.

3.2.3.2 Testing of the Word Processors

Comparing the two word processor applications, the trend of the energy consumption is quite different. Since the typing of words does not lead to significant energy consumptions, we will describe the last part of the results in detail below.

Figure 4 shows the consumption of resources during the last 40 seconds of the measurements, starting at 9:20 min. At 9:21 min. the list of figures is updated (takes five seconds). Afterwards the document is saved (9:30 min.), printed as XPS file (9:36 min.), and the XPS file is saved (9:36 min.). The test ends with closing the document at 9:44 min. During the last testing seconds a new document is prepared.

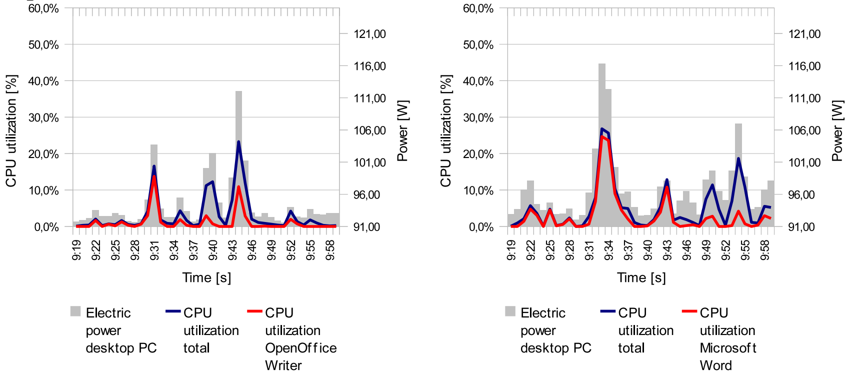


Fig. 4. Consumption of resources of the word processor applications

Over the total measurement period *OpenOffice Writer* induced 15,465 Wh and *Microsoft Word* 15,651Wh. The standard variance is 0,05 Wh for *OpenOffice Writer* and 0,03 Wh for *Microsoft Word*.

3.3 End Users Advice

The test results show that end users can have an influence on the power consumption induced by their software usage. Certainly, the strength of a user's influence force depends on the type of use. One first step towards Green IT for end users is to draw their attention to the influence they can exert. They need to be aware that there is more than one software-option to choose. Next, users should make their software selection by using the information about the energy consumption. In that way, users learn how to affect their environmental influence in a positive way.

Thus, they might have an influence on the software developers, too. There should be "Green Labels" for software products similar to the labels existing for hardware, e.g. the Energy-Star. Hence, users are informed directly about the energy efficiency of products. If the user sets a value on such labels, the market needs to react and the energy efficiency of software products becomes more and more important.

On the other side, software vendors should give users a chance to be aware of their influence on energy consumption of software. The power consumption of any software needs to be more transparent for the user. One possibility might be to include a kind of eco cockpit, showing the resulting energy consumption and influence onto the environment. The tool could be similar to *Granola* [24], but based on the individual software. The software itself should be customizable to the individual needs of the user, e.g. by offering a "light version" of a software product and plug-ins that can be added individually. In general the developers need to focus on developing the usability of products [23] to support users.

4 Conclusion & Perspectives

Renewable energies in the IT sector are discussed worldwide. As we know, end users are so far not directly involved. However, their influence is big, since they are free in their choice of software.

There are three different approaches for the professional or private users to support the development of environmental IT: They can use Green IT in their own surroundings. In addition to the purchase of green electricity, they also have an influence on their hardware equipment. Additionally, they can influence energy consumption by configuring their software. Online, the direct influences of users are limited, but since they get information about e.g. the kind of power the servers use they can support the movement towards a Green Internet indirectly.

In our paper, we presented an approach on how to support the possibilities for the end user. From the local point of view of users, we showed that the software selection can make a difference in its resulting energy consumption. The results of our measurements confirm that the software selection of end users can make an important contribution to the objectives of the Green IT.

All in all, we come to the conclusion that end users need to be involved into the movements of *Sustainable Software Engineering*. It is a point of great significance relating to sustainable development. This should anticipate possible resource-related effects along the entire software lifecycle and soon provide improved resource efficiency.

The user, as social element, can make a difference on the ecological (resource-efficient usage of software) and the economic (cost-efficient usage of software) side. In the long term, sustainable software needs to penetrate all areas of life to lead to real changes of user behavior.

Acknowledgments. This paper evolved from the research and development project "Green Software Engineering" (GREENSOFT), which is sponsored by the German Federal Ministry of Education and Research under reference 17N1209. The authors are solely responsible for the content.

References

1. United Nations General Assembly (1987) Report of the World Commission on Environment and Development: Our common future. UN document no. A/43/427 English, New York
2. Climate Savers Computing Initiative (2010) Tech Industry Leaders Publish New Design Guide of Power Management Standards
3. European Commission (2008) Code of Conduct on Data Centres Energy Efficiency: Version 1.0. http://re.jrc.ec.europa.eu/energyefficiency/pdf/CoC%20data%20centres%20nov2008/CoC%20DC%20v%201.0%20FINAL.pdf. Accessed 15 October 2010
4. FUJITSU (2009) Fujitsu Expands Green IT Initiative Globally: Worldwide implementation of Green Policy Innovation project aims to reduce society's CO2 emissions by more than 15 million tons, Tokyo
5. Heng S, Klusmann B, König F (2010) Green IT: Mehr als eine Modeerscheinung! Economics, vol 81. Deutsche Bank Research, Frankfurt am Main
6. U.S. Department of Energy (2010) Best Practices Guide for Energy-Efficient Data Center Design. Federal Energy Management Program. http://www1.eere.energy.gov/femp/pdfs/eedatacenterbestpractices.pdf. Accessed 17 December 2010
7. BMU - German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (2010) Energy-Efficient Data Centres: Best-Practice Examples from Europe, the USA and Asia. http://www.bmu.de/files/pdfs/allgemein/application/pdf/broschuere_rechenzentren_en_bf.pdf. Accessed 15 October 2010
8. (2008) Energy Efficiency in the Data Center: A Guide to the Planning, Modernization and Operation of Data Centers. Schriftenreihe Umwelt & Energie, Band 2, Berlin
9. BITKOM Bundesverband Informationswirtschaft Telekommunikation und neue Medien e. V. (2008) Empfehlungen für die umweltfreundliche Beschaffung von Desktop-PCs: Leitfaden, Berlin
10. Tepper P, Hidson M, Clement S, Anglada M (2008) Sustainable procurement guidelines for office IT equipment: Product sheet. The copy-and-paste guide to sustainable tendering for office IT equipment. http://www.unep.fr/scp/sun/facility/reduce/procurement/PDFs/SP%20guidelines%20office%20IT%20-%20Product%20Sheet%20-%20final.pdf. Accessed 22 February 2011
11. Capra E, Formenti G, Francalanci C, Gallazzi S (2010) The Impact of MIS Software on IT Energy Consumption. 18th European Conference on Information Systems, 7-9 June 2010, Pretoria, South Africa. http://web.up.ac.za/ecis/ECIS2010PR/ECIS2010/Content/Papers/0073.R1.pdf. Accessed 25 October 2010
12. Walton J (2009) Browser Face-Off: Battery Life Explored.

http://www.anandtech.com/show/2834/1. Accessed 17 May 2010
13. Amsel N, Tomlinson B (2010) Green Tracker: a tool for estimating the energy consumption of software. In: CHI EA '10: Proceedings of the 28th of the international conference extended abstracts on Human factors in computing systems. ACM, New York, pp 3337–3342
14. Dick M, Naumann S, Kuhn N (2010) A Model and Selected Instances of Green and Sustainable Software. In: What Kind of Information Society? Governance, Virtuality, Surveillance, Sustainability, Resilience. 9th IFIP TC 9 International Conference, HCC9 2010 and 1st IFIP TC 11 International Conference, CIP 2010, Held as Part of WCC 2010, Brisbane, Australia, September 20-23, 2010. Proceedings. IFIP International Federation for Information Processing, Berlin, Heidelberg, pp 248–259
15. Naumann S (2008) Sustainability Informatics – A new Subfield of Applied Informatics? In: Möller A; Page B; Schreiber M (eds) Environmental informatics and industrial ecology. 22nd International Conference on Informatics for Environmental Protection ; enviroinfo 2008 ; proceedings of the 22nd International Conference Environmental Informatics - Informatics for Environmental Protection, Sustainable Development and Risk Management, September 10 - 12, 2008, Leuphana University Lueneburg, Germany. Shaker, Aachen, pp 384–389
16. Institut für Handelsforschung GmbH (2010) Entschuldigung, wo geht's hier zur Nachhaltigkeit: Ökologische, ökonomische und soziale Aspekte prägen das Begriffsverständis der Konsumenten zum Thema Nachhaltigkeit und sorgen damit für mehr Komplexität als die Transparenz brauchen kann, Köln
17. Behrendt S, Erdmann L (2009) Computer, Internet und Co - Geld sparen und Klima schützen (Verbrauchertipps). http://www.umweltdaten.de/publikationen/fpdf-l/3725.pdf. Accessed 31 January 2011
18. dena - Deutsche Energie-Agentur GmbH (2009) Beschaffungsleitfaden: Energieeffziente Bürogeräte professionell beschaffen. Beschaffungskriterien, Vergaberecht, Wirtschaftlichkeit. http://www.dena.de/fileadmin/user_upload/Download/Dokumente/Publikationen/Strom/IEE/091001_Beschaffungsleitfaden.pdf. Accessed 16 November 2010
19. Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (2009) Energieeffiziente Rechenzentren Best-Practice-Beispiele aus Europa, USA und Asien. http://www.bmu.de/files/pdfs/allgemein/application/pdf/broschuere_rechenzentren_bf.pdf. Accessed 15 October 2010
20. Focus Online (2008) Computernutzung: Wofür verwenden Sie im Haushalt ihren Computer
21. Dick M, Naumann S, Held A (2010) Green Web Engineering: A Set of Principles to Support the Development and Operation of "Green" Websites and their Utilization during a Website's Life Cycle. In: Filipe J; Cordeiro J (eds) WEBIST 2010 - Proceedings of the Sixth International Conference on Web Information Systems and Technologies, Volume 1, Valencia, Spain, April 07-10, 2010, vol 1. INSTICC Press, Setúbal, pp 48–55
22. Hilty LM (2008) Information technology and sustainability: Essays on the relationship between ICT and sustainable development. Books on Demand, Norderstedt
23. Koch D (2009) Weltverbesserer 2.0: Ressourcenschonung im Informationszeitalter. http://www.heise.de/developer/artikel/Ressourcenschonung-im-Informationszeitalter-879710.html
24. http://grano.la
25. http://www.greentrac.de/
26. http://www.greentrac.de/wie-es-funktioniert/
27. http://www.hitwise.com/us/datacenter/main/dashboard-10133.html

28. http://www.alexa.com/topsites 2010-11-23
29. http://www.w3schools.com/browsers/browsers_stats.asp
30. http://www.webmasterpro.de/portal/news/2010/01/25/verbreitung-von-office-programmen-openoffice-ueber-21.html
31. http://www.automationbox.com/products/mouserobot.html

Co-evolution and co-management of economic and ecological sustainability - A semantic approach to modeling climate adapted land use strategies in northwestern Germany

Nana Karlstetter[1]

[1]University of Oldenburg

nana.karlstetter@uni-oldenburg.de

Abstract. Ecosystems and economic systems are functionally intertwined. With respect to climate change and sustainability conflicting dynamics accelerate. A careful framing of issues is therefore seen as a precondition for structuring complexity without being exclusive. In the project northwest2050 research is conducted on climate adapted innovation strategies in the northwest of Germany. One issue is the regional regulation of land use conflicts. Anticipatory co-management of ecological and economic purposes will be supported by the use of dynamic modeling. Analyzing and regulating socio-economic conflicts requires quantitative as well as qualitative data. Information that is scattered among multiple levels has to be identified, valued, and communicated on the ground. Hence, a semantic approach is presented here that is aimed at structuring the conceptual interfaces the dynamic model is working with. The integration of capabilities of economic actors, who make decisions, with the sensitive bundling of information is built on the concept of ecosystem services. The model serves as a tool for reflecting different settings and adjustments together with regional actors.

Keywords: semantic modeling, ontologies, environmental information management, climate adaptation land use, information processing

1 Introduction

According to Dyer [19] one of the utmost problematic consequences of climate change is dramatically decreasing food security [8; 29]. Renewable energies on the other hand are a necessary effort to mitigate emissions. Moreover, climate change is a problem that interlinks with several other issues such as loss of biodiversity and population growth. Biodiversity as one of the main essentials for

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_17,

sound ecosystems therefore gains importance for the adaptive capacity[1] of agricultural and natural resource systems [53; 11; 13; 30]. This is resulting in land use conflicts already today. Finding measures that regulate land use conflicts and at the same time strengthen regional agriculture in a sustainable and climate adapted way is part of the project northwest2050, which is situated in northwestern Germany. In participatory processes together with regional stakeholders, dynamic models are used as a means to reduce complexity, show the essential relationships and possible developments and therefore establish a basis for communication [26; 64]. Modeling land use with respect to conflicting interests and showing options for conversions between different land use types is dependent on questions like the following: How can anthropogenic implications on ecosystem functions be introduced in economic strategies in order to foster sustainable change?

Economic and ecological processes develop in co-evolution [44; 33]. Since both systems are highly dynamic a navigation of problems cannot be achieved by complete information. Particularly, incompleteness of information is a problem if interpretation of values and data is valid and vital for making decisions. This e.g. holds for sustainable strategies in land use management, where the different aims of future development meet in the regional scopes of agricultural land owners or users [11].

Semantic networks as a means to generate hierarchies and multilevel nets for example in businesses or in the internet [51] are a means to structure and cluster functional but confusing and complex information. While they are often applied for representing information at the interface between humans and IT-systems, here a slightly different approach is chosen. In combination with dynamic modeling the semantic structure of the available as well as the semantic structure of information that is missing is evaluated in participation with regional stakeholders. Hence, the semantic content of the information refers (i) to the link between the various functional levels the information has in reality (for example influences by subsidies and policy regulation on lease prices or interdependencies of land use conflicts with water scarcity). Second, (ii) the semantic content is related to the language of stakeholders and thus to the meaning of interests and demands, that is expressed through it [41]. And third, (iii) a semantic content of a certain relation can give insight in the concept that reveals its priority in a certain context, and therefore might be a way to reasoned linkage of qualitative and quantitative data via the dynamic modeling tool [50]. The idea is to generate dynamic scenarios (for groundwork see for example [9] or [59]) in order to detect, analyze, and regulate conflicts in the given real situation by modeling it with a conflict-free semantic approach [63; 2].

In the next section I will describe the conceptual background. The third section then gives insight in the very situation in the metropolitan region of Bremen-Oldenburg. The forth section will outline the frame of the model. Since this is an

[1] "In short, adaptive capacity refers to the design and potential of natural resource management (expressed in institutions, knowledge, policies and technologies) to change and adapt in response to altered conditions, crises, emergences and unpredictable effects of (co)evolutionary dynamics." [50]

ongoing research project and some of the working steps are yet to come conclusions in section five can only be drawn preliminary.

2 A challenge for modeling: co-evolutionary management

Scarcity of limited common goods such as land is inextricable linked with the sustainability of future development [5]. Especially for the agricultural system co-evolutionary challenges are vital: „A common theme […] is the critical evolutionary and integrated nature of contemporary challenges and opportunities facing agriculture. These challenges and opportunities are evolutionary in the sense that they emerge in unpredictable ways (as with changing trade standards or consumer preferences) and that dealing with these new conditions often requires new alliances and patterns of collaboration." [71]. And: "Evolutionary challenges are strongly related to changing market regulation, changing patterns of competition, and consumer preferences, but also to changes unrelated to markets, such as emerging crop and animal diseases, climatic variability, and natural calamities […]"(ib.).

This co-evolutionary sustainability besides climate adaptation concerns mitigation, loss of biodiversity, and urban sprawl and therefore touches upon ecosystem services as a functional value that is directly linked with economic use of resources and feedstocks [8; 29]. "[E]cosystem services are the aspects of ecosystems utilized (actively or passively) to produce human well-being." [23]. An economically and ecologically feasible management of values thus requires integrative and multifunctional concepts [42]. These concepts and the derived aims and activities, as well as consequences for alliances and changes need to be communicated and realized by the regional stakeholders. They are often overwhelmed by the complexity and dynamic of these processes. Modeling such interdependencies ought to reveal the urge of specific aspects of items that will gain importance in the future but need to be dealt with now. Information plays a key role here [45; 54; 48; 65]. This is confirmed by empirical results (see section 3). The significance of the information is related to (i) provision at the right time, (ii) in the adequate unit depending on the context, (iii) transparency and structure of uncertainty, and (iv) understandability for those who act on the ground. Against this background the useful [22] outlining of scenarios for a sustainable and climate adapted regional strategy could give insight in details where change is necessary and how (e.g. by what kind of interactions) it can be achieved.

The definition of measurements and relevant connections between processes and functions could be made clearer by a model that is flexible and adjustable but also semantically understandable for all being involved [27; 70; 69; 64].

Seen in this way, framing the issue [11], here: >climate adapted regulation of land use conflicts in a regional scope<, depicts a semantic setting for further elaboration of tasks, selection of key actors, identifying drivers and drivens, and outline regulating interactions.

2.1 Key role information - Diversity and processing under uncertainty

The challenge of modeling is to make available the very relationships that hold for changing ongoing dynamics in the given situation. A semantic nexus and its meaning for dynamic cascades throughout the modeled frame could shed light on relevancies in terms of ecosystem functions as well as economic functions. The definition of information, that is vital for sustainable land use management, and its processing between actors and processes (be it communication or e.g. via supply chains), depends on the meaning of it in the context of somebody who is in charge. Therefore an interactive mode of finding these definitions by a dynamic model based on explicit semantics could help, if it is able to show how ongoing developments shape possible futures.

By connecting systems thinking and evolutionary knowledge on ecosystems and economic organizations [44; 17] functional processes between ecosystems and socio-economic-systems can be identified by focusing on task-relation. "Between micro-level interactions and macro-level adaptivity, sustainability arises, if each subsystem fits successfully in the network, and if the network successfully fits into the wider environment." [50]. Diversity in terms of response diversity, biodiversity (agricultural as well as natural), strategic and economic diversity, a variety of business capabilities, diversity of changing dynamics scales and time frames here seems to be central [52; 13] for securing compatibility, because it serves as a basal element for flexible but proactive steering. Thus an appropriate model has to be flexible in itself while simultaneously reducing the complexity of the modeled situation.

The interrelation between ecological and economic processes is basal for a co-evolutionary perspective: "At a general level, we conceive co-evolution as dynamic interactions between two or more interdependent systems which account mutually for each other's development. In detail, co-evolution can be seen as the evolutionary process among two or more elements/sub-systems/systems driven by reciprocal selective pressures and adaptations between these elements/sub-systems/systems. Thus, a co-evolutionary system can be defined by the totality of all interacting elements/sub-systems." [50]. The concept of ecosystem services may be a connecting feature that allows scrutinizing the economic impact on ecosystems. Because of lock-in effects and non-linearities, adaptation to changing environments and sustainable innovation "is based on the capability […] to transmit the acquired knowledge to other(s) – that is to learn and communicate."[58]. The interaction between economic and ecological system thus requires explicit knowledge and flexible information processing to achieve organizational functions of economic actors who then are capable to cope with processes like sustainable adaptation to climate change. Transfer of information across levels, scales and mediation of interests and perspectives can be seen as fundamental in this context. "The process of modeling can (and must) […] serve this consensus-building function. […] Dynamic systems modeling is increasingly promoted as a tool to close spatial and temporal gaps between decisions, actions and results." [15]. The semantic structure of the information vital in certain situations may be conflictive or incomplete [51; 16]. As used in businesses a semantic model could help identifying interfaces and components to regulate and manage [2; 63].

3 Northwest 2050: The case of land use change and climate adaptation in northwestern Germany

Within the project northwest2050 research is conducted on climate adapted innovation strategies in the metropolitan region of Bremen-Oldenburg in northwestern Germany. The project is funded by the German Ministry of Science and Technology for the period 2009 - 2014. The project includes analysis of vulnerabilities and the development of a climate adapted regulation strategy for land use conflicts between production of bio-energy and food security.

So far the empirical results (interviews, workshops, review on literature, statistical data, etc.) show that the actually given dynamic is already conflictive. Conflicts between bioenergy and food production have accelerated due to policy regulation (subsidies for biogas-production) (3N 2010). This e.g. has led to dramatically increased growing of maize and high lease prizes. Embedded in other line of businesses food production in this region is a strong economic sector [7; 34]. Intensive livestock farming and single-crop farming go along with vulnerabilities owing to changing climate impacts [31; 7; 34]. Loss of biodiversity for example impairs resistance to pests and diseases that might be a growing threat with changing climate conditions. Scarcity of fertile land in the future might be correlated with scarcity of water, especially in times of less rain. Loss of fertile land (e.g. due to urban sprawl or degradation) is a problem that is globally relevant as well as in the regional scope [8; 29; 20; 19]. In areas where food production will still be possible under climate change it is of great importance to save fertile soils [20]. In these contexts land is becoming more and more interesting also to non-agricultural investors which is a threat to the regional peasants not only in developing countries [19].

Information is diverse and scattered and dependent on interpretation. The communication of these issues is one of the main difficulties [67; 50].

Thus, the situation is contingent but it is not arbitrary. A co-management would mean to mediate interests and initiate change towards sustainability and climate adaptation. Interpretations and priorities hold for integration of sustainability, adaptation, and mitigation [12; 39; 65].

A model on the one hand ought to reveal the biased and priority dependent situation between regional actors in order to give insight in the ongoing processes. On the other hand it was of great advantage if a model could state deficits concerning synergetic potentials and therefore generate information necessary for possible solutions on the ground [64]. Hence, the complex but regional conditions call for strategic concepts that are derived from the overall purpose but harnessed for a scope of action equivalent with the situation they are meant for [6; 40].

For businesses a co-management of the co-evolving processes at first requires identifying capabilities and organizational conditions to cope with these issues.

Secondly, if decision making processes can be seen in relation with other but correlated fields of action a more comprehensive view can be gained. This possibility to deal with conditions and activities in good time prior to implementation is often missing [56; 62].

The development of scenarios thus aims at showing (a) underlying mental models and (b) the very elements that need to be overcome in order to (i) regulate conflicts and (ii) change for climate adapted and sustainable food production.

4 A semantic frame for a dynamic model using STELLA

The purpose of the model is to develop an integrated view. This implies identification and reduction of vulnerabilities as the above named issues. The structure of the model can be explicated along two dimensions [11]. The first dimension is a logical one, that explains where semantic linkages are necessary and where they are just redundant or unimportant: Generating the relevant information in this dimension can be seen as (i) identifying specific deficits [16] in (ii) a specific context, identifying (iii) the most important relationships and (iv) their mutual impact, and identifying (v) a priority structure that is coded by explicit relationship towards the aim or goal it is derived from [44; 2; 63]. The other dimension is related to the real-world frame that is modeled. The model in this dimension is aimed at revealing insight in processes in terms of (a) embedding the regional scope in global dynamics, (b) concrete issues of changing economic strategies under uncertainty, (c) scrutinizing innovation based on this, (d) defining possible solutions (e.g. new technologies for biogas-productions to decouple this from land consumption) [51].

The model in the further process will serve as a communication tool. The aim is to develop a tool, that is understandable for the stakeholders and shows where specific contexts overlap, where and how economic and ecological processes coevolve [33; 4; 61] and what consequences this might have for the future, regarding that climate change is getting worse. Since scientifically spoken these issues are of great importance at the local level [25; 20; 46] but acting takes places between the practitioners, cooperation, communication and insight in crucial dependencies might foster change. The semantic link between the language and meaning on the ground [41] and a logical structure of interrelations for developing dynamic scenarios seems to enhance communication in spite of high complexity. Intensifying communication on these issues then might serve as a way to push forward the realignment of priorities with respect to a sustainable future: “A key lesson of research on collective-action theory is recognizing the complex linkages among variables at multiple levels that together affect individual reputations, trust, and reciprocity as these, in turn, affect levels of cooperation and joint benefits” [46] And:“If enough individuals initially cooperate, they slowly obtain benefits […], and levels of cooperation grow.” [66]

4.1 Finding integrating units

One of the most difficult problems related to such processes is the definition of suitable units and operationalize a scientifically profound background. The implementation of the conceptual approach will be done by a graphical simulation program to translate complex relationships into a dynamic model [26]: STELLA uses four building block objects for stocks, flows, converters, and connectors. In reference to the concept of ecosystem services finding land use regulation strategies requires careful definition of the semantic background of these building blocks. [14; 23; 37(chapter 1, 2, 5)]. The ecosystem services that are important in the case at hand are water quality, biodiversity and landscape fragmentation. The model is spatially framed for the Metropolitan Region Bremen-Oldenburg (Lower Saxony, Germany) and temporally for the period from now to 2014. Besides this a long term perspective will roadmap the innovation path until 2050.

The orientation is towards sustainability and it is mainly focused at agriculturally used land with emphasis on >food first< as precedence over all other land uses. Note that from the focus on sustainability it follows that ecological soundness has to be included as a prerequisite in this precedence [60]. Kontogianni et al. [36] state "…that cognitive problems are related to the actual units used to express and communicate ecosystem changes. Cognitive problems arise because of the functional opaqueness of environmental assets; therefore, individuals cannot make comparisons across scales and have difficulty converting environmental goods and services into monetarized units for comparison with other goods. […] As a result, there is often no clear connection of ecosystem functions to human services; economic valuation is therefore by necessity directed more towards the valuation of natural assets than towards services." They suggest defining service providing units correlated with defined endpoints in order to assess and communicate ecological values. "Put simply, an SPU (service providing unit) can be defined as the collection of individuals from a given species and their characteristics necessary to deliver an ecosystem service at the level desired by service beneficiaries."[36] The idea of the endpoint is taken from Boyd [10], who describes it as follows: Ecological endpoints are "…concrete statements, intuitively expressed and commonly understood, about what matters in nature." These endpoints are concrete, tangible, and measurable and are a possible means to integrate scientific knowledge in communication with involved stakeholders. Additionally endpoints might help to warrant capacity to act (on time and anticipatory) in spite of uncertainty because endpoints constitute a loose but definite grid of well-chosen but flexibly reference points [67].

Water provision and water quality as one of the relevant ecosystem services in this case (see figure 1) might serve as an example: If due to single-crop farming and less rainfall in early summer farmers start to irrigate large areas, scarcity of water will increase conflicts between stakeholders that are already in a struggle for fertile land. Since ground water is important for the rest of the population as well, communication on this is necessary but might be complicated because urban sprawl already disturbs constructive communication between communities and farmers. A similarly conflictive situation is given between ngos or conservation

activities and regional farmers in terms of the significance of environmental protection, for example biodiversity. The question how concerted units can be elaborated in a participatory process could be answered by defining SPU.
If a set of SPU is connected with the explicit dynamic (and semantically structured) situation between actors and other devices (such as in this case land use conversion) a co-evolutionary management could be made concrete.

Figure 1 shows the different land use types that are given in the metropolitan region of Bremen-Oldenburg [34]. The grey boxes refer to available land; part of it is in use for agriculture. The blue boxes depict building blocks of process-clusters (actors are represented by the yellow buttons) which use land or functionally affect land use. Since the model is aimed at examining the socio-economic conflictive situation, the boxes are not yet represented by percental relations but intend to show the empirically observed inventory of land use types and processes.
Legend for figure 1:

- grey boxes: geographical scope/available land, agricultural subset;
- blue boxes: procedural scope/functional building blocks of land use;
- yellow buttons: stakeholders and influential sub-elements representing different interests; SPU: service providing units, EP: Endpoints,
- red inscriptions: semantic links; black arrows: direction of influence

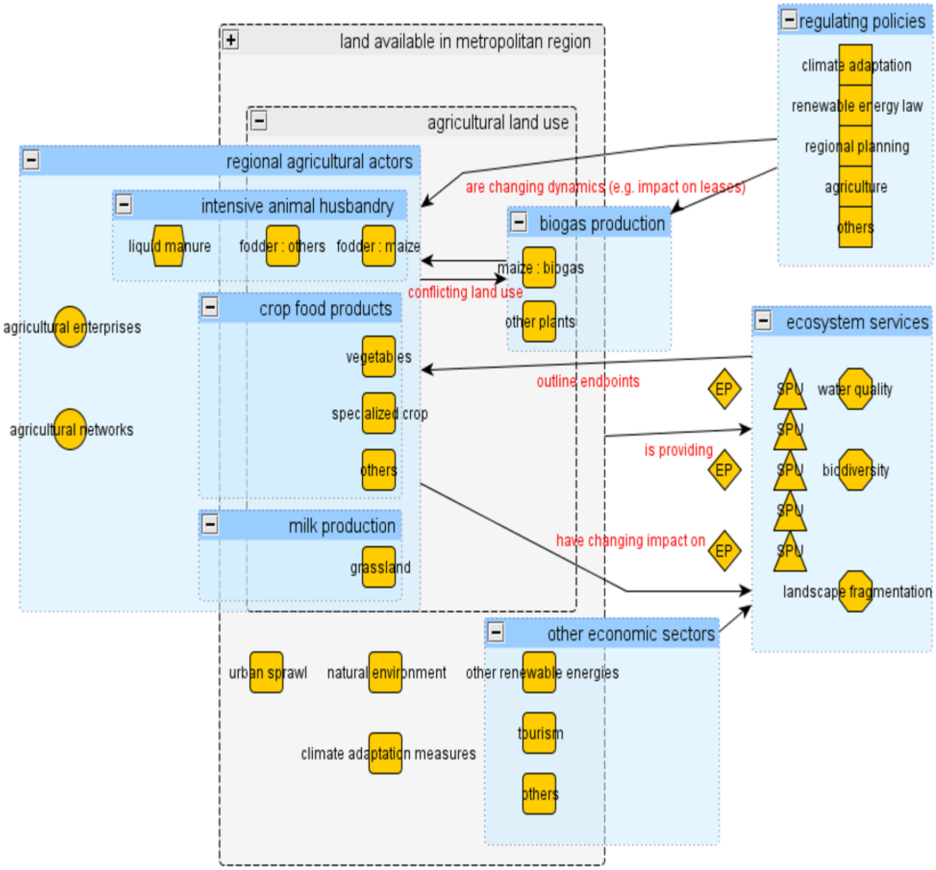


Fig 1. Land use types in the Metropolitan Region Northwest Germany

4.2 Structuring semantics

Strictly speaking, the semantic structure between the nodes in figure 1 is dependent on the yellow buttons that stand for stakeholders and other influential subelements with different claims on land and its use. The semantic linkages are manifold and there are much more relevant inks than shown in the figure due to not cluttering it. Particularly if it comes to details concerning interactions between actors, strategic measurements, and uncertainties with respect to changing climate impacts, mental models and experience connected with different organizational conditions may have strong influence on the factual dynamics.

A prediction of the regional development is just not possible because of its complexity. Choices regulate future development as external events do as well. Choices and decisions are made by a backward and forward orientation of the actor, based on experiences, knowledge, and mental models, such as analogies [24]. But incomplete information in collective settings is also dependent on negotiations [25]. "In real life there will be debate and discussion by different people in favour of one or another choice, and each would cite their own projections about the trade-offs and the overall effect of their choice. However, the actual success that a new practice meets with is predetermined by the "fitness landscape" resulting from the practices already present and what the emergent attributes and capabilities encounter in the marketplace."[4]. This is exactly the situation in the participatory workshops in the project nordwest2050. The assessment of the regional vulnerability referring to land use conflicts is highly dependent on availability of information, because negotiations otherwise do not have a shared argumentative foundation [69; 67; 50]. Structuring the semantic net of the model thus requires an analytical grid in order to distinguish levels of meaning and function in relation to processes and activities of stakeholders in the region. Figure 2 shows a frame that sorts between the dimensions of uncertainty (referring to climate change) and impact on change (referring to land use). Explicit endpoints depend on their value and importance for the ecosystem as well as their functional value for the economic system. The relationships in figure 2 outline an analytical background for weighing and sorting the black arrows with the red inscriptions from figure 1. In an iterative model building process [64; 51; 4] the development of weighing and decision rules could become part of a regional regulation strategy [67]. Therefore, the endpoints would then provide a linking device between economic and ecological processes any kind of weighing rule could refer to [10; 36].

		Ecosystem services ⇩ Endpoints ⇩
Relation of	Degree of uncertainty	Impact on land use change
scarcity (limited land / ecosystems)	low	?
priority (mental models / experience)	middle	high
profit (economic)	high	high

Fig 2. ordering structure for semantic linkages between nodes in figure 1 defining land conversion (arrows show influences on conversion rate cf. arrows in figure 1), *Source: ranking is estimated on base of the current empirical state in nordwest2050*

Scarcity of land is the dimension that is absolutely limited and cannot be substituted (low uncertainty). This dimension is basal for the other two (priority and profit). Since profit in relation to scarcity depends on the chosen priorities it is set in the middle and can be seen as a regulating dimension, because if actors have the capability to learn, this dimension is adjustable [61].

This conceptual frame is harnessing the driving and driven connections. The dynamic model will be outlined with STELLA integrating the semantic structure during the next year. Based on this model scenarios of different conversions between land use types ought to give an improved background for assessing and communicating regulation measures [26; 67].

5 Conclusions

In this contribution it has been shown how functional processes are intertwined with semantic interrelations. Modeling such situations requires explicit access towards the relevant processes. From a co-evolutionary perspective functional interdependencies shape economic as well as ecological systems. Diversity and flexibility of strategies is crucial for successful adaptation to climate change. In this approach ecosystem services are a way to identify concrete endpoints in order to explicate linking elements between ecological and economic functional processes. That is to say the semantic relation reveals information processing, interactions and activities of and between actors, which are vital for regulation land use conflicts and cope with uncertainties concerning climate change impacts.

Since the project northwest2050 is running until 2014 this can only be a preliminary result. On base of the given empirical results and this constitutional frame the next step ahead is to write down the model. This is including the definition of the very endpoints for the ecosystem services water quality, biodiversity, and landscape fragmentation (see figure 1). The outline of appropriate units that allow integrating qualitative and quantitative data, e.g. mental models, interests and priorities with conversion ratios and statistical data will follow. The idea is to conceptualize them as fuzzy sets [61]. Fuzziness is given in terms of concerns, interests, and priorities, because they are overlapping, conflicting, and dynamic; it is also given concerning groups of actors that may be individuals or businesses, and are highly heterogenic. Moreover, fuzziness refers to the assessment of ecological and/or economic values and may be interlinked with different metrics and units (e.g. nitrate impact or productivity per hectare, appreciation of milk or food in general, trust or distrust in future, technology efficiency, economic or ecological carrying capacities, etc.). Fuzzy sets could provide a feasible way to reduce complexity and at the same time outline concrete but flexible units [47; 21]. Explicating the relations between these units will specify the semantic structure (cf. figure 2). All in all this might sketch a tentative framework for harnessing co-evolutionary regional settings and the very tasks of their management.

References

[1] 3N-Kompetenzzentrum Niedersachsen Netzwerk Nachwachsende Rohstoffe (2010) Biogasnutzung in Niedersachsen Stand und Perspektiven

[2] Agt H, Widiker J, Bauhoff G, Kutsche R-, Milanovic N (2009) Model-based Semantic Conflict Analysis for Software- and Data-integration Scenarios, 2009/7

[3] Albeverio S (ed) (2008) The dynamics of complex urban systems: An interdisciplinary approach. Physica-Verl., Heidelberg

[4] Allen PM, Strathern M, Baldwin J (2008) Complexity: The Integrating Framework for Models of Urban and Regional Systems. In: Albeverio S (ed) The dynamics of complex urban systems: An interdisciplinary approach. Physica-Verl., Heidelberg, pp 21–42

[5] Antle J, Capalbo S, Paustian K Ecological and Economic Impacts of Climate Change in Agricultural Systems: An Integrated Assessment Approach, pp 128–160

[6] Baldwin CY, Woodard CJ (2009) The Architecture of Platforms: A Unified View. Harvard Business School Working Papers, 09-034, Harvard

[7] Beermann M (2011) Regionale Vulnerabilitätsanalyse der Ernährungswirtschaft im Kontext des Klimawandels: Werkstattbericht nordwest2050 Nr.7

[8] Bommert W (2009) Kein Brot für die Welt. Riemann, München

[9] Borgida AT, Chaudhri VK, Giorgini P, Yu ES, Mylopoulos J (2009) Conceptual modeling: foundations and applications: Essays in honor of John Mylopoulos, vol 5600. Springer, Berlin

[10] Boyd JW (2007) The Endpoint Problem. http://www.rff.org/RFF/Documents/RFF-Resources-165_EndpointProblem.pdf. Accessed 28 December 2010

[11] Brookfield H, Padoch C (2007) Managing Biodiversity in Spatially and Temporally Complex Agricultural Landscapes. In: Jarvis DI, Padoch C, Cooper HD (eds) Managing Biodiversity in Agricultural Ecosystems. Columbia University Press, New York Chichester, West Sussex, pp 338–361

[12] Brunstad RJ, Gaasland I, Vardal E (2005) Multifunctionality of agriculture: an inquiry into the complementarity between landscape preservation and food security. European Review of Agricultural Economics 32(4):469–488

[13] Ceroni M, Liu S, Costanza R (2007) Ecological and Economic Roles of Biodiversity in Agroecosystems. In: Jarvis DI, Padoch C, Cooper HD (eds) Managing Biodiversity in Agricultural Ecosystems. Columbia University Press, New York Chichester, West Sussex, pp 446–472

[14] Costanza R, d'Arge R, Groot R de, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill RV, Paruelo J, Raskin RG, Sutton P, van den Belt M (1997) The value of the world's ecosystem services and natural capital. Nature 387:253–260

[15] Costanza R, Ruth M (1997) Dynamic Systems Modelling for Consensus Scoping and Consensus Building. In: Dragun AK, Jakobsson KM (eds) Sustainability and global environmental policy: New perspectives. Elgar, Cheltenham

[16] Dau F (2003) The logic system of concept graphs with negation: And its relationship to predicate logic. Lecture notes in computer science Lecture notes in artificial intelligence, vol 2892. Springer, Berlin

[17] Dopfer K (ed) (2005) The Evolutionary Foundations of Economics, Cambridge

[18] Dragun AK, Jakobsson KM (eds) (1997) Sustainability and global environmental policy: New perspectives. Elgar, Cheltenham

[19] Dyer G (2008) Climate Wars. Random House of Canada, Toronto

[20] Edenhofer O (2010) Global aber gerecht: Klimawandel bekämpfen, Entwicklung ermöglichen ; ein Report des Potsdam-Instituts für Klimafolgenforschung und des Instituts für Gesellschaftspolitik München. Beck, München
[21] Eierdanz F, Alcamo J, Acosta-Michlik L, Krömker D, Tänzler D (2008) Using fuzzy set theory to address the uncertainty of susceptibility to drought. Regional Environmental Change 8(4):197–205
[22] Epstein JM (2008) Why Model? Journal of Artificial Societies and Social Simulation 11(4):12
[23] Fisher B, Costanza R, Turner RK, Morling P (2007) Defining and Classifying Ecosystem Services for Decision Making. CSERGE Working Paper EDM, 07-04, Norwich, UK
[24] Gavetti G, Levinthal D (2000) Looking forward and looking backward: cognitive and experiential search. Administrative Science Quarterly 45(1):113–137
[25] Hahn M, Fröde A (2010) Climate Proofing for Development. Adapting to Climate Change, Reducing Risk. Climate Protection Programme
[26] Hannon B, Ruth Matthias (2001) Dynamic Modeling, 2nd edn. Springer, New York
[27] Hekkert MP, Suurs RAA, Negro SO, Kuhlmann S, Smits REHM (2007) Functions of innovation systems: A new approach for analysing technological change. Technological Forecasting and Social Change 74(4):413–432
[28] Helming K, Wiggering H (eds) (2003) Sustainable Development of Multifunctional Landscapes. Springer, Berlin Heidelberg New York
[29] Hirn W (2009) Der Kampf ums Brot. Fischer, Frankfurt am Main
[30] Hooper DU, Chapin IFS, Ewel JJ, Hector A, Inchausti P, Lavorel S, Lawton JH, Lodge DM, Loreau M, Naeem S, Schmid B, Setaelae H, Symstad AJ, Vandermeer J, Wardle DA (2005) Effects of Biodiversity on Ecosystem Functioning: A Consensus of Current Knowledge. Ecological Monographs 75(1):3–35
[31] Idel A (2010) Die Kuh ist kein Klima-Killer!: Wie die Agrarindustrie die Erde verwüstet und was wir dagegen tun können, 2nd edn. Agrarkultur im 21. Jahrhundert. Metropolis-Verl., Marburg
[32] Jarvis DI, Padoch C, Cooper HD (eds) (2007) Managing Biodiversity in Agricultural Ecosystems. Columbia University Press, New York Chichester, West Sussex
[33] Kallis G, Norgaard RB (2010) Coevolutionary ecological economics. Ecological Economics 69(4):690–699
[34] Karlstetter N, Pfriem R (2010) Bestandsaufnahme: „Kriterien zur Regulierung von Flächennutzungskonflikten zur Sicherung der Ernährungsversorgung": Werkstattbericht nordwest2050 Nr.4
[35] Kirsten J (ed) (2010) The new landscape of global agriculture: Proceedings of the twenty-seventh Conference of the International Association of Agricultural Economists, held at the Beijing International Convention Centre, Beijing, China, 16-22 August 2009. Wiley-Blackwell Pub, Malden, MA
[36] Kontogianni A, Luck GW, Skourtos M (2010) Valuing ecosystem services on the basis of service-providing units: A potential approach to address the 'endpoint problem' and improve stated preference methods. Ecological Economics 69(7):1479–1487
[37] Kumar P (2010) The economics of ecosystems and biodiversity: Ecological and economic foundations. Earthscan, London
[38] Limburg K, Costanza R (eds) (2010) Ecological Economics Reviews. Blackwell Publishing, Boston, Massachusetts
[39] Liu S, Costanza R, Farber S, Troy A (2010) Valuing ecosystem services: Theory, practice, and the need for a transdisciplinary synthesis. In: Limburg K, Costanza R

(eds) Ecological Economics Reviews. Blackwell Publishing, Boston, Massachusetts, pp 54–78
[40] Malone TW, Laubacher R, Dellarocas C (2009) Harnessing Crowds: Mapping the Genome of Collective Intelligence. MIT Sloan School Working Paper, 4732-09
[41] Mitchell M (2009) Complexity: A guided tour. Oxford Univ. Press, Oxford
[42] Mooney H, Larigauderie A, Cesario M, Elmquist T, Hoegh-Guldberg O, Lavorel S, Mace GM, Palmer M, Scholes R, Yahara T (2009) Biodiversity, climate change, and ecosystem services. Current Opinion in Environmental Sustainability(1):46–54
[43] Neumayer E (2010) Weak versus Strong Sustainability. Edward Elgar, Cheltenham
[44] Norberg J, Cumming GS (eds) (2008) Complexity Theory for a Sustainable Future. Columbia University Press, Columbia
[45] Olesen JE, Bindi M (2002) Consequences of climate change for European agricultural productivity, land use and policy. European Journal of Agronomy 16(4):239–262
[46] Ostrom E (2010) Analyzing collective action. In: Kirsten J (ed) The new landscape of global agriculture: Proceedings of the twenty-seventh Conference of the International Association of Agricultural Economists, held at the Beijing International Convention Centre, Beijing, China, 16-22 August 2009. Wiley-Blackwell Pub, Malden, MA, pp 155–166
[47] Prato T (2007) Assessing ecosystem sustainability and management using fuzzy logic. Ecological Economics 61(1):171–177
[48] Pretty J (2008) Agricultural sustainability: concepts, principles and evidence. Philosophical Transactions of the Royal Society Biological Sciences 363:447–465
[49] Pugh DS (ed) (2009) Change management. Sage library in business & management, Vol. 2. Sage, Los Angeles
[50] Rammel C, Stagl S, Wilfing H (2007) managing complex adaptive systems - A co-evolutionary perspective on natural resource management. Ecological Economics 63(1):9–21
[51] Reichenberger K (2010) Kompendium Semantische Netze. Springer, Heidelberg
[52] Rerkasem K, Pinedo-Vasques M (2007) Diversity and Innovation in Smallholder Systems in response to Environmental and Economic Changes. In: Jarvis DI, Padoch C, Cooper HD (eds) Managing Biodiversity in Agricultural Ecosystems. Columbia University Press, New York Chichester, West Sussex, pp 362–381
[53] Ring I, Hansjuergens B, Elmqvist T, Wittmer H, Sukhdev P (2010) Challenges in framing the economics of ecosystems and biodiversity: the TEEB initiative. Current Opinion in Environmental Sustainability(2):15–26
[54] Rounsevell MDA, Ewert F, Reginster I, Leemans R, Carter TR (2005) Future scenarios of European agricultural land use: II. Projecting changes in cropland and grassland. Agriculture, Ecosystems & Environment 107(2-3):117–135
[55] Ruth M (2006) A quest for the economics of sustainability and the sustainability of economics. Ecological Economics 56(3):332–342
[56] Ruth M (ed) (2006) Smart Growth and Climate Change: regional Development, Infrastructure and Adaptation. Edward Elgar, Cheltenham, Northampton
[57] Ruth M, Donaghy K, Krishen P (eds) (2006) Regional Change and Variability. Edward Elgar, Cheltenham, Northampton
[58] Sartorius C (2006) Second-order sustainability - conditions for the development of sustainable innovations in a dynamic environment. Ecological Economics 58(2):268–286

[59] Schalley AC, Zaefferer D (2007) Ontolinguistics: How ontological status shapes the linguistic coding of concepts. Trends in linguisticsStudies and monographs, vol 176. de Gruyter, Berlin
[60] Schroeter D. et al. (2004) ATEAM Final report 2004 Section 5 and 6. http://www.pik-potsdam.de/ateam/ateam_final_report_sections_5_to_6.pdf. Accessed 28 December 2010
[61] Senge P, Sterman J (2009) Systems Thinking and Organizational Learning: Acting locally and thinking globally in the organization of the future. In: Pugh DS (ed) Change management, Vol.2. Sage library in business & management, Vol. 2. Sage, Los Angeles, pp 287–306
[62] Teece D (2007) Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. Strategic Management Journal 28(13):1319–1350
[63] Tessier F., Badri L, Badri M (2004) Towards a Formal Detection of Semantic Conflicts Between Aspects: A Model-Based Approach: International workshop on aspect-oriented software
[64] van den Belt M (2004) Mediated Modeling: A System Dynamics Approach to Environmental Consensus Building. Island Press, Washington Covelo London
[65] Varghese S (2009) Integrated Solutions to the Water, Agriculture and Climate Crises. Accessed 28 December 2010
[66] Vollan B, Ostrom E (2010) Cooperation and the Commons. Science 330(6006):923–924
[67] Vries BJM de, Petersen AC (2009) Conceptualizing sustainable development: An assessment methodology connecting values, knowledge, worldviews and scenarios. Ecological Economics 68(4):1006–1019
[68] Wiggering H, Mueller. K., Werner A, Helming K (2003) The concept of multifunctionality in sustainable land development. In: Helming K, Wiggering H (eds) Sustainable Development of Multifunctional Landscapes. Springer, Berlin Heidelberg New York
[69] Wilbanks TJ (2006) Stakeholder Involvement in Local Smart Growth: Needs and Challenges. In: Ruth M (ed) Smart Growth and Climate Change: regional Development, Infrastructure and Adaptation. Edward Elgar, Cheltenham, Northampton, pp 111–128
[70] Winter M (2009) Agricultural land use in the era of climate change: The challenge of finding 'Fit for Purpose' data. Land Use Policy:217–221
[71] World Bank (2006/2010) World Bank Group - Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems

Web-based Information Systems on ICT for Environmental Sustainability Research in Europe

Werner Geiger, Richard Lutz, Christian Schmitt

Karlsruhe Institute of Technology, Institute of Applied Computer Science

werner.geiger@kit.edu, richard.lutz@kit.edu, christian.schmitt@kit.edu

Abstract. For fostering a single European Research Area in the field of ICT for environmental sustainability, the FP7 project ICT-ENSURE (ICT Environmental Sustainability Research) was implemented. Within the scope of ICT-ENSURE, two web-based information systems with free online access have been developed: A Research Programmes Information System and a Literature Information System. The Research Programmes Information System serves as an information source on national research programmes and projects in the European Union in the field of ICT for environmental sustainability. The Literature Information System provides scientific literature on this field to the scientific community and other interested people. Both systems offer various search and navigation facilities to the end users. The information systems are fully integrated and based entirely on open source / free software. In the chapter, the goal, structure, contents, and functionality of the information systems are described and the maintenance and quality assurance of the contents are addressed. Besides presenting the information systems the chapter also aims at promoting the participation of the ITEE community in the contents of these systems in order to proceed further towards a single European research area in the field of ICT for environmental sustainability.

Keywords: ICT for environmental sustainability Web-based information systems, Research programmes information systems, Literature information systems

1 Introduction

An important goal of the research policy of the European Union is building a single European Research Area [3]. In the field of ICT for environmental sustainability, however, the research landscape in Europe is rather fragmented. In order to overcome this problem and to foster research for a Single Information Space in

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_18,

Europe for the Environment [7], the support action ICT-ENSURE was implemented. ICT-ENSURE (ICT Environmental Sustainability Research) was funded within the 7th Framework Programme of the European Union from May 2008 to April 2010 [15].

The ICT-ENSURE project consortium consisted of three partners: Graz University of Technology (TUG) that acted as project coordinator, the International Society for Environmental Protection (ISEP), Vienna, representing the scientific coordinator, and the Karlsruhe Institute of Technology (formerly: Karlsruhe Research Centre) that was responsible for the development of the information systems. In addition, several subcontractors for specific tasks were involved in the project.

A main problem with respect to a single European Research Area in the field of ICT for environmental sustainability is that information on current research activities and research results often are not generally available or can be obtained with a high expenditure only. This especially applies to research funded on the regional level and on the level of the Member States of the EU. In order to overcome this problem, two web-based information systems with free online access were developed within the ICT-ENSURE project [5]:

- A Research Programmes Information System which supplies information about national research programmes and projects in the field of ICT for Environmental Sustainability in Europe.
- A Literature Information System which offers meta information and full text papers of various conferences and workshops in this field in Europe.

This paper provides an overview on the objectives of the two ICT-ENSURE information systems. The common software architecture of the Research Programmes and the Literature Information Systems and interfaces with external information systems for indexing the literature will be described. The procedures chosen for the acquisition of metadata on national research programmes and projects and for the collection of the literature metadata will be dealt with. At this, also a summary of the current contents of both information systems will be given. Thereafter, the functionality of the two systems, including the user interface and the various access paths to the information, will be explained. Finally, the maintenance and quality assurance of the contents will be addressed.

2 Objectives and Basic Concept of the Information Systems

For researchers as well as research programme managers, it is time-consuming and costly to obtain an overview of research activities in the field of ICT for environmental sustainability in Europe.

Some information on research programmes and projects is being provided e.g. by the CORDIS information system, the ERAWATCH website, and the UFORDAT information system. The CORDIS information system of the European Commission [2] offers information on research programmes funded by the EC. However, it does not supply information on national research programmes. The ERAWATCH website [4] focuses on national research policies, but offers information on few (very large) national research programmes only. The UFORDAT information system of the German Federal Environmental Agency [16] includes some research projects in the field. However, UFORDAT is geographically restricted to Germany, Austria, and Switzerland and is focused on the environment. In addition, the CISTRANA IST Research Portal [1] supported information on national programmes, but only on ICT programmes, not on ICT application programmes, and the CISTRANA portal is not available on the internet any more.

Information on scientific literature in the field of ICT for environmental sustainability (documenting the *results* of research) predominantly consists in conference proceedings [13]. However, these proceedings were available almost exclusively to the conference participants (with little spread beyond). No or little support was provided when searching literature in these proceedings to a given topic and the full texts generally were available for downloading neither on the website of the publisher of the proceedings nor on the website of the conference organiser. Some literature has been included in the ULIDAT environmental literature database of the German Federal Environmental Agency [17]. But this literature database comprises only a small part of the literature on ICT for environmental sustainability, since it is a literature database focusing on environmental topics. In addition, it is restricted to German-language publications and it has not been updated systematically since 2004.

The Research Programmes Information System and the Literature Information System developed within ICT-ENSURE are tools to overcome these gaps.

The Research Programmes Information System serves as a central information source on national and regional research programmes and projects in the field of ICT for environmental sustainability in the European Union. The system helps programme managers, scientists, and experts to easily obtain information on research programmes and projects in the various EU Member States. Hereby, it supports the exchange of expertise and cooperation in this research field and, in this way, contributes to the development of a pan-European research strategy.

For the characterisation of the research topics of the programmes and projects, a classification scheme for the field was developed. European national experts (subcontractors) compiled predefined metadata on national research programmes and projects, classified them using the classification scheme, and entered this information into the system by means of its authoring component.

The Literature Information System provides scientific literature on the field of ICT for environmental sustainability in general and on environmental informatics in particular to the scientific community and other interested people. It offers metadata and - as far as possible - links to the full texts of conference and workshop contributions. So far, mainly conferences and workshops of the Technical Committee “Environmental Informatics” of the German Society for Informatics (Gesellschaft für Informatik GI) have been included (see Chapter 4).

A critical problem in the development of the Literature Information System was the settlement of the rights for supplying full texts of the publications on the internet. In case of conference and workshop proceedings issued by a publishing house, these rights are typically settled in a contract between the publishing house and the organiser. The publishing house generally does not make the publications available on the internet with free access. However, in many cases in the field of ICT for environmental sustainability the organisers of conferences or workshops have the right to publish the proceedings on *their* websites some time after the conference with free access. This particularly applies to the EnviroInfo conferences held since 2004.

Because of this, the Literature Information System has been conceived in such a way that the full texts of the publications can also be stored on external web sites (in general on web servers of organisers of conferences). The publications may be stored there as separate PDF files per paper or in the form of complete proceedings volumes. In the latter case, the links from the information system to the papers refer to the first pages of the papers within the proceedings volumes (see Chapter 4).

3 Architecture

To implement both information systems, several alternative architectures were studied in terms of navigation facilities, maintainability, security, and integration of search engines (web application with database, wiki, content management system, Java portlets, etc.). Both information systems of ICT-ENSURE offer access to different information. By abstraction of the requirements and functionalities, however, both systems could be implemented on a joint basis.

The systems are based on the Model-View-Controller architectural pattern that separates presentation from business logic. Accordingly, the system is divided into three layers. The model layer is responsible for the administration of the underlying data stock. The view layer focuses on the presentation of the user interface. The control layer administrates data processing and is used as an interface between the model layer and the view layer.

Both systems were implemented on the basis of the Java EE servlet technology and can be used in a platform-independent manner.

Presentation of the websites to end users is accomplished using the Apache Velocity template engine. Another interface links the Literature Information System with literature harvesters by the OAI-PMH protocol (Open Archives Initiative – Protocol for Metadata Harvesting) [12]. In this way, the literature information can be used by a large number of literature search engines supporting this protocol. This enhances the awareness of the system and its contents. A popular OAI harvester and OAI search engine is ScientificCommons. To integrate literature information into the German Environmental Portal PortalU, an additional interface is currently being implemented based on a DSC iPlug and the iBus of PortalU [8].

The data are processed by Java servlets. With the help of a Java Persistence API (JPA), the object-oriented Java model is converted into the relational structures of the MySQL database used for data storage. The Hibernate JPA implementation offers an interface to Apache Lucene for full text search [10].

4 Contents Acquisition and Current Contents of the Systems

The Research Programmes Information System is aimed at compiling and presenting information on relevant national research programmes and projects on ICT for environmental sustainability in Europe. However, the information on national research programmes and projects available on the internet often is available in the national language only and it is frequently insufficient and/or outdated. Collection of information for such a system – at least, initial collection – may be accomplished with good quality only with the support of national experts in this research field speaking the respective country's local language.

All in all, 20 national experts investigated research programmes and projects and entered the collected data in the information system by means of the system's authoring component.

In March 2011, the Research Programmes Information System contained more than 100 programmes and 120 projects with information from all EU Member States. More than 240 programme managers and other contact persons are involved in the acquired research programmes and projects. These contact persons are an important target group for updating the information and for investigating new programmes and projects.

The collection and preparation of metadata for the *Literature Information System* started right at the beginning of the project parallel to the software development of the final information system (cf. Chapter 3). A rapid prototype of the database was built using the commercial database product FileMaker Pro by FileMaker Inc. [14]. The prototype database was used for collecting and validating the literature metadata of the EnviroInfo conferences. The data of the prototype system were imported in the final system by means of a dedicated import interface which also performs a number of quality checks.

In March 2011, the Literature Information System comprised the metadata of more than 1700 and the full texts of more than 1000 publications. It included the publications of all EnviroInfo conferences from 1997 to 2010 and the publications of the Towards eEnvironment conference that took place in Prague in March 2009. Furthermore, the system included the papers of the workshops "Environmental Information Systems" 2005-2010, which were held by the corresponding Working Group of the German Society for Informatics. For the majority of these conferences and workshops, the full text papers are available as separate PDF files for downloading at the websites of the conference organizers or promoters.

5 Functionality and User Interface

Both research information systems offer similar search and navigation facilities to the end users and largely have the same layout.

The search facilities provide information retrieval capabilities from the meta databases via full text search and attribute search. The navigation facilities allow browsing the database via different access paths as well as navigation via cross-references between related entries.

Fig. 1. Screenshot of the Research Programmes Information System

Figure 1 shows a screenshot example of the Research Programmes Information System. The different search and navigation aids can be found on the left. They include full text search, search in major object classes (programmes, projects, organisations) according to given criteria for their attribute values, and the navigation in the classification of the research field. In addition, access is offered via the list of countries (selection via a map) or the list of programmes, projects, and organisations. The menu bar with a link to the Literature Information System can be found at the top right.

The metadata of a research project or programme are represented on the right. These metadata include the acronym of the project or programme, its name in the English and national language, an abstract, a short description, responsible and participating countries and organisations, a contact partner, and other entries. By selecting the links, it is possible to navigate interactively through the data inventory.

Fig. 2. Screenshot of the Literature Information System

Figure 2 shows a screenshot example of the Literature Information System. In the Literature Information System, full texts (PDF files) stored on external websites are integrated in full text search apart from the metadata of the database (cf. Chapter 3). If the individual papers are available as parts of complete proceedings volumes only, full text search (full text indexing) and linking in the result list are made accurately to the paper within the proceedings. The “search by criteria” offers a search in the attributes of the object classes of articles, chapters, and volumes, e.g. a search for all publications of a specific author or all publications with a given term or combination of terms in the title.

In addition, the Literature Information System offers access to the literature via a hierarchical list of all conferences and workshops contained in the system on the left. The user can select hierarchically the conference or workshop, the volume of the conference/workshop proceedings, the chapter in the volume, and the article in the chapter and is given the list of the metadata of the corresponding conference contribution (see Figure 2, right).

The metadata of a contribution comprise various attributes: The list of authors and their associated institutions, the related conference, the publishing year, the abstract of the article (as far as available), and start/end page in the volume. The reference to the chapter and to the conference volume containing the article can be used for browsing through the database of the information system. If it is possible to download the full text of the article, a link to the download location is provided along with a text with information about the hosting server.

Furthermore, the system offers a possibility to download literature references. Three popular citing formats are provided: RIS, EndNote, and BibTeX.

6 Maintenance Tools and Quality Assurance

Both information systems were made available in the web in April 2010 and are in operation and have been extended since then. Maintenance and quality assurance of the operational systems is a challenge, since a number of parties from all over Europe are involved in the contents of the systems. In order to support maintenance and quality of the databases, various tools have been developed, manuals have been prepared, and measures taken.

To ensure the quality, validity, and up-to-dateness of the information in the Research Programmes Information System, the contact partners of programmes and projects and the national experts involved in the initial data investigation are contacted regularly. The contact partners are informed about their programmes and projects in the information system and the data currently stored. They are asked for a confirmation or correction of this information. Furthermore, they are asked for new programmes and projects relevant to the information system for extending the content of the information system and improving the coverage of the research field.

For updating of the metadata by the national experts themselves, the authoring component of the Research Programmes Information System (already applied for the acquisition of the initial data) can be used. Alternatively, the data can be gathered offline by means of a Microsoft Excel™ sheet (template) provided and then entered into the system by the institution maintaining it.

The authoring component automatically performs various data quality checks and offers various quality support functions to the authors. In a separate system administrator account, further data analysis and presentation facilities are provided for controlling the quality of the entered data.

Also for extension and quality assurance of the Literature Information System various tools have been developed. To import the metadata of additional conferences, an import filter has been implemented. This import filter can be customised to various data sources. A special version of the filter can import metadata from MS Excel™ sheets in a dedicated format for which a template is being provided. In addition, some routines have been implemented for plausibility checks of the contents of the Literature Information System. These routines check the values of attributes (e.g. syntax of ISBN numbers) and the cross-references between various object classes (e.g. whether every article is linked with at least one author).

7 Concluding Remarks

Both information systems – the Research Programmes Information System as well as the Literature Information System – are appreciated well by researchers and persons responsible for research programmes or projects. Interviews with national experts confirmed that the information systems close a gap in the needs of the European research landscape and facilitate an alignment of own research projects, plans, and results with similar or related programmes or projects in other European countries [11].

KIT guarantees the provision of both information systems in the web for at least two years after the end of project funding, i.e. at least until March 2012. The Technical Committee “Environmental Informatics” of the German Informatics Society is interested to take over the Literature Information System within this time period. Alternatives for the future operation and update of the Research Programmes Information System have been examined [6] and efforts are being undertaken to ensure the sustainability of the service.

In autumn 2010, the first systematic update of the contents was made and the tools for maintaining the contents of the systems were employed at this (cf. Chapter 6).

All responsible persons registered in the Research Programmes Information System were addressed and asked for a quality check of their data stored in the system and for naming other relevant research programmes and projects. Most of the contact partners answered, which also confirmed the interest in the system and in being represented in it.

Currently (March 2011), a study is being made for providing the data of the system to other research information systems via an XML interface, e.g. based on the data model and exchange format CERIF of euroCRIS. First results have shown that the essential data of the Research Programmes Information System can be mapped well to the CERIF format. However, the interface shall be implemented only in case of a positive result of a cost-benefit analysis.

The content of the Literature Information System was extended in autumn 2010 by the full texts of the 2009 EnviroInfo conference and the metadata of EnviroInfo 2010. Thereby, the tools for importing literature data via the Excel sheet and the corresponding import interface were applied for the first time. These tools can also be used for efficiently integrating the literature (metadata, full texts) of further conferences and workshops. At this, the ITEE community would be a valuable partner.

The Literature Information System can be the basis for a joint provision of literature information of different scientific communities in Europe in the field of ICT for environmental sustainability. By this, it can be an even more valuable contribution for establishing a single pan-European research area in this field.

Acknowledgments. The project results have been developed by the ICT-ENSURE project (European ICT Environmental Sustainability Research, www.ict-ensure.eu). ICT-ENSURE is financed under the grant agreement number 224017 of the European Commission's Seventh Framework Programme, Theme 3, Information and Communication Technologies. The authors thank Dr. Heinrich Schneider (nuvelo) for the coordination of the investigations for national research programmes and projects. In addition, the authors thank Martin Schreiber (Leuphana University of Lüneburg) for the development of a prototype version of the Literature Information System.

References

[1] CISTRANA (2010) CISTRANA: coordination of IST research and national activities. European Commission, ICT Research in FP7. http://cordis.europa.eu/fetch?CALLER=PROJ_ICT&ACTION=D&CAT=PROJ&RCN=71899. Accessed 20 December 2010.

[2] CORDIS (2010) Community research and development information service of the European Commission. http://cordis.europa.eu/home_en.html. Accessed 20 December 2010.

[3] ERA (2007) Green Paper on the European Research Area: New perspectives. Commission of the European Communities, COM (2007) 161. http://ec.europa.eu/research/era/pdf/era_gp_final_en.pdf

[4] ERAWATCH (2010) CORDIS ERAWATCH. http://cordis.europa.eu/erawatch/. Accessed 20 December 2010.

[5] Geiger W, Lutz R, Maurer L, Pillmann W, Schmitt C, Schreiber M, Tochtermann K (2009) Information systems for building an ERA in the field of ICT for environmental sustainability. In: H ebí ek J (ed.) Proc. of the TOWARDS eENVIRONMENT, Opportunities of SEIS and SISE: Integrating Environmental Knowledge in Europe, Prague, March 25-27, 2009. Masaryk University, 438-444.

[6] Geiger W, Lutz R, Schmitt C (2010) The final version of the Research Programmes Information System. ICT-ENSURE project website, addendum 1 to deliverable D9.3, http://www.ict-ensure.eu. Accessed 20 December 2010.

[7] Hřebíček J, Legat R, Nagy M, Pillmann W (2008) Challenges of SEIS and SISE: Integrating Environmental Knowledge in Europe. In: Möller A (ed) Environmen-

tal Informatics and Industrial Ecology, Proc. of the EnviroInfo 2008, Lüneburg, Sept. 10-12, 2008. Aachen: Shaker Verlag, pp. 182-89.
[8] Klenke M, Kruse F, Schenk F (2010) OpenSearch. Simple formats to share environmental information. In: Greve, K (ed) Integration of Environmental Information in Europe : 24th Internat. Conf. on Informatics for Environmental Protection (EnviroInfo 2010), Köln/Bonn, October 6-8, 2010. Aachen : Shaker Verlag, pp.518-28. ISBN 978-3-8322-9458-8.
[9] Lutz R, Schmitt C, Geiger W (2009) The ICT-ENSURE information system on national research programmes in EU Member States. In: Wohlgemuth V (ed) Environmental Informatics and Industrial Environmental Protection: Concepts, Methods and Tools; Proc. of the 23rd Internat. Conf. on Informatics for Environmental Protection (EnviroInfo 2009), Berlin, September 9-11, 2009. Aachen : Shaker Verlag, Vol. 2, 205-212, ISBN 978-3-8322-8397-1.
[10] Lutz R, Geiger W, Schmitt C, Schreiber M (2010) Information system on literature in the field of ICT for environmental sustainability. In: Greve K (ed) Integration of Environmental Information in Europe : 24th Internat. Conf. on Informatics for Environmental Protection (EnviroInfo 2010), Köln/Bonn, October 6-8, 2010. Aachen : Shaker Verlag, 2010 pp.104-11. ISBN 978-3-8322-9458-8.
[11] Maurer L, Tochtermann K, Geiger W, Pillmann W (2010) ICT-ENSURE: European ICT Environmental Sustainability Research, D8.2b Final Survey Report. ICT-ENSURE project website, http://www.ict-ensure.eu. Accessed 20 December 2010.
[12] OAI (2010) The Open Archives Initiative Protocol for Metadata Harvesting. Open Archive Initiative, http://www.openarchives.org/OAI/openarchivesprotocol.html, Document Version 2008-12-07T20:42:00Z. Accessed 20 December 2010.
[13] Pillmann W, Geiger W, Voigt K (2006) Survey of environmental informatics in Europe. Environmental Modelling & Software, 21, 1519-1527.
[14] Schreiber M (2010) Information system on literature in the field of ICT for environmental sustainability. Internat. Congress on Environmental Modelling and Software, Ottawa, CDN, July 5 -8, 2010.
[15] Tochtermann K, Granitzer G, Pillmann W, Geiger W (2008) ICT-ENSURE – A 7th Framework Programme support action for building the European Research Area in the field of ICT for environmental sustainability. In: Möller A (ed) Environmental Informatics and Industrial Ecology, Proc. of the EnviroInfo 2008, Lüneburg, Sept. 10-12, 2008. Aachen: Shaker Verlag, 456-463.
[16] UFORDAT (2010) Umweltforschungsdatenbank UFORDAT. Umweltbundesamt, http://doku.uba.de/ > UFORDAT. Accessed 20 December 2010.
[17] ULIDAT (2010) Umweltliteraturdatenbank ULIDAT. Umweltbundesamt, http://doku.uba.de/ > ULIDAT. Accessed 20 December 2010.

Sustainable CRM for Mobility Services based on SOA architecture

Ammar Memari, Benjamin Wagner vom Berg, Jorge Marx Gomez

University of Oldenburg

memari@wi-ol.de, suepke@wi-ol.de, wagnervomberg@wi-ol.de,
jorge.marx.gomez@uni-oldenburg.de

Abstract. Transportation is a field that has potential for reducing emission and pollution through technological and social innovation. Today we face the problem of sustainable multi-modal transportation. This chapter presents a way to approach the problem by increasing the user's sustainability awareness using an adaptive application. The proposed application is strongly related to a CRM system since today CRM aims at increasing consumption of customers with the goal of profit maximization without integrating sustainability into CRM strategies, processes and systems. The solution is built on top of a framework taking into account a set of requirements for the New Generation of Adaptive Applications. These requirements originate both at the field of Adaptive Hypermedia and the field of Business Informatics.

Keywords: sustainability, semantic web, SOA, agents

1 Motivation and background

Sustainability is a topic gaining more and more importance as time goes by. The financial crisis 2009, the oil disaster in the Gulf of Mexico and many more current events and existing social, economical and ecological deficiencies worldwide are showing, that we can't go on in the way we do if we want to save an appropriate standard of living for the following generations.

"Sustainable CRM" sets on the root to change our behavior of consumption and by this our handling of resources in a sustainable way. Customer relationship management (CRM) is a central element of our current growing economy, with methods of customer acquisition and customer loyalty to tie customers for increasing demands and consumption [9].

Innovative ways of mobility are becoming a must for higher sustainability of resources as well as lower impact on the environment. Electric mobility offers the

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_19,

solution for a row of serious problems within the range of individual mobility, which primarily come from limited oil and the environmental impacts by combustion engines [34]. Semi-structured and weakly-organized transportation methods (e.g. car sharing) can be integrated into a business model that is attractive for customers. In the center of attention is no longer the supply of a vehicle, but the supply of services for mobility with different choices (own car, car-pooling, car-sharing, train etc.) [18]. For the penetration of such new business models, customer acceptance and customer satisfaction are crucial; two central fields of CRM.

This chapter will present first results of a project group with the goal to develop an application based on an innovative SOA-architecture that allows offering multi-modal mobility planning services from different providers via a smart phone. This application is able to raise the awareness of the customers on environmental aspects by providing information not only about costs but also ecological effects of the transportation means (e.g. values for carbon emission and energy consumption). This puts the customer in the position to choose his mobility services under criteria of sustainability. The additional use of a CRM system gives the chance to influence the customer behavior towards a sustainable way of moving. This happens by collecting knowledge about user behavior and creating individualized recommendations for more sustainable transportation means and providing them through different channels (e.g. messages via the app, marketing campaigns etc.) to the customer.

However, many obstacles appear when talking about multi-modal transportation planning since required information are vast in amount and heterogeneous in nature [25]. Provided information about a certain transportation service vary from simple bus timetables to full-fledged planning service that includes environmental information like “deutschebahn.de”. Further information like weather forecasts, traffic information, delays etc. are needed for a useful trip-planning. Integrating this information is the goal of the project in addition to filling the gaps in sustainability calculations to provide an all-in-one solution to the customer and adapt it to their needs.

Moreover, needed information is represented using different heterogeneous standards because they are coming from different providers, for example, HTML, WSDL, RSS, Databases, Ontologies and many others. This heterogeneity does not make it any easier for the information filtering and retrieval efforts.

On top of that, information goes through many changes, which creates volatile information spaces for applications. Information is added, removed or updated on a daily or hourly basis and even major web search engines are not capable of keeping their index as fresh as needed [32].

For solving the issue of information filtering and adaptation, the research area of Adaptive Hypermedia was founded. This area dates back to 1996 and finds its roots in the field of User Modeling. The paper of Brusilovsky [3] is considered by many to be the corner stone of the research field.

Even though research in this field has recently started to focus on new technologies of the Web like Semantics, Ubiquity and Services [22], it was not able to provide a complete solution. Almost 60 percent of research in that field targeted the educational domain, which inherently uses a body of information that is fixed and unchangeable (Closed Corpus) similar to a curriculum in an educational application. Moreover, research in this field does not focus on adaptive structure of applications, which is crucial for them to achieve a higher order of adaptation.

In this paper we will adopt three promising paradigms in order to overcome the problems:

1. Semantic Web: has passed the hype phase into the productive phase by evidence that Ontologies are accepted in many fields as a standard for specification of conceptualizations [10]. In Adaptive Applications Ontologies are needed for providing a meta-description of various models like the User Model, the Domain Model, and the Context Model. Using Ontologies for this purpose guarantees reusability in the first place so one application could reuse what another application had already learned about a user. Additionally, standardizing this specification in this way allows deriving new adaptation rules from existing ones and standardizes the matchmaking process.

2. Software Agents: According to the vision of the Semantic Web, main consumers of machine-understandable annotations are Software Agents [35], which we will be using in the proposed framework.

3. Artificial Bee Colony: is the branch of Artificial Intelligence that studies systems which resemble the behaviors of bees. Bees have caught the attention of biologists for several hundred years back; however, two main points of bee behavior have attracted computer scientists. The first point is foraging pattern, where the beehive is able to optimally divide the workforce of bees among nectar sources based on their distance and quality [31]. The second point is Path Integration where the bee is able to fly back to the hive using the shortest path and not having to use the same path used in the onward journey. According to a study by Lemens [19], bee-based algorithms are more scalable with the size of the world and require less time for the complete computation. Navrat et. al. [27] tried to use an updated beehive model for web search, problems with this model will be shown in this paper and a correction is suggested in order to use the beehive model for dealing with the Open Corpus in an efficient manner.

2 Requirements for the next generation of Adaptive Applications

Adaptive Applications need to satisfy different requirements forced by the current situation of the information space and of the technological advances. Main requirements are:

Second-order adaptation

Subject of adaptation according to which adaptation is performed is the user preferences (User Model), and object of adaptation is usually represented by the Domain Model. Adaptation is performed based on Adaptation Rules that define where and how it should be done. However, sometimes it is necessary to adapt the adaptation rules themselves. As an example, a user is accessing a website which detects the location of his IP and adapts the language to suit the user's location. However the user does not want the language to be changed so he reverts to the original language. Here the application should be able to imply that this adaptation rule (changing the language) does not apply to this user, and it must adapt the rule by weakening it. Adapting the adaptation rules and process is what's called a second-order adaptation.

Open Corpus adaptation

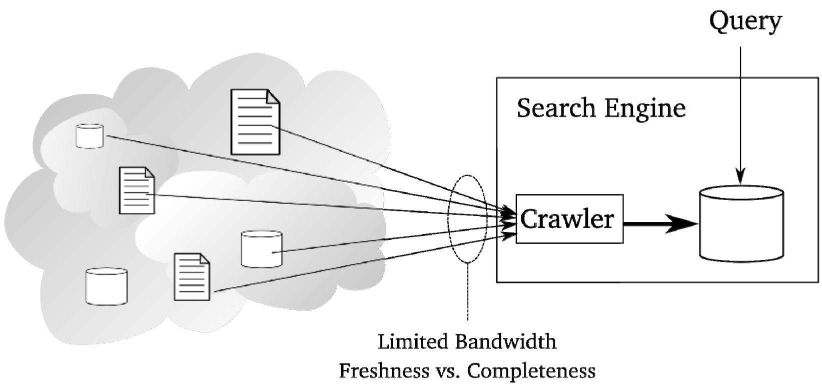


Fig. 1. Transforming Open Corpus to Closed Corpus in Search engines and the trade-off between Freshness and Completeness

Dealing with bodies of information where addition, update and removal are frequent is the trend of applications, and is at the same time the generic case. An application that is able to deal with Open Corpus is definitely able to deal with Closed Corpus. Search engines are able to deal with the open corpus of the Web simply by transforming it into a closed corpus through the crawling and indexing processes as seen in Figure 1. However, there is always a limited bandwidth available for crawling, and that leaves the application with no choice other than to sacrifice completeness to favor freshness or vice versa [20], [28], [32]. Another example would be an online satellite imagery service, this service has a limited amount of airplanes that can "crawl" the face of the planet and take aerial photos, so it has to favor some locations over others and photograph them more frequently just like a search engine crawling blogs and .com website more frequently than other web-sites. That causes people who live in small villages to have outdated images of their areas. In this paper we argue that personalization to the user's preferences on the Open Corpus must start from the crawling phase by following a Personalized Crawling Mechanism, and that the foraging pattern of the beehive is a good way to accomplish that [23].

Conceptual space and shared conceptual space

As mentioned before, usage of Ontologies for describing the user, the domain and the context is encouraged since a main issue in Adaptive Hypermedia is reusability. Authoring an adaptive content is a tedious and time-consuming task; therefore it is most welcome that other adaptive applications are able to use the same content. The same can be said about the User Model and the Context Model. [16]. Even when different Ontologies are used for describing different user models Ontology mapping can be used for solving this issue.

User clustering and pattern recognition

Clustering the users in naturally-appearing clusters provides an easy way for adaptation. Many existing adaptive applications and recommendation systems use this way. For example, Amazon.com recommendation engine clusters the users based on their purchased items, and recommends to a member of the cluster what other cluster members have bought. Dealing with users as clusters reduces granularity without affecting the adaptive experience, and by that improving performance of the system.

Context Awareness

In many occasions, applications need to adapt to some factors that are not directly related to the user's preferences these factors is what we call context, for example, a trip planner needs to check the weather at the time of the trip, and when rain is expected, it has to remove the bike from the list of transportation possibilities. Other examples for context include device screen size, connection speed, connection type, location...

Ethical Requirements

Personalization and adaptation raise many ethical issues mainly originated at the sensitivity of personal information, and technical solutions must be found for solving these requirements. For example, to comply with certain regulations and provide maximum privacy, personal information are not permitted to leave the user's machine so to deal with it code must move to where the information is instead of moving information to where the code is.

Since an adaptive application shapes the world to the user, a high level of trust must be present, so the system must be able, when requested, to explain in a human-readable language why it has recommended an item and hid another. That in-scrutability of the system discussed in works of Kay [15]. Another phenomenon that can appear in Adaptive applications is Tunneling, where the user's attention is directed strictly to what the application recommends and other potentially irrelevant information is cut off. To avoid such situations a certain level of randomness must remain in the system.

Supporting Diversity

The concept of diversity sounds very attractive in the field of Semantic discovery and retrieval since no single algorithm proved to be dominant [33]. Moreover, by aggregating different implementations of the same functionality we end up with an application more capable of maintaining its performance within a changing environment.

Diversity had its days of adoption through N-Version Programming [4] and more recently in Meta-search Engines featuring a variety of result merging strategies. However what requires to widely sup-porting this idea is the current trend towards unifying description standards and the expanding usage of Ontologies, which can automate discovery of functionally-equivalent implementation-diverse components and services.

Service-Oriented Architecture (SOA)

It is required for an Adaptive Application to have a flexible structure that enables it to easily and smoothly replace pieces of functionality with other, more adapted pieces. This is satisfied through SOA which also provides a parallel execution framework for running functionally-equivalent implementation-diverse services as mentioned above in section 2.7 as a Horizontal Composition of services [1].

3 Approach

3.1. Implementing SOA using Agents

According to the (W3C 2004), SOA is about creating a number of loosely coupled, reusable services that could then be assembled and reassembled into applications. These services must be publicly accessible, and independent from implementation.

SOA is implemented in many different ways and predominantly using Web Services. However, we argue that Web Services alone are unable to fulfill the promises of SOA because they lack means for load balancing, choreography, composition and security.

Based on that, we have opted for encapsulating services with software agents that are able to fulfill these non-functional properties of services without violating encapsulation or compromising reusability.

3.2 The Reference Model

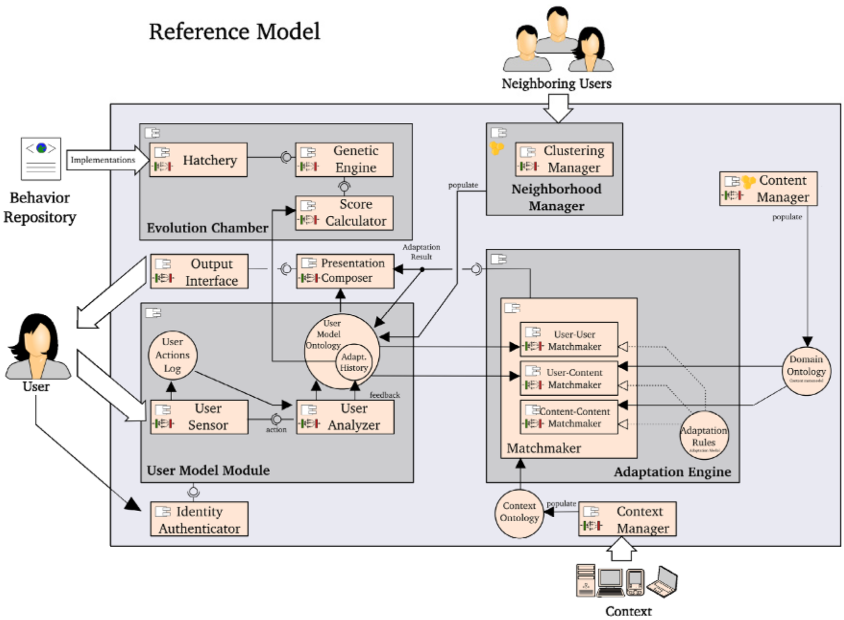


Fig. 2. The proposed Reference Model in a pseudo-UML component diagram

The proposed Reference Model is shown in figure 2. The used notation here is not pure UML diagram but a variation of it, which is done intentionally for taking into account the two different audiences of Information Systems according to guidelines for research communication.

As stated by the requirements, the model uses an Ontology for keeping the User Model along with the public parts of User Models of neighboring users. Another Ontology for the Domain Model and another for the Context Model.

At the heart of the Model is the Matchmaker, split into three sub components for item-item matching, user-user matching and user-item matching. Another part of the matchmaker are the adaptation rules, rules were favored over other kinds of adaptation specifications due to their scrutability. The Content Manager, Context Manager and Neighborhood Manager are crawling the outside environment and populate the corresponding Ontology. From the stereotype on each it is indicated that the used foraging pattern is Personalized Crawling. The mathematical model behind that is de-scribed and validated in details in [23].

Most of the components in the model have the "diversified" stereotype, which is used to denote that this component's functionality is delegated to agents that encapsulate services and run in parallel. Figure 3a shows that workflow and depicts an interface for receiving score for involved agents so the aggregator can assign weights to inputs based on score of each agent. The score comes from the Score Calculator and is based on the user's feedback on the adaptation process itself. When that is applied to components such as the matchmaker, the user sensor or the output interface, it is a means for adapting the adaptation process based on user's feedback, and that satisfies requirements by providing a second-order adaptation. Another way for providing second-order adaptation and a means for code management of agents is the Evolution Chamber illustrated in figure 3b. The Behavior Repository is an XML file that contains the code for different behaviors of different agents; each of the behaviors has a unique id. In order for an agent assembler to build an agent out of this code, he needs to provide information about which implementation is to be used for each behavior of the agent. This information constitutes a data structure that we will call the DNA of the agent. The role of the Hatchery is to get the DNA, fetch the referenced code from the behavior repository, compile an agent class, load it, and then instantiate it to create agents. Different DNA's will create different breeds of agents.

The DNA can come from the genetic engine that has the mission of deciding the best performing breeds based on their score, crossbreed them and end up with a DNA that will create the next generation of agents. This allows the system to evolve based on user's feedback in a process we call Personalized Evolution where the driver behind evolution is not global performance rather individual user preferences.

a) b)

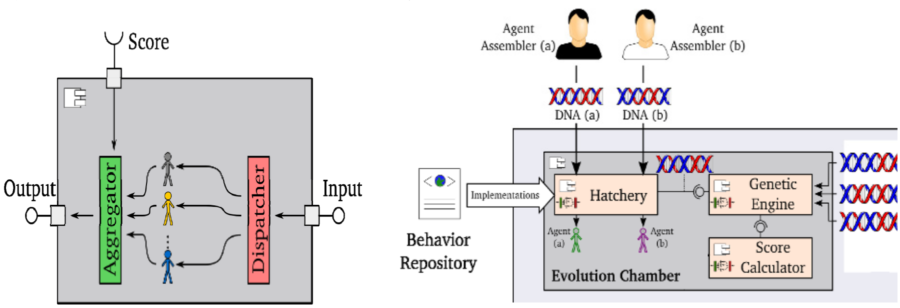


Fig. 3. a. (left) Workflow in each of the components that have the "diversified" stereotype **b. (right)** Evolution Chamber as a means for Personalized Evolution

3.2.1 Jinengo – multi-modal mobility

Jinengo is the name of the project group. The name comes from the Chinese words "Jie neng" what means "saving energy". Eleven Master students are working for one year on the creation of a software application for sustainable transportation planning that is named Jinengo as well. The application is connected to a Microsoft Dynamics 2011 CRM-System that runs in the cloud.

The planned application will follow the aforementioned reference model and offer the user a comfortable way to plan all his trips (daily trips, vacation trips, business trips etc.) through his smart phone. The user will set his parameters for the trip (destination, date, time) and his preferences (costs, comfort, flexibility etc.) and as a result he gets back different possibilities with different means of transportation for the trip based on his stored User Model. The following means of transport are planned to be included: train (mainly Deutsche Bahn), bus, carpooling (e.g. car2gether), car-sharing (e.g. car2go, Cambio car sharing), own car (electric or conventional car), own bike and walking. For every single option the user gets information about costs, sustainability and further information. The sustainability could be expressed in CO2 emissions, CO2 equivalents and resource/energy consumption. The best way for the sustainability expression is still in consideration and is open due to the flexible nature of the reference architecture. Also context information e.g. the weather will be integrated and considered in forming the list of alternative means of transport. To provide the necessary information the application will integrate already existing planning services for the offered means of transportation (e.g. from Deutsche Bahn) and CO2 calculators for emissions (e.g. OPTIRESOURCE by Daimler AG). In a further step also a booking option can be included. Keeping diversity will enable the application to reduce risk e.g. of a biased evaluation of CO2 emission by averaging different sources.

3.2.2 Considerable business models

To bring Jinengo to market different business models are possible. As a first option it is possible to use Jinengo as a customer front end to provide a service of multi-modal mobility planning that includes also the use of different offered means of transport as described previously. Here the customer pays in the first line for the different transport services provided after criteria of sustainability. In this case there still can be a trade-off between sustainable goals and profit goals [26] because most sustainable offers don't have to be most profitable ones for the provider.

A second option is to offer Jinengo as a pure information service where the user can get the necessary information for his sustainable trip-planning. The user pays e.g. for the single trip-planning transaction or only for premium services or the service is financed by advertisement. In this case there is no connection between the chosen means of transport and the profit of the provider and so no trade-off exists.

A third option that also can be included in option one or two is to sell the generated user and usage data to mobility providers like Deutsche Bahn. The providers can gain profit from this data by using it for their CRM/marketing and they can adjust their services and products to the preferences and needs of the customers.

3.2.3 CRM Integration

A definition of CRM reads as follows: „CRM is a customer-oriented enterprise strategy, which tries with help of modern information and communication technology, to develop and strengthen profitable customer relations in the long term by holistic and individual marketing, sales and service concepts [9]. The term CRM names the strategy and the software (often also eCRM or CRM-system). Within the customer-oriented strategy CRM is a central component to reach the classical company targets [12].

The here described activities can be supported by CRM on strategic level and on system level because CRM is an essential part of marketing. The linkage between Green marketing and CRM is still missing attention and there are only a few works that address this linkage [17]. The application Jinengo will be connected to a Microsoft Dynamics CRM-system to provide usage data to the CRM database. The User model (user information, preferences etc.) will be stored in the CRM database. This data will be analyzed to find out user patterns and to do customer segmentation. It is also possible to integrate a Business Intelligence tool (e.g. Microsoft Analysis Services).

The Entity Relationship Model (ERM) of the CRM-System has to be modified also to use data for sustainability aspects. Based on this data the CRM-System is used e.g. to initiate marketing campaigns or provide data to the customer (e.g. his aggregated CO2 emissions for one year). The goal is to modify the architecture and to create processes that allow to support and to lead the customer to a more sustainable way of moving. A concrete example of use would be the following scenario: A customer drives each day 50 km from his home city to his working place using his own car. This behavior is recognizable within the data of the CRM system and the customer receives in the context of a campaign an offer for the use of a more sustainable transportation alternative (e.g. railway or car pooling) connected with a bonus (e.g. additional railway miles).

3.2.4 Influencing customer behavior towards more sustainability

Influencing the customer behavior towards a more sustainable behavior is the essential aim. The usually quoted definition for sustainability is the following one of the Brundlandt commission from the year 1987: "Permanent development is development, which satisfies the needs of the present, without risking that future generations do not satisfy their own needs [7]". This idea is located in the area of green marketing where Grant defined different activities for supporting a more sustainable consumption. In this case we are talking about cultural reshaping by making new ways of live and business models acceptable [6]. For Jinengo this means that customers should be influenced in the way that they choose a sustainable mean of transport or at least a more sustainable one that fits to their requirements and preferences. First of all we have to find out some more about the sustainability of the different means of transport. Figure 4 shows a comparison of different means of transport according CO2-emissions.

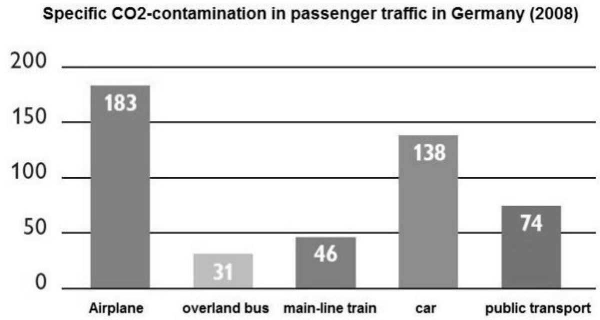


Fig. 4. CO2-emissions of different means of transport in Germany, *Source* [11]

CO2-emissions are only one important aspect according sustainability because also e.g. the resources for production of vehicles have to be considered. Also some other aspects have to be kept in mind [2]. The value for the car is based on the emissions of conventional cars and also like already said the values are different depending on statistics [24]. But it can be said for sure that Electric Vehicles would be arranged somewhere between the conventional car and the public transport. To consider car-pooling, we can use a simple factor depending on the number of passengers. So we are not dealing with 100% valid data and they have to be calculated more accurately as mentioned before, but for the first step these considerations enable us to create a clear ranking for different means of transport regarding sustainability. To encourage a customer to move more sustainably we have to identify an alternative mean of transport (e.g. train) that is more sustainable to substitute the preferred mean of transport (e.g. car). There are some important variables that have to be considered in this context:

- actual preferred mean of transport
- availability of the alternative mean of transport
- travel distance
- travel frequency
- travel preferences (comfort, costs, flexibility,...)

To apply different marketing activities e.g. a mailing campaign by E-Mail we have to identify users with similar variables (clustering). Then we can offer this group of users a specific offer according their preferences.

3.2.5 Sustainable offers to influence Customer behavior

CRM offers different techniques to modify customer behavior [13]; [30] we can use to influence the moving behavior of the customer e.g. within marketing campaigns. We even can use knowledge about the customer preferences to develop individual campaigns. E.g. there is a segment of customers who rated “comfort” very high and should be convinced to use the train instead of a car. The campaign can focus on comfort characteristics of trains like sleeping in the train, working in the train, no stress because of traffic jams etc. For cost-sensitive customers we can give discounts for train tickets and so on.

We have also the choice between different ways of marketing activities on the side of the output. We can do classical campaigns like E-Mail campaigns. But we also can post individual banners or snippets within the application. We can easily integrate a recommender system that directly make suggestions to the user since it fits well to the nature of Adaptive Applications upon which our application is built. Recommendation can be either asynchronous or it can be done directly by modifying the result list that the user gets for a request for a trip whereby more-sustainable choices could be highlighted or ranked higher. Services like Google or Amazon use different algorithms and techniques like this very successfully in a profit-oriented way. Jinengo can easily adapt these techniques to use it in a sustainable-oriented way.

4 Conclusion and Outlook

In this paper we have presented a technological as well as a business model for approaching the problems of multi-modal transportation planning and sustainable mobility. As a result the software will enable the customer to plan his trips easily on basis of vast and various data under criteria of sustainability and his preferences. The provider of the platform is enabled to influence the customer by using the generated data within a CRM system towards a more sustainable way of moving. By the name Jinengo goes our project as an implementation of the models.

Jinengo falls into the category of Adaptive Applications, a breed of applications able to sense surrounding variables and change behavior accordingly. CRM is where customer information is stored within the enterprise so it is the natural place for storing User Models, we propose Jinengo to have a firm connection to the CRM module of Enterprise Architecture and use the Microsoft Dynamics CRM for the implementation purpose.

Still the software has to be finished and evaluated by usage in real world. A project with a large German power supplier is in preparation for this purpose.

References

[1] Ben Hassine A, Matsubara S, & Ishida T (2006). A Constraint-Based Approach to Horizontal Web Service Composition. In The Semantic Web - ISWC 2006 (pp. 130-143). Retrieved from http://dx.doi.org/10.1007/11926078_10

[2] Black WR (2010) Sustainable Transportation: Problems and Solutions. New York, NY: Guilford Publications Inc.

[3] Brusilovsky P (1996) Methods and techniques of adaptive hypermedia. User Modeling and User-Adapted Interaction, 6(2), 87-129. doi:http://dx.doi.org/10.1007/BF00143964

[4] Chen L, Avizienis A (1995) N-Version Programming: a Fault-Tolerance Approach to Reliability of Software Operation. In Twenty-Fifth International Symposium on Fault-Tolerant Compu-ting, 1995, ' Highlights from Twenty-Five Years'., (p. 113).

[5] Disney J (2008) Competing through quality in transport services. Managing Service Quality, 8(2), 112–118.

[6] Grant J (2007) The Green Marketing Manifesto. England: John Wiley & Sons Ltd.

[7] Hauff V (Ed.)(1987) Unsere gemeinsame Zukunft: Der Brundtland-Bericht der Weltkommission für Umwelt und Entwicklung. Greven: Eggenkamp Verlag.

[8] Hippner H, Wilde KD (Ed.).(2006) Grundlagen des CRM: Konzepte und Gestaltung. 2nd Edi-tion. Wiesbaden: Gabler Verlag.

[9] Hippner H, Wilde KD (2006) CRM – ein Überblick. In Helmke,S. & Dangelmaier,W. (Ed.), Ef-fektives Customer Relationship Management. 2nd Edition. Wiesbaden: Gabler Verlag.

[10] Hitzler P, Janowicz K (2010) Semantic Web – Interoperability, Usability, Applicability. Semantic Web, 1(1), 1-2. doi:10.3233/SW-2010-0017

[11] ifeu (2010) Datenbank Umwelt & Verkehr 2010. Retrieved November 2010 from www.ifeu.de. Johannes S (2009) Green/Sustainable CRM. Retrieved October 24, 2010 from http://crmtiger.blogspot.com/.

[12] Kaiser MO (2005) Erfolgsfaktor Kundenzufriedenheit: Dimensionen und Messmöglichkeiten. 2nd Edition. Berlin: Erich Schmidt Verlag.

[13] Kantsperger R (2006) Modifikation von Kundenverhalten als Kernaufgabe von CRM. In Hippner

[14] H, Wilde KD (Ed.), Grundlagen des CRM: Konzepte und Gestaltung (pp. 291-304). Wiesba-den: Gabler Verlag.

[15] Kay J (2006) Scrutable Adaptation: Because We Can and Must. In Adaptive Hypermedia and Adaptive Web-Based Systems (pp. 11-19). Springer Berlin Heidelberg. Retrieved from http://dx.doi.org/10.1007/11768012_2

[16] Knutov E, De Bra P, Pechenizkiy M (2009) AH 12 years later: a comprehensive survey of adap-tive hypermedia methods and techniques. New Review of Hypermedia and Multimedia, 15(1), 5 - 38.

[17] Landua Ina (2008) Gaining Competitive Advantage through Customer Satisfaction, trust and Confidence in Consideration of the influence of Green Marketing. Unpublished master thesis. University of Gävle – Department of Business Administration, Gävle.

[18] Landmann, Ralf; Hasenberg, Jan-Phillip; Steffen, Nicole; Lutz, Antje; Wünsche, Matthias: Winning the powertrain race – The frontline role of marketing & sales, Roald Berger Strategy consultants, 2009
[19] Lemmens N, de Jong S, Tuyls K, Nowé A (2008) Bee Behaviour in Multi-agent Systems. In Adaptive Agents and Multi-Agent Systems III. Adaptation and Multi-Agent Learning (pp. 145-156). Retrieved from http://dx.doi.org/10.1007/978-3-540-77949-0_11
[20] Lewandowski D (2008) A three-year study on the freshness of web search engine databases. Journal of Information Science, 34(6), 817-831. doi:10.1177/0165551508089396
[21] Lommatzsch A, Mehlitz M, Kunegis J (2007) A Multi-Agent Framework for Personalized In-formation Filtering. Retrieved from http://edoc.mpg.de/316556
[22] Marx Gómez J, Thanh Tran D (2009) A Survey on Approaches to Adaptation on the Web. In M. D. Lytras & P. O. D. Pablos (Eds.), Emerging Topics and Technologies in Information Sy-tems. Idea Group Inc (IGI).
[23] Memari A, Heyen C, Marx Gómez J (2010) A Component-based Framework for Adaptive Ap-plications. In Modeling of Business Information Systems (MoBIS). Presented at the Model-ing of Business Information Systems (MoBIS), Dresden, Germany: Gesellschaft für Informa-tik E.V.
[24] MIT & CRA (Massachusetts Institute of Technology and Charles River Associates Incor-po- rated). (2001). Mobility 2001: World Mobility at the End of the Twentieth Century and Its Sustainability. Prepared for the World Business Council for Sustainable Develop-ment.Cambridge, MA: MIT Press.
[25] Mobasher B, Tuzhilin A (2009) Preface to the special issue on data mining for personalization. User Modeling and User-Adapted Interaction, 19(1), 1-3. doi:http://dx.doi.org/10.1007/s11257-008-9060-2
[26] Müller-Christ G, Hülsmann M (Ed.)(2007) Nachhaltigkeit und Widersprüche: Eine Managementperspektive. Hamburg: LIT Verlag.
[27] Navrat P, Kovacik M, Ezzeddine AB, Rozinajova V (2008) Web search engine working as a bee hive. Web Intelli. and Agent Sys., 6(4), 441-452.
[28] Ntoulas A, Cho J, Olston C (2004) What's new on the web?: the evolution of the web from a search engine perspective. In Proceedings of the 13th international conference on World
[29] Wide Web (pp. 1-12). New York, NY, USA: ACM. doi:10.1145/988672.988674
[30] Rapp R (2000) Customer Relationship Management. Das neue Konzept zur Revolutionierung der Kundenbeziehungen. Frankfurt a.M.: Campus Verlag.
[31] Seeley TD (1996) The Wisdom of the Hive: The Social Physiology of Honey Bee Colonies. Harvard University Press.
[32] Toyoda M, Kitsuregawa M (2006) What's really new on the web?: identifying new pages from a series of unstable web snapshots. In Proceedings of the 15th international conference on World Wide Web (pp. 233-241). Edinburgh, Scotland: ACM. doi:10.1145/1135777.1135815
[33] Tsetsos V, Anagnostopoulos C, Hadjiefthymiades S (2007) Semantic Web Service Discovery: Methods, Algorithms, and Tools. In J. Cardoso (Ed.), Semantic Web Services: Theory, Tools and Applications. IGI Global.
[34] Wagner vom Berg B, Köster F, Marx Gómez J (2010) Elektromobilität: Zukunft oder Gegenwart? - Förderung der Elektromobilität durch innovative Infrastruktur- und Geschäftsmodelle. In Schermann, M. (Ed.), MKWI 2010 Working Conference on Automotive Services (pp.111-124). Norderstedt: Books on demand GmbH.
[35] Walton C (2006) Agency and the Semantic Web (1st ed.). Oxford University Press, USA.

Conception of interactive information and decision support system for urban and industrial air quality management - model and evaluation

Cezary Orłowski[1], Łukasz Szczygielski[1]

[1] Gdansk University of Technology

cezary.orlowski@zie.pg.gda.pl, lukasz.szczygielski@zie.pg.gda.pl

Abstract. This article presents conception of interactive information and decision support system for urban and industrial air quality management. The emphasis of the project is on real-time analysis and multi-media information, and the support of distributed and mobile clients through the Internet. The approach integrates meteorological data and forecasts, air quality and emission monitoring including mobile sources such as traffic, dynamic 3D simulation modelling and forecasting, GIS, expert systems, optimization, decision support and reporting tools in a unified, modular client/server framework implemented as a range of web accessible application services.

Keywords: air, management, urban, support, system, industrial, interactive

1 Introduction

The aim of this paper is to present a model of a decision support system and its application to air quality management.

The project is within the framework of the global undertaking "Eureka WEBAIR”. The first part presents the general characteristics and assumptions of "Eureka WEBAIR”. Then the merits of the project for the Tri-City area are discussed and the main objectives of the decision support system created for the project are characterized. The next section discusses the construction of the model and the stages of its implementation. The presented work is concluded with a summary and an assessment of the system’s practicality.

2 Background of the model - Eureka WEBAIR project

The emphasis of the project is on real-time analysis and multi-media information, and the support of distributed and mobile clients through the Internet. The approach integrates meteorological data and forecasts, air quality and emission monitoring including mobile sources such as traffic, dynamic 3D simulation mod-

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_20,

elling and forecasting, GIS, expert systems, optimization, decision support and reporting tools in a unified, modular client/server framework implemented as a range of web accessible application services.

WEBAIR will develop, test, and implement a web based information- and decision support system for urban and industrial air quality assessment and management in support of relevant EU Directives such as the Air Quality framework Directive for urban conglomerates (96/62/EEC) and major industrial emission sources such as thermal power plants (88/609/EEC) or incinerators (89/429/EEC, 89/369/EEC), and 90/313/EEC on freedom of access to environmental information.

The basic idea is to offer an integrated set of tools to support regulatory compliance and reporting requirements for and on behalf of cities and industries subject to the above environmental directives. The basic business concept is complete or partial outsourcing of a range of web-accessible application services for distributed and mobile clients. Regulatory reporting as well as public information is the information product derived as an added value service from basic meteorological and environmental data. Value added in public-private partnership, and open access to environmental information as foreseen under (90/313/EEC), packaged as attractive, informative, and educational multi-media content for a range of user communities, are key concepts.

Technically, the emphasis is on real-time analysis, combining on-line monitoring and model-based assessment into multi-media information and report for a broad range of consumers, including the general public interested in environmental quality. The support of distributed and mobile clients through the Internet adds an additional business perspective for network and mobile phone operators.

The approach integrates a range of real-time and on-line data sources and tools: meteorological data and forecasts, air quality and emission monitoring including mobile sources such as traffic from on-line observations and counts, dynamic 3D simulation modelling and forecasting, GIS, expert systems, optimization, decision support and reporting tools in a unified but modular client/server architecture implemented as a range of web accessible application services. In addition to real-time monitoring and assessment with on-line publication of the information in real time as well as forecasts, and regular compliance reporting to meet regulatory requirements, the tools will also support strategic analysis of emission control using complex optimization technologies.

The technological developments in WEBAIR will focus on a number of specific closely related areas:

- Acquisition and real-time processing of monitoring and observation data; the emphasis is on capture of potentially large volumes of diverse data, efficient storage, quality assurance (plausibility, completeness, consistency) and retrieval in support of real-time processing, integration of diverse data sources including meteorological data and forecasts, air quality monitoring, satellite imagery, emission monitoring, and traffic observations.

- Integration of real-time modelling tools to augment the monitoring data from a few locations into a complete yet detailed spatial coverage of air quality information; in addition to the real-time now casting and data assimilation, short and medium term forecasts based on meteorological forecasts and dynamic emission models will be run on a regular basis, synchronized with the observation frequencies. Specific topics will include complex terrain, coastal locations and sea breeze, urban heat islands, behavior of fine particles and the explicit treatment of urban structures in dynamic 3D models.
- Automatic translation of this information into attractive multi-media formats for web access including low-resolution mobile clients, as well as the automatic generation of summary reports over various periods according to the regulatory requirements.
- Testing these components under real operational conditions in a number of applications and developing the necessary exception handling and error correcting methods for an automatic but highly reliable assessment and high availability mission critical performance.

The project invites industries subject to the Major Source Directive or cities subject to the Air Quality Framework Directive as test users of the system. Technology partners sought include manufacturers of monitoring equipment and systems for meteorological data, ambient air quality, emissions, and traffic data. WEBAIR currently includes partners from Austria, Switzerland, Russia, Finland, Portugal, Cyprus, Morocco, Italy and Lithuania and Poland.

The Tri-City (Gda sk, Sopot, Gdynia), together with all its urban area is the largest industrial and cultural center in Central Pomerania. Its specific geographical location, the presence of all the everyday means of transport (road, rail and air) and the fact that it is home for some large and environmentally burdensome industries (such as shipyards, power plants, a refinery), are all sources of air pollution, and pose a threat of a major industrial incident. The communication system, and in particular the main thoroughfare that passes the centers of all the three cities, with dense housing either side, is also unfavorable from the viewpoint of environmental risk. From the main thoroughfare, there are connections to such areas as the ports, shipyards and other industrial plants.

It seems appropriate to create a distributed IT system to manage air quality, which takes into account this specific communication system and the influence of large companies (Lotos, CHP plant, the Port of Gdansk) on the formation of the air pollution map in the Tri-City. The developed solution will be an easily adaptable system for any urban area dealing with environmental problems and industrial hazards and the consequences for residents which arise from these risks.

The system developed under the Eureka WEBAIR project will create conditions for the construction of multi-annual investment plans and development strategies. It will be possible through the use of fuzzy urban development scenarios (Polish partner's contribution) and their verification in an integrated IT urban-ecological environment. This approach will allow for the verification of the effectiveness of company environmental management systems, based on ISO 14000 and EMAS, but will also allow for the rapid identification of possible risks arising from road transport.

3 The decision support system model for air quality management

The aim of the Polish part of the project is to develop a decision support system by building a distributed system to manage air quality in urban areas. It is aimed at the needs of large urban decision-makers to assist their planning decisions. Its design is based on the construction and use of fuzzy decision-making scenarios and their subsequent processing.

The system developed within the Eureka project will help build and verify the long-term investment plans and development strategies for Gdansk up to the year 2025, while taking into account the specific communication system and the influence of large companies (Lotos, CHP plant and the Port of Gda sk) on the formation of the pollution map in the urban area of the Tri-City. There is also a plan to use an alarm-warning system, in the event of threats resulting from transport, or industrial incidents.

The developed solution will be a system easily adaptable to any urban area dealing with environmental problems and industrial hazards and the consequences for the inhabitants resulting from the aforementioned threats. Therefore, an open solution will be implemented (in view of the other project partners) which will enable the system to cooperate with other systems to provide and publish data by these systems. It is also assumed that it will cooperate with the central national air pollution base JPOAT, and the system developed under the SUTRA project. In both cases, the system will automatically deliver online to the other systems the revised time series describing air pollution and the meteorological situation.

A general decision support system model for air quality management is shown in figure 1.

Data from scattered measurement stations are transmitted to the central station. Then, the collected data are sent to the server in real time mode, which allows the measurements to be published online. These data are collected, processed and verified for the construction of decision-making scenarios. The revised scenarios for decision-making feed into the knowledge base of the expert system. The stages of the implementation of the model are shown below:

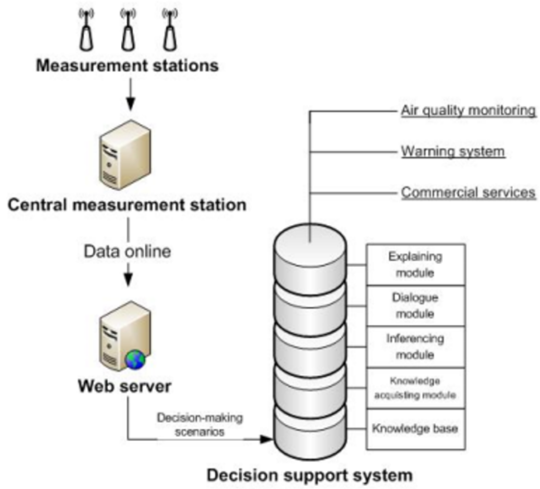


Fig 1. Decision support system

Stage 1. Extending the activity of measurement stations with devices and functions for checking air quality

The provision of data for decision-making scenarios will be implemented by the Technical University of Gda sk in cooperation with the ARMAAG Foundation and the Marshal's Office. The ARMAAG Foundation has 10 stations and central station software (CAS) assisted by applications for the verification, validation and visualization of information. The standard network activity of automated stations is carried out on the basis of the QA / QC quality assurance plan for (Quality Control / Quality Assurance).

Due to the needs of the decision-making scenarios, it will be necessary to ensure the quality of the automated measurements, which will require the application of appropriate quality control procedures throughout the measuring process. The data from all the automated stations will be transmitted to the central station in real time. The results and statuses of the measurements will be archived in local stations and stored in a raw data database without the possibility of changes being made by the operator. In addition, to ensure the quality of data, a plan for calibration is to be developed, according to which operations will be made to be included in the full calibration of an instrument.

It is also planned to expand networks in certain zones which, after consultation with the ARMAAG Foundation, were considered insufficient in terms of providing measurements (e.g. along the main thoroughfare of the Tri-City, as well as in areas of increased industrial hazard). To achieve this aim, modern monitoring stations, designed at the Multimedia Systems Department, are to be used. Apart from providing noise measurement and image analysis, they will cooperate with a highly integrated autonomous weather station. Moreover, thanks to its modular design, the system can be extended with pollutant sensors: SO2, NO2, CO, C6H6, O3, WWA, PM10, PM2.5 as required. Such a plan will provide sufficient accuracy and quality of calibration, and thus will ensure the high quality (accuracy, completeness and consistency) of data collected with the use of analyzers prepared in such a way.

The concept of using online data in the construction of decision-making scenarios assumes that the data will be provided by a coherent measurement program and a model showing how the emitted substances spread, which will be well-suited to the local (regional) conditions. In the construction of decision-making scenarios, the policy makers - planners will need to take into account the specific meteorological and functional conditions of the Gdansk urban area (Sopot has the status of a spa), for which the objectified measurement system will become an indispensable and irreplaceable tool. Therefore, the quality of the measurements will be critical for the overall decision support system [4].

Stage 2. The development of a solution to provide pollution and meteorological data online to the needs of a web server.

It is suggested to develop a platform for a web application based on OpenACS (Open Architecture Community System - http://openacs.org). This offers a range of services necessary for creating web-based applications:

- a system of access rights defining precisely which functions can be implemented by individual users of the system;
- a secure user authentication using encrypted transmission SSL and user sessions based on a mechanism of digitally signed cookies;
- standard components of the user interface, a template system which allows:

a. separation of the logic of the application and of the presentation layer in accordance with the MVC design pattern (Model - Viewer - Controller),
b. mechanisms for putting application data into packets to allow software modularity,
c. mechanisms to monitor the process of running the application, watchdog, security logs and backup,
d. mechanisms for load-balancing, clustering and database replication, allowing an application to be built within a system which ensures high reliability and scalability,
e. the handling of database connection pools and a mechanism for SQL dialect abstraction of a specific product, the so-called Query Dispatcher.

On the basis of the above-mentioned services, it will be possible to efficiently create web-based applications with high performance and reliability.

Stage 3. Data acquisition and verification

For the selection of decision-making scenarios, it is planned to provide historical data from monitoring the stations of the ARMAAG network and eleven upgraded stations belonging to the Provincial Sanitary - Epidemiological Station, where automated equipment will be implemented. The responsibility for this task will lie with: the Technical University of Gdansk and the ARMAAG Foundation. Data obtained from monitoring stations, and IT solutions for transferring and storing the data will be subject to verification processes. Therefore, it is assumed that the prepared solution should have the following features:

- Automation of the measurement data publishing process and the simplicity and convenience of publishing supplementary information, giving the opportunity to operate an updated Internet service;
- A mechanism to automatically create back-up copies to protect against physical damage to the measurement system and its central station;
- Professional security;
- The possibility to adapt the model for the collection of environmental measurements to any system for measuring and collecting results from multiple measurement systems simultaneously;
- The function of automated standardization of measurements, allowing the independence of changes in the configuration of the measuring system;
- The possibility of full control over published volumes of measurements thanks to modular validation of standardized measurement data;
- The possibility to export the measurement data, giving the option of processing them using external specialized tools;
- The publishing of up-to-date messages about environmental quality and detailed measurement data, with access to historical information;
- A simple and convenient user interface, accessible from anywhere on the Internet with a standard web browser, which does not require the installation of client applications;
- A modular construction, which allows the implementation of the system in stages, and helps to respond to a client's needs;
- The possibility to adapt the function of the modules to particular implementation requirements;
- A remote maintenance system which eradicates the need for employing highly qualified personnel to work on site.

Stage 4. The requirements of decision-making scenarios

It is suggested to develop decision-making scenarios in collaboration with the Municipal and Marshall's Offices. These scenarios will be built based on the requirements of specialist decision makers from the Departments of Spatial Planning and on the basis of zoning plans prepared for the Tri-City. An analysis of zoning plans, selecting a group of experts and the construction of zoning plans with the help of specialists in scenario implementation are also planned.

Stage 5. The construction of decision-making scenarios

Detailed linguistic scenarios are suggested on the basis of the developed groups of scenarios. On the basis of these developed linguistic scenarios, their fuzzy implementation is planned [1,3]. First, the number of input and output variables should be determined. It is assumed that this number should not exceed six in the first case, and three in the second. The choice of variables should be consulted with experts in the field of planning and pollution.

Then the construction of membership functions for input and output variables will be carried out. Multiple verification of parameters and shape is assumed. Then the process of fuzzy modeling, including inference and sharpening processes, will be conducted. Experts will suggest the values of output variables for the inference processes. The staff from the Technical University of Gda sk will perform the fuzzy modeling processes, as well as coordinating the cooperation with experts from the planning department.

Stage 6. The implementation and verification of decision-making scenarios

The implementation of decision-making scenarios and the fuzzy model will be carried out in two stages. First, using such a design tool as a spreadsheet for the easy modification of scenarios and membership functions. In the second stage, the implementation of the model through a scripting language and its evaluation by the project partners are planned.

It then, in addition, becomes necessary to build a graphical user interface in English, as well as to construct an additional base for storing customer records and their feedback. This solution will shorten the verification time of the system by project partners. After the development of the model, decision-making scenarios will be subject to assessment. As was the case in the previous point, the use of the graphical user interface and the new database to record customer feedback is also suggested here.

Stage 7. Constructing the model of the decision support system

The system will be built based on the architecture of open expert systems [2,4], consisting of the following modules:

- A knowledge base containing a compartmentalized object description of decision-making scenarios;
- A module of knowledge acquisition – enabling, in dialogical form, the acquisition of linguistic knowledge from experts in the field of spatial planning;
- Inference module - which creates conditions for the processes of prognostic and diagnostic reasoning, based on the decision-making scenarios in the knowledge base;
- Dialogue module - containing commands that allow the user to communicate with the system;
- Explaining module - software for the interpretation of the decision.

Stage 8. The implementation and verification of the decision support system

The result of the implementation process will be a web content management system (CMS), the functions of which will be implemented using the following modules:

- The management of the published information structure, enabling the addition and deletion of pages as well as their organizing into hierarchical structures to be used as a basis for clear navigation, a selection of published content on individual web pages and templates determining the appearance of the pages;
- A content repository for storing and organizing content for publication;
- A system of presentation templates for different types of information stored in the content repository.

The CMS system typically supports content in an unstructured form. The solution also offers the definition of additional attributes of objects which enables the process of storing structured information in the form of records. Structured information related to objects will also be published with the use of presentation templates.

Furthermore, adding support for structured information can simplify the management of large data sets. The CMS system and the content repository will also enable the management and publishing of information in the form of illustrations, files, multimedia, electronic maps, numerical data in graphs, tables, summaries and reports. Its capabilities will also encompass the process of allowing access to objects managed by additional modules, which possess some logic, such as polls, surveys, forms, interactive reports and statistics. The verification of the system will be implemented via expert sessions. Such sessions with the system will be carried out by different partners of the Eureka project. It is planned that the results of the sessions be collected by use of, as was previously mentioned, graphical user interfaces and databases to keep records of the session results. They will form a basis for making changes to the system in accordance with the observations of potential users.

4 Summary

This paper presents the possibility of using an expert system for decision support related to the management of air quality. The suggested approach allows the use of an IT system to monitor air quality in urban areas and to support decisions (the alarm-warning role of the system). The use of fuzzy decision-making scenarios (easy to implement by experts and users of the system) as well as their subsequent processing, will provide users with accurate information about air pollution prognosis.

The system will comply with any spatial infrastructure arrangement, including the specific communication system of the Tri-City and the influence of large companies in shaping the map of air pollution in the Tri-City. The suggested solution is an indispensable tool for the implementation and monitoring of regulations under the Environment Protection Act. The open approach, which assumes the easily adaptable nature of the system, allows the use of the system in any urban area dealing with problems of environmental protection.

References

[1] Górski J, Orłowski C (2010) Inżynieria oprogramowania w procesach integracji systemów informatycznych, PWNT, Gdańsk
[2] Niederliński A (2006) Regułowo-modelowe systemy ekspertowe. Komputerowa Jacka Skalmierskiego, Gliwice
[3] Stefanowicz B (2003) Systemy eksperckie. PWN, Warszawa
[4] Zieliński J (2000) Inteligentne systemy w zarządzaniu. Teoria i praktyka. PWN, Warszawa

An Environmental Management Information System for the basin of Sagua la Grande, Cuba

Saumel Enriquez Caro[1] , Maybel Anido Bada[2], Ramdy Ramirez Leal[2], Henly E. Garcia Solenzal [1], Zenia Padilla Velázquez [1]

[1] Informatic Studies Center, Central University of Las Villas,
[2] Center of Software Development, University of Informatic Sciences,

senrique@uclv.edu.cu, anido@vcl.uci.cu, rlea@vcl.uci.cu, zpadilla@uclv.edu.cu, hsolenzal@uclv.edu.cu

Abstract. This article is dedicated to describe the development of a system that provides to management of the Company of Water Resources in Villa Clara, essential information for decision making related to sanitation and water care in the country. The Environmental Information Management System (SisGIM) has been designed with the aim of supporting the management of the company in the qualitative and quantitative assessment of water resources of the basin of Sagua la Grande, province of Villa Clara, allowing them to display the results of historical data analysis taken from monitoring stations in the area. The implementation of this system is based mainly on management and evaluation of indicators and their integration with web technologies and geographic information systems for the representation of geographically referenced data. An infrastructure to manage this kind of Information System is presented and other cases of study are implemented to use it.

Keywords: Geographic Information Systems, Geographic Information Systems.

1 Introduction

During the latest years the perception about the planet's natural resources has changed, largely due to pollution and depletion of water sources [1]. This large increase in environmental problems has stimulated the development of computer systems increasingly more powerful and faster for handling large amount of information from various data sources [2]. Cuba is not a strange to these problems and since some time ago has promoted the development of applications that help with environmental care. That is the case of the study performed for Sagua la Grande basin in the province of Villa Clara in order to determine quality indices for water sanitation and quantify the degree of deterioration or improvement of the waters. This article describes the design and implementation of SisGIM developed for the Company of Water Resources of Villa Clara in order to support with updated summary information the decisions to make by the management regarding to protection and care of water resources of the mentioned basin.

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_21,

2 Design and Implementation of the System

The system was designed primarily and mainly for business executives of the organization, allowing them, through an application on-line in a simple and intuitive environment, to monitor and detect deviations in the behavior of the variables involved in water quality in the basins of the country. So far the executives were able to make their decisions and actions only based on reports received from specialists in the field at certain times, information which in turn was applied to monitoring stations and, usually, was not updated at the moment to be analyzed by the management of the company

2.1 Structure of SisGIM

Three basic modules compose the SisGIM. The first and principal module is aimed to the management of indicator related with the quality and care of the water in all the basins of the country. The second one was created with the intention of supporting the management of indicator allowing the visualization of spatial information. There is also a small module to handle the security and the user access.

The main challenge of SisGIM was precisely the module called Management of Indicators (MI) responsible of making all updates in the variables from the monitoring stations and be consulted on-line for the managers in the Company. This idea was supported with the module of Visualization (GIS & SV) that allows analyze the behavior of these variables on the maps. This module was conceived in the beginning for the use of the executives of the company, but with the development of the tool several useful functionalities were added for the specialist on maps.

2.2 Why should Balanced Scorecards, Geographic Information Systems and Scientific Visualization be integrated?

Several technologies where analyzed to find out the most appropriated combination to solve this problem, these are some of the main reasons to use these ones:

1. It makes possible to determine how the geography influences on the variables and indicators that MI measures.
2. It enables business users to see the impact of their changes automatically reflected in maps and tables.
3. Geographically referenced information presented in summary form provides a quick overview.
4. MI integrated with a GIS is a powerful tool in regard to management and support decision making by executives.

2.3 Module Management of Indicators (MI)

The module Management of Indicators is the main objective of the system which allows, based on the analysis of environmental variables, to assists business managers in making decisions. After an in-depth study on the issue and taking into account the needs of the Company of Water Resources it came to the conclusion that CMI could not be a traditional solution to this particular problem, because it would only implement a subset the objectives of the strategy of the organization, thereby creating the GI taking from CMI methodology those aspects that, according their main defenders, should never be absent from this type of solution. This module is aimed at executive management in its fullest extent and specialists in the matter in order to monitor the indicators and include new measurements for the variables involved.

Data were provided by specialists from the Company of Water Resources in the province of Villa Clara and were split in two categories: historical data and geospatial data. Historical information is from the measurement of variables which include data from 1993 up to 2008, taken in two periods each year, dry and rainy season for each one of the thirty monitoring stations, twenty-three of them belong to the underground sources and the other seven belong to surface sources. Hydrochemical classifications were also obtained to establish, by using the pre-fixed coefficient ranges of quality (Qi) of each individual variable and also the classification of the general Water Quality Index (WQI), both of them included in the range of 0-100 units, with different intervals depending on the variables in question.

Table 1. Range, classification and color of the Qi.

Range	Quality	Color
0 • Qi • 30	Highly Contaminated	Red
30 < Qi • 45	Contaminated	Yellow
45 < Qi • 60	Medially Contaminated	Green
60 < Qi • 80	Acceptable Quality	Blue
80< Qi • 100	Excellent Quality	Dark Blue

In Cuba, several researchers have developed an index to evaluate the quality of water for different uses [3]. This index is calculated by the following equation [4]:

$$ICA = \prod_{i=1}^{n} (Qi^{Wi}) \qquad (1)$$

Where Wi are the specific weights assigned to each variable (i) and weighed between 0 and 1, so that it meets the sum is equal to one, Qi is the quality of the variable (i), which is calculated based on the magnitude of the i evaluated according to the quality curves whose classification varies between 0 and 100. The indexed product represents the multiplicative operation of the variables raised to the Wi Qi.

Finally, ICA in (1) is a figure between 0 and 100, which rates the quality, and from which, and depending on the use of water, allows to estimate the contamination level.

2.3 Module Geographic Information System and Scientific Visualization

This module is due to the thought of a visual reinforce of the information consulted by the managers of the company with graphs and percentages on the maps of the monitoring stations of the basin. Taking this as a start point a new interest also came up and in turn additional persons involved in the project: mapping specialists, who until now did not have any web application for visualization, which prevented them from simultaneous access to centralized data of the basins, of course this caused them countless problems when they needed to synchronize the results of everybody´s works.

GIS & SV provides the ability to view geospatial data in such a way that allows the user to apply various techniques to data from the Scientific Visualization in order to reveal the correlations and patterns between attributes. Business users want to see the impact of their changes reflected automatically in the maps, providing as well a dynamic and easy-to-understand feedback.

The data used in this module are the same historical data from geospatial GI, they are in Shapefile format and contain the geographic coordinates of the maps corresponding to different layers that make up the basin, including roads, villages, monitoring stations, hydrographs, geology and others.

What is proposed is an information system able to collect and display a set of digital maps that may characterize the area under study so that allows the personnel involved to obtain the same visual information independently. Also in order to establish a layered structure that reflects relations between the different coverage that make up the basin, thus enabling, for example, establish a settlement or a reservoir as a reference point to identify a particular station in the basin or simply know to which town belongs a reservoir or a station.

It also includes the ability to apply some Scientific Visualization techniques to the variables corresponding to each one of the monitoring stations for the behavior of water, specifically the techniques of parallel coordinates and segments of circles, which can be applied dynamically on the selected station and the outcome of their application is automatically displayed on that station.

3 Architecture of SisGIM

The SisGIM development is based on a client/server architecture and its basic operation is shown in Figure 1:

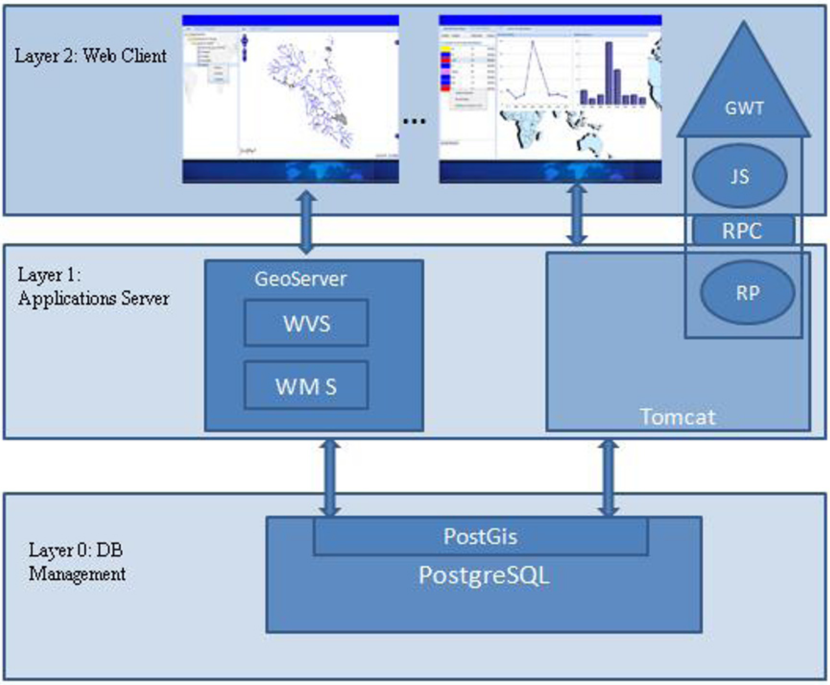


Fig. 1. General Structure of the System, three levels defined

Web Client: Provides access to application modules SisGIM. The first module (from left to right) includes geospatial visualization and application of various visualization techniques through the Visualization Web Service (WVS). The second module is dedicated to the assessment and management of indicators, in order to understand and evaluate the state of water resources in the basins of the country.

Visualization Web Service: Web Service for the application of scientific visualization techniques, which allows to apply a selected technique for a particular data set in order to establish correlations between them.

By accessing SisGIM application, the client can request on any of the two main modules: GIS & CV and GI. The GIS module & VC, if the request was to represent spatially map data from a given, the application transforms these requests to the standard library using OpenLayers WMS. These requests, in a formal way, are forwarded to the GeoServer map server, which sends back the response by querying the spatial database. Otherwise, if the request was to apply some of the Scientific Visualization techniques implemented, the request is sent to the server through the service WVS, which in turn also sends back the response to the application by querying to the database in a dynamic way.

The client requests that reach the GI module are sent to the server through Remote Procedure Call (RPC) service, which as well as WVS service, sends back the response using dynamic queries to the database.

The following describes each of the elements involved in the implementation of the application:

- Database Manager: PostgreSQL 8.4 with the geo extension PostGis 1.5.1.
- Geographic Server: GeoServer 2.0.0.
- Application Server: Apache Tomcat 6.0.18.
- Development platform: JDK 1.6.0_12.
- Development language: Java.
- Development IDE: NetBeans 6.7.1, including the plugin org-netbeans-modules-gwt4nb-6.7.nbm.
- Libraries used: OpenLayers_gwt 0.4, GWT-Ext 3.0

3.1 Preparation and Content

About system design and content were taken into account the following steps for its development:

- The first phase: the most important variables or key aspects to consider for proper measurement are defined.
- Second phase: the selected variables are quantified in the time periods that are considered appropriate.
- Third phase: features that allow management and evaluation of the variables involved with the help of thematic maps and graphs are implemented.

3.2 Implementation of SisGIM

In relation to the system design and how to present it, the following ideas were taken into account:

- Submit only information really necessary, in a simple and, of course, synoptic summary.
- Highlight what is truly important, offering a greater emphasis on more meaningful information by using different colors.
- Do not forget the importance of both graphics and thematic maps, because they are true supporting links of all the information summarized that you want to recall.
- Uniformity in the way to work out the system is important, as this will enable a true standardized reporting to be use by the the Water Resources Company.
- The system must be easy to understand, pleasing for watching, so it could be desirable for the specialists who must use that system, otherwise they will never get ride of the former methods.

4 Conclusions

As a result of this research was developed Environmental Information Management System (SisGIM) on the Web, which allows the staff of the Enterprise of Water Resources in the province of Villa Clara the information management. New technologies were implemented and its integrations has proven that Information management systems are a powerful tool to estimate how the development of the society can impact on the environment and how it is possible to maintain the progression of the life in the earth without affecting the future generations. The balanced scoreboards were the basis to measure the levels of contamination in the waters of the country, it resulted a very good idea to show the information to executives and allow them take better actions with the finality of protect the environment.

References

[1] Enkerlin, C., Cano, E., Gernimo, A.: Environmental Science and Sustainable Development. pp. 181—184, International Thomson Editors, Mexico (1997)
[2] Armenteras, C.: Geographic Information System at the Alexander Von Humboldt University. Humboldt J., 195--197 (2001)
[3] Garcia, J.M., Beato, O., Gutierrez, J..: index to evaluate Superficial Water Quality. pp. 47—52, Voluntad Hidraulica , Cuba (1979)
[4] Enkerlin, C., Cano, E., Gernimo, A.: Environmental Science and Sustainable Development. pp. 181—184, International Thomson Editors, Mexico (1997)

Part III
Environmental Performance Indicators

Including Environmental Performance Indicators into Kernel based Search Space Representations

Joerg Bremer[1], Barbara Rapp[1] , Michael Sonnenschein[1]

[1]University of Oldenburg

joerg.bremer@informatik.uni-oldenburg.de,
barbara.rapp@informatik.uni-oldenburg.de,
michael.sonnenschein@informatik.uni-oldenburg.de

Abstract. Virtual power plants are considered a promising concept for the integration of decentralized energy resources into the future electricity grid. But such a plant must not only optimize load schedules merely according to given economic objectives and technical constraints, if it is to be considered as a green technology. Hence, environmental issues have to be incorporated into optimization objectives, too. Here, we show the possibility of integrating respective performance indicators into search space descriptions in a way that enables direct incorporation into optimization. A meta-model for constrained search spaces based on one-class support vector machines is enriched with information on individual environmental impacts.

Keywords: Environmental Performance Indicator, Support Vector Methods, Virtual Power Plants, Power Generation Planning, Smart Grids

1 Introduction

Currently, virtual power plants (VPP) are expected to play an important role for the integration of distributed energy resources (DER) into the energy grid in the near future [6, 3].

We consider a VPP as an orchestrated group of DER that communicates with and is controlled by a central controlling unit that is responsible for seeing that the group as a whole fulfills certain objectives like bundling for greater market power or grid stabilizing by reduced stochastic feed-in.

In order to make a VPP a properly orchestrated group, a frequently run scheduling task is involved. In this way, it is the task of a scheduler to find a schedule for each participating DER for a given (future) time frame such that the sum of all schedules results in a desired (e.g. offered at an energy market)

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_22,

aggregated schedule. These schedules then specify the course of power production or consumption of each individual DER. At the same time, several operational constraints have to be obeyed while searching for appropriate schedules. We do not deal with any concrete objective here, but we assume that a central scheduling unit has to search the space of alternative load schedules for each DER in order to find an appropriate one that fits best for the problem at hand.

To be able to do so, the scheduler must know for each individual DER which schedules are operable (no constraint violation) and which are not. Recently, an approach for a compact encoding of the bounded (by constraints) sub-spaces of operable schedules that form the search space of a DER has been introduced [2]. This approach allows for a description of all the regions that are to be scoured for appropriate schedules with the help of learned (support vector) example schedules. As yet, the evaluation of a found solution (sum of schedules from individual DER) is based merely on the proximity to a target schedule that is supposed to be achieved. The encoding so far comprises the set of operable schedules but no additional information for evaluation. There are usually more criteria to be involved, considering for example the concurrent minimization of individual cost. If a VPP is to be considered a green technology, individual environmental impacts (e.g. avoidable energy losses) of alternative schedules have to be incorporated in evaluation as well. If the central scheduler is supposed to select alternative schedules according to their individual environmental performance, then such information must be incorporated as additional feature sub-space into the search spaces of the individual energy re- sources. Without knowing the respective functional relationship, the environmental performance cannot be derived directly from the load schedule.

In the remaining part, we will discuss some DER related indicators for evaluating individual environmental performance during optimization. We will then demonstrate that the mentioned support vector approach for encoding the load schedules of a DER is flexible enough to incorporate additional information about the individual environmental performance of each alternative. While learning the geometrical structure of the space of feasible schedules the approach is able to concurrently learn the (probably hidden) functional relations between schedule and assigned performance indicators. In this way, each individual alternative load schedule can be annotated with its individual environmental performance. We will geometrically discuss the regions of operable schedules (the search space) and describe how environmental performance indicators (EPI) as individual annotation fit into this representation and how this new representation is encoded. We will conclude with some simulation results that demonstrate that the individual environmental information for each alternative schedule can be reconstructed from the submitted support vector information.

2 Environmental performance indicators

Environmental performance indicators like carbon or energy footprint usually measure the environmental impact of the activities of organizations. In this way, they are a measure that reflects the performance in achieving the actual objectives with respect to environmental issues (cf. [5]).

The OEPI-project (http://www.oepi-project.eu) aims at developing a set of standardized EPIs and a software solution for collecting and managing environmental performance information and reporting based on EPIs. The OEPI project aims at business users across industries and supply chains and particularly at a vision of a continuous reduction of environmental impact of daily operations. To achieve this, the visibility of EPIs of alternative decisions in corporate and supply chain operations is enlarged.

If EPIs from different DER are to be compared during an optimization process for environmentally conscious decision making, a unified description language is required that unambiguously defines how an EPI was computed and what data was considered. OEPI is also developing a language using a reference-ontology to de- scribe data semantics.

Currently, such measures are applied on a long term (usually annual) or on a one-time basis, what naturally limits the scope of application for such EPIs. Annual sustainability reporting is one example for today's use of EPIs - with the aim of merely gaining legal compliance. At present, the need for a shift from such strong operational focus to a more strategically oriented realignment of e.g. corporate environmental information systems (CEMIS) can be observed [9]. However, two use cases currently scrutinized in OEPI are:

Sustainable procurement is an example for a use case calling for EPIs being avail- able virtually on demand. It integrates a concept for supplier-dependent EPIs into business processes for procurement. Here, one goal is to enable the business user to take action (and responsibility) according to different environmental impacts of different alternative material sources. This is currently hardly possible because the individual variations are not captured in the procurement information systems [4].

Design for environment as a second example from the OEPI project aims at product engineers and the integration of environmental impact awareness during the product design and optimization process. One result will be a faster evaluation of alternative designs with different environmental footprint.

Both use cases can be adapted for the load planning process within a VPP. In this way, we will here consider the procurement of a different product. Inside a VPP, a DER has several alternative load schedules to offer as the product that is sought after by the utility. As every material (physical) product, it is also possible in such a scenario, to assign measures of individual environmental impact to each alternative load schedule. Examples for EPIs concerning DER in the context of VPPs are:

- Static losses, i.e. the loss of energy due to imperfect insulation e.g. in a thermal buffer store. The higher the temperature is in the store, the higher are the losses;
- Too many cold starts (e.g. for μ CHP) entail increased fuel consumption and

abrasion;
- Low generation rates often lead to a declined efficiency as fig. 1 shows using the example of the SOLO-Stirling-CHP [10].

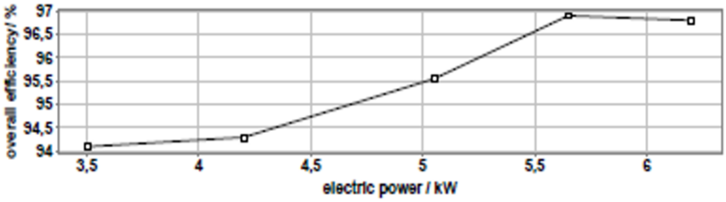


Fig. 1. Relationship between generation rate and overall efficiency for a SOLO-Stirling-CHP. *Source: Modified from [10].*

If each alternative load schedule was annotated with appropriate EPIs, the scheduler could choose schedules for integration into the optimization process not only by appropriateness but also by environmental considerations. Overall, this would result in a new use case, that makes these EPIs (on an even smaller time scale) not only available for business users for their daily business decisions, but integrates EPIs into an fully automated optimization and decision process.

3 Kernel based search space descriptions

Clearly, each DER has to serve the purpose it has been built for. Often, this purpose may be achieved in different alternative ways. For example, it is the (intended) purpose of a µ CHP to deliver enough heat for the varying heat demand in a household at every moment in time. Nevertheless, if heat usage can be decoupled from heat production by use of a thermal buffer store, different production profiles may be used for generating the heat what in turn results in different electric profiles, too. Different alternatives for production have different environmental impacts, but currently no use is made of this information although it may be available at appliance side.

3.1 Scope of action of DER

Up to now, we see a schedule as a data vector $x \in \mathcal{X} \subseteq \mathbb{R}^d$, with number of periods d. For each period the i-th element of x describes the respective amount of energy produced or consumed in this period or respectively the mean power output or input.

Here, operable means that such a schedule can be operated by the DER without violating any technical constraint. Moreover, we consider additional non-technical constraints that may restrict the possible operations of a DER. Each

DER has to restrict its possible operations due to several constraints. These can be distinguished into hard constraints (usually technically rooted, e.g. minimum and/or maximum power input or output) and soft constraints (often economically or ecologically rooted, e.g. personal preferences like noise pollution in the evening). In this way, we define the scope of action of a DER as the set of operable schedules for a given future time horizon.

3.2 Geometric interpretation

The set of alternative, operable schedules is called the scope of action of a DER. For encoding with support vectors, it is interpreted geometrically as (arbitrary shaped) set of sub-regions inside the space of all schedules. For a better understanding of the encoding procedure, we will briefly introduce the geometric interpretation of schedules and constraints analogue to [2].

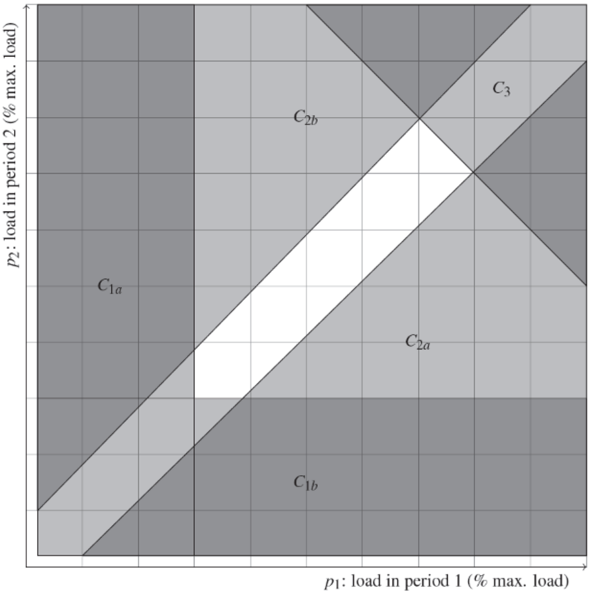


Fig 2. A two-dimensional ex- ample with three constraints:

C_1 Energy level restrictions: The region $p_1 \in [0, pmin]$ (C_{1a}) and $p_2 \in [0, pmin]$ (C_{1b}) is prohibited due to modulation restrictions.
C_2 Limited acceleration: No instantaneously changes. Constraint C_2 prohibits all schedules with a difference $\|p_1 - p_2\| > \delta max$ above a given threshold δ_{max}.
C_3 Nearly charged storage: Buffer is nearly charged and no heat is used, the sum $p_1 + p_2$ might be limited by an upper bound as shown with constraint C_3.

We aim for submitting a compact description of the scope of action of a DER by means of support vectors. This description will be based on topological properties.

Figure 2 shows a simple two-dimensional example. With a maximum load of 100% (and a minimum of 0%) as the only constraint, the space of feasible schedules would be $\mathbf{L}_\mathrm{f} = [0, 1]^2$ - i.e. the whole rectangle in figure 2. Different constraints prohibit the use of different regions; depicted are three examples.

Modulating co-generation plants are usually able to vary their electricity generation between a minimum and a maximum load. Shutting down the device is naturally an additional valid option. Therefore, such a constraint (C_{1a} for the first period and C_{1b} for the second) prohibits the region between zero (but not zero itself) and minimum power.

Due to inertia, physical devices cannot act instantaneously. Often, additional reasons prohibit a too quick changing of generation level even for longer terms. Constraint C_2 prohibits all schedules with a difference above a given threshold.

Every CHP plant needs to have the concurrently generated thermal energy either used or buffered. If the buffer is nearly charged and no heat is used, the sum (C_3) is limited by the remaining storage capacity.

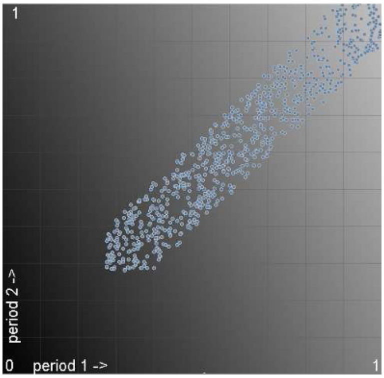


Fig 3. Depiction of an EPI. For demonstration purpose, the static heat losses due to charging a thermal buffer store by a µ CHP has been chosen as an example EPI. For each 2-dimensional schedule (point plane) the gray scale denotes the heat loss resulting from the respective electric schedule scaled to [0, 1]. Black denotes the lowest possible losses (constantly lowest allowed temperature), white the highest.

Only the extant region (white color in figure 2) finally represents the scope of action of the energy resource (in this example a co-generation plant) that has to be encoded for submission to the central scheduler.

Figure 3 shows the scope of action (as sample of operable schedules taken from a simulation model) for a µ CHP together with the color-coded static losses. The actual value of such EPI for each schedule from the scope of action is individual information and should be attached to the respective schedule.

Information on e.g. how this EPI was calculated, uncertainty, data type etc. (i.e. information describing the semantics) is the same for each schedule and might be treated separately.

It is actually the combination of all scopes of action from all DER within a VPP, that has to be scanned for solutions that fit best to achieve the given objective. A direct annotation of each schedule with EPIs leads to an increase in dimensionality. On the other hand, it allows for an integration of EPIs as a sub-space of schedules what allows in turn for an equal treatment (as not annotated schedules) for encoding.

3.3 Ontology based EPI description

If EPIs from different DER are to be compared for environmentally conscious decision making, a unified description language is required that unambiguously defines how an EPI was computed and what data was considered. The OEPI project aims at developing an EPI description language based on the use of ontologies. In this way, semantic reasoning over the EPIs becomes possible, but moreover, it allows for a standardized description. The language will allow developers to build applications with automatic gathering, searching, analysis and delivery of environmental data.

Using ontologies also indicates some (software-) technical needs for appropriate requesting the annotation with certain EPIs as well as for answering such requests. The description of the EPIs will be given in terms of an ontology based description language leading to ontology based queries for annotated schedules. The actual problem arises for encoding the answer. With the herein described encoding method, it will not be possible to encode in terms of an ontology. Encoding will only be possible if the value of each EPI that is assigned to a schedule can be expressed as a (probably unknown) function f of this schedule:

$$(e_1,\ldots,e_\pi) = (f_1(x),\ldots,f_\pi(x)).$$

For encoding we will use

$$\mathbf{X}^* = (x_1,\ldots,x_d,e_1,\ldots,e_\pi) = (x_1,\ldots,x_d,(f_1(x_1,\ldots,x_d),\ldots,f_\pi(x_1,\ldots,x_d))),$$

instead of $x \in \mathbf{X}$. In addition, we assume that the additional meta-information for each EPI is the same for all schedules so that they might be treated separately from data values.

3.4 Encoding the search spaces

The support vector approach proposed in [2] encodes the space of alternative load schedules by means of support vector data description techniques. By mapping all load data to some high dimensional space and calculating the smallest enclosing hyper-sphere there, it becomes possible to describe the sub-space of feasible alternatives by a comparatively small subset of example schedules. This technique enables a central scheduling unit to only select from appropriate (in the sense of operability) schedules for each energy resource. However, up to now, environmental considerations had been neglected.

We will now give a short introduction to support vector data description (SVDD) and how it is used for encoding and representing the search spaces. Given a set of data samples, the inherent structure of the scope of action where the data resides in can be derived as follows: After mapping the data to a high dimensional feature space by means of a Gaussian kernel, the smallest enclosing sphere in this feature space is determined. When mapping back this sphere to data space, it forms a set of contours (not necessarily connected) enclosing the given data sample. Using $\mathbf{X}$ instead of $\mathbf{X}$ automatically incorporates the EPIs into this process.

For an explanation of the discussed approach, we follow [1, 2] but now consider data points from the above sketched data space $\mathbf{X}^*$

Let $\{x_i\}_N \subset \mathbf{X}^* \subset R^{d+\pi}$ be a sample of N data points with dimension d and π EPIs included. We now consider a nonlinear mapping Φ: $\mathbf{X}^* \to \mathbf{H}$, $x \to \Phi(x)$, of points $x \in \mathbf{X}^*$ to an high or possibly infinite dimensional feature space $\mathbf{H}$. The smallest sphere with radius R and center a in feature space that encloses $\{\Phi(x_i)\}_N$ can now be derived from

$$\|\Phi(x_i) - a\|^2 \leq R^2 + \xi_i \quad \forall i \tag{1}$$

with $\|.\|$ denoting the Euclidean norm and incorporating slack variables $\xi_i \geq 0$ introducing soft constraints for sphere determination. Introducing β_i and μ_i as the Lagrangian multipliers, the minimization problem (1) becomes

$$L(\xi,\mu,\beta) = R^2 - \sum_i (R^2 + \xi_i - \|\Phi(x_i) - a\|^2)\beta_i - \sum_i \xi_i \mu_i + C\sum_i \xi_i. \tag{2}$$

$C\sum \xi_i$ is a penalty term and determines size and accuracy of the resulting sphere by determining the number of rejected outliers. Usually C reflects an a priori fixed rejection rate. This equation can be relaxed to the Wolfe dual form [2]

$$W(\beta) = \sum_i \Phi(x_i)^2 \beta_i - \sum_{i,j} \beta_i \beta_j \Phi(x_i)\Phi(x_j). \tag{3}$$

At this point, we may harness the well known Mercer's theorem [7] and calculate dot products in $\mathbf{H}$ by means of a Mercer kernel in data space: $\Phi(x_i) \cdot \Phi(x_j) = k(x_i, x_j)$.

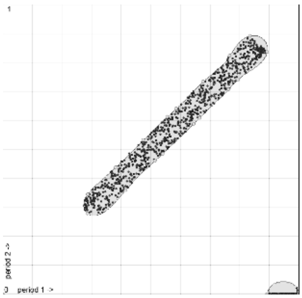
A Gaussian kernel: $k_{\mathcal{G}}(x_i, x_j) = e^{-\frac{1}{2\sigma^2}\|x_i - x_j\|^2}$ is used in our approach. Putting it all together now, we arrive at the equation that has to be maximized in order to determine the desired sphere:

$$W(\beta) = \sum_i k(x_i, x_i)\beta_i - \sum_{i,j} \beta_i \beta_j k(x_i, x_j). \quad (4)$$

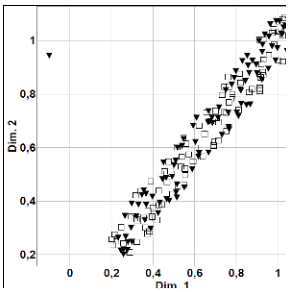
As usual in support vector methods, the result is represented in terms of an expansion into the feature space, i.e. our sphere is represented by a center $a = \sum_i \beta_i \Phi(x_i)$ and a radius R_S. However, the distance R (in feature space) of the image of an arbitrary data point $x \in R^d$ to the center of the sphere might be calculated in data space:

$$R^2(x) = 1 - 2\sum_i \beta_i k_G(x_i, x) + \sum_{i,j} \beta_i \beta_j k_G(x_i, x_j). \quad (5)$$

Support vectors are mapped onto the surface of the sphere. Therefore, the radius of the sphere can be calculated with the help of (5) and $R(x_i)$ represents the radius of the sphere iff x_i is a support vector, i.e. satisfies $0 < \beta_i < C$.



(a)



(b)

Fig 4. Sample of operable schedules from a 2-d example and the shaded region of points with a radius less then the radius of the sphere on the left and an example with 8-dimensional schedules that has been reduced to a 2-dimensional representation by means of Sammon's projection on the right. It compares original schedule (□) with re-sampled schedules at scheduling unit.

Calculating the radius of an arbitrary point in data space (note that knowing Φ is not necessary) and comparing with the radius of the sphere, enables the distinction between points lying inside (or on the boundary of) the area of the original point cloud and the ones outside. The sphere in $\mathbf{H}$ and thus also the contour of $\mathbf{L}_f$ can be fully described by means of (5). Let R_S denote the radius of the sphere, then

$\{x | R(x) \leq R_S\}$ describes the set of schedules that are inside or on the surface of thesphere and hence inside or on the boundary of the region of feasible schedules that are compliant with all constraints and contain correct EPI values. So, the vector β and the set $SV = \{x | x \in \mathbf{X}^* \wedge R(x) = R_S\}$ of support vectors is the only necessary information on the scheduler side to reconstruct the region of feasible schedules. All other load profiles x_i from the sample that are not a support vector do have a respective value of $\beta_i = 0$. For this reason they do not contribute to the radius calculation in (5) and are hence dispensable.

Figure 4 visualizes how this approach works so far with schedules that have not yet been annotated with additional information.

Schedules are drawn from a μ CHP model that has been parameterized with constraints similar to the example from section 3.2. Circles depict original data points. Larger, non-filled circles on the boundary have become support vectors. In this con- text, we will refer to them as support schedules. Dark circles represent schedules that are mapped to the interior of the sphere. It is sufficient to submit the comparatively small subset of support schedules to a central scheduling unit. With this information it is possible to determine all schedules with a radius less or equal to the radius of any of the submitted support schedules. The area these valid schedules reside in has been shaded to light grey in Fig. 4(a). Figure 4(b) shows an example with schedules of a higher dimension. Because there is no virtue in displaying examples with dimension $d > 3$, the data of these examples has been prepared with dimension reduction techniques.

The topological traits of a scope are captured by the support vector description. It defines an envelope around the set of alternative schedules. In this sense, valid schedules can be separated from invalid ones. A description of the region of feasible schedules in this way incorporates implicitly the model of the energy resource and all constraints. Therefore no explicit modeling of the device within the scheduler is necessary for a discovery of the alternative choices for different operable schedules.

4 Simulation results

So far, we tested the proposed encoding method with simulated DER within VPP scenarios. Among the simulated devices are: co-generation devices with thermal buffer store, controllable cooling devices and shiftable loads like e.g. dishwashers.

All simulations have been done with power scaled to [0, 1]. All simulations incorporating a μ CHP also encompass the simulation of the respective household that is heated by this μ CHP. This implies the simulation of the respective heat demand, heat use, different weather conditions or heat losses by thermal diffusion processes.

On scheduler side, the optimizing unit can use this information to decide, which schedules may be considered for fulfilling the optimization objective and which may not [2]. What so far has been neglected is the individual environmental impact as additional basis for decision-making.

4.1 Integration of EPIs into the optimization process

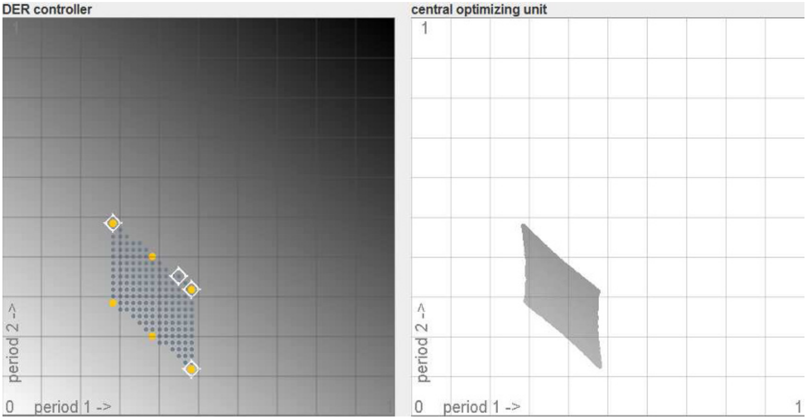
Currently (without the integration of EPIs) the workflow is the following:

1. The scheduling unit requests the scope of action for a given time horizon from each single DER
2. The (μ)controller draws a sample of operable schedules from a mathematical model and harnesses the outlined support vector method.
3. Prior to submission with an agreed protocol, the information (set of support vectors and a weight vector) is encoded according to the protocol at hand.
4. The encoded scope of action of the DER is transmitted to the scheduler.
5. The scheduler uses the submitted schedules and weight vectors to decide if a schedule is operable.

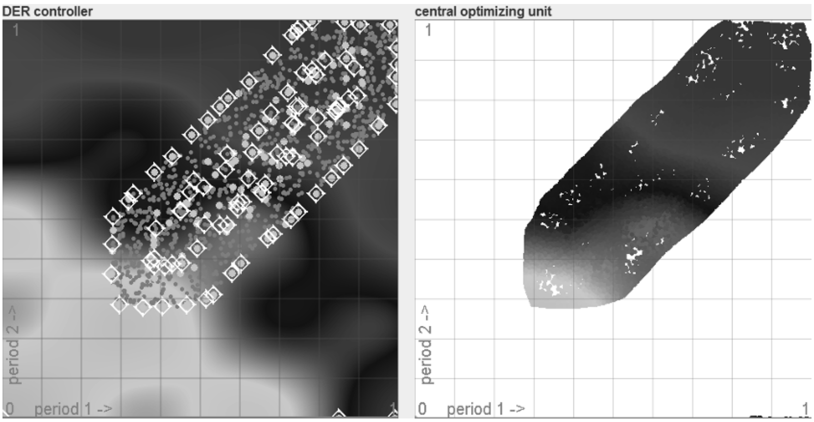
With included EPIs, it seems more appropriate not to use the decision boundary directly during optimization as the encoded EPIs are usually singular values and not taken from an interval. One way to overcome this problem is the generation of a set of operable schedules for each DER prior to optimization. In this way, the decision function (Eq. 5) can still be used as usual. Nevertheless, better results can be expected with integrated slack: $\{x| \, ||R(x) - R_S|| \leq \varepsilon\}$.

In this two-step-approach, EPIs are incorporated in the optimization process as follows: for each DER, a set of random vectors ($\in \mathcal{X}^*$) is generated and checked against the radius function. Random vectors with a radius $\geq R_S$ have either a non- operable schedule or wrong EPI values or both. Only vectors with correct (operable) load schedules and correctly assigned EPI values become part of a candidate set of the respective DER. During the optimization procedure as a second step, one vector is picked from each candidate set in order to get a solution for evaluation. The first part of each vector containing the data $(x_1, \ldots, x_d, \ldots)$ will be summed up to an overall schedule as hitherto, the second part $(\ldots, e_1, \ldots, e_\pi)$ will be used for further evaluating the solution's environmental impacts. In this way, they will become part of the objective function.

Within such an scenario, optimization methods from combinatorial optimization are required that are able to find a sub-set of schedules such that only one is taken from each DER's candidate set and such that the optimization objective is met.



a



b

Fig. 5 Two examples for reconstructed scopes of action with annotated schedules

4.2 Examples for EPI reconstruction

Figure 5 shows two example results. The first one (5(a)) is taken from an adaptive fridge [8]. The grey circles on the left pane depict a set of operable schedules for a time horizon of two periods. The background color represents for each (including not operable) schedule the resulting temperature as an EPI reflecting the use of energy (the darker the colder and therefore the higher the energy input). The few bigger and brighter colored circles are the support schedules that are necessary for encoding this scope of action including the EPI. The support schedules additionally surrounded by a white diamond are the ones that would have been necessary for encoding the scope without EPI. Clearly, embedding additional information leads to an increase in encoding. The right pane shows the set of schedules (candidate set) that have been re-sampled from the submitted information with each schedule colored according to the encoded EPI information. Hence, the position denotes the load values of the respective schedule and the color represents the encoded EPI.

In order to have a more complex EPI and for better demonstration of the methods capabilities, Bohachevsky's test function

$$F_{B_2}(x) = x_1 + 2x_2 - 0.3 \cdot \cos(3\pi x_1) \cdot \cos(4\pi x_2) + 0.3$$

has been used as an artificial EPI in the second example in Fig. 5(b). In this way, the applicability of a more complex relationship between schedule and EPI can be demonstrated. The depicted scope of action has been taken from the model of a μ CHP. As can be seen on the right side, the respective (EPI) values for each schedule are reconstructed properly even in face of the function complexity. In both cases, the candidate set from the right pane would be used during optimization.

5 Conclusions

It is feasible to integrate the learned relationship between the alternative load schedules of an arbitrary DER and the respective environmental performance of this schedule into the support vector based encoding by adding the EPIs as additional dimensions of the scope of action. Clearly, this increase in information content leads to larger encodings. Further studies still will have to show, how acceptable this increase is for larger numbers of encoded EPIs.

So far, we have focused on an appropriate description for communicating the scope of action of arbitrary DER to a central scheduling unit. This communication is now possible with annotated schedules that include information about individual environmental performance. Of course, other costs might be incorporated in exactly the same way. We have already started integrating the original method into small and medium sized optimization scenarios.

We will now start integrating environmental decision making into the optimization process for determining the best orchestration within the VPP, too. Thus, if an optimization approach is enriched in this way, an integration of energy efficiency, green house gas reduction and further global objectives can be easily addressed as an additional objective for virtual power plants.

Acknowledgements This work was partially funded by the European research project OEPI (Solutions for Managing Organizations Environmental Performance Indicators, 748735).

References

[1] Ben-Hur, A., Siegelmann, H.T., Horn, D., Vapnik, V.: Support vector clustering. Journal of Machine Learning Research 2, 125–137 (2001)

[2] Bremer, J., Rapp, B., Sonnenschein, M.: Support vector based encoding of distributed energy resources feasible load spaces. In: IEEE PES Conference on Innovative Smart Grid Technologies Europe. Chalmers Lindholmen, Gothenburg, Sweden (2010)

[3] Caldon, R., Patria, A., Turri, R.: Optimal control of a distribution system with a virtual power plant. Bulk Power System Dynamics and Control, Cortina. d'Ampezzo, Italy (2004)

[4] Dada, A., Staake, T., Fleisch, E.: Reducing environmental impact in procurement by integrating material parameters in information systems: The example of apple sourcing. AMCIS 2010 Proceedings (2010)

[5] Hrebíček, J., Misarová, P., Hyršlová, J.: Environmental Key Performance Indicators and Cor- porate Reporting. In: Environmental Accounting and Sustainable Development Indicators (EA-SDI 2007), pp. 978–980. Universita Jana Evangelisty Purkyně (2007)

[6] Lukovic, S., Kaitovic, I., Mura, M., Bondi, U.: Virtual power plant as a bridge between distributed energy resources and smart grid. Hawaii International Conference on System Sciences 0, 1–8 (2010). DOI http://doi.ieeecomputersociety.org/10.1109/HICSS.2010.437

[7] Schölkopf, B., Mika, S., Burges, C., Knirsch, P., Mü ller, K.R., Rätsch, G., Smola, A.: Input space vs. feature space in kernel-based methods. IEEE Transactions on Neural Networks 10(5), 1000–1017 (1999)

[8] Stadler, M., Krause, W., Sonnenschein, M., Vogel, U.: Modelling and evaluation of control schemes for enhancing load shift of electricity demand for cooling devices. Environmental Modelling & Software 24(2), 285–295 (2009)

[9] Teuteberg, F., Gómez, J.M.: Green computing & sustainability - Status Quo und Herausforderungen für BUIS der nächsten Generation. Praxis der Wirtschaftsinformatik 47(274), 6–17 (2010)

[10] Thomas, B.: Mini-Blockheizkraftwerke: Grundlagen, Gerätetechnik, Betriebsdaten. Vogel Buchverlag (2007)

Light-Weight Composite Environmental Performance Indicators (LWC-EPI) Concept

Naoum Jamous[1], Frederik Kramer[1], Gamal Kassem[2], Jorge Marx Gómez[3], Reiner Dumke[2]

[1]OVGU Magdeburg, Otto-von-Guericke-Uni., Dept. Tech. and Bus. Inf. Sys.
[2]OVGU Magdeburg, Otto-von-Guericke-Uni., Dept. Of Computer Sciences
[3]OLD Oldenburg, Carl von Ossietzky Uni., Dept. of Computer Sciences

naoum.jamous@ovgu.de, frederik.kramer@ovgu.de, gamal.kassem@iti.cs.uni-magdeburg.de, jorge.marx.gomez@uni-oldenburg.de, dumke@ivs.cs.uni-magdeburg.de

Abstract. Rapid environmental change requires a widely changing attitude starting from individuals over corporations to governments. A closer and more critical review of current environmental policies is needed. Corporate environmental management information systems (CEMIS) can play a major role to change attitudes by providing information that enables users to assess the current environmental impact of their processes and operations. One important question with regard to this is whether an organisation is complying with regulations. If the organisation is not complying with regulations the gap must be identified. Focusing on the growing environmental awareness and the needs of small- and medium-sized enterprises (SME) we shed light on the information provisioning role of CEMIS as well as on the environmental impact of SME operations as a whole. The main objective of our work is to provide a dashboard information system to control and monitor the organizations environmental performance indicators (EPI). This shall lead to a reduced gap between the estimated and current values of company's environment impact on an almost daily basis. In this chapter we will focus on explaining the concept of Light-Weight Composite Environmental Performance Indicators (LWC-EPI), providing clear terms and definitions and presenting technologies which can be used to implement it.

Keywords: Corporate Environmental Management Information Systems (CEMIS), Environmental Management Information Systems (EMIS), Environmental Performance Indicator (EPI), Greenhouse Gas (GHG), Global Reporting Initiative (GRI).

1 Introduction

Rapid environmental change requires a widely changing attitude starting from individuals over corporations to governments. A closer and more critical review of current environmental policies is needed. Corporate environmental management information systems (CEMIS) can play a major role to change attitudes by providing

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_23,

information that enables users to assess the current environmental impact of their processes and operations.

Since the last century, enormous developments have been witnessed with positive impacts on the society. Besides that, it also has considerably affected the environment. Today, environmental effects are in all fields one of the challenging tasks for the world. Environmental problems remain the same whether they are related to manufacturing, logistics, IT, Cattle industry, or transportation (tourism, travelling etc). Global warming or the rapid change of the world climate is a key issue to prove that significant changes happened recently compared to previous decades. The ozone layer depletion and the ozone hole is one of the examples. Another example is the increasing temperature. GHG's emission is one of the basic reasons for this climate change. In power stations, fossil fuel (coal, petroleum, natural gas etc) is used for energy generation that emits large amounts of GHG. Similarly, corporations do not fully implement environmental standards and sink wastage material (like chemicals etc) without proper measures to earth. This conduct does not only pollute the water resources but also affects the agriculture sector as well.

UK environmental organizational (DEFRA) has defined environmental performance indicators for various industries and expect organization to implement/measure less than 5 KPIs out of 22 KPI [3]. As analysis suggest that 80% of companies likely to have 5 or less KPIs for their environmental reporting.

2 Social, political and business new environmental approach

The U.S. Energy Information Administration (EIA), Department of Energy, published on July 2010 the International Energy Outlook 2010 report. The report presents international energy projections through 2035, including outlooks for major energy

Table 1. The ratio of Renewable Electricity to non-renewable electricity used in the world. World areas sorted based on 2007 ratio.

World area // Year	1980	1990	2000	2007	Avg.
Central & south America	0.764	0.881	0.865	0.819	0.832
Europe	0.233	0.196	0.225	0.227	0.220
Eurasia	0.157	0.158	0.221	0.203	0.185
Africa	0.354	0.200	0.207	0.194	0.239
North America	0.225	0.204	0.179	0.167	0.194
Asia and Oceania	0.229	0.200	0.159	0.148	0.184
Middle East	0.114	0.047	0.021	0.038	0.055

fuels and associated carbon dioxide emissions [6]. Based on the realised data, we prepared two tables. Table 1 and figure 1 present the ratios of renewable electricity to non-renewable electricity used in the world. We can directly see the huge gap between Central & South America, with an average of 83%, and the other worlds areas.

Table 2 and figure 2, shows the tons of Carbon produced by a person per year. The data cover the time area from 1980 till 2007.

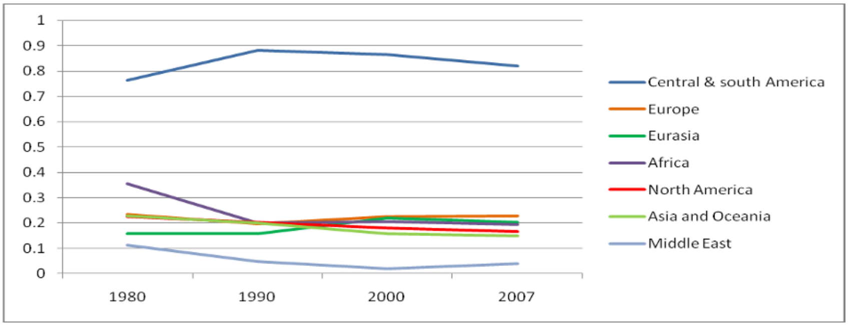


Fig 1. The ratio of Renewable Electricity to non-renewable electricity used in the world. World areas sorted based on 2007 ratio.

Due to the increasing environmental issues' awareness in public, it also becomes a hot topic in governments' and companies' politics. For example, it is uncommon today to see an election campaign without a proposed environmental policy, section or aim. After a quick look on the two tables and figures, we can see that governments' policies affect directly the environment. In addition, it may have an effect on the trade relations among countries. For instance, if Europe reduces the GHG emission and another country does not act upon environmental standards then there would be a business relation problem between Europe and that country.

Table 2. Tons of Carbon produced by a person per year. World areas sorted based on 2007 data.

World area // Year	1980	1990	2000	2007	Avg.
Africa	1.125	1.152	1.109	1.153	1.135
Central & south America	2.150	2.006	2.364	2.582	2.275
Asia and Oceania	1.442	1.796	2.131	3.175	2.136
Europe	8.875	8.202	7.719	7.876	8.168
Middle East	5.166	5.395	6.455	8.048	6.266
Eurasia	11.631	13.292	8.082	9.183	10.547
North America	17.126	16.015	16.495	15.913	16.387

As we said, emergent social awareness or public interest in environmental issues and governmental policies affect business policies in many ways. Green IT, Green Logistics, insurance of environmental sustainability and energy efficiency are becoming new challenges for today's companies. Environmental legislation is exerting additional pressure. The same holds true for the mass media and society as a

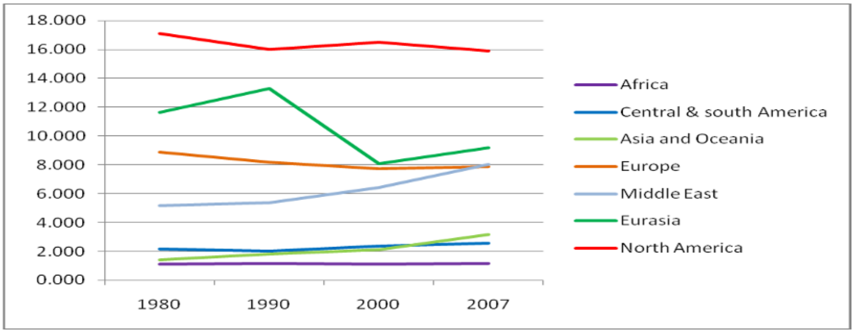


Fig. 2. Tons of Carbon produced by a person per year. World areas sorted based on 2007 Data

whole. Our focus in this chapter will be on the SMEs' sector which is one of the biggest sectors in businesses. For example, the European Commission for Enterprise and Industry stated that in 2009, 20 million SMEs operated in the European Union which represents 99% of businesses[4].

Companies that see the future and plan themselves in advance will get the competitive advantage in the market. People started to realize the environmental issues, and have shown the interest to know more about the environmental performance of companies before product purchases. Similarly, the companies also market their products with environment friendly slogans and details.

In the close future, certain directives would be passed that only those products (from organizations) which are compliant with environmental standards will be allowed to freely trade, as now a days with CE standard. So companies fail to follow environmental standards may risk to lose the potential markets & customers in future.

Environmental directives would not only a benefit for the environment but also for the companies; like to use reusable materials, reduce their costs, improve the processes and make the processes flexible to accept the changes from market.

3 Samples of environmental policies, standards and initiatives

The Earth Summit held in Rio de Janeiro in June 1992 (referred to as Eco 92, hereafter), is a good example to show the worldwide increasing concern on environmental issues. The audience discussed many environmental issues like motivate public transportation usage, and the alternative energy's sources which can be leveraged in order to replace the use of fossil fuels which are linked to global climate change. In addition, the 'Eco 92' points out the threat coming from the declining water resources worldwide [5]. Eco 92 important achievement was the

Kyoto Protocol which defines legal binding commitments to reduce or limit the emission of GHG. After the ‘Eco 92’, policies’ makers gave more attention on how business and industry tried to achieve sustainable development [5].

Environmental standards, initiatives and directives were defined associated with products life cycle from manufacturing to disposal face. The international Organisation for standards (referred as to ISO, hereafter) started to develop international standards on environmental performance to assure that companies were operating in an environmental friendly way [14]. World Resource Institute (WRI) introduced a protocol for measuring GHG emission. The GHG emission is categorized in three categories; Direct emission (emission from fossil fuel burned for power or transportation); Indirect emission (emissions for purchased electricity); and other indirect emission [18].

The European Union (EU) has also been an important driver for the promotion of sustainable development and the Single European Act and the Fifth Environmental Action Program require environmental considerations to be incorporated into all EU policies [15]. The EU ETS (EU Emission trading scheme) is the largest multi-national emissions trading scheme in the world [7; 1] and is a major pillar of EU climate policy. German and Austrian authorities introduced the environmental data catalogue (UDK) for public, industry and governmental institutions for easier access to environmental databases. Other EU initiatives are Eco taxes and the Eco-management and audit scheme (EMAS).

4 Environmental Performance Indicators “EPIs”

Decision-making and management of complex issues requires methods for representing these issues by simple units of measure which can be presented as quantitative or qualitative variables and called indicators. The natural environment is a typical example of such a complex issue for which there is a need for appropriate indicators. It is obvious that the precise nature of the information required for decision-making varies with the type of decision to be made, the context of decision-making and the stakeholders involved. For instance, a private consumer may only want a simple signal that says whether a consumer product is “green” or not, while an engineer engaged in product design needs more complex information that can guide specific design strategies.

During the execution of daily business processes, SMIs can collect large amounts of data. This data can provide information for environmental related issues of the organization. In other words, such data can be used as source for the extraction of environmental indicators. Nowadays modern information systems like ERP systems contain the data of almost all business processes in an organization (manufacturing, logistics, waste management, accounts etc.). By processing and cross-referencing data footprint indicators, material flow information and many other environmental indices can be made available [16]. Describing how this will be done in the LWC-EPI is one of the next research steps.

5 Corporate Environmental Management Information Systems (CEMIS)

Business activities of all enterprises, whether they manufacture products or provide services, have an impact on the environment. Identifying & measuring these impacts is one of the basic steps. Collection of such data is required from power plants, factories, ware houses, distributors, so we know how much a specific enterprise affects the environment. Collection of such data becomes more important when you have to trade emission credits in market.

The concept of environmental information management system is not new since the discussion about the architecture of the environmental system started already in the 80s [3]. Information technology created new ways of managing the business processes. IT also provides support for business process executions in an environmentally friendly way like logistic management and so on. Environmental issues are also handled by information technology since most of the organizational data is accessible through information system. Information system can provide reporting and monitoring facilities of business processes in various aspects.

Reporting is necessary for the organization itself since it would reveal the actual situation of its business processes in an environmental aspect. Environmental aspect reporting of business processes would tell where business processes are lacking the compliance with environmental regulations or where improvements are needed to save costs (in terms of energy, efficiency etc). Environmental performance reports of business processes could be necessary to be send to the environmental regulatory authorities or to exhibit the potential customers/investors.

Currently, enterprises use EMISs, more specifically LCAs tools to support business strategies, R&D, as input in process design, education and labelling on the products. Environmental dashboards are now one of the solutions provided by most of the IT solution providers for the enterprises. This enables organizations to assess the compliance with environmental regulations and evaluate their process executions in this regard. Most of the software solutions are built on data-warehouse technologies to collect data from various sources and then present environmental indicators for evaluation to management and experts.

In order to provide a common understanding, we will present some commonly used terms' definitions. An organization has to manage and organize its environmental programs in a comprehensive, systematic, planned and documented manner. This is usually done with the help of so called environmental management systems. ISO 14001 standard defines these systems as: ''The part of the overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy'' [12].

The term environmental management can refer to the management of all environmental components including biotic and abiotic. In other words, environmental management refers to the interaction of human societies and the environment, as well as to the environmental impact of human activities. This task is often addressed by the implementation of an environmental management information system. If software comes into play for supporting the task of environmental management, these tools are usually referred to as EMIS or newly CEMIS.

Corporate environmental management information system (CEMIS): According to older definitions , a CEMIS is regarded as an organizational and technical system that offers the possibility of systematically covering, analysing, processing, appraising and archiving all environmentally relevant information [13; 9]. Those systems support a strategic as well as operative management by planning, control and transaction of an organization's environmental-issue measures [17]. We have to know that CEMIS are often also simply referred to as EMIS, without qualifying them as corporately used software tools.

6 Light-weight Composite EPIs (LWC-EPI)

This paragraph starts with the explanation of frequently used terms and then outlines the problems we aim to solve with our tool. After that the structural design will be briefly described and some technology alternatives will be addressed. An evaluation/validation step for the proposed model will be part of our future research.

In general, constructing or extracting environmental information is expensive and time consuming [9]. CEMIS's require both internal and external auditing for environmental issues and the publication of results of these audits [8].

SMEs face major problems using such systems. For example, SMEs do not need all system components. The demand for expensive hardware, extensive customization efforts, conditioning, maintenance and the need of expert users drive huge information systems too costly for SMEs [2]. SME usually have problems financing CEMIS thus. However 93 % of all European enterprises have less than 10 employees [10] and represent as much as 99% of the total amount of businesses in Europe [4].

Another issue we should deal with is the non industrial sector like service enterprises, where work processes or the business information data can not directly be used as environmental data even though it often contains environmental information that could be used to build up an EPI after transformation [9].

Our aim is to use company's data “information system, raw data or any other source” beside the implicit environmental information data to make it explicit as input to build appropriate EPI. Therefore, our challenge is to find an efficient solution taking into consideration the size and type of an organisation and its needs and priorities. Proposing a way that helps the enterprise to find the appropriate EPIs which address primarily those environmental impacts that are most significant and which the enterprise can influence by its operations, management, activities, products and services.

6.1 LWC-EPI structural design and technologies

LWC-EPI will consist of 3 main layers; Presentation layer, application layer and data base layer. As mentioned before, LWC-EPI system targets the SMEs. So to be a suitable alternative for SME, LWC-EPI must follow a light-weight design, supported by an easy graphical user interface and high implementation efficiency. In the next paragraph we will propose some starting ideas on how this could be achieved, in each layer.

6.1.1 Database layer

LWC-EPI will use two main sources of data; operational data which comes mainly from the enterprises' information systems, and external data which is accessible via internet and that provides general/common specific sector/domain data.

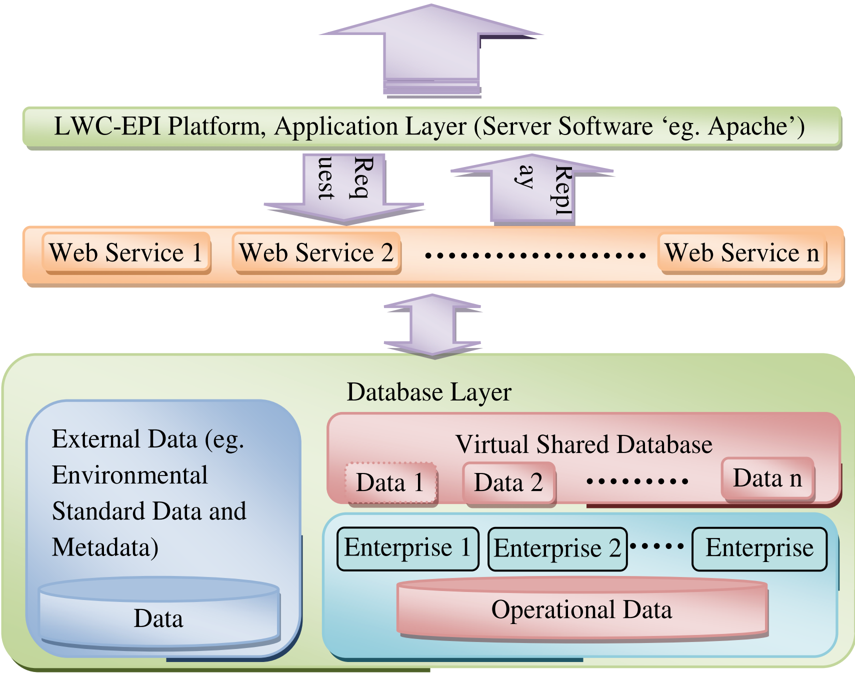


Fig 3. Database layer structural design.

For the operational data, the system will use a virtual shared database, where all interested enterprises could provide an access link to the LWC-EPI platform. In this case, we don't have to load all the data in the LWC-EPI database. External data will be used mainly for data transforming, integrating or restoring the business processes data to specify an appropriate multi dimensional model, as well as to calculate EPIs.

As we can conclude, we will use gathered data from more than one source - like the "Virtual Shared Database" where data comes from many enterprises and the external data coming from the internet – so we used the word "composite" before the EPI in the LWC-EPI name.

Service oriented architectures and more specifically web services are one of the appropriate solutions to be used to link this layer with the platform layer. Figure 3 shows the structural design of the database layer.

6.1.2 Application layer

The application layer is the middleware layer between the database and the presentations layer, where the business logic of the application resides. Needed data will be selected and extracted from the operational databases and then integrated and consolidated in a multi dimensional data warehouse system (DWS). Since most data extracted from enterprise information systems is generated by the running business processes it is often not efficient to use data directly as an environmental data source. Even though this operational data might contain implicit environmental information, that could be used to build up an EPI after some transformation [9] it is transformed and harmonized by the application layer.

Before new data sources are linked to the information system, they should be transformed in order to be meaningfully usable in the calculation of environmental indicators. The application layer hence contains the preparation, transforming and integration process of singular data sources. To match the LWC-EPI objective of being a light-weight solution, the system shall be operated by a mediator. The mediator will host and operate the system and will be the responsible party for the service [2]. SME deal with this mediator and their end users need to access the user interface offered by the presentation layer only. The application layer will be hence integral part of the mediators' service.

6.1.3 Presentation layer

The presentation layer comprises the user interface to access LWC-EPI. It presents the results of the analysis and presentation process.

The user interface enables user interaction that is managed by the components of this layer. The presentation layer receives the user requests and formats and filters this request. The formatted and filtered request is finally sent to the application layer for processing and applying business logic. The presentation finally displays calculated results for end users delivered by the application layer. In general the presentation layer hence consists of two main application types: the user interface components and the presentation logic components[11].

The user interface component uses graphing and visualization of results in order to facilitate the usage of the system. This does not only drive quality of the displayed information but also increases user acceptance and drives quality of inputs.

The presentation logic components implement the logical behaviour and the structure of the application, while being autonomous from any specific user interface implementation.

As we mentioned, our aim is to provide a light weight solution for SME. The presentation layer will be merely hosted by individual SMEs or even become part of their own information systems. This means the presentation layer component has to be developed against a rigour application layer specification and on top of ideally platform independent components. Today, a variety of technologies for developing presentation layers like Java Server Faces (JSF), Apache Wicket (Wicket), Google Web Toolkit (GWT) and Microsoft.Net can be found on the market. Selecting an appropriate technology and the criteria to be followed will be part of future research.

7 Conclusion and future steps

Starting from the mid of the last century, people, governments and enterprises began to take more and more care of environmental issues. Today determining environmental effects is one of the most challenging tasks. Decisions makers and enterprise management need powerful information systems to provide them with required data and to keep them well informed on the impact of their decisions on the environment. It needs to be able to provide frequently updated information more effectively.

In this chapter we shed a light on the growing importance and needs of SME for such systems, in order to control and monitor their EPIs on a more frequent basis. Afterwards we explained the LWC-EPI concept and how we understand a light-weight and efficient solution suitable for SME. In addition, we proposed some initial ideas on the structural design of LWC-EPI, especially the database, application and presentation layer as a first step. An evaluation/validation step for the proposed model will be the next step.

Future research will provide a more detailed architectural analysis. Recommended technologies that could be used and selection criteria to be followed will be presented then. Case study research will evaluate the conceptual model and the technology selection thereafter. Development and implementation of a prototypical implementation will start after having a solid architecture and a well-proven conceptual model.

Acknowledgment. Part of this research has been funded under the EC 7th Framework Program, in the context of the OEPI project (748735). The authors thank for the support.

References

[1] Aruvian's Research. "Analyzing the Carbon Emissions Trading in Europe - The EU ETS Scheme." *researchandmarkets.com.* November 2010. http://www.researchandmarkets.com/reportinfo.asp?report_id=681603&t=d&cat_id=.

[2] Asfoura, Evan, Naoum Jamous, Gamal Kassem, and Reiner Dumke. "FERP Mall Role in FERP Web Services Marketing." *The International Conference on Information Society (i-Society 2010).* London, 2010. 156-161.

[3] DEFRA. "Environmental Key Performance Indicators - Reporting Guidelines for UK Business." *www.defra.gov.uk.* Department for Environment Food and Rural Affairs "DEFRA". 2006. http://www.defra.gov.uk/environment/business/reporting/pdf/envkpi-guidelines.pdf (accessed March 2009).

[4] EC-E&I. "European Commission for Enterprise and Industry." *European Union.* 2009. http://ec.europa.eu/enterprise/policies/sme/index_en.htm.

[5] Eco92, UNConf. *The United Nations Conference on Environment and Development (Eco92).* Department of Public Information. May 23, 1997. http://www.un.org/geninfo/bp/enviro.html (accessed January 15, 2009).
[6] EIA. "International Energy Outlook 2010." *U.S. Energy Information Administration.* 2010. http://www.eia.doe.gov/oiaf/ieo/pdf/0484(2010).pdf.
[7] Ellerman, A. Denny, and K.Barbara Buchner. "The European Union Emissions Trading System: Origins, Allocation, and Early Results." *Review of Environmental Economics and Policy* (Association of Environmental and Resource Economists) 1, no. 1 (2007): 66-87.
[8] Honkasalo, Antero. "The EMAS scheme: a management tool and instrument of environmental policy." *Journal of Cleaner Production* (Elsevier) 6, no. 2 (1998): 119-128.
[9] Jamous, Naoum, Gamal Kassem, Jorge Marx Gómez, and Reiner Dumke. "Proposed Light-Weight Composite Environmental Performance Indicators (LWC-EPI) Model." *the 24st International Conference on Informatics for Environmental Protection (EnviroInfo2010).* Bonn & Cologne: shaker Verlag, 2010.
[10]Lukacs, Edit. "The Economic Role of SMES in World economy, Especially in Europe." *Institute of Business Sciences, University of Miskolc, Hungary.* 2005. www.uni-miskolc.hu/uni/res/kozlemenyek/2005/pdf/lukacs.doc (accessed 2009).
MSDN. *The Microsoft Developer Network, library.* 2010. http://msdn.microsoft.com/en-us/library/ee658081.aspx (accessed 2010).
[11]Olsthoorn, Xander, Daniel Tyteca, Walter Wehrmeyer, and Marcus Wagner. "Environmental indicators for business : a review of the literature and standardisation methods." *Journal of Cleaner Production* (Elsevier) 9, no. 5 (2001): 453 - 463.
[12]Rautenstrauch, Claus. *Betriebliche Umweltinformationssysteme : Grundlagen, Konzepte und Systeme ; mit 8 Tabellen.* Springer, 1999.
[13]Rennen, Ward, and Pim Martens. "The Globalisation timeline." *Integrated Assessment* (Taylor & Francis) 4, no. 3 (2003): 137-144.
[14]Smith, Ann, Robert Kemp, and Charles Duff. "Small firms and the environment: factors that influence small and medium-sized enterprises' environmental behaviour." In *Small and Medium-Sized Enterprises and the Environment: Business Imperatives* by Ruth Hillary, 24 -34. New York: Greenleaf Publishing, 2000.
[15]Stevens, Candice. "Statistics brief." *the Organisation for Economic Co-operation and Development (OECD).* Sep. 2005. http://www.oecd.org/dataoecd/60/41/35407580.pdf (accessed Dec. 2010).
[16]Teuteberg, Frank, and Jorge Marx Gómez. *Corporate Environmental Management Information Systems: Advancements and Trends.* IGI Global, 2010.
WRI. *The World Resources Institute.* 2010. http://www.wri.org .

Administrating Environmental Performance Indicators Utilizing Lightweight Semantic Web Services

Daniel Meyerholt, Tariq Mahmoud, Jorge Marx Gómez

Carl von Ossietzky University Oldenburg, Department of Computing Science, Business Information Systems, Very Large Business Applications (VLBA),

daniel.meyerholt@uni-oldenburg.de, mahmoud@wi-ol.de, jorge.marx.gomez@uni-oldenburg.de

Abstract. The proposed OEPI platform and its accompanying services are implemented specific to the industrial partners of the OEPI consortium and cannot be adapted by other companies without engineering the whole OEPI platform. Especially SMEs cannot afford the development efforts needed to implement OEPI's reference model in their own infrastructure. In this chapter a proposed solution using a more generic architecture that will be applied to the specific area of environmental performance indicators will be presented. It is an ontological SOA-based solution that deals with semantic-annotated Web Services. The main outcomes that can be harvested from using this solution in the environmental field are: the high reusability of its components where each component can be seen as a standalone system, the utilization of Web Service-based workflows that takes benefit from the market best practices, the design of an applied ontology model for Web Services and finally Web Service validation and ranking. Moreover, One of the main purposes of this architecture is to group the Web Services based on their actual domain to which they are related (the area of interest). This solution will be applied as an example to the difficult task of handling diverse environmental data sources in the OEPI project.

Keywords: Environmental Performance Indicators, Ontological SOA, Environmental Ontology, Semantic-annotated Web Services

1 Introduction

Companies and other organizations in general publish environmental information to communicate their efforts to reduce their environmental impacts or to provide information on their environmental management in general. This information is now extended by economic and social values to create a more comprehensive sustainability report. For the environmental aspects of such reports, the information is captured using environmental performance indicators (EPIs) which are based on common standard sets like that proposed by the Sustainability Reporting Guidelines [3] of the Global Reporting Initiative (GRI). The indicators themselves

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_24,

are mostly captured and managed in a Corporate Environmental Management Information System (CEMIS) [6].

As most of the sustainability reports are published in a one shot process to create for example an annual report, the environmental information managed by a CEMIS is mainly unused in improving daily business tasks like production or the procurement process of businesses. To overcome this shortcoming, the EU funded research project “Solution and Services Engineering for Measuring, Monitoring and Management of Organizations’ Environmental Performance Indicators”[7] (OEPI) aims to improve over traditional CEMIS for example by reintegrating EPIs into enterprise systems and thus to improve directly for example the environmental impact of the product design or the procurement process [5].

To overcome the shortcoming of no common agreement in handling environmental performance indicators throughout available software systems, OEPI leverages achievements of the field of Semantic Web technologies. Research and industry have realized that the Semantic Web can facilitate the integration and interoperability of intra- and inter-business processes and systems, as well as enable the creation of global infrastructures for sharing documents and data, to ease and make the information searching and reusability more efficacious. This means that Semantic Web is an evolving extension of the existing web in the way that the semantics of information and services on the web must be defined, making it possible for the web to understand and satisfy the requests of people and machines to use the web content [1].

As the data sources and formats to be used in OEPI are manifold, a comprehensive software component has to be developed that fulfills several requirements to use the data sources available. Due to this nature the data source handling will be accomplished by following Semantic Web techniques and a Web Service-based Service Oriented Architecture (SOA) approach.

Nowadays, a lot of companies had been encouraged to move their entire information infrastructures towards the Web platform by applying Web Service-based SOA solutions, offering a unified and standardized access for their customers, suppliers and employees to the information and services offered by those companies [4; 2].

The remainder of this paper is organized as follows: In section two a brief introduction into OEPI’s overall concepts with a focus on the data source layer is performed. The concrete requirements and the problems that arise in the development of that component are discussed there. In section three the SESOA framework for organizing Web Service and annotating them with semantics is presented together with the interaction of components as well. Concepts of the assemblage and the assemblage ontology are described in that section to show how Web Services in the framework are organized and classified. After that, section four proposes the main idea of how to use the SESOA framework to accomplish the implementation of the data source adaption layer in OEPI. Finally this paper concludes with the main outcomes of the proposed solution.

2 The approach of OEPI

As OEPI will be realized using the SOA approach and consists of many separate components and subsystems, it is necessary to provide a short overview of the basic concepts of the architecture. This architecture's details are partially still in flux, but the main concepts are already set. The brief introduction to the overall OEPI architecture is given in figure 1 to have the concepts presented better.

Three different types of clients ranging from the OEPI client application, mobile clients to mashups & widgets utilize different types of components that will be exposed as web services. Either they are directly embedded into the OEPI platform which serves as the Service Runtime here or they access the OEPI platform using a service integration layer. The details are not of interest here. In this paper the data adaption layer which is responsible in accessing different types of data (mainly Environmental Performance Indicators) from various data sources is focused.

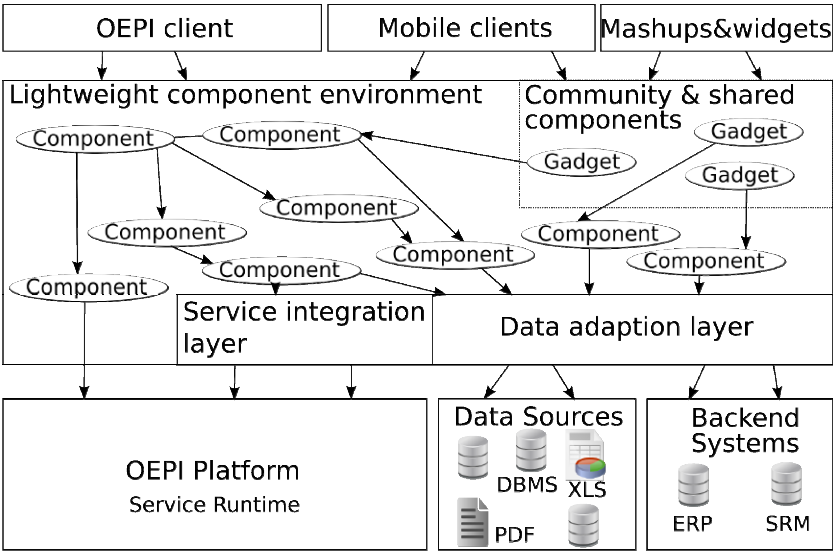


Fig 1. Overview of OEPI's Architecture

The data adaption layer therefore serves as a bridge that can be used by OEPI's components to access arbitrary underlying data sources. The data exchanged will be mainly EPI based but may also incorporate other structures as for example hierarchies, stakeholder information or even documents. To deal with this diverseness of information in terms of data access and interpretation creating a mediator serving as the main component for the data adaption layer is suggested. The design itself will be largely influenced by an ontology that is currently being developed for describing EPIs.

A more detailed view of the data adaption layer is shown below in figure 2.

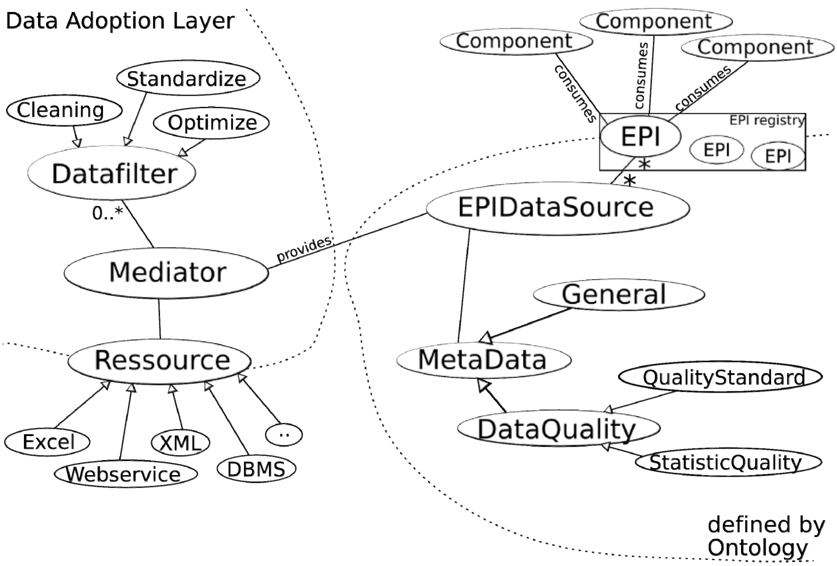


Fig 2. The Data Adaption Layer

The OEPI components are represented using the components in the upper right corner. Those components just request to consume a specific EPI (and its associated data structures) from an EPI registry. The EPI registry looks up desired information needed to furthermore create a specific request to the data adaption layer that provides the EPI in the backend. This registry may provide a thin layer of caching to reduce the traffic needed to fetch each EPI again from its sources. It is advisable to distinguish EPIs using a unique Resource Description Framework (RDF) Identifier. This RDF tuple should be attached to the requested EPI in the EPI registry to have an unique mapping.

One EPI may be provided by several data sources. This makes sense when for example reference data is represented by a specific EPI: Several databases may provide the same EPI values but may have different properties in terms of access duration, latency etc. OEPI's components shall not deal with the selection of a specific data source they should only handle the EPI and its values. Here a potential issue might be what happens, when the data sources do not contain the same EPI values and are thus are not properly synchronized. This has not been considered so far and is another concern to be investigated in the future.

As can be seen the EPI and its data sources with the accompanying metadata will be described by OEPI's core ontology. The underlying data structures of the architecture leverage therefore the development efforts of the ontology and it may for example be possible to use semantic reasoning when dealing with EPIs and related metadata. The automatic generation of data structures out of the ontology (in terms of model driven development) is another thing that will be considered during the current development as well.

Using the EPI's related RDF tuple, the mediator component is able to lookup how to access the specific EPI data using its own repository of resources. The mediator then decides how to handle that specific type of data source. The access to the data itself must be handled in a plug-in manner for each type of data source. Such plug-in may provide the mediator for example with extracted data values of:

- a document like a PDF file,
- an Excel spread sheet,
- databases in general or
- Web Service provided data.

Another type of data source, as also depicted in figure 1, may be a backend enterprise system like a traditional Enterprise Resource Planning (ERP) or a Supply Chain Management (SCM) system which can provide additional information or at a later stage may itself consume data of OEPI.

One additional concept used in the data adoption layer is the usage of a data filter chain that may be applied on the extracted data. Several different data filters may be applied to the EPI values. These filters may include:

- Data cleaning: Remove erroneous or unneeded data,
- Data standardizing: Recalculate values gathered to have for example a common unit or to standardize the values from percentages to values ranging from 0 to 1,
- Data optimization: Tasks possible here are for example sorting data or reordering them for improved performance in the later processes.

The implementation of the data adaption layer will be a very challenging task as many things must be considered from a theoretical and from the practical side. Some work in the data access plug-ins may be reduced by reusing existing solutions and frameworks like for example JAX-WS (Java API for XML - Web Services) to access web services or by using the widely used Hibernate Framework for database access.

To implement the mediator, the Semantic-enabled Enterprise Service Oriented Architecture (SESOA) framework is going to be used. It is built using Microsoft .NET Framework, Windows Communication Foundation and Workflow Foundation services together with annotating the services' capabilities and requests using RDF tuples.

3 The SESOA framework

The main goal behind SESOA is to have an automatic business solution in which Web Service consumers can discover, select and invoke services that fulfill their requests. These services are supplied and published by disparate service providers. By using SESOA framework, these services will be semantically annotated, evaluated and validated.

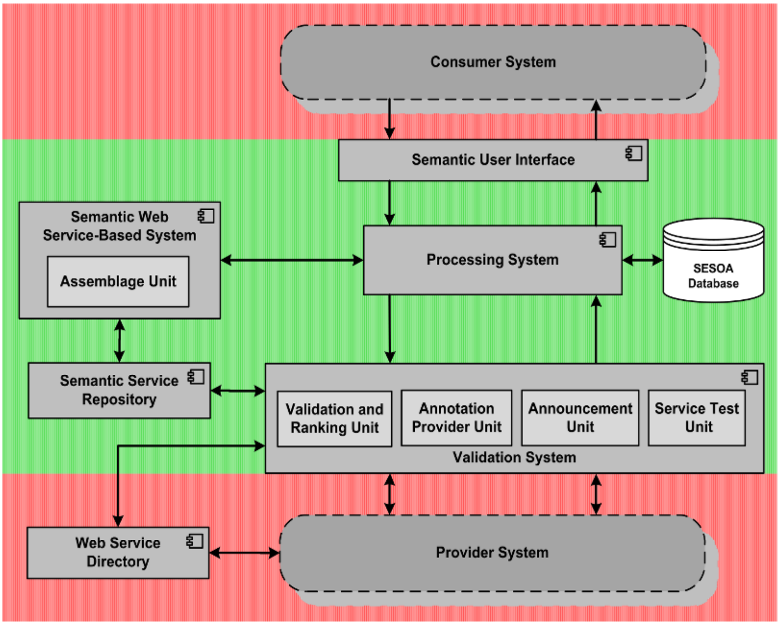


Fig. 3. SESOA Framework

As depicted in figure 3, the request in the SESOA framework is sent from the consumer system via the semantic user interface to the processing system. This interface is fragmenting the request to object and store them in the so-called semantic dictionary. This dictionary is linked with assemblage list that is created by the assemblage unit in the semantic Web Service-based system.

From the one hand, the link between the dictionary's objects and the assemblage list's assemblage is annotated semantically using RDFS tuples. From the other hand, all the services that are supplied by service providers are registered in the assemblages based on the area of interest (following the assemblage's description). The request is forwarded to the processing system to start executing one of its business processes. The business processes themselves are exposed as workflow host services so that they can be invoked as normal Web Services. Most of the activities within the business processes are exposed as Web Services as well. So the request triggers a business process to be executed and the control will be given to the semantic web service-based system. It will be then go to the semantic service repository to fetch the suitable service back to the semantic web service-based system. The result is sent then to the processing system which in turn locates it in the validation and ranking unit within the validation system to monitor the behavior (e.g. availability, latency, price…) of the external Web Service(s) in order to update its validation results. This validation is applied on the non functional properties of the external Web Services as criteria for validation (it differs from business to another). The service unit test subsystem is utilized by the validation and ranking unit to validate the Web Service functional properties (like properties, data types…) to register the service in the semantic service repository.

Upon validation, the validation system will annotate the resulted Web Service(s) with RDFS tuples compatible with the one used to link the semantic dictionary's objects with the assemblages. Then the control of the business process in the processing system is given to forward the requested semantic-annotated Web Service(s) to be sent to the consumer via the semantic user interface (normally it is interested just in the result not in the annotation).

To displace any ambiguity in the matchmaking process between service's request and response, it is explained here briefly how this process happens. The request is mapped firstly to the assemblage that in turn forwards it to the proper service (member) within it. This mapping is done by using URIs for the dictionaries' objects that are mapped to the assemblages' Web Services URIs. In other words, there is a link between the dictionaries' objects and the assemblage and another link between the assemblage and its services which makes the relation between the objects and the services transitive.

The main advantages that can be seen from the SESOA framework are:

- To have a lightweight semantic-enabled business annotation solution;
- To expose all the business functionalities in form of Web Services as activities in workflow host services;
- To validate the services on both functional and non-functional levels;
- To have a machine to machine evaluation of business-related validated web services and
- To enhance the process of web service selection by grouping Web Services in SESOA's assemblages together with the traditional Web Service indexing in registries.

4 Towards OEPI Data Source handling using SESOA Framework

After explaining the data source adaption layer in OEPI project and the main characteristics of SESOA it is depicted how to handle the data sources using SESOA's main components. As explained previously all the EPIs in OEPI project are going to be realized using Web Services. On the one hand, these services will be linked to the assemblage unit in the semantic Web Service-based component in SESOA framework using RDF annotation. In other words, the relation between EPIs services and assemblages will be annotated from the service provider perspective. On the other hand and from a consumer perspective, the requests' objects will be stored in semantic dictionaries and these dictionaries will be linked with the assemblages using similar RDF annotation like the one used by EPIs-assemblages relations. The big picture can be seen as a workflow of how the full request/response scenario is going to be realized. The consumer will write his/her data handling request and submit it to the SESOA framework (the Mediator in figure 2). This request will be part of a bigger workflow in the processing system (see figure 3) that will be fulfilled by specific Web Service(s) in one or more assemblages. The semantic Web Service-based component will look up its assemblages to see whether the request can be fulfilled or not by checking the semantic service repository. In the case that the request can be fulfilled, the workflow gives the control to the validation system to call the service from the external data service provider (Excel, XML, PDF and other external services), validate it following the business criteria and deliver the result back to the consumer system.
The matchmaking process between the request objects and the service(s) is done using the RDF annotations between the semantic dictionary – assemblage and the assemblage – Web Service(s) relations taking into consideration that the actual request's objects are stored in this dictionary. The first annotation process is done by the semantic user interface component and the second on is done by the annotation provider unit in the validation system. Both annotations are then stored in the SESOA database.

From quality control and performance perspectives, all the data source Web Service are validated and evaluated using the validation and ranking unit in the SESOA validation component. The validation is done on the functional attributes (data types) and the evaluation is merely machine-to-machine reputation based on access time and availability criteria of the services. By using this validation and evaluation the OEPI concept is eased to involve multiple EPI data source providers.

5 Conclusions and Outlook

This paper begun with giving the environmental outline of the further topics discussed here. The OEPI platform was introduced to give an impression of the challenging tasks that CEMIS are facing today. The specific task of heterogeneous data integration is focused there. After that the SESOA framework is presented in general and further detail that is needed for the tasks to be accomplished in this context. Finally in section four the implementation of the described data source adaption layer using the SESOA framework is proposed to provide a fitting and comprehensive solution. Further components of OEPI may be developed using SESOA as well and current research in that area is underway. Additional topics originating from this work like for example the data integrity issue involving multiple data sources is worth to investigate more thoroughly as well.

Acknowledgements This work was partially funded by the European research project OEPI (Solutions for Managing Organizations Environmental Performance Indicators, 748735).

References

[1] Berners-Lee T, Hendler J, Lassila O (2001) The Semantic Web. Scientific American Magazine. May 17, 2001

[2] Cardoso J, Hepp M, Lytras M (2007) The Semantic Web. Real-World Applications from Industry, (1), 308, Springer

[3] Global Reporting Initiative (2002) Sustainability Reporting Guidelines. http://www.globalreporting.org/ReportingFramework/G3Guidelines/. Accessed 30. December 2010

[4] Mahmoud T, Marx Gómez J (2010) Applying Semantic SOA-Based Model to Business Applications. In: Cruz-Cunha M; Varajao J (Editors): Enterprise Information Systems Design, Implementation and Management: Organizational Applications Book

[5] Meyerholt D, Marx Gómez J, Dada A, Bremer J, Rapp B (2010) Bringing Sustainability to the Daily Business: The OEPI project. In: Berre AJ, Roman D, Maué P (ed) Proceedings of the Workshop "Environmental Information Systems and Services - Infrastructures and Platforms". CEUR workshop proceedings, vol. 679, ISSN 1613-0073

[6] Teuteberg F, Marx Gómez J. (ed) Corporate Environmental Management Information Systems: Advancements and Trends; IGI, 2010

[7] http://www.oepi-project.eu/

Sustainability and Global Risks: Example of Selected Countries in Asia

Victoria A. Bakhtina

International Finance Corporation (IFC), Washington DC

vbakhtina@ifc.org

Abstract. Systemic approach to innovative development, creation and implementation of efficient mechanisms of innovation policy, sustainable, balanced, and harmonious development of countries based on investment innovative models, call for creation and implementation of innovative product to support strategic decision-making based on integrated index and risks in a triune concept of sustainable ecological, social and economic development in the global, regional, and national contexts. Current research illustrates one of the approaches to the indicated model, using an example of South East Asia and Oceania, and taking into consideration risks and opportunities of innovative development of the countries.

Keywords: sustainability risk, investment innovative models decision-making, regional sustainability

1 Introduction

XXI century brings cardinal changes to defining direction of economic progress; shifting the focus to solution of problems of innovative development acceleration; transfer to economy of knowledge with the foundation on intellectual resources, intellectual capital, science, education, and processes of transfer of intellectual activity results to creation of material and spiritual goods. The end goal is improvement of people's life quality, amplification of people's opportunities, and sustainable, balanced, and harmonious development of society.

Modern vision of advancing sustainable development systematically joins three main components – economic, ecological and social. In the human consciousness, new quality of economic component more and more often is linked with the concept of human development. Human, or social dimension becomes a defining dominant while potential of material well-being becomes a condition of the development.

Life may require a transition to a regulated model of market economy, with a significant part of direct and indirect state influence. This approach assumes devis-

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_25,

ing an objectively justified investment innovative policy, development and implementation of priorities system; and creation of concrete mechanisms, ensuring formation of national and international innovative systems. To achieve this, it is necessary to facilitate systematic information-analytic support and provide a foundation to strategic decision-making in respect to investment and technical assistance activities, and devise recommendations on the basis of priority risks, and monitoring the progress in the context of sustainable development (global, regional and national).

The concept of Sustainable Development was first introduced by Vernadsky [1] at the beginning of the 20^{th} century, and attracted a lot of interest after Brundtland Commission published its report in 1987 [2]. Ecological, economic and social components are closely interrelated, and call for creation of integrated assessment studies which would analyze the three aspects of sustainable development jointly. Historically, starting 1972, numerous research was dedicated to simulation of sustainable development looking jointly at such factors as economic growth, human and environmental systems [3], [4], [5], modeling the three domains of sustainable development and estimating the relations among the components and possible outcomes for various scenarios. Some efforts also focused on operationalizing the concept of Sustainable Development and utilizing the existing models to analyze the relationship between environmental change and human development [6], [7]. The difficulty of implementation of such approaches is linking and compatibility of all underlying models and their assumptions. In addition to that, the synchronization of data dependencies among the models with no circular reference is a clear challenge. This is why approaches utilizing integrated indices are becoming more and more popular.

Sustainability is complex to measure, and requires extensive statistical data and broad range of indices. One of the most well-known and broadly used indices is Human Development Index, first introduced in 1990. It integrates such aspects as longevity, literacy and income, and ranks the world's countries based on their integrated assessment. The HDI ranks the countries based on the level of Human Development, but does not include ecological component directly. At a later point, Sustainable development index incorporating ecological component and important extension to dimension of risk were brought up, and the concept of developmental or sustainability risk was introduced, illustrating the model using data for Africa and Latin America [8], [9], [10].

There is a clear gap in interpreting and using the output of the existing models for the decision-making process and policy development. The goal of this publication is to propose a structure for integrated sustainability model which would utilize the results derived from the two types of indices: Sustainable Development index and Developmental Risk Index [8], [9],[10], focusing on a subset of the countries from different regions.

Based on publicly available data, the author created tables and graphs demonstrating the structure of the application, and illustration of the model with the help of Principal Components Analysis. References to all the databases are given at the end of the publication.

2 Structuring Integrated Sustainability Model

We suggest structuring an information-analytic support for innovative development covering the following segments:

1. Creation and utilization of holistic sustainability risk models and respective systems;
2. Devising methodology facilitating prioritization of sustainability risks in the regional and national context;
3. Integrate existing resources and knowledge to perform forecasting, sensitivity and scenario analysis for investment activities and technical assistance. Adjoin trend analysis and evaluation of investments in a global sustainability context;
4. Suggest approaches to further help in detecting integrity gaps and vulnerable spots;
5. Provide active input to qualitative knowledge management.

On Figure 1 we explain how an integrated sustainability model operates, required inputs, and results.

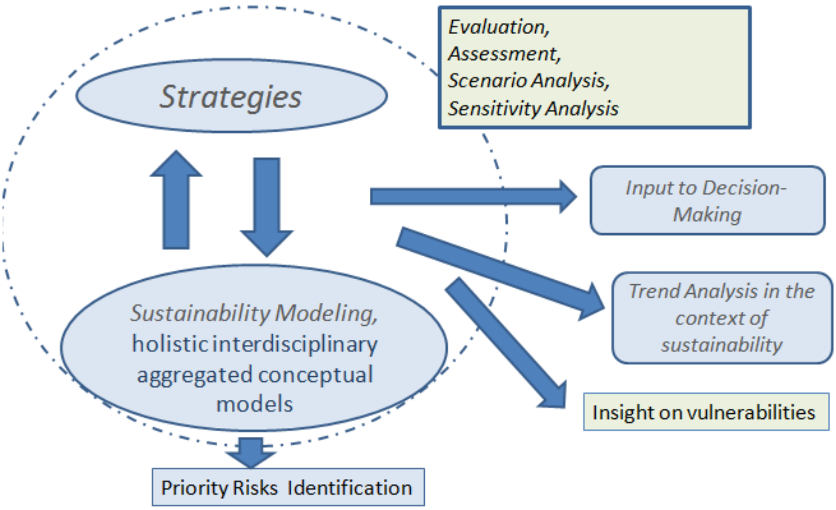


Fig. 1. Integrated sustainability model

On Figure 2 we suggest one of ways to structure the process of information-analytic support.

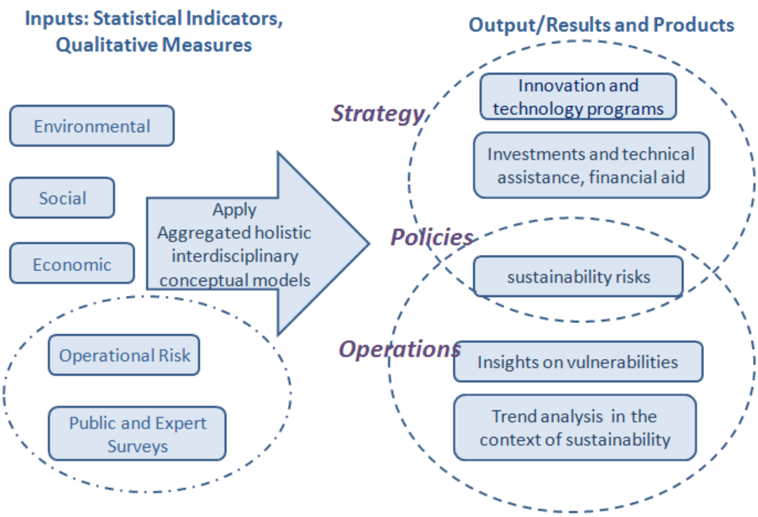


Fig. 2. Schema of Information-analytic support for decision-making in the context of global sustainability

3 Sustainability and Global Risks Modeling

In the current research sustainable development measurement is performed jointly using economic, social, and ecological components. Each of the components, ideally, shall take into account as many comprehensive indicators as possible. The research is based on a methodology of global sustainability processes modeling [8], and integral sustainability risk[1] models in a regional context [9], [10]. Sustainable development measures would ideally incorporate as many comprehensive characteristics encoded in the sustainability dimensions, as possible. The most widely used indicators are GDP, economic freedom, human development, business environment, ecosystems and ecological footprint. Review of South East Asia and Oceania countries allowed to conclude that it would be sufficient to use a socio-economical index supplemented with the ecological component.

The sustainability index for Asia is structured as follows. Two indicators are considered: Human Development Index (HDI) [11] and carbon intensity [12]. Human Development Index (HDI) belongs to socio-economical category. It is composed of education index, showing the relative achievement in adult literacy, and

[1] "Sustainability risk" concept will be used interchangeably with "developmental risk"

involvement in tertiary education, life expectancy index, showing life expectancy at birth, and GDP index, which reflects the relative level of well-being in the country. It is presumed that GDP index represents a complete measure of economic component and combined education and life expectancy indices are measures of social component. Carbon intensity is one of most broadly used measures of the countries CO2 pollution strength relative to the economy activity[2]; it can be reduced by using cleaner fuels and reduced fuels consumption via innovation. An ecological component is represented by carbon efficiency.

Moreover, specifics of the indicated region allowed to separate the following risks, covering all three domains of sustainable development: (1) disbalance between economical and human development, (2) lack of education (3) low life expectancy, (4) lack of access to portable water and sanitation facilities, (5) HIV epidemics, (6) greenhouse gas (GHG) emissions, (7) political stability and corruption, (8) natural disasters, (9) unsustainable business environment. The objective of current research is selection of proper measures for each risk, and subsequent analysis of risk for each country. For each country, we can get an insight to the question how balanced and sustainable the country's development looks relative to peers, and what is the remoteness of the country from the crisis based on the series of risks considered. Correlations between the components suggest a strong relationship between GDP, Education and Longevity, strong correlation between GDP, Education and corruption perception shows that countries where economy is performing well and education system is well designed are generally perceived as less corrupt. Strong correlation also exists between enabling business environment and education.

4 Sustainability and Risks for South East Asia and Oceania: Empirical Evidence

Current research reviews 27 countries from South East Asia and Oceania[3] excluding Japan, North Korea and Kiribati. The set of countries is chosen with the fo-

---

[2] CO2 intensity reflects the emission intensity, or the average emission rate of a CO2 from a given source relative to the intensity of a specific activity. Carbon intensity of the economy can be observed in two main relationships: energy intensity and carbon intensity of energy use.

[3] The countries include Bangladesh, Bhutan, Cambodia, India, Laos, Maldives, Mongolia, Myanmar, Nepal, Papua New Guinea, Samoa, Solomon Islands, Sri Lanka, Timor-Leste, Tonga, Vanuatu, Vietnam, Brunei Darussalam, China, Fiji,

cus on IDA countries and emerging economies. Only 27 countries are covered due to data limitation. Japan is ranked 10 in Human Development which is significantly over-performing the rest of the region. In spite of one of the highest risk of natural disasters in the region, implied by Disaster Risk Index (DRI), Japan has the most advanced social and economic components. The author is planning to apply the model to developed economies and include Japan to the analysis.

For each risk factor, a representative measure is assigned based on publicly available statistical information. The following measures were selected for each of the risks indicated in part 1: (1) (GDP Rank – HDI Rank)(DEHD)[11]; (2) education index(EI)[11]; (3) life expectancy index(LI)[11]; (4) access to improved water supply(AWS)[13]; (5) HIV infected population, %[13]; (6) carbon intensity(CI)[12]; (7) corruption perception[14] (CPI), and political stability and absence of violence(PSAV) indices [8] ; (8) disaster risk index (DRI) [15], covering number of deaths from natural disasters; and (9) doing business indicators(EDB)[17]. For each country, a global risk resilience index[4] is built using a formula: $RR = \sqrt[p]{\sum_{i=1}^{k} X\, i^p}$, where k is a number of risks, Xi is a respective quantitative index, normalized to the scale [0;1], and p represents the sensitivity of the global risk to relative impact separate risk components. Generally, $p=3$ gives enough sensitivity and provides good practical results [3]. For convenience, RR is normalized to the scale [0; 1]. $RR^0 = \frac{RR - RR_{min}}{RR_{max} - RR_{min}}$. RR^0 represents a ‘‘distance’’ of each country to the totality of selected threats. The shorter the distance, the higher is the risk for an indicated country. The countries are ranked from the shortest distance to the largest, and clustered into the groups with similar properties.

An example of South East Asia and Oceania, shows that resilience to global risks is higher for the countries with higher level of social component of sustainable development. High human development provides for higher quality of education, - a necessary condition for innovation, and opens new opportunities to combat the risks.

The existing information is supplemented with an innovation index for the following countries: Singapore, South Korea, Hong Kong SAR, Malaysia, China, Thailand, India, Philippines, Sri Lanka, Indonesia, Vietnam, Mongolia, and Nepal [18]. The example showed that Human Development Index is also higher for the countries with higher innovation potential. At the same time, the better the level of

---

Hong Kong SAR, Indonesia, Malaysia, Philippines, Singapore, South Korea, Thailand.

[4] All underlying risk indicators are normalized to the scale [0,1], where 0 indicates the weakest performance, and 1- the strongest performance.

education is, the higher the innovation potential. In case when the level of education is low, the necessary conditions, and a fundament for innovation is absent.
Innovative and well-balanced countries such as Singapore, South Korea, Hong Kong SAR and Malaysia, provided the highest level of human development in the region, all established specifically targeted programs for stimulating innovation. We create an illustration of this approach in figure 3.

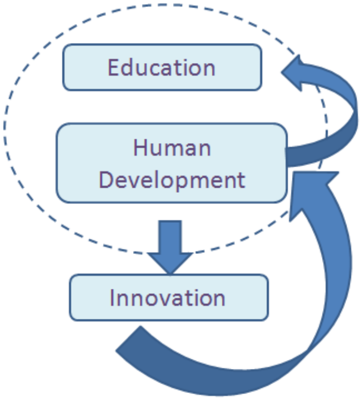


Fig. 3. Development chain: innovation stimulates human development

4 Practical Applications

Based on the derived indices of sustainable development, and harmonization all countries are clustered[5] into groups based on the level of sustainable development, its balance, and distance to the set of threats. The grouping is provided in Appendix 1. The countries with the highest level of sustainable development are Hong Kong SAR and South Korea. These countries have the highest levels of human development, economy, and innovation. The next cluster includes Singapore, Brunei Darussalam, Samoa, Sri Lanka, Vanuatu, Malaysia, Philippines, Maldives and Tonga. Singapore and Brunei have the most advanced social dimension, Samoa, Sri Lanka and Vanuatu are top performers on ecological component, Philippines, Maldives and Malaysia are balanced in social, economic and ecological aspects. Mongolia takes the last place on the level of sustainable development; Myanmar and India are among the lowest performers, with lowest values in all three dimensions compared to other countries in the group.

Principal Components Analysis (PCA) applied to the risk results, illustrates how the model input can be used to make investment decisions. (Appendix 2) Three first components describe approximately 72 percents of variance. The components can

[5] Clustering is performed using Ward agglomerative method

be interpreted the following way, based on their structure. First principal component (F1) – “Socio-Economical State with Accent on Education”, second principal component(F2) implies that balance between economic and social development may lead to decrease in life expectancy, the suggested name “ Disbalance between Economic and Human Development and its Impact on Life Quality”, third principal component (F3) has the highest loadings on HIV, carbon intensity, and natural disasters. The suggested interpretation: “HIV Epidemics, Environment Deterioration, and Natural Disasters”.

According to the interpretation, it clearly follows that the main direction for the investments is Social/or Human Factor, specifically education of the population, and balancing economical activity with human development. The second direction will cover health, ecology and natural disasters. Each country can be located on the axis of the principal components, and compared to the other countries. Figure 4 also shows the class each country belongs to, from Class1 – the riskiest countries, to Class 6- the safest countries. Bangladesh, Nepal, Cambodia and Papua New Guinea are among the first who require significant help in the social sector, especially, in regards to literacy ratio. Nepal, Sri Lanka, Indonesia and Philippines are least politically stable and are perceived as most corrupt in the region. The illustration suggests that India, Solomon Islands and Laos need help in setting up infrastructure projects. Tonga, Mongolia and China are among the countries with the highest disbalance between economic and social components, and at the same time, highest carbon intensities. Timor-Leste and Myanmar are excluded from the display as they are very close to the state of crisis. Hong Kong, South Korea and Singapore are excluded as they significantly over-perform the rest of the countries.

Figure 4 is derived by the author with the help of Principal Component Analysis, shows the region countries relative to the main risk factors.

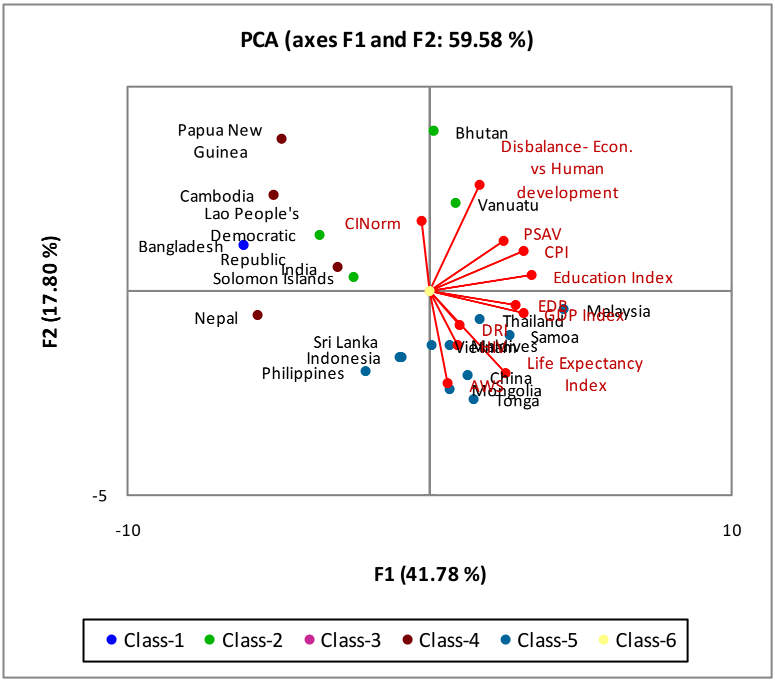


Fig. 4. South East Asia countries and the main risks

Principal Components Analysis applied to sustainable development dimensions similarly to the risk analysis, shows that the main principal component is significantly correlated with social and economical factor, social having higher correlation. The second component is closely related to ecological component. Each quadrant shows countries with different properties. The upper part of right quadrant and the right part of F1 axis shows the most prominent in relation to sustainable development nations: Hong Kong, South Korea, Singapore, and Brunei. The lower left quadrant shows the countries with the lowest values of social, economic and ecological indices. The analysis, similar to the risk results, implies that most attention shall be given to those countries located in the down left quadrant: India, Myanmar, Papua, and Timor-Leste.

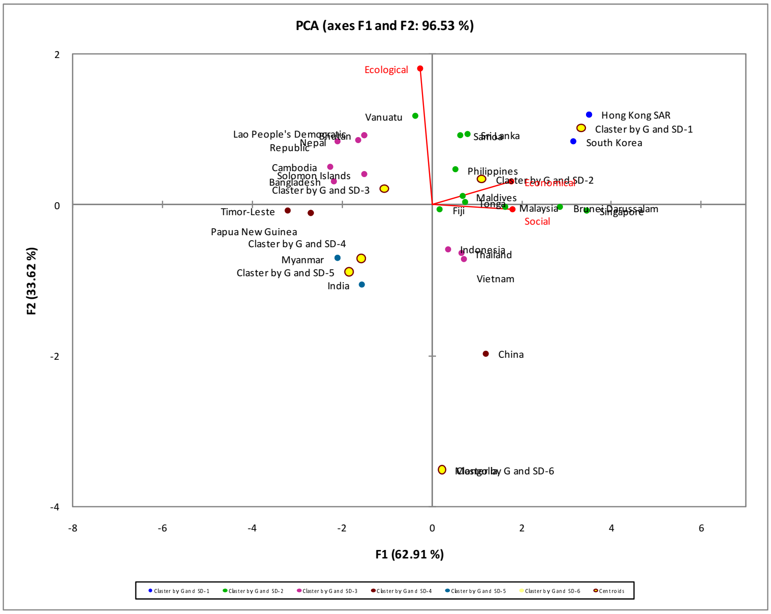


Fig. 5. South East Asia countries and sustainable development components

The interpretation of the sustainable development indices shall be always considered in conjunction with the risks. In case the level of development is high, and risks are high, such as, for example, Brunei, Philippines and Fiji, the efforts may be directed to address natural disasters and social sectors.

5 Conclusion

The research of 27 countries from South East Asia and Oceania illustrates a potential implementation of sustainability models for information-analytic support and input for decision-making. It is shown that sustainable development, its harmonization, and resilience to global risks are higher for the countries with better developed social sector which makes a social sector a defining component of sustainable development. An interpretation of derived results is provided from the prospective of sustainability magnitude and balance, and from the prospective of sustainability risk using principal component analysis. The conclusions of the two models should be reviewed jointly. Among the countries needed most aid in social sectors are Timor-Leste, Bangladesh, Nepal, Papua New. In addition to that, we separated sets of countries with high human development but prone to the risks of natural disasters, such as Brunei Darussalam. Mongolia and China stand out due to average human development but strong underperformance on ecological dimension. The ideal development would require a balanced combination of the two directions of investments: social and environmental, possibly focusing on the innovative technologies of clean fuels utilization and efficient fuel consumption.

There is a lot to be done in the direction of sustainability modeling, the set on indicators can be expanded and extended to more countries, particular sets of innovative financial instruments or special types of technical assistance can be analyzed. But the main focus should be on a social dimension for the set of indicated countries.

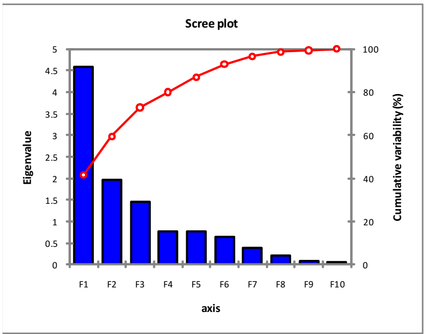
Appendix 1. Grouping of countries by sustainable development index, harmonization and resilience to global risks.

COUNTRY_NME	(G) Harmonisation	(SD) Sust. Dev. Index	Resilience to global risks	Class by G and SD	Class by Risk
Hong Kong	0.99	1.64	0.75	Best	Best
South Korea	0.97	1.58	0.80	Best	Good
Singapore	0.85	1.47	1.00	Good	Low
Brunei Darussalam	0.88	1.45	0.81	Good	Low
Samoa	0.91	1.43	0.69	Good	Good
Sri Lanka	0.90	1.43	0.51	Good	Good
Vanuatu	0.82	1.39	0.55	Good	Very Low
Malaysia	0.93	1.37	0.74	Good	Good
Philippines	0.95	1.36	0.40	Good	Good
Maldives	1.00	1.33	0.54	Good	Good
Tonga	0.98	1.32	0.62	Good	Good
Bhutan	0.79	1.29	0.63	Medium	Very Low
Lao People's Democratic Republic	0.79	1.28	0.41	Medium	Very Low
Fiji	0.99	1.28	0.40	Good	Good
Thailand	0.89	1.24	0.66	Medium	Good
Nepal	0.74	1.22	0.34	Medium	Medium
Solomon Islands	0.84	1.22	0.32	Medium	Very Low
Cambodia	0.79	1.21	0.31	Medium	Medium
Indonesia	0.91	1.21	0.39	Medium	Good
Vietnam	0.84	1.19	0.43	Medium	Good
Bangladesh	0.78	1.14	0.12	Medium	Worst
Papua New Guinea	0.83	1.09	0.28	Low	Medium
China	0.65	1.07	0.42	Low	Good
Myanmar	0.96	1.05	0.09	Very Low	Medium
Timor-Leste	0.78	1.04	0.00	Low	Worst
India	0.94	1.03	0.34	Very Low	Medium
Mongolia	0.38	0.83	0.42	Worst	Good

Appendix 2. Principal Component Analysis. Application to risks.

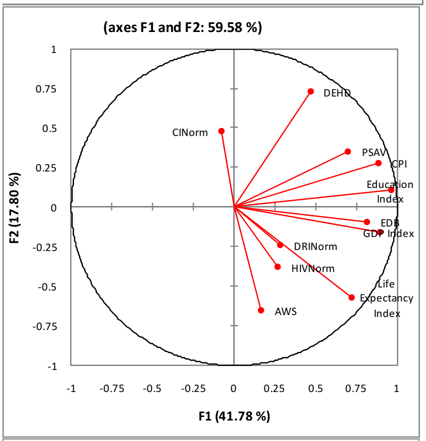
Eigenvalues:

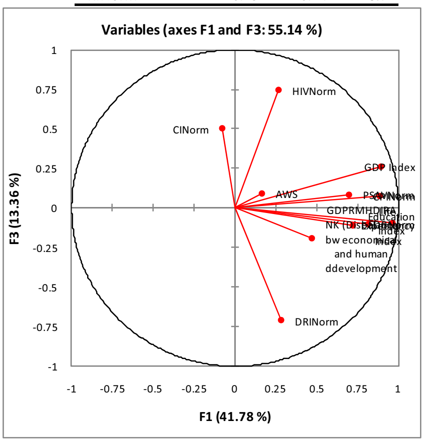
	F1	F2	F3	F4	F5	F6
Eigenvalu	4.596	1.958	1.469	0.779	0.775	0.655
Variability	41.779	17.801	13.358	7.080	7.043	5.957
Cumulativ	41.779	59.580	72.938	80.018	87.061	93.018

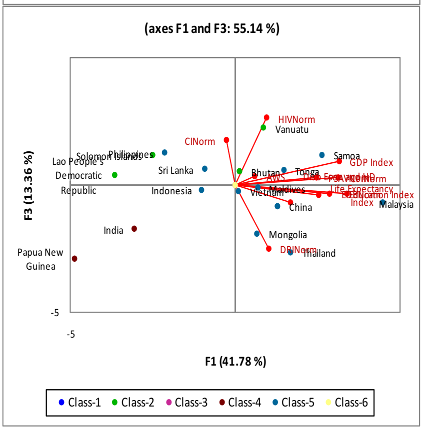


Factor loadings:

	F1	F2	F3
GDP Index	**0.89**	-0.16	0.26
LI	0.72	**-0.57**	-0.11
Education Index	**0.96**	0.10	-0.10
EDHD	0.47	**0.73**	-0.19
AWS	0.16	**-0.65**	0.10
HIVNorm	0.27	-0.38	**0.74**
EDBNorm	**0.82**	-0.09	-0.10
CINorm	-0.08	0.48	**0.50**
CPINorm	**0.89**	0.28	0.08
PSAVNorm	0.70	0.35	0.09
DRINorm	0.29	-0.24	**-0.71**







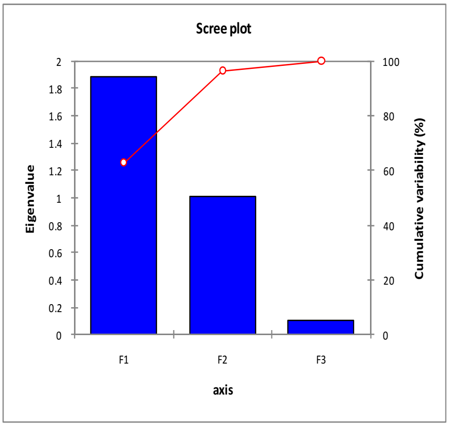
Appendix 3. Principal Component Analysis. Application to sustainable development and harmonization indices.

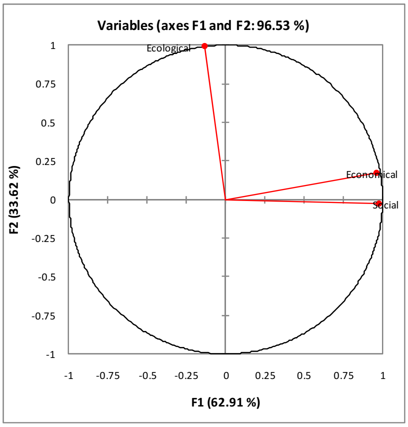
Eigenvalues:

	F1	F2	F3
Eigenvalu	1.887	1.009	0.104
Variability	62.908	33.624	3.469
Cumulativ	62.908	96.531	100.000

Factor loadings:

	F1	F2	F3
Economic	0.960	0.170	-0.224
Social	0.973	-0.028	0.227
Ecological	-0.137	0.989	0.045





Appendix 4. Correlations among key risk variables.

Variables	GDP Index	Life Expectancy Index	Education Index	DEHD	AWS	HIV	EDB	CI	CPI	PSAV	DRI
GDP Index	**1**	**0.718**	**0.861**	0.238	0.224	**0.441**	**0.689**	0.026	**0.768**	**0.468**	0.095
Life Expectancy Index	**0.718**	**1**	**0.648**	-0.131	0.327	0.293	**0.652**	-0.298	**0.406**	0.309	**0.419**
Education Index	**0.861**	**0.648**	**1**	**0.597**	0.129	0.136	**0.731**	-0.014	**0.871**	**0.612**	0.342
DEHD	0.238	-0.131	**0.597**	**1**	-0.193	-0.258	0.226	0.089	**0.604**	**0.542**	0.024
AWS	0.224	0.327	0.129	-0.193	**1**	0.244	0.144	-0.200	-0.001	-0.144	0.082
HIV	**0.441**	0.293	0.136	-0.258	0.244	**1**	0.034	0.032	0.203	0.240	-0.218
EDB	**0.689**	**0.652**	**0.731**	0.226	0.144	0.034	**1**	-0.152	**0.683**	**0.490**	0.148
CI	0.026	-0.298	-0.014	0.089	-0.200	0.032	-0.152	**1**	0.088	0.036	-0.256
CPI	**0.768**	**0.406**	**0.871**	**0.604**	-0.001	0.203	**0.683**	0.088	**1**	**0.633**	0.148
PSAV	**0.468**	0.309	**0.612**	**0.542**	-0.144	0.240	**0.490**	0.036	**0.633**	**1**	0.101
DRI	0.095	**0.419**	0.342	0.024	0.082	-0.218	0.148	-0.256	0.148	0.101	**1**

References

[1] Vernadsky V.I., 1926. Biosphera (The Biosphere), Nauchnoe khimiko-technicheskoye izdatel'stvo (Scientific Chemico-Technical Publishing): Leningrad, 200p.
[2] Our Common Future (1987), Oxford: Oxford University Press. ISBN 0-19-282080-X
[3] Meadows D.L., Meadows D.H., Randers J. and Behrens W.W. (1972): Limits to growth. Universe Books, New York.
[4] Hughes B.B. (2006) Assessing the Credibility of Forecast Using International Futures (IFs): Verification and Validation, Graduate School of International Studies University of Denver.
[5] Forrester J.W. (1971): World Dynamics. Wright-Allen Press, Cambridge, Mass., 160 pp.
[6] Boumans R., Costanza R., Farley J., Wilson M.A., Portela R., Rotmans J., Villa F. and Grasso M. (2002): Modeling the dynamics of the integrated earth system and the value of global ecosystem services using the GUMBO model. Ecological Economics, 41: 529–560.
[7] Henk Hilderink (ed.), Paul Lucas (ed.): Towards a Global Integrated Sustainability Model, GISMO1.0 status report, Netherlands Environmental Assessment Agency, 2008
[8] Згуровский М.З., Гвишиани А.Д.: Глобальное моделирование процессов устойчивого развитияв контексте качества и безопасности жизни людей (2005-2007/2008 годы), Киев, НТУУ «КПИ», «Политехника», 2008 , ISBN 978-966
[9] Bakhtina V., Zgurovsky M.: Key developmental risks in Africa and their impact on sustainability, Proceedings of 21 CODATA International Conference, Kiev, 5-7 of October 2008. 244-250p
[10] Zgurovsky M., Bakhtina V.: Composition of aggregate developmental risk index for selected subset of countries in Latin America, Системні дослідження та інформаційні технології, 2008, № 4, ISSN 1681–6048, 33-40p
[11] Human Development Reports (UN), 2008
[12] Carbon intensity, internet: http://www.eia.doe.gov/emeu/international/carbondioxide.html
[13] Little Data Book, World Bank, 2008
[14] Transparency International, Internet: http://www.transparency.org/
[15] Disaster risk index http://www.undg.org/archive_docs/2367-DAC_Methodological_Note.pdf
[16] Kaufmann, Daniel, Kraay, Aart and Mastruzzi, Massimo: Governance Matters VI: Governance Indicators for 1996-2006, (July 2007). World Bank Policy Research Working Paper No. 4280
[17] Doing Business Indicators: www.doingbusiness.org
[18] The innovative imperative in manufacturing. How the United States can restore its edge, the BCC Group, March 2009
[19] Chi, Wei and Qian, Xiaoye: The role of education in regional innovation activities and economic growth: spatial evidence from China; Online at http://mpra.ub.uni-muenchen.de/15779/ MPRA Paper No. 15779, posted 17. June 2009

Uncovering non-obvious relationship between environmental certification and economic performance at the food industry

Marival Segarra-Oña[1], Angel Peiró-Signes[1], Lluis Miret-Pastor[1],

José Albors-Garrigós1

[1]Universidad Politécnica de Valencia

maseo@omp.upv.es, anpeisig@omp.upv.es, luimipas@esp.upv.es, jalbors@doe.upv.es

Abstract. This research is an attempt to explore how an incremental organizational eco innovation (the ISO 14001 environmental standard certification system) affects economic performance of firms belonging to one of the most important GPD generator in developed countries: food industry. The analysis is based on a sample of 6118 Spanish firms. We have used quantitative analysis techniques to correlate economic indicators with the implementation of the ISO 14001. Food industry operates in an economy and a society context increasingly concerned with wide and diverse environmental issues. In the case of the food industry this has been augmented by the food security standards. In this context, many companies decide to go beyond the formal legal requirements and take a proactive stance on environmental issues. The study results show how environmental focused companies are able to create a competitive advantage by the earlier implementation of an eco-management tool.

Keywords: Eco-innovation, competitiveness, environmental proactivity, food industry, low tech industry

1 Introduction

Food industry is the largest industrial sector in both, the EU and the U.S, feature that persists in Spain where it accounts for 17% of total industrial sales, 7% of GDP, and employs over 500,000 people [33]. However, different analysis [8; 46; 15] warn about the loss of competitiveness that this sector can suffer in the next years.

Food industry faces a series of structural changes: first, we detect a growing tendency to sell processed foods [39], secondly, shows major and rapid changes in consumer preferences caused by economic development, changes in population

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_26,

structure and the emergence of new lifestyles [46] and, finally, important technological changes in areas such as biotechnology or technology information systems, which are leading to new products and new methods on how to organize food supply chain [46].

Moreover, the food industry operates in an economy and a society increasingly concerned with wide and diverse environmental issues [31]. Companies are being demanded an increasing environmental awareness [8], in the case of the food industry is increased by the continuing food security alarms.

In this context, many companies decide to go beyond the formal legal requirements and take a proactive stance on environmental issues [41].

Taking care of the environment can be a competitive advantage that allows the firm to reach the access to new markets and differentiate themselves from competitors [36; 12]. In this regard, in recent years has been observed a significant increase in the number of companies with ISO 14001 environmental certification. In the case of the Spanish food industry has grown from 3 companies certified (with EMAS or ISO 14001) in 1997 to 298 in 2008, representing 3.45% of total registered companies in Spain [33].

Business companies are giving more and more consideration to aspects connected with sustainable development, environmental awareness, eco-innovation or environmental management, a first-class strategic asset [7; 12; 21; 34]. Standardised environmental management can be classified according to the criteria of the recognised authorities [35] as incremental organizational innovation.

In this context, management of sustainable development becomes a crucial process [41], eco-efficiency is considered as one of the major challenges for R&D practice [34], as well as the need for implementation of quality control mechanisms that assure that products and services comply with stipulated standards of excellence related to the principles and practices of sustainability [45] and value creation through environmental certification [9] and especially through the ISO 14001 [28; 37].

Eco-innovation plays a pivotal role in the search for a sustainable economy and society, since it joins together the two pillars of sustainability: environmental quality and economic welfare. It gives added value to producers and consumers while at the same time reducing environmental impact [44]. Otherwise the same food industry has the opinion that eco-innovation has to be considered as a key for increasing their competitiveness [8].

2 Objectives and structure of the chapter

In a global economy in which Europe has lost a great part of its price advantage, innovation is one of the resources and strategies that can maintain or increase competitiveness [13; 22]. The aim of the present chapter is to make a contribution, trying to understand the role of proactive environmental management tools and incremental organizational eco-innovation in creating value in the Spanish food sector by means of an analysis of the effects of the ISO 14001.

Many studies can be found in the literature on business proactivity applied to specific sectors. For example, in Spain, Aragón-Correa et al [2] found that in the automotive repair industry, firms with the most proactive practices exhibited a significantly positive financial performance.

Martín-Tapia et al. [27] studied the food industry and found a correlation between advanced environmental strategies and export intensity of SMEs. Among the studies dealing with the implementation of environmental management tools, McKeiver and Gadenne [28] analysed both, the external and internal factors that influenced the implementation of an environmental management system.

At the present time, no studies have been found that link the implementation of management tools with economic performance, nor have any been found on the relationship between both concepts according to the type of firms involved as regards the importance of size.

Bearing in mind all that has been explained up to this point, the aim of this work consists on evaluating the impact of the implementation of an environmental management tool, the ISO 14001, in food companies on the firms' business results. Our main hypothesis states that *Environmental management through the ISO 14001 in food companies is linked to economic performance.* From this line of study, we will determine whether it is possible to identify moderating factors that influence this link, considering the *size of the firm* as a variable.

A review of the existing literature on environmental will be made and the implementation of environmental management systems at the food industry, trying to identify the most important aspects that affect the economic performance of food companies. An analysis and evaluation of a food companies sample that have implemented the ISO 14001 will then be made, as compared to a sample of companies that have not done so. Empirical relationships will be established between environmental management with the ISO 14001 and business performance. After the statistical analysis and discussion of the results, the conclusions drawn from the study will be given.

3 Environment, certification and food industry

Certification can be defined as a voluntary checking process, that audits and gives written assurance that a process, product or service meets a specific set of standards [3; 30]. These standards, in regard to environmental management, provide guidance to implement an Environmental Management System (EMS).

In fact, there are several works that recomend the use of environmental certification as an instrument for measuring eco-innovation [43; 24] taking into account the posibility of adapting what is already stated in the report of the OECD about Governance of Innovation Systems [38] for the use of certification indicators in innovation studies. In any case, the certification would not be indicative of radical eco-innovations, but the eco-called incremental innovations. The ISO 14001 standard is the most widely used environmental management. From 1996 to 2008 rose from 1491 to 129,199 licenses worldwide. 40% of these certificates are produced in the European Union. There are extensive literature that examines the economic impact of the companies that implement ISO 14001 system. Melnyk et al. [29] or Montabon et al. [32] found empirical evidence to say that the ISO 14001 improves both the environmental and the business image. Economic improvements occur through several pathways, such as cost reduction [16], improving the reputation [12], or increases in productivity [5], although the interest of the academic community about the issues of environmental management in Food Industry is still scarce [17] and despite the changes in preferences consumer and technology, different authors [4] lead to assert that the food industry is an industry where environmental issues and food safety will play a key role in the coming years, especially in developeded countries. On the other hand, food industry has a strong environmental impact because it is intensive in resources use, produces high pollution levels, needs heavy and intensive transport and generates a considerable amount of waste 18], as can be seen in table 1.

Table 1. Environmental impact of the EU food industry

	% of total manufacturing industries	% of total EU
Water consumption	12%	1-1'8%
Greenhouse gases emissions	7%	1'5%
Solid waste generation	12'5%	3'25%

Source: European Environment Agency (2007)

In fact, there are some previous works focused on the food industry that relate the proactive environmental attitude to various aspects of management, as increases in export levels [17;27] or productivity improvements and competitiveness [17; 6, 26].

In any case, at the food industry is particularly important to distinguish between eco-labeling and environmental certification [11]. The numerous existing eco-labels are informing customers about specific environmental attributes in the product (general attributes as in the case of the European Ecolabel or specific product labels as organic food or sustainable fishing).

A feature of the literature on proactive environmental strategies is that it focuses on large firms, due to the commonly accepted idea that the larger companies maintain more proactive environmental strategies [42; 40] arguing that the SMEs are less environmentally proactive due to lack of resources as by a lack of experience in Environmental Management. This idea has been extrapolated to the food industry and various reports such as that of the European Commission [14] indicates the unwillingness of SMEs in the sector to go beyond the requirements of environmental legislation and justify it primarily based on the lack of information, the financial capacity to undertake major investments, to its small size and low pressure from consumers.

This vision has led much of the literature, that does not consider SMEs in their studies. However, excluding SMEs from the analysis of the food industry in Europe, means to exclude the 99'1% of existing firms, the 61'3% of employment and 47'8% of total turnover [8]. In fact, in recent years, some studies are beginning to reconsider their position and to analyze the environmental attitude of small and medium enterprises [27; 28].

This chapter studies the food industry from an aggregate level and also segmented by size, which will allow us to gain knowledge about the behaviour of firms in terms of size.

However, there is a lack of research on the correlation between ISO 14001 certificated firms and their economic performance in crisis situations and also between the different size in the same industry.

This is the direction in which we planned our work should go, with our principal hypothesis being, *H1: Eco-innovation in environmental management by the application of the ISO 14001 standard contributes to creating value in the Spanish food industry by improving economic performance*.

The second hypothesis is derived from the first, *H2: Organizational eco-innovation has an unequal influence on the economic performance of Spanish food industry firms according to their size.*

4 Methodology

4.1 The sample

It is important to identify the characteristics of firms since this affects their environmental management practices. Although at first we had thought of adopting smaller and more homogeneous regions, we considered that analysing a broader scenario could help us to obtain better results. Given the strategic importance of the food industry in Spain, we included firms from all the Spanish regions in the study.

Data referring to food firms with environmental certification were taken from the IHOBE database, (considering CNAE codes 10, food industry and 11 beverage industry) which consists of a monthly updated comprehensive list of Spanish companies certified according to the ISO 14001 standard, with a search system by sector, National Spanish Activities Classification, CNAE, or province. Affiliate level information includes name of the affiliate; host-region and economic activity as defined by the CNAE codes, the address, and the certifying organization.

Of the 6.118 Spanish food companies identified, economic information was obtained from the SABI database for the year 2008. Of these firms, only 150 had ISO 14001 certification. Table 2 shows the data divided into total companies and companies with ISO 14001 certification.

Table 2. Classification of firms studied according to its size

	WITH ISO	WITHOUT ISO	TOTAL
<50 employees	69 (1,27% of total)	5354	5423
50-249 employees	46 (8,07 % of total)	524	570
> 250 employees	35 (28% of total)	90	125
TOTAL	150 (24,5 % of total)	5968	6118

Source: IHOBE and SABI databases.

Data in the table above confirm the relationship between size and environmental certification. Although in absolute numbers most certified companies belong to small and medium enterprises (115), these figures represent only 1.27% of total existing small businesses in the industry and 8.07% of medium, while 28% of large companies are certified.

We can say that the percentage of certified firms goes up with size. Thus, only the 1.27% of small firms are certified, a percentage that rises to 8.07% for medium enterprises and reaches 28% of large enterprises. According to the segmentation, four separate studies will be made, one for the food industry in general (analyzing first hypothesis) and one for each of the three segments in which we divide the industry by size of firms (which will serve to validate the second of the hypotheses).Company size measured by number of employees (European Commission 2003).

4.2 Data analysis

To validate our hypotheses, we applied the ANOVA test that can detect mean differences across business functions comparing ISO 14001 certified with non certified firms, using specific performance indicators such as Trading Income, (TI), net sales (NS), size by number of employees (SZ), Profit Margin, (PM), Earnings on sales before interest, taxes, depreciation and amortization, (EBITDA), Ordinary incomes before taxes (OIBT), and Profit per employee (PPE).

The same indicators had previously been used to analyse financial performance in Spain [1]. To construct the indicators, information was taken from the SABI database and was subsequently processed.

The ANOVA analysis seeks to break down the variability in a study into independent components that can be assigned to different causes. It is a statistical technique designed to analyse the significance of the mean differences of the different populations, and as such, it is considered as an extension of the means difference test, and is used to study the relationship between nominal, ordinal and interval variables [20]. The ANOVA technique indicates whether or not we reject the null hypothesis that reflects the equal means value for each level of significance. In this way we confirm whether the mean of the variable performance is significantly different for the firms according to their ISO 14001 environmental certification. The database was analysed using SPSS.17.0. (See Table 3).

Table 3. Comparison of means (one-way ANOVA) for economic performance. All the sample.

ANOVA	ISO 14001	Mean	F	Sig.
	WITH ISO	1,06E+05	628,360	0,000*
TI	WITHOUT ISO	7050,68158		
	TOTAL	9457,24156		
	WITH ISO	1,03E+05	621,174	0,000*
NS	WITHOUT ISO	6969,42915		
	TOTAL	9318,28039		
	WITH ISO	361,41	559,235	0,000*
SIZE	WITHOUT ISO	29,82		
	TOTAL	37,89		
	WITH ISO	1,15E+04	634,722	0,000*
EBITDA	WITHOUT ISO	4,68E+02		
	TOTAL	7,36E+02		
	WITH ISO	5782,079	438,162	0,000*
OBIT	WITHOUT ISO	164,01035		
	Total	300,81248		
	WITH ISO	1,30E+01	4,190	0,041*
PPE	WITHOUT ISO	2,79E+00		

*Significance at the 0,05 level is shown in italics.

After analysing the overall mean value of the six studied variables, it was found that all of them revealed significant differences between firms with ISO 14001 certification and those without.

It is interesting to observe how the mean values of all of them are considerably higher than those in non-certified firms. Considering the mean size gives some indication of the relationship between size, process organisation and economic performance. This indication is supported by the EBITDA and the PPE values.

A total of four one-way analyses of variances were conducted on each of the different performance measures in order to examine differences among the three segment groups identified. The results analyses are shown in Tables 4, 5 and 6.

Table 4. Comparison of means (one-way ANOVA) for economic performance. Small firms.

ANOVA	ISO 14001	Mean	F	Sig.
	WITH ISO	1,05E+04	91,132	0,000*
TI	WITHOUT ISO	2895,40839		
	TOTAL	2991,87811		
	WITH ISO	226,77368	7,949	0,005*
NS	WITHOUT ISO	49,48983		
	TOTAL	51,74552		
	WITH ISO	41,29	22,376	0,000*
SIZE	WITHOUT ISO	15,13		
	TOTAL	15,21		
	WITH ISO	7,62E+02	77,600	0,000*
EBITDA	WITHOUT ISO	1,93E+02		
	TOTAL	2,01E+02		
	WITH ISO	226,77368	7,949	0,005*
OBIT	WITHOUT ISO	49,48983		
	Total	51,74552		
	WITH ISO	9,18E+00	0,858	0,354
PPE	WITHOUT ISO	2,14E+00		

*Significance at the 0,05 level is shown in italics.

Small firms performed very similarly to the whole sample, with TI, NS, Size, EBITDA and OBIT revealed significant differences between small food firms with ISO 14001 certification and those without. Only PPE (Profit per employee) shows no difference between small food firms with ISO 14001 certification and those without, although as we can see in table 3, mean values of certified firms are significantly higher (more that four times). Similar values of most analized varibles to the whole sample revealed significant differences between firms that had adopted this eco-innovation tool and the rest of the sample. We can notice that mean value of number of employees is double in certified firms than in non-certified companies. Here again, a relationship between size, organizational innovation and economic performance can be observed.

Table 5. Comparison of means (one-way ANOVA) for economic performance. Medium firms.

ANOVA	ISO 14001	Mean	F	Sig.
	WITH ISO	3,71E+04	2,646	0,104
TI	WITHOUT ISO	27233,04707		
	TOTAL	28012,76852		
	WITH ISO	3,64E+04	2,491	0,115
NS	WITHOUT ISO	26925,8259		
	TOTAL	27676,11317		
	WITH ISO	107,13	0,806	0,370
SIZE	WITHOUT ISO	100,51		
	TOTAL	101,03		
	WITH ISO	3,88E+03	11,295	0,001*
EBITDA	WITHOUT ISO	1,96E+03		
	TOTAL	2,11E+03		
	WITH ISO	1883,37824	3,900	0,049*
OBIT	WITHOUT ISO	911,23991		
	Total	987,98768		
	WITH ISO	1,29E+01	0,797	0,372
PPE	WITHOUT ISO	8,70E+00		

*Significance at the 0,05 level is shown in italics.

The data obtained from the ANOVA analysis of medium food firms shows significant results for the EBIDTA and OBIT values, although no differences in mean income or total sales can be observed in this industry segment. An explanation could, perhaps, be found in the size factor, due to its similarity between size in certified firms with those non certified. Despite this, the main indicator of profitability due to ordinary incomes revealed significative for ISO 14001 certified firm**s.**

Table 6. Comparison of means (one-way ANOVA) for economic performance. Big firms.

ANOVA	ISO 14001	Mean	F	Sig.
	WITH ISO	3,83E+05	25,857	0,000*
TI	WITHOUT ISO	135181		
	TOTAL	203885		
	WITH ISO	3,73E+05	25,341	0,000*
NS	WITHOUT ISO	133427		
	TOTAL	199986		
	WITH ISO	1358,86	22,822	0,000*
SIZE	WITHOUT ISO	486,56		
	TOTAL	728,87		
	WITH ISO	4,25E+04	33,695	0,000*
EBITDA	WITHOUT ISO	8,02E+03		
	TOTAL	1,76E+04		
	WITH ISO	21746,58189	25,988	0,000*
OBIT	WITHOUT ISO	2590,90462		
	Total	7911,92608		
	WITH ISO	2,05E+01	7,851	0,006*
PPE	WITHOUT ISO	7,19E+00		

*Significance at the 0,0,5 level is shown in italics.

Results obtained from the analysis of the big firms segment is very similar to the whole sample results, with significance difference between certified and non certified firms for all the variables studied. The mean size of big firms with the ISO 14001 standard (1359 employees) is significatively higher of those without (487 employees).

5 Discussion

First of all, our findings showed that the use of ISO14001 as an environmental management tool had a significant impact on several economic performance variables, which led us to conclude that there is a direct relation between ISO 14001 and corporate performance, thus validating our main hypothesis, which stated that eco-innovation in environmental management by the application of ISO 14001 contributes to value creation in the food spanish industry by improving business results.

The ANOVA analysis revealed significant differences in economic performance in the total sample, composed of all food companies with ISO 14001 environmental certification.

In the analysis of the sample segmented by size it can be seen that size is a distinguishing factor, although in the three samples differences between firms certified and those non certified were importante, number of firms certified increased in direct correlation to firm size and in the three segments studied mean size were higher in certified firms.

The second hypothesis is validated by the fact that the so-called organizational eco-innovation has an influence one way or the other on the firms results according to their size measured by number of employees. The most important difference lays in size. Even in the small firms group we have found differences in economic performance between firms that have implemeteded ISO 14001 but the mean value of certified firms doubles size of non-certified firms (Mean value Size of non certified= 15,13, mean value size of certified firms= 41,29).

A large number of empirical studies have confirmed that the use of formal systems for achieving greater coordination characterises evolutionary periods [19]. This could explain why there is a direct relation between applying innovative organizational systems and better business management and performance. The data analysed in this research seem to be in agreement with other studies. The results show that firms with proactive practices exhibited a significantly positive economic performance [2; 27]. In addition, as could be expected from the theory [25], small firms need support systems to help managers in their development needs, while larger firms can afford to have a team of specialists.

To sum up, our analysis shows that the best performing firms in the Spanish food industry are those that have adopted the ISO 14001 proactive environmental management tool, considering size acts as a moderating factor.

The results indicate the options that can be used to address the problem and an analysis of the economic, social and environmental impacts of proactivity shows the way future eco-innovation policy-making should go [23; 10].

Furthermore, we would like to point out that one of the limitations the research holds is that it has only been made from a quantitative analysis perspective. Future research will focus on the use of different methodologies. An in-depth case study will be necessary to obtain further information on the results obtained by the different food industry segments. Another line of research will consist of studying the performance of the same industry in other countries, such as France and Italy, in which food industry makes a considerable contribution to the GDP.

Acknowledgments. The authors would like to thank the Ministerio de Ciencia e Innovación for their financial support for this research project (EC02008-05895-C02-01/ECON).

References

[1] Albors-Garrigós, Marquez P B, Segarra-Oña M (2009) Internet como herramienta de creación de valor en sectores maduros. El caso de los productores y distribuidores cerámicos en España. Bol. Soc. Esp. Ceram. 48:273-278

[2] Aragón-Correa J A, Hurtado-Torres N, Sharma S, García-Morales V J (2008) Environmental strategy and performance in small firms: A resource-based perspective. Journal of Environmental Management 86: 1.

[3] Bhaskaran S (2006) Incremental Innovation and Business Performance: Small and Medium-Size Food Enterprises in a Concentrated Industry Environment. Journal of Small Business Management 44:64–80.

[4] Bellesi F, Lehrer D, Tal A (2005) Comparative Advantage: The Impact of ISO 14001. Environmental Certification on Exports. Environmental Science and Technology 39(7):1943–1953.

[5] Bleischwitz R (2010). International economics of resource productivity. Relevance, measurement, empirical trends, innovation, resource policies. Int Econ Econ Policy 7:227–244.

[6] Carpentier C L, Ervin D E (2002) Business Approaches to Agri-Environmental Management: Incentives, Constraints and Policy Issues. OECD, Paris.

[7] Christmann P (2000) Effects of “Best Practices” of Environmental Management on Cost Advantage: The Role of Complementary Assets. The Academy of Management Journal 43(4): 663-680

[8] CIAA. Confederation of the Food and Drink Industries in the EU (2010) Supporting the competitiveness of the European food and drink industry. CIAA Competitiveness Report 2010, Brussels.

[9] Daviron B, Vagneron I (2011) From Commoditisation to De-commoditisation and Back Again: Discussing the Role of Sustainability Standards for Agricultural Products. Development Policy Review 29, 1:91–113.

[10] Del Brio J A, Junquera B A (2003) Review of the literature on environmental innovation management in SMEs: Implications for public policies. Technovation 23:939–948.

[11] Delmas M, Grant L (2010) Eco-labeling Strategies and Price-Premium: The Wine Industry Puzzle. Business and Society. doi:10.1177/0007650310362254

[12] Esty D C, Winston A S (2006) Green to Gold, How smart companies use environmental strategy to innovate, create value, and build competitive advantage. John Wiley & Sons. Hokoben, New Jersey.

[13] European Commission (2009) The links between the environment and competitiveness. Project ENV.G.1/ETU/2007/0041, IEFE, Università Bocconi (co-ordinator), Wuppertal Institute, Adelphi Consult, FFU Berlin, IEEP London.

[14] European Commission. (2007) Promoting Environmental Technologies in SMEs: Barriers and Measures. Directorate-General Joint Research Centre. Institute for Prospective Technological Studies.

[15] Fischer C, Schornberg S (2007) Assessing the competitiveness of the situation of EU food and drink manufacturing industries: an index–based approach to agribusiness. Agribusiness, 23(4):473–496.

[16] Florida R, Davison D (2001) Gaining from green management: environmental management systems inside and outside the factory. California Management Review 43(3): 64–84.

[17] Galdeano-Gomez E (2009) Exporting and Environmental Performance: A Firm-level Productivity Analysis. World Economy. 33(1)**:**60-88.

[18] Gerbens-Leenes P W, Moll H C, Schoot Uiterkamp A J M (2003) Design and development of a measuring method for environmental sustainability in food production systems, Ecological Economics 46(2)**:** 231-248.

[19] Greiner L E (1997) Evolution and Revolution as Organizations Grow: A company's past has clues for management that are critical to future success", Family Business Review 10(4). Reprinted by permission of Harvard Business Review. From "Evolution and Revolution as Organizations Grow" by Larry E. Greiner, July–August 1972.

[20] Hair J F, Anderson R E, Tatham R L, Black W C (1998) Multivariate Date Analysis, 5th ed., Prentice-Hall, Englewood Cliffs, NJ

[21] Hart S (2007) Beyond greening: Strategies for a Sustainable World (99-124), in Harvard Business Review on Green Business Strategy, Harvard Business School Press, Boston

[22] Hidalgo A, Albors J (2008) Innovation management techniques and tools: a review from theory and practice. R&D Management 38(2):113-127.

[23] Kandel N, Thoraval L, Oosterhuis F, Shaw B, Ekins P (2007) Designing environmental policy to be innovation friendly. Final Report Edited by Yves Tressel.

[24] Kemp R y Pearson P (2008) Final report of the project "Measuring Eco-Innovation". Brussels.

[25] Kroeger C V (1974) Managerial development in the small firm. California Management Review, Fall XVII(1):41-47.

[26] Managi S, D Karemera (2005) The Effects of Environment and Technology on Agricultural Export. International Journal of Agricultural Resources, Governance and Ecology 4(1):45–63.

[27] Martín-Tapia I, Aragón-Correa J A, Rueda-Manzanares A (2010) Environmental strategy and exports in medium, small and micro-enterprises. Journal of World Business 45:266-275.
[28] McKeiver C, Gadenne D (2005) Environmental management systems in small and medium business. International Small Business Journal 23:513–537.
[29] Melnyk S, Sroufe R, Calantone R (2002) Assessing the impact of environmental management systems on corporate and environmental performance. Journal of Operations Management 336:1-23
[30] Miret-Pastor L, Segarra-Oña M, Peiró-Signes A (2011) Environmental certification as a tool to measure and promote ecoinnovation in the tourist sector. Research Studies in Tourism and Environment, Nova Publishers, Hauppauge, NY, USA.
[31] Mondéjar-Jiménez J A, Cordente-Rodríguez M, Meseguer-Santamaría M L, Gázquez-Abad J C (2011) Environmental Behavior and Water Saving in Spanish Housing. Int. J. Environ. Res. 5(1): 1-10.
[32] Montabon F, Melnyk S, Sroofe R, Calantone R (2002) ISO 14000: Assessing its perceived impact on corporate purchasing performance. The Journal of Supply Chain Management 36(2):4-15.
[33] Muñoz C, Sosvilla S (2010) Informe Económico 2009. Federación Española de Industrias de Alimentación y Bebidas. FIAB, Madrid.
[34] Noci G, Verganti R (1999) Managing "green" product innovation in small firms. R&D Management 29(1):3-15.
[35] Oslo Manual (2005) Guidelines for Collecting and Interpreting Innovation Data, OECD- EUROSTAT, Luxembourg.
[36] Porter M E, Van der Linde C (1995) Toward a new conception of the environment competitiveness relationship. Journal of Economic Perspectives 9(4):97–118.
[37] Raines S S (2002) Implementing ISO-14001: An international survey assessing the benefits of the certification. Corp. Environ. Str. 9:418–426.
[38] Remøe S (2005) Governance of innovation systems. OECD, Paris.
[39] Ruan J, Gopinath M (2008). Global productivity distribution and trade liberalisation: evidence from processed food industries. Eur. Rev. Agric. Econ. 4:439-460.
[40] Russo M V, Fouts P A (1997) A resource-based perspective on corporate environmental performance and profitability. Academy of Management Journal 40:534–559.
[41] Segarra-Oña M, Peiro-Signes A, Albors-Garrigos J, Miret-Pastor L (2011) Impact of innovative practices in environmentally focused firms. Moderating factors, Int. J. Environ. Res. 5(2).
[42] Sharma S (2000) Managerial interpretations and organizational context as predictors of corporate choice of environmental strategy. Academy of Management Journal 43:681–697.
[43] Speirs J, Pearson P, Foxon T (2008) Adapting Innovation Systems Indicators to Asses Eco-Innovation. DIME Conference, France 2008.
[44] Van Berkel R (2007) Eco-Innovation: opportunities for advancing waste prevention. International Journal of Environmental Technology and Management 7(5-6):527-550.
[45] Weaver D B, Lawton L J (2007) Twenty years on: The state of contemporary ecotourism research. Tourism Management 28:1168–1179.
[46] Wijnands J H M, Bremmers H J, Van der Meulen B M J, Poppe K J (2008) An Economic and Legal Assessment of the EU Food Industry's Competitiveness. Agribusiness 24(4):417–439.

Part IV
Information Management and Decision Making in Sustainable Organization

Sustainable, Multi-Criteria Biomass Procurement – a Game Theoretical Approach

Barbara Rapp[1], Jörg Bremer[1], Michael Sonnenschein[1]

[1]University of Oldenburg, Department of Computing Science

barbara.rapp@informatik.uni-oldenburg.de, jorg.bremer@informatik.uni-oldenburg.de, michael.sonnenschein@informatik.uni-oldenburg.de

Abstract Biomass exploitation asks for intelligent management strategies for linking multiple alternatives of exploitation as well as alternative paths in order to produce (multiple) products and energy (directly used or stored) at the same time. By means of loose (and therefore flexibly alterable) coupling, a regional network of (basically) small players is formed, that offers an extensible portfolio of processes, which can be used in flexible combination.

1. Introduction

Biomass may be harnessed as a substitute for fossil fuels but also represents a rich source of energy and materials for chemical products. The resulting increased demand for non-food applications has meanwhile become a valuable competitor for the maintenance of crops as the most important feedstock for food and feed. Biomass has become a scarce commodity. Thus, exploitation should consider different basic needs and a mostly complete utilization. Intelligent management strategies are required to choose between multiple alternatives of exploitation as well as alternative paths in order to find optimal linkages for the production of (multiple) products and energy (directly used or stored) at the same time. A common information and knowledge management system is necessary for linking different biomass players to a network of loosely coupled participants with a flexible and extensible portfolio of materials and processes. In order to achieve this objective, the concept of a virtual biorefinery has been introduced [5] in dependence on regional (recycling) networks.

This networking concept incorporates superior sustainability objectives, which means taking into account energy efficiency, ecological rucksack and other higher-level objectives simultaneously during network formation. In order to solve the arising problem of assigning limited resources to utilization processes in a global optimal way, two main building blocks are necessary: 1) Appropriate algorithm for this network optimization are needed that are able to handle different (and

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_27,

competing) objectives. 2) The (environmental) performance of different alternatives (in material input, linkage or utilization process) has to be captured and described in a way that allows for algorithmic processing.

We will here describe the extension of an approach [6] for single cost functions. This extension determines a compromise that combines an arbitrary number of single-cost-function-problems to a Pareto optimal solution with quantifiable quality. We will continue with a discussion of a preliminary set of performance indicators that are used for defining cost functions. The proposed approach is tested in a simulation setting. The benefits for a sustainable and multi-criteria biomass procurement that the OEPI project will contribute by enabling machine processable EPI descriptions concludes the paper together with a discussion of further add-ons.

2. Algorithm

The procurement problem considered here, can be abridged as follows: A set of (spatially distributed) biomass offers is in demand by a second set of (likewise distributed) requesting manufacturing processes. After decomposing the offers into subsets of offers, each containing merely substitutable goods, the procurement problem can be regarded as a set of classical transportation problems (TP). This problem is a standard question from OR, initially formulated by Monge in 1781. As in our case (currently) only linear cost functions are considered, it is a special case of linear programming. Otherwise, the chosen heuristic already allows the use of arbitrary cost functions.

The offered biomass deposits have to be partitioned and procured (transported) to the requesting processes. The costs of this procurement resulting from the transport have to be minimized. Transport, in turn, depends on the chosen partition and on the links (and therefor on the routes) between offers and requests. Other costs depend on the chosen manufacturing process for an offer (quality, prices, etc.). Different cost functions lead to different solutions. Hence, the overall solution must be a compromise between these different solutions that reflect the interests from different stakeholders. For this reason, a two-stage approach has been chosen for solving: in a first step, each TP is solved by Vogel's approximation once for each objective with the respective cost function. The result is a set of solutions that have to be combined to a single compromise solution reflecting all objectives to the maximal possible degree. This compromise is achieved by a matrix game.

2.1. Solving the Transportation Problem

For solving the TP we harness Vogel's approximation [7], a heuristic from OR with the advantage of very good (often already optimal) solutions. The algorithm operates on a cost matrix $C \in M(m \times n, \mathbb{R})$, where m denotes the number of offers and n the number of requests. An element c_{ij} specifies the costs that arise if offer o_i from the set of biomass offers O is matched with request r_j from the set of biomass requests R. The costs are assigned by a cost function k as $c_{ij} \coloneqq k(o_i, r_j)$. The cost function k can be any function that determines the resulting costs based on the information provided by the corresponding offer and request. For example k may reflect transport costs, environmental impact or performance and may be based upon the current location, the distance to be driven or the means of transport.

The algorithm results in a matrix $G \in M(m \times n, \mathbb{R})$, where the transport volume (exactly: the amount procured between offer o_i and request r_j) is represented by $g_{i,j}$. The available (from o_i) and demanded (by r_j) amount is taken into account as a constraint. Other constraints like restrictions on transport capacity, prices or degree of purity are also possible.

Vogel's approximation works by reducing cost matrix C. In each row or column (series) the smallest element (of the respective row or column) is subtracted from each other element in that series, such that each series contains at least one element equal to 0. In addition, two vectors d_{row} and d_{column} are calculated, containing the difference between the two smallest elements for rows (d_{row}) and columns (d_{column}). This allows for a rating of the zero elements, because elements $c_{ij} = 0$ with a large difference to the next higher costs imply higher possible savings at a total cost level. The approximation requires the following steps:

1. Calculate the differences d_{row} and d_{column}.
2. The series with maximal difference $argmax(d_{row} \cup d_{column})$ is chosen. The smallest element c_{ij} from that series determines the corresponding element g_{ij} that is assigned the maximal possible amount subject to the constraints.
3. A row (offer is completely procured) or column (request is completely satisfied) or both can be marked if the constraints are satisfied. That means they are excluded from the subsequent calculations.
4. As long as a series with more than one non-marked element exists, go to 1.
5. At last the remaining offers are shared between the remaining unsatisfied requests, corresponding ascending c_{ij}.

Vogel's approximation often obtains a very good (and frequently optimal) solution – especially for a small problem size. The strength of this approach is that constraints might be easily integrated. Originally, this method was intended for use with constraints comprising transport capacities. However, constraints concerning the applicability of the offered biomass can be treated in the same way.

2.2. Finding a Compromise

Solving the transport problem for different cost functions results in different matrices G - each a possible result. This results are taken into account when finding a compromise. The overall minimal costs of a solution are based on costs C and transport volume G and are calculated as

$$z(C,G) = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} g_{ij}$$

Finding a compromise that satisfies all objectives is done with the help of a game theory approach [8]. The approach calls for no-altering constraints. In case of biomass procurement the amount simply depends on offer, request, how well one goes with the other, transport restrictions, etc. Only the cost functions differ and are used for influencing the procurement process in the following way:

- From an offerer's point of view by focusing on maximizing (one's own) profit.
- From a requester's point of view by favoring low prices.
- From an environmental perspective by concentrating on an environmental friendly procurement.

Let's assume that s transportation problems T with s different (or opposed) costs C already have been solved. Then $G_i (1 \leq i \leq s)$ is a valid (although not necessarily optimal) solution for $T_j (1 \leq j \leq s)$ because the constraints are equal and only the cost functions vary. In order to evaluate how good solution G_i achieves the objective function $z(C_j, G_j)$ of T_j the ratio

$$w_{ij} = \frac{z(C_j, G_j)}{z(C_j, G_i)}, with\, W \in M(s \times s;]0,1])$$

is determined. Here $w_{ij} \cdot 100$ denotes (in %) how good objective j is achieved by the solution of the i-th transportation problem.

Because of $w_{ij} \in]0,1]$ the evaluation matrix W can be considered as payoff for a matrix game. Conflicting situations between two players P_1 and P_2 can be defined as a matrix game, if the revenue for one player is equal to the costs of the other player. The game is represented by a matrix, where the rows are actions for P_1 and the columns are the actions for P_2. The interior provides the payoff that is received if an action is taken. Solving such matrix games means finding the optimal solution x for P_1 and y for P_2 that maximize P_1's revenue and minimize the costs for P_2 at the same time. In case x is known, a compromise K can be found by using the weights of P_1's strategies and derive K additively from $G_1, \dots, G_s$ as $K = \sum_{i=1}^{s} x_i G_i$.

In order to identify the optimal strategy, the matrix game has to be solved using W as payoff matrix. The matrix game can easily be solved by approximation, that means by simulating several games.

It is assumed that every player (P_1 and P_2) is aware of the other players actions and therefore is able to play in an optimal way. The relative frequency of the actions taken and the resulting revenue and costs are used for approximating an optimal strategy (x for P_1 and y for P_2) and for calculating a quality criterion v for the identified compromise. Solving the matrix game involves the following steps:

1. P_1 chooses any row.
2. In that row, P_2 chooses the column that contains the smallest element.
3. In that column P_1 chooses that row that contains the greatest element.
4. A new row is formed by summing up the two selected rows.
5. In P_1's selection P_2 chooses that column that contains the smallest element.
6. A new column is formed by summing up the two selected columns.
7. Goto 2.

After q steps the algorithm is terminated and the components of x and y are determined by dividing the number of rows and columns selected by q. The value of the game v ranges from the median costs of P_2 to the median revenue of P_1. The value v will be used to determine the quality of the compromise solution.

3. Sustainability as Optimization Objective

Today, biomass players are acting on a local level without seeing the resulting impact on the global level. A superior point of view allows picking among alternatives, choosing the best one based on sustainability criteria (cf. [2]). This kind of benchmarking may incite players to continuously reduce at least their environmental impact.

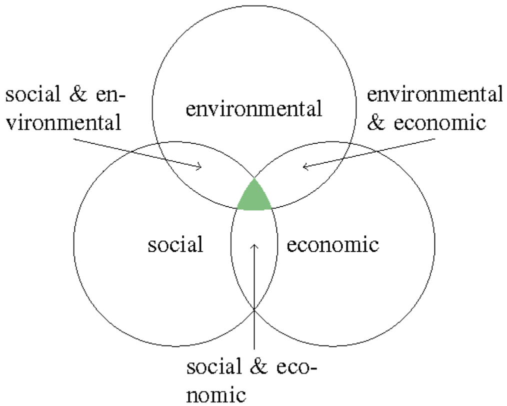


Fig. 1. The building blocks of sustainability.

3.1. Sustainability

A popular definition for sustainability and sustainable development is that of the Brundtland Commission [9]:

> [Meeting] the needs of the present without compromising the ability of future generations to meet their own needs.

Sustainability is made up of three building blocks: environment, society and economy. This constituent parts describe the triple bottom line. Figure 1 shows the relationship between the environmental, social and economic aspects and sustainability (center), that also make up our demand in biomass procurement.

3.2. Performance Indicators

According to [3] a performance indicator provides information about the social, environmental and economic impact or performance of an organization. Within the process of biomass procurement, performance indicators are used as a benchmark for determining the costs of a provided solution. The subsequent list of indicators extends the list of indicators already used in [6] in the face of biomass procurement.

environmental indicators

emission: For a later point in time it will be possible to assess the environmental impact that is caused by one resource used for different utilizations. Such indicator descriptions are currently under development in the OEPI project.

social indicators
road class: In order to avoid traffic within the boundaries of an urban area, higher ranked road classes are preferred. The use of a motorway doesn't increase the costs of a route. Using a street tagged as living street (priority of pedestrians, playing children, low maximum speed) instead would add additional costs to the route. This performance indicator is used within the procurement process (see for example section 5).
priority of food: Currently, the resources procured are not distinguished between food, feed, chemicals, materials and energy. Therefore this indicator is not implemented yet, but it will be used in the future.

economic indicators
cost-efficiency: Procuring biomass in an cost effective way asks for taking into account the different prices buyer are maximal willing to pay and vendors are minimal wanting to earn. This will be possible at a later point in time.
quality of resource: The quality of a matching is also governed by the quality of the procured resource. Due to the fact, that poor quality of resource ask for pre-

treatment which rises the procurement costs in turn. This type of additional costs is not considered yet, but will be in future.
energy output: It is assumed that the net energy output decreases due to increased losses resulting from transport. Currently, energy output is considered that way, that shorter overall routes are preferred.

social-environmental indicators
noise pollution: Clearly, the faster one drives the more noise is emitted. This emission has to be put into perspective by the number of effected people. This indicator is partly considered due to preferences defined within the road class (see above).
odor nuisance: This indicator behaves similar to the emission of noise.

environmental-economic indicators
distance: Primary the length of a route has a high impact on the overall route costs. Secondly the distance has affect on the fuel consumption taking into account the road class. Currently the distance is used as a cost function (see for example section 5).
left-hand-turn elimination: U.P.S. limited the number of left-hand-turns, taken by their more than ninety-five thousand trucks. This results in an overall reduction of 28.5 million miles, which in turn yields savings in the amount of approximately three million gallons of gas and 31,000 metric tons of CO_2 emission, according to a U.P.S. spokeswoman (cf. [4]). This performance indicator is used within the optimization of the procurement result (see section 5).

social-economic indicators
time & fuel consumption: From an economic point of view the road class can be used for measuring the duration of a journey and for estimating the fuel consumption. Higher ranked routes (that means lower costs) will be preferred. This performance indicator is currently in use (cf. section 5).

4. Simulation Setup

For each simulation, a random set of biomass resources is created and routing is applied. In a next step the costs for each route are estimated for each selected performance indicator. Afterwards a compromise solution is determined, that provides information about the optimal interlinkage of biomass players according to the performance indicators used.

The optimization's runtime depends on the number of participants, the supplier-requester-ratio and the number of performance indicators used. The supplier-requester-ratio affects the runtime, because the number of routes that have to be considered is calculated as $number\ of\ suppliers \times number\ of\ requesters$, with a fifty-fifty ratio as worst case. Currently, routing is the most time consuming step.

4.1. Scenario Description

The participants that should be interlinked by biomass procurement are represented by a set of biomass resources, also referred to as players. This set is generated randomly and each player has a fifty percent chance of being an offerer or requester. The location and the offered or requested amount of each player are also determined randomly. After completing the generation of the set, routes for each pair of offer and request are calculated.

The region chosen for scrutinizing the scenarios is of approx. 300 km^2 in size. In this paper, examples from the city of Oldenburg in Lower Saxony, Germany are given. The region is intersected by the Hunte river with only a limited number of five bridges available within the urban area. 13.27% of the urban area are dedicated as public thoroughfares, whereof ca. 8.5 km^2 are roads. The road transport infrastructure is determined by residential roads (quite often with a speed-limit of 30 km/h), followed by secondary highways (B-roads) and a ring of motorways (express highways).

Besides the area of the city, the region compromises a few small municipalities, some small forests and lakes and mostly agricultural areas. Railway transport is not considered for instance due to the fact, that the feature of switching the transport vehicle along one route is not meaningful for small distances and as a result it is not implemented yet.

Currently, (exactly) one type of biomass is regarded. Follow up versions will deal with different types of biomass, that itself can differ in prize or purity for example.

4.2. Determining Link Costs

The underlying optimization objective is interlinking the participating players in an optimal way using selected performance indicators as cost functions. An optimal interlinkage is achieved if the Pareto optimal network is found. In this context Pareto optimal denotes that no link between two players can be changed without increasing the costs for at least one stakeholder. The performance indicators used for assessing the costs to a route are the distance that has to be covered, the classes of roads used and the number of left turns needed.

The value of the first quite obvious cost function is very easy to obtain: by summing up the length of the routes selected. The network with the smallest overall length wins (with regard to this performance indicator).

For routing motorized vehicles the following road class hierarchy is used: motorway, trunk, primary, secondary, tertiary, unclassified, residential/service, living street and track. This hierarchy is in ascending order. That means a section of road of class motorway adds additional costs of zero, whereas the road class trunk rises the costs for this section by one. If a section's type is not contained in the list, it is assumed that this section is of class void, which adds twice the highest value to the costs. The list's sorting is geared to the administrative status and physical structure of a road. That means the easier the travel the lower the additional costs.

Another performance indicator that directly operates on the course of the road is called left-hand-turn elimination. Each time the route contains a left turn (according to the current driving instruction of the routing algorithm) the costs are raised. If the left turn is supported by a traffic signal, the increase amounts to only 50%.

Due to the poor data available, only route and transport related costs are currently considered. Nevertheless, four out of the given six building blocks of sustainability can be covered, at least indirectly.

4.3. Technical Setup

Reusing some components developed for use in the context of recycling networks (cf. [1]) caused further development also to be in the Java programming language. The components reused enable the current system to use Vogel's approximation and to find compromises.

In order to interlink the participating players by means of procuring biomass the resulting transport distance is determined as shortest route between two players via a specialized A*-algorithm. Routing is done with the help of the OSMNavigation library that is working on top of OpenStreetMap. The OpenMap™ toolkit is used for the depiction of maps and calculated routes.

5. Result

This section presents some first results. Figure 2 shows different interlinkages of the same biomass players resulting from the different performance indicators used as cost function and the final compromise solution. It is quite obvious that each interlinkage (sub-solution) looks different, because each sub-solution is optimized according to a specific cost function. The graphic presentation focuses on the cost optimal routes and the transported amount. Table 1 lists the interlinkage depicted in figure 2. Both show the matrices G and K (see section 2). The calculated distance or identified road class also includes a qualification of energy output or time and fuel consumption, due to the fact that these indicators are related.

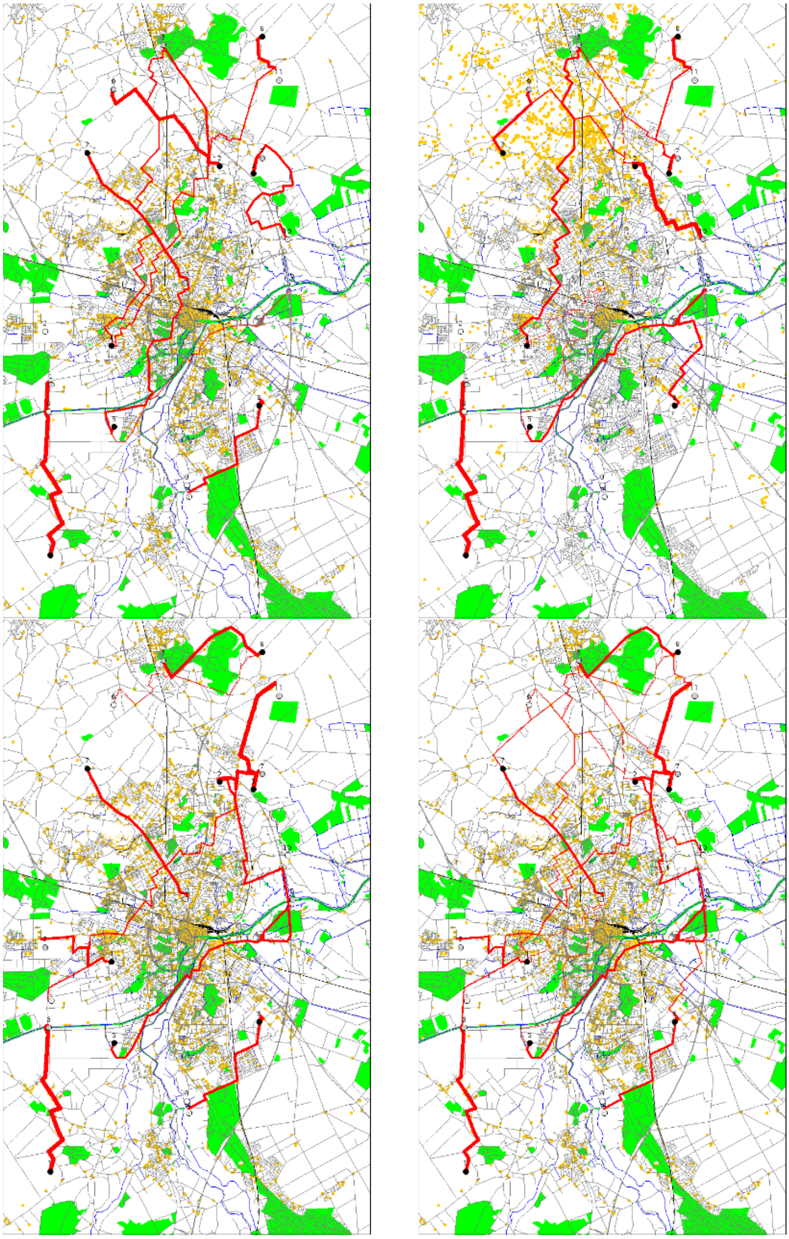


Fig. 2. Comparison Comparison of sub-solutions and final compromise solution - each optimal according to specific cost functions. The thicker the route, the higher the amount transported along this route.

	req1 309.0	req2 177.0	req3 208.0	req4 308.0	req5 292.0	req6 334.0	req7 230.0	req9 236.0	req10 294.0	req11 303.0	req12 298.0	cost function
	299.0											road class
s1	299.0											distance
299.0						299.0						left-hand-turns
	67.3					**231.7**						compromise
			131.0					236.0				road class
s2			14.0					59.0	294.0			distance
367.0					137.0		230.0					left-hand-turns
			3.2		**106.2**		**178.3**	**13.3**	**66.2**			compromise
							230.0		139.0			road class
s3			52.0				230.0			87.0		distance
369.0	66.0									303.0		left-hand-turns
	51.2		**11.7**				**51.8**			**254.41**		compromise
			77.0							69.0		road class
s4			142.0								4.0	distance
146.0		146.0										left-hand-turns
		113.2	**32.0**								**0.9**	compromise
					15.0						121.0	road class
s5					132.0						4.0	distance
136.0					136.0							left-hand-turns
					135.1						**0.9**	compromise
				160.0								road class
s6					160.0							distance
160.0				160.0								left-hand-turns
				124.0	**36.0**							compromise
											177.0	road class
s7								177.0				distance
177.0											177.0	left-hand-turns
								39.8			**137.2**	compromise
										216.0		road class
s8										216.0		distance
216.0			208.0					8.0				left-hand-turns
			161.2					**6.2**		**48.6**		compromise

Table 1. Quantitative comparison of sub-solutions and final compromise solution - each optimal according to specific cost functions. Requester 8 is never part of the network and therefor he is omitted for the sake of clarity.

The data shows that a global optimization approach can be realized and allows for a comprehensive survey of sustainability aspects within network formation. As stated in section 2.2 the quality v of the found compromise can be calculated. The value v specifies the maximum fulfillment of all objectives (cost functions). In the example presented here, v is 0.904 (center of interval), i.e. all three objectives (together) have been achieved to an amount of 90.4%.

6. Further Work

The promising results gained during the optimization and simulation encourage us to extend the presented approach. Subsequently, some possible add-ons will be introduced:

As a first improvement, the integration of further performance indicators seems promising, as well as taking into account prices, purity or considering toll or other fees. Additionally, the diversification of biomass types will be introduced. This includes for example different types of biomass and processing options. Also the network's infrastructure may be extended by collecting points and intermediate storage, due to the fact that randomly generated nodes (offers or requests) do not always have a direct road access (this happened to requester 11).

As a second step the biomass procurement will benefit from the OEPI project that aims at bringing sustainability to the daily business by developing services that calculate environmental performance indicators and integrate them into business solutions. With the problem of sustainable biomass procurement as it has been stated here, a new kind of possible end user arises: an algorithm like the sketched procurement optimization process. A standardized EPI description language for example will have the following advantages:

1. Standardized description based on ontologies enables machine processing and integration into algorithms.
2. EPIs from different biomass deposits become comparable.
3. EPIs (and their reliability, uncertainty, etc.) become calculable.
4. OEPI will enable a comprehensive (and automated) sustainability reporting on the procurement results as well as for the participants.
5. New EPIs can be easily integrated due to their standardized description.

Acknowledgments This work was partially funded by the European research project OEPI (Solutions for Managing Organizations' Environmental Performance Indicators, 748735).

References

[1] Bremer, J., Rapp, B., Vogel, U., Sonnenschein, M.: Metadata driven acquisition, search and procurement of secondary materials within an internet-based marketplace. In: L.M. Hilty, X. Edelmann, A. Ruf (eds.) Proceedings of the 8th World Congress on Integrated Resources Management (2007)

[2] Dada, A., Staake, T., Fleisch, E.: Reducing environmental impact in procurement by integrating material parameters in information systems: The example of apple sourcing. AMCIS 2010 Proceedings (paper 369) (2010). http://aisel.aisnet.org/amcis2010/369
[3] Global Reporting Initiative: Sustainability Reporting Guidelines, Version 3.0 (2006)
[4] Lovell, J.: Left-hand-turn elimination. The New York Times (2007)
[5] Rapp, B., Bremer, J.: Paving the way towards virtual biorefineries. In: F. Teuteberg, J.M. Gómez (eds.) Corporate Environmental Management Information Systems: Advancements and Trends. IGI Global, Hershey, PA (2010)
[6] Rapp, B., Bremer, J., Sonnenschein, M.: Simulating the transport performance of online traded biomass. In: K. Greve, A.B. Cremers (eds.) Integration of Environmental Information in Europe - 24th International Conference on Informatics for Environmental Protection, pp. 657–666. Shaker Verlag (2010)
[7] Reinfeld, N., Vogel, W.: Mathematical Programming. Prentice Hall, Englewood Cliffs, New Jersey (1958)
[8] Stopp, F., Schiemann, G., Ose, G., Baumann, H., Körner, W., Lochmann, G.: Lehr- und Übungsbuch Mathematik, vol. 4, 12 edn. VEB Fachbuchverlag, Leipzig (1990)
[9] World Commission on Environment and Development: Our Common Future, Report of the World Commission on Environment and Development (1987)

An integrated decisions support system and a GIS tool for sustainable transportation plans

Jesús Racero, Marta Hernández, Fernando Guerrero, Gregorio Racero

Edifício Escuela Superior de Ingeniería Informática

jrm@esi.us.es

Abstract. The Kyoto Protocol agreement sets to Spain a 15% of increment in the emissions from 1990, on the other hand, they fixed the reduction of 8% in the European Union. Today, Spain is at 52% over the base year, the transport is one of a major source (15%). Likewise, the road transport accounts for 80% of emissions divided equally between urban and interurban.
The Sustainable Urban Mobility Plans arise as a shock measure, with the aim of increasing energy efficiency, environmental quality and externalities reduction from the road transport. This chapter describes the design and development system that manages sustainable mobility plans. The system is based on free tools, as geographic information system libraries (OpenLayer), Java programming environment and MySQL database manager in an open distributed system, which are used to support data collection and mobility analysis.
Also, a decision support system based on socio-economic indicators, mobility, energy and environmental indicators has been integrated to aid in the evaluation and strategies selections.

Keywords: Sustainable Transportation, GIS, Decisions support system, Energy and pollution inventories

1 Introduction

1.1 Climate change and transportation

Climate change may be the most significant issue facing transportation today. Scientific consensus on climate change has grown rapidly in recent years as advances in analysis have been achieved. As evidenced by the most recent draft report of the Intergovernmental Panel on Climate Change (IPCC), the reality of climate change – and the anthropogenic influences on that change – is now broadly

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_28,

accepted by both national and internationally-recognized scientific organizations and governments.

The Kyoto Protocol agreement, that came into effect in 2004 (figure 1), established an excess of emissions for Spain of 15% in relation to the emissions of 1990 while in the European Union it was established in an 8%. Nowadays, Spain is placed in a 28.5% in relation to the reference year being the transport sector with the 15% one of the main sources ([2], [16]).

Analysing the sectors in detail, the studies indicate the road transport as the biggest contributor to the warming from the end of 195th century, followed by the aviation. Other means of transport, like the train, have reduced their influence during the last years.

The transport is responsible of the 26% of the carbon dioxide emissions (CO2), the main greenhouse gas, and the road transport is responsible of the third part of this percentage. The way this works is caused by the increasing on road and air traffic (which are the most inefficient means) together with the increasing loss of the transport efficiency etc.

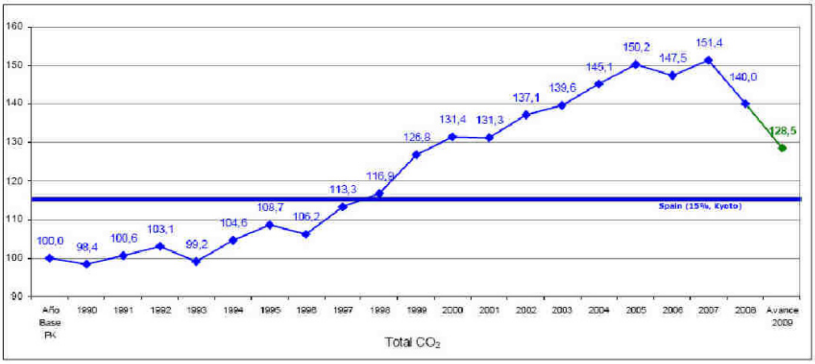


Fig. 1. Greenhouse gases emissions evolution, *Source: MMA 2009*

Contamination becomes worse for weather situations, thermal inversions and traffic congestion in rush hours. In Madrid, Barcelona and in other Spanish cities year by year during November, December and January the contamination will reach excessive limits that generate irritation of the respiratory tracts and negative effects in the long term for health.

1.2 Transport situation in Spain

Apart from the consequences derived from the gas emission to the environment, transport generates several adverse effects in people's daily live (externalities).

The externalities (pollution, accident rate y congestion) assume nowadays an 8% of the Gross Domestic Product and it is foreseen that it raises until the 12% for 2012 year. The traffic in cities generates the 80% of the noise, as well as it generates insecurity situations to the walking users, being these ones the most vulnerable collective of the road users. A high traffic generates a larger rate of accidents of vehicles and pedestrians, generating a considerable number of dead victims and material damages. All this amount of vehicles absorb a big quantity of urban space too, which is addressed to the vehicles to be able to circulate comfortably, and to the vehicles, above all private ones, to be able to park.

During the last years, surveys have been developed with the aim of knowing and analysing in depth the characteristics of the transportation in Spain. The results of these surveys can be found in MOVILIA and published by the MINISTRY OF PUBLIC WORKS/ECONOMIC DEVELOPMENT in relation to "How Spaniards move" ([9]). The main conclusions of MOVILIA show that the number of daily travels is 3 regardless of the town size. The 40% of the travels are for work reason and the main way of travel is the private vehicle (60%) which increases in a way the population of the town decrease.

The urban dispersion is one of the main responsible of the increase of the private transportation demand. The congestion and damage of the environmental quality in an area promotes the socio-economic factors as a base towards urban expansion patterns. The urban expansion with low density of population encourages the private transportation caused by the inefficiency of the public transportation that at the same it leads to a massive use of the private vehicle. In Spain, this pattern has been shown in the level of motorization (vehicles every 1000 inhabitants) where in the last 15 years the level of motorization has increased from 350 vehicles every one thousand inhabitants until 550 vehicles. Likewise, the level of average occupation of the vehicles is of 1.2 people.

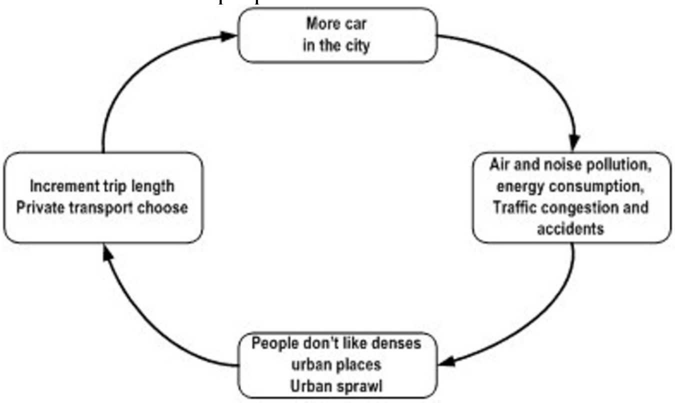


Fig. 2. Mobility effect, *Source: [11]*

Given the possibility of reducing the negative impact of the transportation emerge the concept of sustainable mobility which is the base for the development of the plans of the sustainable urban mobility (PMUS) and transportation plans for workers (PTT).

1.3 Sustainable Transport

The term transport refers to the way of travel, that is, the different possibilities of travels that may exist. We have to differentiate then the term “transport” from the term “transportation”. “Transport” refers to the collective of people and mobile objects, meanwhile the “transportation” only considers transfers of mechanical type, leaving apart the most important and plentiful social sector: pedestrians. Therefore, a definition of mobility is summarized as the group of transfers that people and goods make for work, formative, health, social, cultural, leisure time or for any other reason.

On the other hand, sustainability refers to the needed resources for the development of an activity. The sustainability entails satisfying the needs of the current generation without compromising the possibilities of the ones of the future in order to assist their own needs.

Sustainable transport is defined as the transport that satisfies within a reasonable time and cost and minimizes the negative effects on the environment and people quality of life

In the last decade the studies and the interventions directed to the increase of energetic efficiency and the environmental quality in many towns. The development of transport plans has been characterized for not being a normalized process, being in a way very varied works and finding some differences among them which prevent them from comparing one to another in order to be able to establish common policies of present and future performance in relation to the characteristics of each town.

The following work has the objective of describing the processes and works for being developed in the field of the plans of sustainable transport which can be used as reference in the obtaining of rules and norms of performance in order to increase the energetic efficiency in the urban transport field.

2 Plans of sustainable urban transport

2.1 Plans of sustainable urban transport and plans of transportation for workers

The plans of sustainable transport (PMUS) are defined as a group of stages which have the aim of the diagnosis of the sustainable urban transport in order to propose the establishment of the ways of most sustainable transfers (walking, bikes, public transportation, optimization of the private transportation) in a town, that is, of ways of transportation which make compatible the economic growth, social cohesion, and defense of the environment. ([11], [12]).

In Europe, this task has been developed in the last two decades by means of the plan of déplacements urbains (PDU, [1]) initiated in France in 1982, “the Local Transport Plans (LTP, [10]), the English ones or the Piani Urbani de Mobilitá [PUM, 18] the Italian ones. The Italians ones has as an objective the diagnosis, the design and the establishment of means which increase the energetic efficiency in the transfer and improve the transport.

Nowadays in Spain two guides are available. In these guides, the stages for the development and establishment of the plans of sustainable urban transport and the plans of transportation for workers in a way that their use and monitoring is focused in a mere identification of stages are described in a superficial way.

2.2 Design of a plan of sustainable urban transport. (PMUS plan de movilidad urbana sostenible)

A PMUS can be structured in 5 big phases (Fig. 3). Although the first four phases usually develop in a sequential way is possible that part of the tasks associated to different phases can be executed in parallel. The possibility of executing partial tasks in parallel comes as a result of the subdivision of the phases in work sections, where initially it is executed an individualized analysis by sections (diagnosis) in order to execute subsequently a partial altogether analysis, grouping sections, and total one. The sections to take into consideration are:

Social-economic aspects and road uses. The social-economic structure of the town is crucial for the analysis of the transport demand, the places that attract and generate trips (uses of the road), the localization of the educational, health care, economic, commercial and industrial activities and even to identify the collectives and associations existing in the town that will take part in the plan must be identified for their subsequent analysis of the influence in the transport.

Private vehicle transport. The private transport includes parking place, transport demand, accessibility to towns and centres (educative, administrative, and health care) or areas and of course the road network (offer).

Public transportation transport: The collecting data, diagnosis and performances in relation to public transport lines which include information associated to the ways, stops, accessibility, coverage, information level. To sum up, the aspects that affects the competitive of the public transport system.

The collecting data, the diagnosis and performances in relation to the cycling transport, pedestrian and transportation of goods are interrelated. Although the diagnosis can be developed in a independent way, with some common parts, it is recommended a joint treatment so that the performances, in any of these fields, pay special attention into themselves being necessary the complementation of correction performances and reducers of the negative effects.

Cycling transport: the collecting data, diagnosis and performances are associated to know the used routes, the typology of the transfers, parking and timetables. Analysing the opportunities, weaknesses, threatens, and strengths that the town provides for a cycling transfer.

Pedestrian transport: one of the priorities is the promotion of the pedestrian transport for which is necessary to gain space for the pedestrian space, detect, and solve insecurity vial problems so in a way it becomes a securer and more comfortable mean of transport in short distances.

Transportation of goods: the transport of merchandise accounts until the 25% of the transfers in the towns (city logistics). An organization, procedure and regulation of the transportation of goods help to improve the mobility, the environmental quality and the energetic efficiency of the group not only from the general point of view but also from the particular point of view of the truck drivers.

Each phase of the PMUS is composed by work stages where the processes and the activities to develop are defined stages. The results of each phase are reflected in two types of informs. The first one describes the tasks fulfilled and the obtained results and a final document which contains the fulfilled results in the phase. The phases are composed by activities which describe the processes that have to develop in the production of the PMUS. Finally, the processes have techniques and gadgets associated which are employed in each stage for the collecting data, analysis and diagnosis and assistance to the making decisions in relation to the performances.

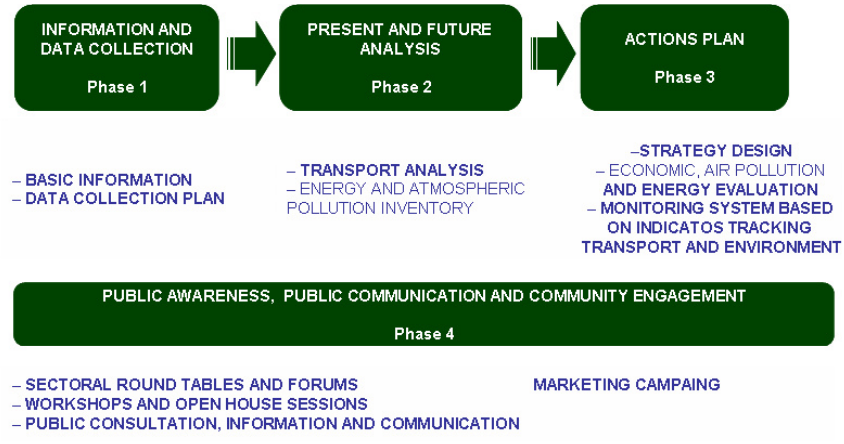


Fig. 3. Stages of the transport plans production

Finally, a transport plan is linked to an intense process of participation, public awareness and civic information. The process of participation and information is developed in parallel to the collecting data tasks, diagnosis and performances but at the end of each phase is necessary some acts where the results are presented and inform about the possible performances. This phase includes several activities, such as group procedure techniques, gadgets and face to face/on line sessions of information and participation.

3 Systems of transport analysis

3.1 The system of the geographical information

Nowadays the geographical information can be transferred, edited, visualized, superimposed, processed using many IT applications (information technology), some of them can be found in the market and some other in a free way. In the industry of the companies dedicated to the commercialization of SIG as ESRI, Intergraph, Mapinfo, Autodesk o Smallworld offer a complete whole of applications.

The SIG were at their peak some years ago. In the 90´s, the data of the SIG were located in big computers and they were used to keep internal registers, it was independent of the software. However, with the advent of internet to the present society more and more it is being chosen the distribution of data through the net. The current SIG which are in the market are a mixing of interoperable applications and API.

The applications SIG can be grouped in six sections depending on the type of IT applications:
GIS of desk: It is used to edit, create, analyse and manage the geographical information. It is very often to find SIG of desks of different types, the most usual ones are:

- Viewfinder SIG: They usually are easy applications that allow to visualize the geographical information in the viewfinder, besides being able to choose different layers to visualize.
- Editor SIG: They are applications whose main function is analysing and processing the geographical information. Usually, the inherited data or taken from other systems and transfer them to a format the software can understand.
- SIG of analysis: They are applications that provide with the function of spatial analysis and cartographic modelling of the processes.

Spatial or geographical Database Management System (DBMS). Basically, they are employed to keep the geographical information, although they often manipulate and analyse too the data which is stored. A spatial or geographical database is a data base with extensions which give support to geographical objects allowing the storage, indexation, consulting and manipulation of geographical information spatial data, if these have implemented functions of geoprocessing, this implies that it can storage the georeferenced data.
Cartographic Servers: They are used to distribute maps through Internet. The most useful ones are Open Geospatial Consortium WFS (Web Feature Server) and WMS (Web Map Server).
GIS Servers: They provide basically the same functionality the GIS desk has but they allow to access to these utilities of geoprocessing through a technological net.
GIS web customers: Its main function is to access to the data of a SIG server. There is a distinction between two types of customers, the light ones which are the browser and have the functionality of visualizing and making consults about the information of the server or the heavy customers which are the desktop applications. These one allow edit, analyse and process the data.
Libraries and spatial extensions: These are functionalities which are added to tool and are not necessary for the daily use of the application. These expansions can be functionalities like the change from an external format to another that use the application, units of specific functionalities of analysis, etc.
GIS mobile: These GIS have the main advantage of being able to take data from the field through mobile devices (PDA, Smartphone, Tablet PC, etc.). The introduction of data on these devices which have integrated a GPS tracking system that allows collected data to be already georeferenced.

Finally, note that there are many disciplines that have benefited from the development of GIS and its implementation on the Internet. The active market for Geographic Information Systems has resulted in lower costs and constant improvements in hardware and software systems. This has led to universities, governments, businesses and institutions to use this technology in sectors such as real estate, public health, criminology, national defence, sustainable development, natural resources, archaeology, town and country planning, urban planning, transport and logistics among others.

3.2 GIS tools and models applied to sustainable mobility

GIS applications on the current market haven been cited on previous section. Following section will focus on the description of tools which use GIS applied to sustainable mobility. It has to be said that they are associated with environment, and the display of pollution levels.
TRAEMS (Transport planning Add-on Environmental Modelling System): a development of road transport plans tool which has been developed using MapInfo GIS. Its main features are [5]:

- Prediction of roads transport impact,
- Traffic noise calculation models,
- Air pollution calculation models,
- Energy consumption calculation models,
- Water pollution on clouds from that area calculation models.

Other applications with similar features are ESTEEM [13], SPARTACUS [17], IMPEACT [24], PROPOLIS (2001) and ADMS-Urban [19].

There are tools that offer features more focused on pollution and pollutant gasses emissions such as: (Ruwin, 2008). Likewise, there are extensions (ArcView) Operational Street Pollution Model OSPM, [3], which have functions for calculating emissions in the streets [23], [3].

Other independent works of geographical information systems are Emission Inventory System from Transport EIST, [22] which calculates the emissions caused by traffic.

Finally note that there are models based on neural networks, specifically the Perceteptron Multilayer type (Multilayer Perceptrons, MLP), which are the most widely used artificial neural networks for predicting air pollution. [21].

4 System Design

The diagnosis of mobility plans help system is a distributed system that manages the entire process of data collection and of mobility. The system consists of 5 blocks that interact between each other to monitor the work of data collection and obtain the results of the diagnosis (Fig 4).

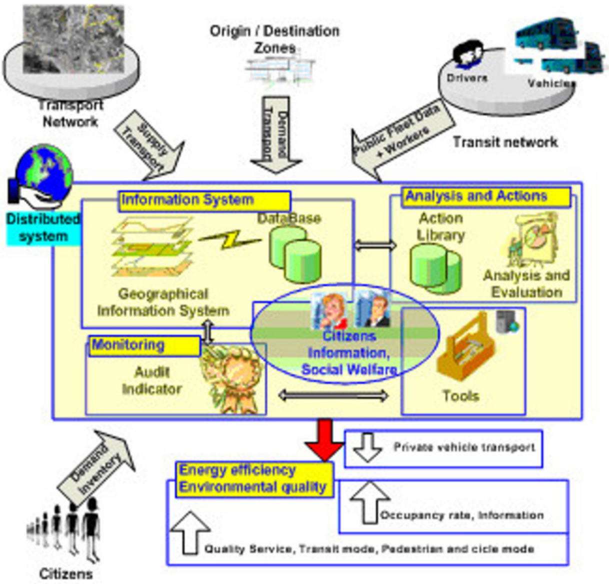


Fig. 4. System's conceptual design

4.1 Information Subsystem

The main component is a database and a Geographic Information System (GIS) which stores all information (graphic and non-graphic) related to the study area.

The information system is responsible of managing and generating dialogues for data collection and processing of information which is adapted to the needs of the system. The basis of the information system is a GIS environment where road is shaped and digitized; the centre, aim of study, is localized and adjacent centres which influence in the mobility and it is the support of automation and monitoring of data collection.

The information system manages not only data entry but also serves as support to field work by the generation of data collection cards based on the digitization of the road. The data collection cards are generated based on the digitization of the road by a directed graph G (V, A), where the vertices are intersections and arcs sense of journey. The basis of the digitization of the road is the orthophotos (aerial photography standardized and imported from the GIS).

DENOMINACIÓN DEL TRAMO					
NODO ORIGEN		NODO DESTINO		Nombre calle	
Sentido único		Carril Bici	S / N		
Doble sentido		Carril BUS-VAO	S / N	Nº carriles	

OFERTA TRANSPORTE			
ACERADO		ACERA DERECHA	ACERA IZQUIERDA
Ancho acerado (m)			
Rebaje acerado		S/N	S/N
APARCAMIENTOS		Nº Plazas	Nº Plazas
Aparcamiento Batería			
Aparcamiento Cordón			
RESERVA ESPACIOS	Nombre	Horario	Horario
Zonas de C/D			
Movilidad Reducida		Nº Plazas	Nº Plazas
Aparcabicis			
Existencia de Vados		S / N	S / N
Nº Pasos de cebra			Nº Pasos de cebra sobre elevados
Tipo de pavimento			

Fig. 5. Digitalization of the road by a graph and data collection cards of streets.

4.2 Diagnosis subsystem

Diagnosis of mobility is not a simple task that can be established based on the value of an indicator. Actions based on a diagnosis depend on several factors that in many cases are an expert or group of experts who decide on the diagnosis and mode of action on the issues.

The main characteristic of this system is the development and automation of processes that commonly have been developed in the area of mobility and have served as a basis for establishing a diagnosis of the situation and proposing actions to improve mobility. The diagnostic phase of mobility can be structured in 2 points:

- **Mobility diagnosis**. Analysis process of information associated with the movements taking place in relation to the supply of available transport and mobility needs expressed in the demand. The supply analyzes the different modes of transport, availability and available means of transport. The demand focuses on meeting the needs of displacement in the area studied.
- **Energy and environmental inventories**. The final goal of a sustainable urban mobility plan is an energy and environmental inventory which can be the base of evolution analysis or municipality trend. The energy inventory is the first indicator which expresses the goodness of the actions proposed in the next phase.

As the data collection phase, the diagnostic process is also subject to monitoring and tracking tasks of work.

Although in many cases the diagnosis is done once the process of data collection is completed, need not be so, because some may be developed in parallel with data collection. The diagnosis process can be divided into several stages. The first is the most critical stage because until this one will not be completed, the remaining stages will be blocked. The stage can be developed in parallel with data collection and is where the database is design physically, ordering each one of them adequately for the calculations required at the different stages of diagnosis.

Stage 2 allows the statistical data evaluation obtained from surveys, analyzing in detail the information. Stage 3 is more complex and wide than previous one, as it goes more deeply into the data analysis related to the existing road network in the locality. This stage analyse the "pedestrian network", in which existing roads and characterization of pedestrian's space in the locality, as well as its main deficiencies are detailed. The "access road network" characterizes each of the entrances to the town and analyzes the traffic intensities in different directions of movement. The "internal road network" examines the characteristics and possibilities of the internal road as well as its use. This stage is divided into the analysis of the traffic intensity, the calculation of road capacity and service level. The geographical information system is the base for obtaining graphical and representative maps and graphics from the municipality.

Stage 2 also analyses aspects from "road safety" which evaluates the points concerning the signposting adaptation and road interference layout in order to define and manage the potential problems in this field. Once it is completed, existing infrastructure are analysed in terms of "cyclist mobility", as well as if these infrastructures are properly, analyzing its use according to existing capacity. At this point, it is important to highlight all difficulties in this transport type. Of course, a key point in the mobility analysis is the study of "public means of transport", determining how they work according to existing needs, as well as the facilities suitability. It is important to verify the range of citizens covered by this service and identify deficiencies in certain areas regarding the possibility of access to this means of transport. Another point to study is the "parking", in which a thorough analysis of its use in the locality is done as well as the location and management of the spaces reserved for that purpose. Finally, there is the analysis of the "loading and unloading of goods". This section focuses on the analysis of the spaces reserved for goods loading and unloading in the locality, and the management and operation of the use made for that purpose. Similarly, an analysis of the use for loading and unloading areas not reserved for that purpose is done.

Stage 3 studies from existing data which is the trend on the number of cars in the town, as well as which is the evolution on the different locality's access, anticipating future possible incidents in these places and globally in the locality.

Stage 4, "analysis of the origin-destination matrix", examines population groups' mobility in the locality thanks to statistical samples and zonal division. This allows identifying a kilometre route average and a number of trips between the areas previously identified for the study. Like that you can get an estimate of how population moves and the total route kilometres that are made daily.

Finally and linked to the previous stage we can find the "energy and environmental inventory" stage, which allows to estimate the pollutants generated in everyday journeys, as well as the total consumption of fossil fuels, by two different methods: aggregate method and disaggregate method. Once the energy inventory is completed, diagnosis phase focused on the generation of an emission model to predict from noise data generated on city roads from wheeled traffic taking into account the structural characteristics and around the tracks, would be completed. Energetic and environmental inventory is an strategic tool that allows to know the energy consumption and pollutant emissions due to mobility and establish reduction aims and commitments on how to quantify the expected results of implementing energy efficiency actions. The inventory is made from the municipality's mobility demand and emission factors (table 1) representing a map of streets consumption and emissions.

Table 1. Emission factors according to vehicle's typology

EMISION FACTOR [gr./passenger·km]	Private vehicle	Bus	Train (diesel)	Train (electric)
CO_2	240	70	80	16
CO	21	1	0.01	0.001
HC	2.9	0.5	0.004	0.0004
NOx	1.5	0.9	0.3	0.05

4.3 Subsystem proposals and actions subsystem (tools)

Proposals or actions on the mobility field are based on diagnostic results and aim to improve the current situation.

As same as on previous modules, actions subsystem has a database manager, decision model and the user interface. The database manager stores actions, giving them an economic cost, indicators values involved in its selection and indicators for performance monitoring. The decision model is in charge of selecting different implementation alternatives based on the diagnosis and decision rules based set of indicators. The user interface not only shows alternatives but should be an interactive support where solutions implementation plan is described, allow the updating or addition of new decision rules and new actions.

4.4 Monitoring Subsystem

It is responsible for ensuring the success of the actions by monitoring indicators. The monitoring process sets, according to associated measures, collected information based on the data collection cards. Also, this system from the information associated with the indicators sets the level of deviation or problems in the implementation, subsequently providing recommendations about complementary and/or enhancer actions.

4.5 Management subsystem and citizen participation

Citizen participation is a key element to the plan success. The participation process is structured in 2 complementary phases: presential and virtual phase. The management subsystem organizes each one of the agents involved in the plan, neighbours, associations, hauliers, public administration and through a virtual system provides information on the evolution of each one if the phases also serves as agenda for presential sessions, as a information centre and opinion forum through the virtual platform available 24 hours a day, 365 days a year.

5 Results

The described system is still under consideration and validation. The results obtained in this phase focus on the development of tests on different municipalities (particularly in a municipality in the metropolitan area of Seville). The first step in developing a mobility plan is the digitalization of the road where a graph is defined and in which intersections and streets are represented. Simultaneously, the system generates data cards that will be the reference to the fieldwork and in the updating of the database of geographical information system (fig 6).

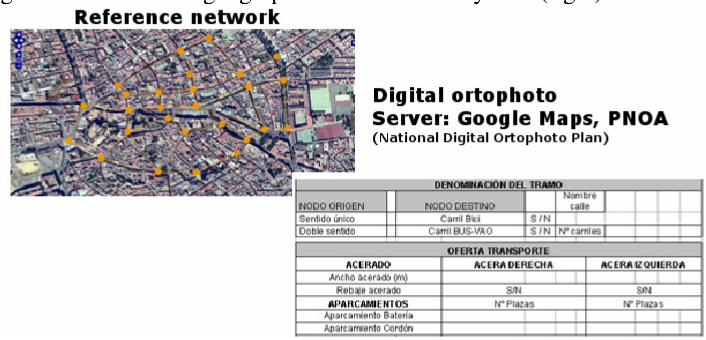


Fig. 6. Digitalization interface and generation of fieldwork cards

The diagnosis subsystem provides information about mobility in the study area, from the data collected, indicators, graphs and maps are generated which provide the basis for the diagnosis of the current situation. The graphics are arranged into pedestrian mobility, cyclist mobility, private mobility (parking and displacement, figure 7 and 8), and public transport mobility transport goods mobility.

Fig. 7. Mobility diagnosis results sample

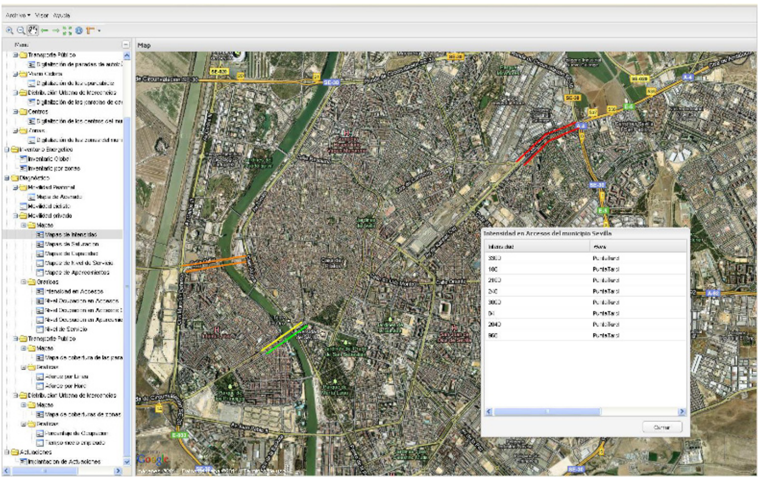


Fig. 8. Intensity maps

The diagnosis ends with the development of an energetic and environmental inventory based on mobility surveys developed in the data collection. Mobility surveys allow to estimate the journeys matrix which describes the displacement between each pair of zones defined in the study area (Fig 8). Finally, energetic and environmental inventories are obtained based on the average distance of displacement, average speed and emission factors table (table 1). The results are obtained in aggregated and disaggregated form by location (table 2).

Table 2. Energy and environmental inventory based on the mobility of areas

		Pollutants (Tn/year)			
AREAS	Fuel (toe / year)	COV	NOx	CO	CO_2
1	107,412	4,867	2,517	35,245	402,797
2	52,961	2,4	1,241	17,378	198,605
3	28,539	1,293	0,669	9,364	107,021
4	174,228	7,895	4,083	57,169	653,357
5	597,243	27,06	13,99	195,97	2239,661
TOTAL	960,383	43,51	22,50	315,126	3601,441

6 Conclusions

In recent years, a wide variety of sustainable urban mobility plans have been developed that follow general guidelines very similar but with great disparity in techniques and procedures which have influenced in the inability of having a common and standard base which work as a of base of knowledge for a common and coordinated strategy among municipalities. This disparity between the contents of sustainable urban mobility plans is aggrieved because local, provincial and regional agencies do not have the enough means for standardization of work that allows transposition measures in municipalities.

The following chapter focuses not only on the standardization of mobility plans development but provides techniques and tools that in a semi-automated way allow the development and control of mobility plans. This chapter has focused on:

- Standardization of data collection work by developing a tool for digitalization and generation of cards.
- Automation of diagnosis process based on the data collection.
- Library of parameterized actions by features of the municipality.
- Monitoring and management system of PMUs, monitoring and recommending actions based on indicators.

Acknowledgments. This chapter has been developed within the project SIE2-PMUS (Integral System for the Development and Evaluation of Sustainable Urban Mobility Plans) funded by the Ministry for Science and Innovation in the National Sustainable Mobility Sub-programme of the Strategic Action on Energy and Climate Change (reference E 26/08).

References

[1] ADEME/CERTU. Plans de déplacements urbains et merchandises en vile. Réflexions à destinations des èlus. ADEME/CERTÚ 2001

[2] Avances de emisiones Gases de efecto invernadero. Secretaría de estado de cambio climático. Ministerio de medio ambiente, y medio rural y marino. 2009 http://www.mma.es/secciones/calidad_contaminacion/atmosfera/emisiones/pdf/Avance_Inventario_de_Emisiones_GEI.pdf (last accessed December 2010)

[3] Berkowicz R., Winther M., Ketzel M. (2006). Traffic pollution modelling and emission data. Environmental Modelling & Software 21 ,454-460

[4] Berkowicz R , Ketzel M, Solvang Jensen S, Hvidberg M, Raaschou-Nielsen (2008) O. Evaluation and application of OSPM for traffic pollution assessment for a large number of street locations. Environmental Modelling & Software 23,296-303

[5] Brown A.L. Affum J.K(2002). A GIS-based environmental modelling system for transportation planners. Computers. Environment and Urban Systems. 2002 577-590

[6] Coman A, Ionescu A, Candau Y (2008). Hourly ozone prediction for a 24-h horizon using neural networks. Environmental Modelling & Software 23, 1407–1421

[7] Costabile.F, Allegrini I. (2008). A new approach to link transport emissions and air quality: An intelligent transport system based on the control of traffic air pollution. Environmental Modelling & Software 23, 258-267

[8] EMEP/EEA Air pollutant emission inventory guidebook 2009. http://www.eea.europa.eu/publications/emep-eea-emission-inventory-guidebook-2009 ((last accessed December 2010)

[9] Encuestas de movilidad de las personas residentes en España. MOVILIA (2007). http://www.fomento.es/MFOM/LANG_CASTELLANO/INFORMACION_MFOM/INFORMACION_ESTADISTICA/movilia/ (last accessed December 2010)

[10] Guidance on Second Local Transport Plans. Progress Reports (2008), Department for Transport, London. http://www.dft.gov.uk/pgr/regional/ltp/ (last accessed December 2010)

[11] Guía práctica para la elaboración e implantación de Planes de Movilidad. Urbana Sostenible (2006), Instituto para la Diversificación y Ahorro de la Energía (IDAE), Madrid . ISBN: 978-84-86850-98-2

[12] Guía práctica para la elaboración e implantación de Planes de Transporte a trabajadores,(2006) Instituto para la Diversificación y Ahorro de la Energía (IDAE), Madrid. ISBN: 978-84-86850-99-9.

[13] Hall, S., Titherridge, H., Banister D., (1999). ESTEEM: a GIS-based model for assessing the sustainability of Urban Development Policies. Proceedings of CUPUM'99 Conference, Venice 8–11 September,1999

[14] Hansen J, Sato M, Ruedy R, Lacis A, Oinas V(2009) Global warming in the twenty-first century: An alternative scenario

[15] International Energy Agency Key words 2007

[16] IPCC, 2007: Cambio climático 2007: Informe de síntesis. Cuarto Informe de evaluación del Grupo Intergubernamental de Expertos sobre el Cambio Climático [Pachauri,R.K. y Reisinger, A.]. IPCC, Ginebra, Suiza

[17] Lautso, K., Martino, A. & Toivanen, S. (1998). SPARTACUS: an integrated system to assess transport and land-use urban sustainability policies. International Symposium on Technological and Environmental Topics in Transports, 27–29 October 1998

[18] Ministero dei Trasporti “PIANO GENERALE DELLA MOBILITÀ.2001 http://www.trasportiambiente.it/pianif.html Legge FinanziarIa 2007. (last accessed December 2010)
[19] Owen, B., Edmunds, D. J., & Carruthers, D. W. (1999). Use of a new generation urban scale dispersion model to estimate the concentration of oxides of nitrogen and sulphur dioxide in a large urban area. The Science of the Total Environment, 235, 277–291
[20] Panagiotis Symeonidis, Ioannis Ziomas, Athena Proyou (2004). Development of an emission inventory system from transport in Greece. Environmental Modelling & Software 19, 413–421
[21] Salazar-Ruiz E., Ordieres J.B, Vergara E.P., Capuz-Rizo S.F..(2008)Development and comparative analysis of tropospheric ozone predictionmodels using linear and artificial intelligence-based models in Mexicali,Baja California (Mexico) and Calexico, California (US). Environmental Modelling & Software 23 1056-1069
[22] Samaali M, Francois S, Vinuesa J, Ponche J, (2007). A new tool for processing atmospheric emission inventories: Technical aspects and application to the ESCOMPTE study area. Environmental Modelling & Software 22 1765-1774
[23] Tang U.W., Wang Z.S. (2007). Influences of urban forms on traffic-induced noise and air pollution: Results from a modelling system. Environmental Modelling & Software 22 1750-1764
[24] Taylor, M. A. P, Wooley, J. E., Young, T. M., & Clement, S. J. (1994). Energy and environmental effects of road traffic, SENRAC Report No. 4. Australia: Transport Systems Centre, University of South Australia.

Do companies know which are the barriers and facilitators that enable proactive environmental orientation of the industry? An empirical study of a low tech industry

María-del-Val Segarra-Oña, Conrado Carrascosa- López,
Baldomero Segura-García-del-Río

Universitat Politècnica de València

maseo@omp.upv.es, concarlo@upvnet.upv.es, bsegura@upvnet.upv.es

Abstract. A growing number of companies consider aspects tied to sustainable development, environmental attitude, eco-innovation or environmental management to be a first-class asset on a strategic level. In this context, management of sustainable development becomes a crucial process.
The aim of this work is to analyze the real incorporation of environmental proactivity into company's global strategy as a value generating element. The methodology used is case study analysis, with personal interviews to people in charge of the environmental management department that answer an environmental proactivity survey. The empirical application focuses on a low-tech industry, the Spanish food sector. The objective of the research is to identify which aspects determine company's environmental strategy, which are the barriers and facilitators that enable proactive environmental orientation of the industry studied and to verify what benefits companies can obtain from its application.

Keywords: Environmental proactivity, Sustainable development, Strategy, Management, Food industry, Low tech industry.

1 Introduction

Traditionally the industrial sector has been considered as the most directly responsible for environmental degradation, although this impact has been declining in recent years thanks to rising environmental concerns and the implementation of laws and regulations by governments to control pollution [16]. These changes have led to the implementation in companies of different environmental strategies, since environmental response to environmental proactivity [23], [24].

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_29,

Nowadays, environmental care is often considered in the business strategy of companies [51]. Establish how to incorporate environmental orientation in business is a competitive priority to be taken into account in the manufacturing strategy [13]. Environmental proactivity offers a vision that integrates medium and long term objectives. Local, global, social and economic actions are integrated as well. Economic issues and the environment are interdependent and inseparable components in human progress [42].

An increasing number of companies consider issues related to sustainable development, environmental attitude, eco-innovation or environmental management as a first class asset at the strategic level [14], [12], [40]. In this context, sustainable development management becomes a necessary process.

The need for companies to differentiate through sustainability is growing in importance, but there is still no scientific basis for measuring. Because of this, it is necessary to analyze the environmental factor as a proactive aspect of business management, as well as factors that motivate companies to move towards environmental protection in what is called corporate environmental science [6], [7]. Several authors have analyzed integration of environmental factor in business [25]. In general, the influence of factors such as social pressure [28], environmental legislation [54], competitive advantages [1], [48] and management commitment to the company's environmental focus [45] and also studied aspects of their strategies [57], [9], [31] or its adaptation to the rules [36], [11].

2 Research approach

2.1 Objectives and chapter structure

Several authors have studied how environmental management tools affect business competitiveness; Russo and Harrison [45] pointed out that incentives were a valuable tool to improve environmental performance and, therefore, the promotion of environmental performance could be an opportunity to shape the redesign of an organization to be more proactive. McKeiver & Gadenne [34] analyzed both external and internal factors that influence the implementation of an environmental management system. Other authors studied how competitive advantage could be gained through environmentally-oriented activities [50] or how business performance can be improved taking into account environmental concerns [23], [24], [35].

Several studies have studied the empirical level of environmental proactivity in the industry. In Spain, Aragón-Correa et al [4] observed that in the automotive repair industry, companies with proactive practices got better economic performance. In the work done by Martin-Tapia et al [33] the food sector was studied, and evidence was found of the correlation between environmental strategies and advanced level of exports.

It is a need, at this time of economic difficulties, because environmental liability can be a source of financial risk [8], to analyze the inclusion of environmental proactivity in the overall strategy of organizations as a differentiator, creator of competitive advantage, analyzing the degree of inclusion of environmental factor as part of business strategy.

Considering the above, the main objective of this research is to analyze environmental proactivity as an aspect of business management and to identify factors that help companies to move towards sustainable management; The specific objectives are to identify factors that characterize environmental performance and the identification of facilitators and constraints encountered by companies regarding their environmental management [57].

This study has been developed in the Spanish food sector, analyzing company's business operations in order to identify potential improvement actions.

This research verifies the existing literature on environmental proactivity, environmental strategy and environmental determinants in the industry, to identify the most representative factors affecting the decisions of companies in the food sector. The study sample consists of 18 heterogeneous firms, all of which have in common the membership to the food and beverage sector.

A survey has been developed to measure environmental integration [47], used as a tool to guide the interviews, through a case study that contributes to the development and accumulation of knowledge [19], [53]. The results of the interviews with responsible persons of the environment department have been analyzed; they have been grouped according to the type of company (national, multinational, size). The results help explain the differences between the companies, all in the same industry. After analysis and discussion of the results obtained, the chapter concludes with the presentation of its findings.

The structure of this chapter is as follows. First we review the existing literature on environmental strategy, applied to the case study of the Spanish food sector, adding a current view of the situation of that sector. The following step is to show the methodology applied, and the analysis of the results: the identification of facilitators, barriers and benefits of environmental proactivity. Finally the work ends with a discussion of the results and conclusions.

2.2 Review of literature on environmental strategy

There have been made different classifications in accordance to the environmental strategy, however, in general, there have been defined four groups in terms of exogenous and endogenous environmental risks: preventive, strategic, proactive and reactive [59], [55], [21]. In order to identify the factors taken into account for classification purposes, the Spanish Fundación Entorno [21], classifies the companies as leaders, those who recognize in the environment opportunities for innovation and improvement; enthusiasts, those with implemented environmental management systems; proactive, those that integrate environmental considerations into their operations and are prepared to take advantage of opportunities offered by the environment; reactive, those that react to environmental obligations, and make decisions strictly to comply with environmental legislation; and indifferent; those that see difficulties in taking the necessary measures and are not involved and even see environmental concerns as a threat to its operations and its existence.

There are different classifications in response to different criteria. According to Hunt and Auster [26]: in beginner, fighter, concerned citizen, pragmatist or proactive. Winsemius and Guntram [59]: as reactive, receptive or proactive. Roome [44]: as non compliance, compliance, compliance plus, excellent and leading edge. Azzone and Bertelé [5]: as stable, reactive, anticipatory, proactive or creative. Vastag et al. [55]: as reactive, crisis preventive, strategic or proactive. Schaefer and Harvey [46]: as beginner, fighter, concerned, pragmatic or proactive and according to González-Benito [23], [24] as reactive, pro-certification, pro-design, pro-logistics or pro-commercial.

It has also been considered the combination of the resource-based view, RBV [41] with the development of a theoretical framework to analyze the relationship between environmental strategies and development of specific environmental responsibilities [56], [49], [13], [52].

Although they may look different, they all have in common that they analyze the strategic position in various intermediate stages between the more reactive and more proactive point of view [2].

Moreover, the determinants of proactive environmental orientation are classified as internal aspects of the company (size, level of internationalization, position in value chain, management attitude, motivation and strategic approach of the companies as well) externalities (sector and geographic location) and as a determining factor, the involvement of owners and shareholders [23], [24]. Also Murillo [38] classify factors as external (legislation, customers, vendors, companies in the sector, financial institutions, insurance, media, environmental and / or citizens or nearby communities) and internal (management, partners and shareholders and / or employees). Managers' commitment to contribute to sustainable development may be a source of competitive advantage [32].

Some studies have been developed trying to identify factors that affect the environmental orientation adopted by companies. In the consumer goods sector, factors such as the influence of external pressures, environmental orientation, marketing and corporate strategies, company size, sector size, and whether or not the company has a marketing department, have influence on the environmental strategy adopted [10], [39]. González-Benito [23], [24] identified various proactive environmental strategies in three industrial sectors, electricity, chemicals and furniture, noting the multidisciplinary nature of environmental proactivity.

The hypothesis of this research are then raised:

H1: Small size is a barrier to a company's environmental proactivity.

H2: Multinational nature of a company facilitates its proactive environmental orientation.

H3: Direct involvement of management is essential to facilitate proactive orientation.

2.3 Methodology

Following Kaplan, it is difficult to imagine that theories can be verified in the field of business management if the study is not made within the organizational context. According to Rouse and Daellenbach in-depth case studies provide valuable field data to point out factors that influence management. There have been written several case studies focused in the sustainable agriculture in Netherlands [27], in the French wine industry, [3], therefore it is interesting to study the food sector in Spain in a case study.

The method used in this study, interviews, is classified as direct collection of information [53]. The type of interview used is called a structured open-ended interview [29]. This technique combines the advantages of closed questionnaires with qualitative research open questionnaires. According to [15] case studies require some recommendations for achieving a high level of rigor in research. These recommendations have been followed in this study and are the following: Firstly, considering aspects related with the design, identifying research questions, secondly aspects of data collection itself, procedural aspects, such as the number of interviews, interviewed, using an interview guide, etc.., effective use of tables to summarize information about the process of data collection or how to triangulate data to increase the internal validation of the results and clear explanations of the process. And finally with data analysis procedures, in order to provide clear descriptions of the analytic methods and procedures techniques to compare the results with existing literature.

A questionnaire Likert scaled was prepared, with five possible answers and an additional alternative response that indicates that there is insufficient information to answer. The questionnaire has been filled in person by the authors of the study, in order to characterize the company and their level of environmental proactivity and thus establishing a system to measure integration of environmental proactivity on business strategy.

On the other hand, the interview is conducted personally by one of the researchers, in order to collect all possible qualitative information. Through informal talks with employees, you can see different aspects of products, processes, and know how of the company [53].

The questionnaire consists of a total of 42 questions designed to identify aspects that characterize the company in terms of environmental proactivity, organizational aspects as well, establishing a system to measure integration of environmental proactivity into company's business strategy.

Before use, the questionnaire was submitted to a test to see and discuss the suitability of the questions. The interviews were conducted to company managers personally to obtain more reliable results.

3 Practical application to the Spanish food sector

This practical application is based on the Spanish food sector. This sector is one of the three pillars of the Spanish industry, together with automobile and chemical industry. A brief description of this sector is shown, based on the information obtained from the FIAB, Spanish federation of food and beverage industry, (2010). The food and beverage industry had in Spain in 2009, 30650 companies. Among these, 99, 2 % are considered SME´s (Small and medium enterprises) and only 0, 8 % Big companies. This sector employs 17% of the total jobs on the industry. The Spanish sector of the food industry had 84,600 million Euros net sales in 2009; this represents 14% of the industry's net sales and 8.04% of Spanish GDP. In terms of foreign trade, the export value accounted in 2009 15053 million euros, compared to a value of imports of 14.787 million euros. This represented a positive trade balance in 2009 of 266 million euros. This sector helps to level the foreign trade balance in Spain. This sector has a higher rate of innovative companies than in the rest of the Spanish economy.

It is worth the deep study of this sector, because it is considered that adopting environment-friendly practices has a greater influence in it than in manufacturing sectors [22]. Few empirical studies have been conducted in the agriculture and food and beverage industry [17]. There is high interest in formulating priority challenges for managerial improvements to increase sustainability of the food sector [20].

4 Results analysis

The sample studied is composed of 18 heterogeneous companies, all of them belonging to the FIAB (Spanish federation of food industry and beverage). The sample is mixed, 38% are big companies and 62% are SME´s (Small and medium enterprises). Among these companies, 72% are only Spanish companies, and 28% are multinational.

In terms of environmental department it's important to mention that 55% of the companies of the sample have own environmental department. The same amounts of companies (55%) have environmental accreditation already gained or are in process of obtaining it. It is interesting to disaggregate this data according to the size of the companies, because 71% of the big companies have the accreditation or are in process to gain it, while only 45% of SME´s (Small and medium enterprises) are in the same situation. If the info is disaggregated according to the national or multinational characteristic of the companies, the result is the following: 60% of the multinational companies have the accreditation or are in process to gain it, while only 53% of national companies are in the same situation.

According to the first of the hypotheses based on the study of literature, the larger companies are a larger percentage of environmental proactivity they should have. According to the second hypothesis, multinational companies should provide a better percentage of environmental proactivity than national ones.

According to the third hypothesis; companies with management directly involvement in environmental matters should provide a higher percentage of environmental proactivity.

In the last section of this chapter these hypotheses are contrasted with the reality of the companies studied.

4.1 Facilitators identification

Facilitators of environmental proactivity are defined as those factors that help and lead the company to be more proactive. Their identification is one of the objectives of this study; it was carried out by analyzing the results of surveys to each of the companies, first recognizing those companies with better environmental performance, and then relating what characteristics have helped these companies achieve this best performance.

According to [24], facilitators of corporate environmental proactivity may be internal or external. This study focuses on the internal ones; the analysis of the survey shows three: the size of the company, its degree of internationalization and management involvement with the environment. From the analysis of those questions used to characterize the environmental performance is obtained a percentage that indicates the environmental performance of the companies.

The groups considered come from the breakdown of each of the facilitators, and companies are grouped in three different ways: firstly by size: SME´s (Small and medium enterprises) and big companies, secondly according to their degree of internationalization in national and multinational, and finally according to the environmental implication of management: high or low.

In the following table (see table 1), the environmental performance of companies is characterized after taking into account the grouping with the before mentioned facilitators.

At the horizontal level are represented actions that characterize the environmental performance and the columns are clusters of companies according to the above-mentioned facilitators, in that way that a high percentage indicates that the group required can be considered as environmentally proactive.

Table 1: Facilitators identification

	Company size facilitator		Internationalization facilitator		Management implication facilitator		
-	Small and medium	Big	National	Multinational	Low implication	High implication	Total
Energy saving	69,09%	80,00%	72,31%	76,00%	70,00%	75,00%	77,65%
Usage of ecological products in production	32,73%	37,14%	27,69%	52,00%	16,67%	43,33%	36,47%
Water saving	69,09%	80,00%	70,77%	80,00%	60,00%	80,00%	77,65%
Waste managed	81,82%	97,14%	84,62%	96,00%	76,67%	93,33%	92,94%
Recyclable products	72,73%	74,29%	72,31%	76,00%	63,33%	78,33%	77,65%
Training in environmental matters	47,27%	71,43%	52,31%	68,00%	50,00%	60,00%	60,00%
Ecological reasons used in marketing	30,91%	37,14%	35,38%	28,00%	20,00%	40,00%	35,29%
Environmental costs and savings quantified	67,27%	85,71%	72,31%	80,00%	70,00%	76,67%	78,82%
Information of measures taken externally reported	32,73%	42,86%	38,46%	32,00%	33,33%	38,33%	38,82%

The aggregation of the surveys and the grouping of companies according to different facilitators, enable to see the influence of each of them on the behaviors that characterize environmental proactivity, which are detailed in the left column.

4.2 Obstacles identification for environmental proactivity

The biggest obstacles companies face when trying to adopt a more proactive environmental strategy, as obtained from the analysis of surveys, and in aggregated value of the total sample, are the following, the higher percentage, the biggest importance is given by companies to that obstacle; Short financial support (72,22%), Lack of institutional support (64,44%), Lack of tools information

(54,44%), Lack of technical solutions (51,11%), Lack of qualified human resources (46, 67%).

The following table describes the obstacles to environmental proactivity, as the perception of companies, grouped taking into account the above-mentioned facilitators.

Table 2: Obstacles for environmental proactivity

	Company size facilitator		Internationalization facilitator		Management implication facilitator		
-	Small and medium	Big	National	Multinational	Low implication	High implication	Total
Short financial support	78,18%	62,86%	73,33%	76,00%	73,33%	71,67%	72,22%
Lack of institutional support	67,27%	68,24%	66,67%	68,00%	63,33%	65,00%	64,44%
Lack of tools information	56,36%	57,65%	50,00%	64,00%	53,33%	55,00%	54,44%
Lack of qualified human resources	52,73%	49,41%	45,00%	52,00%	46,67%	46,67%	46,67%
Lack of technical solutions	56,36%	54,12%	50,00%	52,00%	40,00%	56,67%	51,11%

Again, the aggregation of the surveys and the grouping of companies according to the different facilitators enable to see the influence of each and the relationship of each with the obstacles noted in the left. This detailed information indicates what are the difficulties encountered by each one of the groups, and could be considered the basis to suggest potential actions for improvement.

4.3 Benefits identification for environmental proactivity

Companies identify potential benefits resulting from the implementation of actions from proactive environmental management. These are listed below in order of importance; the higher percentage indicates the importance given by companies to that benefit: 1) Avoid sanctions (85, 56%), 2) Improvement of corporate image (78, 89%), Long term cost savings (77, 78%) and Long term economic benefits (74, 44%).

The breakdown in the table below shows the benefits seen by companies according to the grouping considered.

Table 3: Benefits of environmental proactivity

	Company size facilitator		Internationalization facilitator		Management implication facilitator		
-	Small and medium enterprises	Big Enterprises	National	Multinational	Low implication	High implication	Total
Long-term economic benefits	69,09%	82,86%	66,67%	88,00%	56,67%	83,33%	74,44%
Long-term cost savings	76,36%	80,00%	73,33%	84,00%	53,33%	90,00%	77,78%
Improvement of corporate image	72,73%	83,53%	75,00%	84,00%	60,00%	88,33%	78,89%
New business opportunities	63,64%	69,41%	61,67%	72,00%	50,00%	73,33%	65,56%
Increase of customers	63,64%	61,18%	56,67%	60,00%	43,33%	65,00%	57,78%
Competitiveness increase	67,27%	70,59%	63,33%	72,00%	43,33%	78,33%	66,67%
Short-term economic benefits	65,71%	55,29%	48,33%	52,00%	40,00%	58,33%	52,22%
Short-term cost savings	65,71%	51,76%	41,67%	56,00%	33,33%	56,67%	48,89%
Avoid sanctions	91,43%	90,59%	83,33%	96,00%	83,33%	86,67%	85,56%

The aggregation of the surveys and the grouping of results by the different facilitators, allow to see the influence of each and the relationship with each of the benefits seen in the left column.

This information is very revealing, because although the social level of environmental awareness is a factor that is present in society, its practical application, its potential economic benefits, its contribution to the improvement of competitiveness of the company that applies it [13], its vision that integrates short-, medium and long term objectives [42] is not as present in the corporate culture.

5 Results discussion and conclusions

5.1 Model developed and verification of hypotheses

Environmental proactivity of a low-technology industry has been studied; specifically the Spanish food sector, and the barriers and facilitators considered important for the inclusion of environmental proactivity on business strategies have been identified by companies. Figure 1 shows the model developed by the authors based on field work.

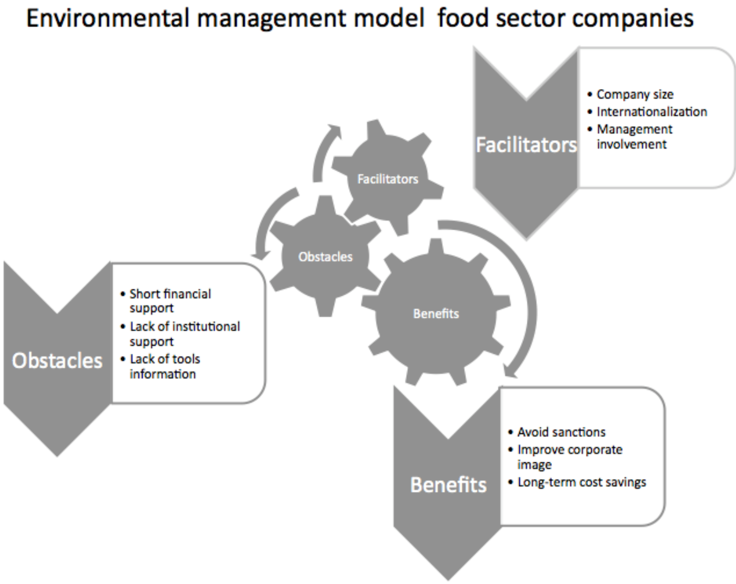


Fig. 1. Environmental management model food sector companies

With respect to the hypotheses in our study,

H1: Small size is a barrier to a company's environmental proactivity.

With the information obtained after the surveys analysis, this hypothesis is not verified. Although in table 1, is observed that in average, big enterprises have a better environmental performance than Small and medium enterprises, it's interesting to mention that there is one exception. There's one small company with better environmental behavior than big companies. This company is multinational and its management is highly implicated in environmental management. This demonstrates that facilitators multinational nature and management involvement seem to be more decisive for companies to have a good level of environmental proactivity. Clearly, the study is based on Spanish food sector companies, and is for these companies for which we can conclude that small size is no barrier. It is also verified that big size of companies acts as a facilitator of environmental proactivity.

H2: Multinational nature of a company facilitates its proactive environmental orientation.

This hypothesis is fulfilled because multinational companies have better environmental behavior than national ones.

***H3: Direct involvement of management is essential to facilitate proactive orientation*.**
This hypothesis is verified because companies with high implication of management have better environmental behavior than the other ones.

5.2 Conclusions

As for the obstacles observed for environmental proactivity; the most important one is the short financial support (72, 22%), followed by lack of institutional support (64, 44%) and Lack of tools information (54, 44%). This perception is common for all groups of companies, except for big enterprises, Lack of institutional support (68,24%) is the biggest problem followed in this case by short financial support (62,86%) and Lack of tools information (57,65%).

As for the benefits observed of environmental proactivity, the major one is to avoid sanctions (85,56%) followed by the improvement of corporate image (78,89%), long-term cost savings (77,78%) and long-term economic benefits (74,44%). It is important to point out, that for those companies with highly implicated management, the most important benefit perceived is long-term cost savings (90%), the second one is improvement of corporate image (88,33%) and the third one is to avoid sanctions (86,67).

The Analysis conducted to the Spanish food sector, with the deep analysis of these Surveys, and all qualitative information obtained after the personal interviews, verifies the internal factors driving environmental proactivity [23], [24]. With the In-depth study of other sectors, and the comparison between the results of these studies, we could get more information about firm's external factors that also promote environmental proactivity.

As the aim of this study is to analyze the causes of problems, to suggest potential areas for improvement, as final conclusions the following suggestions could be made, these emerge from the observation of the obstacles to environmental proactivity, their facilitators , and the potential benefits of its application: improving the funding of companies so they can deepen environmental proactivity ; improving institutional support for environmental issues; awareness of managers and shareholders on matters of environment, where there is agreement about the need to act [37], as a value generating element to take into account because of its potential to improve the corporate image and for its resource optimization and cost savings possibilities. Adoption of Environmental Management Systems, as ISO 14001, results in a more cost-effective production [43].

There are studies that show that the EU food industry's competitiveness is weak [58]. These measures to support environmental proactivity would be rewarded with improvements arising from the potential benefits of its application. Following the contingency approach developed by Lawrence and Lorsch [30] applied to the food sector. Some are short-term benefits, other longer-term, but all in the end profitable to maintain a sustained growth of business and by extension of society [50], [23], [24], [35], [4], increasing companies competitiveness [32] and therefore contributing to the economy improvement.

Acknowledgments. The authors acknowledge the financial aid received from the Spanish Ministry of Science and Innovation through research Project reference no. EC02008-05895-C02-01/ECON.

References

[1] Albors-Garrigós J, Hervás-Oliver JL (2006). La industria cerámica europea en el siglo XXI. Retos tecnológicos y desafíos de la próxima década. *Boletín Sociedad Española. Cerámica.. V., 45, 1,* 13-21.

[2] Álvarez Gil MJ, De Burgos Jiménez J, Céspedes Lorente JJ (2001). Un análisis exploratorio de las estrategias medioambientales y el contexto organizativo de los hoteles españoles, *Cuadernos de Economía y Dirección de la Empresa, núm. 8*, pp. 5-32.

[3] Amadieu P, Viviani J P (2010). Intangible Effort and Performance: The Case of the French Wine industry. *Agribusiness Vol. 26 (2)* 280-306.

[4] Aragón-Correa JA, Hurtado-Torres N, Sharma S, García-Morales VJ (2008). Environmental strategy and performance in small firms: A resource-based perspective. *Journal of Environ Management, Vol. 86, 1.*

[5] Azzone G, Bertele U, (1994). Exploiting Green Strategies for Competitive Advantage, *Long Range Planning, Vol. 27, No. 6,* pp. 69-81

[6] Banerjee SB (2002) Corporate environmentalism, the construct and its measurement. *Journal of* Total *Business Research Vol. 55*, pp. 177-191.

[7] Banerjee SB, Iyer SY, Kashyap RK (2003) Corporate environmentalism Antecedents and influence of industry type. *Journal of Marketing Vol. 67*, pp. 106-122.

[8] Billiot MJ, Daughtrey ZW (2001) Evaluating Environmental Liability through Risk Premium Charged on Loans to Agribusiness Borrowers. *Agribusiness, Vol. 17 (2),* 273-297.

[9] Bravo Gil R, Fraj Andrés , Martínez Salas E. (2005). La importancia del factor medioambiental en las estrategias corporativa y de marketing: una aplicación al sector de bienes de consumo. *Cuadernos de estudios empresariales, No 15*, 199-224.

[10] Buil-Carrasco I, Fraj-Andrés E, Martínez-Salinas E, Matute-Vallejo J, (2005) Tipología de empresas medioambientales en el sector de bienes de consumo final. *Revista de economía y empresa, nº 54 y 55, Vol. XXIII* (2ª época), 2º y 3er cuatrimestre, 69-93.

[11] Carretero Peña AA (2009). Aplicación de la Norma UNEE 150008:2008 para la realización de Análisis de Riesgos Medioambientales en el contexto de la ley 26/2007 de Responsabilidad Medioambiental. *Boletín Sociedad. Española. Ceramica. V., 48*, 4, 7-8.

[12] Christmann P (2000). Effects of 'best practices' of environmental management on cost advantage: The role of complementary assets. *Academy of Management Journal, 43,* 663–680.

[13] Da Silva EM, Jabbour CJC, Santos FCA (2009). Integrating environmental management and manufacturing strategy: an emerging competitive priority. *International Journal of Environmental Technology and Management. V.10, No 3*, pp. 397 – 411.

[14] Dowell G, Hart S, Yeung B (2000). Do corporate global environmental standards create or destroy market value? *Management Science, 46*: 1059–1074.

[15] Dubé L, Paré G (2003). Rigor in information systems positivist case research: current practices, trends, and recommendations. *Mis Quarterly, Vol. 27, Nº 4,* pp. 597-635

[16] Fairchild R, (2008). The Manufacturing Sector´s Environmental Motives: A Game-theoretic Analysis. *Journal of Business Ethics, Vol. 79, No. 3*, pp. 333-344.

[17] Fernández-Olmos M, Rosell-Martínez J, Espitia-Escuer M (2009). Vertical Integration in the Wine Industry: A Transaction Costs Analysis on the Rioja DOCa. *Agribusiness, Vol. 25 (2)* 231-250 (2009)

[18] FIAB Federación española de industria de la alimentación y bebidas (2010) *Economic report 2009*. www.fiab.es/es/zonadescargas/industria.

[19] Flyvbjerg B, (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry.Vol. 12 No 2*, pp. 219-245

[20] Fritz M, Schiefer G (2008). Food Chain Management for Sustainable Food System Development: A European Research Agenda. *Agribusiness, Vol. 24 (4),* 440-452.

[21] Fundación Entorno (2003). *Entorno 2003. Informe sobre la gestión ambiental en la empresa española. Avances hacia la sostenibilidad*. Madrid.

[22] Galdeano-Gómez E, (2008) Does and Endogenous Relationship Exist between Environmental and Economic Performance? A Resource-Based view on the horticultural sector. *Environ Resource Econ, 40:73-89 DOI 10.1007/s10640-007-9141-4*

[23] González Benito J, González Benito O., (2005). Environmental proactivity and business performance: an empirical analysis. *Omega International. Journal of Management Science, Vol. 33. No 1,* pp.1-15.

[24] González Benito J, González Benito O, (2006) A review of determinant factors of environmental proactivity, *Bus Strat and the Envir, 15*, 87-102.

[25] Hitchens D, Thankappan S, Trainor M, Clausen J, De Marchi B (2005) Environmental performance, competitiveness and management of small businesses in Europe. *Tijdschrift voor economische en sociale geografie. Vol. 96, No. 5,* pp. 541–557.

[26] Hunt CB, Auster ER, (1990). Proactive environmental management: avoiding the toxic trap, *Sloan Management Review 31 (2)*, pp. 7–18.

[27] Ingenleek P, Meulenberg MTG (2006). The Battle between Good and Better: A strategic Marketing Perspective on Codes of Conduct for Sustainable Agriculture. *Agribusiness, Vol. 22 (4),* 451-473.

[28] Kalantari K, Asadi A (2010) Designing a structural model for explaining environmental attitude and behavior of urban residents (Case of Tehran). *Int. J. Environ. Res., 4 (2),* pp. 309-320.

[29] King N (1994) "*The qualitative research interview*", pp. 14-36. En Qualitative methods in organizational research, Cassel, C. y Simon G. Eds. Sage Publications, Ltd. London.

[30] Lawrence PR, Lorsch JW (1967) Organization and Environment Managing Differentiation and Integration. Boston, MA: Harvard University.

[31] Liu X, Liu B, Shishime T, Yu Q, Bi J, Fujitsuka T (2010) An empirical study on the driving mechanism of proactive corporate environmental management in China. *Journal of Environmental Management. Journal of Environmental Management, Vol 91*, pp.1707-1717

[32] López-Gamero MD, Claver-Cortes E, Molina-Azorín JF (2008): Complementary Resources and Capabilities for an Ethical and Environmental Management: A

Qual/Quan Study. *Journal of Business Ethics(2008) 82:701-732 DOI 10.1007/s10551-007-9587-x.*

[33] Martin-Tapia I, Aragón-Correa JA, Rueda-Manzanares A, (2009) Environmental strategy and exports in medium, small and micro-enterprises *Journal of World Business. In press doi: 10.1016/j.jwb.2009.09.009.*

[34] McKeiver C, Gadenne D, (2005) Environmental management systems in small and medium businesses, *International Small Business Journal, V. 23, n 5, 513-537.*

[35] Melnyk SA, Sroufe RP, Calantone R, (2003) Assessing the impact of environmental management systems on corporate and environmental performance *Journal of Operations Management. Vol. 21, No 3,* 329-351.

[36] Mezquita A, Monfort E, Zaera V (2009) Sector azulejero y comercio de emisiones: reducción de emisiones de CO2, benchmarking europeo. *Bol. Soc. Esp. Ceram. V., 48, 4,* 211-222.

[37] Michaels S, Furuseth OJ (1997). Innovation in environmental policy: the National Environmental Policy Act of the US and the Resource Management Act of New Zealand. *The Environmentalist 17*, 181-190.

[38] Murillo, Garcés, Rivera (2004) Estrategia empresarial y medio ambiente: opinión de un grupo de expertos, *Universia Business Review- Actualidad económica, cuarto trimestre*, 52-63.

[39] Mitchell R, Com MA, Wooliscroft B, Higham J (2010). Sustainable Market Orientation: A New Approach to Managing Marketing Strategy. *Journal of Macromarketing, doi:10.1177/0276146710361928.*

[40] Noci G, Verganti R, (1999) `Managing Green' product innovation in small firms. *R&D Management 29*, 1

[41] Peteraf M (1993) The cornerstone of competitive advantage: a resource based view, *Strategic Management Journal, Vol. 14*, pp. 179-191.

[42] Porter ME, Van der Linde C, (1995) Toward a new conception of the environment competitiveness relationship, *J. of Econ Persp, 9 (4)*, 97–118.

[43] Ratnasingam J, Wagner K (2010) The Impact of ISO 14001 on the Operations Management of Wooden Furniture Manufactureres in Malaysia. *Eur. J. Wood Prod. 68:479-481 DOI 10.1007/s00107-009-0370-9.*

[44] Roome N (1994) Business strategy, R&D management and environmental imperatives, *R&D Management 24, Vol. 1*, pp. 65–82

[45] Russo MV, Harrison NS (2005) Organizational design and environmental performance: clues from the electronics industry. *Academy of Management Journal, V. 48, No 4,* pp. 582-593.

[46] Schaefer A, Harvey B, (1998) Stage models of corporate 'greening': a critical evaluation. *Business Strategy and the Environment 7(3)*, 109-123.

[47] Segarra-Oña M, Segura B, Martínez M (2009) La integración de la proactividad medioambiental en la estrategia empresarial: un estudio empírico. *XI Reunión de Economía mundial. Congress proc. (I.S.B.N.: 1887-9489)*

[48] Segarra-Oña M, Peiro-Signes A, Albors-Garrigos J, Miret-Pastor L (2011): "Impact of innovative practices in environmentally focused firms. Moderating factors" *Int. J. Environ Res., 5 (2), Forthcoming*

[49] Sharma S, Aragón-Correa JA Rueda-Manzanares A (2007) The contingent influence of organizational capabilities on proactive environmental strategy in the service sector: an analysis of North American and European ski resorts. *Canada Journal of Administrative Sciences, V. 24*, pp. 268-283.

[50] Sharma S, Vredenburg H (1998) Proactive corporate environmental strategy and the development of competitively valuable organisational capabilities. *Strategic Management Journal Vol. 19*, pp. 729–753.

[51] Singh RK, Murty HR, Gupta SK, Dikshit AK (2008) Development and implementation of environmental strategies for steel industry, *Int. J. Environmental Technology and Management, Vol. 8, No. 1,* pp. 69-86.

[52] Smith AD (2010) Growth of corporate social responsibility as a sustainable business strategy in difficult financial times. *International Journal of Sustainable Economy Vol. 2, No 1*, pp.59-79

[53] Stake RE (1995) *The art of case study research*. Thousand Oaks, CA. Sage.

[54] Telle K, Larsson J (2007). Do environmental regulations hamper productivity growth? How accounting for improvements of plants´ environmental performance can change the conclusion. *Ecological Economics, Vol. 61*, pp. 438-445.

[55] Vastag G, Kerekes S Rondinelli DA (1996) Evaluation of corporate environmental management approaches: A framework and application. *International Journal of Production Economics.V. 43, No 2-3*, pp. 193-211.

[56] Verbeke A, Bowen F, Sellers M (2006). Corporate environmental strategy: extending the natural resource-based view of the firm. *Acad of Management Best Paper*

[57] Walker H, Di Sisto L, McBain D (2008). Drivers and barriers to environmental supply chain management practices: lessons from the public and private sectors. *J. of Purchasing & Supply Management, Vol. 14*, pp. 69-85.

[58] Wijnands JHM, Bremmers HJ, Van der Meulen BMJ, Poppe KJ (2008) An Economic and Legal Assessment of the EU Food Industry's Competitiveness. *Agribusiness, Vol. 24 (4)*, 417-439

[59] Winsemius P, Guntram U (1992) Responding to the environmental challenge, *Business Horizons 35 (2)*, pp. 12–20.

Environmental Management Systems In Learning Organizations In Health Care

Lars Rölker-Denker

OFFIS – Institute for Information Technology

lars.roelker-denker@offis.de

Abstract. The increase of information and knowledge is a general phenomenon and thus also applies to health care. Dynamic political and economic environments strengthen these effects. Multiple concepts addressing this challenge can be identified and "learning organizations" are one key concept in economics to handle knowledge increase and dynamic environment. Environmental Management Systems based on ISO 14001 or EMAS (Eco Management and Audit Scheme) are possible ways to extend the organization's environmental awareness. The goal of this contribution is to analyze whether environmental management systems have this effects on (German) hospitals or not. So this chapter combines the concepts of environmental management systems and learning organizations in context of hospital organizations. After a short introduction to environmental management systems the concept of organizational learning in the three dimensions of learning levels, learning types and learning determinants is pointed out. German hospitals and their organizational attributes as the object of study are introduced next. The main part of this chapter is the analysis of organizational learning processes initiated by environmental management systems. It is shown that these processes can be found in all three learning dimensions in a hospital. So the implementation of environmental management systems could be a possibility to extend organization's environmental awareness. At least empirical surveys are recommended to approve these mainly theoretical outcomes.

Keywords: Environmental Management System, Eco Management and Audit Scheme, Organizational Learning, Health Care

1 Introduction

A hospital acts in a dynamic environment. Beyond its primary function of patient treatment, the hospital needs to manage an increase of knowledge and quality

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_30,

in health systems by providing suitable regular training, advanced training and continuous education for medical and nursing staff on the one hand and by research activities in the medical and nursing disciplines on the other hand. Furthermore there are political, economic, technical, social and increasingly ecological requirements to consider. The idea of learning organization has several concepts to face this challenge. Environmental Management Systems (EMS) are rarely analyzed in this context. The intention of this chapter is to bring these concepts together and give some stimulation for further research. A brief overview on EMS, the theory of learning organizations and the organizational view on German hospitals is necessary before the concepts of organizational learning and EMS can be integrated.

2 Environmental Management Systems (EMS)

An EMS has the purpose of developing, implementing, managing, coordinating and monitoring organizations environmental activities to achieve two goals: compliance and waste reduction [9]. Similar to quality management systems there are standards describing fundamental requirements. The international standard is ISO 14001 [10], the European standard is EMAS (Eco Management and Audit Scheme) [1]. There are 43 health care organizations certified on EMAS in Germany [4], reliable figures for ISO 14001 are not available.

3 Learning Organizations

Learning organizations can be described from different viewpoints. In this chapter the learning organization is analyzed in sense of Wengelowski. He defines three main areas: learning levels, learning types and learning determinants which all can be practical mapped over an organization for analyzing its accordance with the learning organization concept [17].

Four learning levels can be distinguished: individual learning, group (team) learning, organizational learning and inter-organizational learning. Individual learning means the changes in behaviour, theories and concepts by an individual whereas group learning means the same in a group context. Organizational learning focuses on the changes in organizational behaviour or theory. If more than one organization is involved in the learning process then inter-organizational learning can be identified.

Learning types can be differentiated into single-loop learning, double-loop learning and deutero learning [6]. Single-loop learning focuses on incremental changes inside a constant framework while double loop learning focuses on the framework. At least, the process of learning itself is in the focus of deutro learning. The learning types are base on each other [see fig. 3.1].

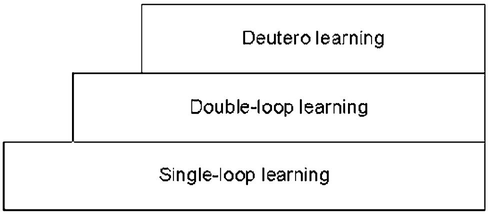


Fig. 3.1 Learning types

The abstract theories of learning levels and types are brought together into the organization by the learning determinants. Three determinants are discussed in literature: organizational member, organizational structure and organizational culture [17].

The specific utilization and advancement of competencies and qualifications among the organizational members are fundamental tasks in learning organizations. Each organizational member has its unique setting of competencies and qualifications, e.g. professional or social competence. Important levers are human resource development (further and advanced education) as well as staffing. The organizational structure gives the framework for all intra-organizational and partly inter-organizational processes and sets the scope of action for the organizational members. Following the organizational view a differentiation can be made between organizational structure, process organization, communicational organization and informational organization. Organizational culture can be interpreted as the informal organizational structure. This chapter uses the approach of Schein [14]: subjects of study are artefacts, values and tacit assumptions. In context of the learning organization three different types of culture can be distinguished: learning culture, communication culture and culture of trust.

4 Organizational View on German Hospitals

Most organizational structures in German hospitals follow the matrix organization with a strong diversification by profession and function. Hierarchical structures are built among the professions and segmented into medical services, nursing services and administration with a steering board on top including the head of each profession. With the launch of the German DRG-system and case-based lump sums the process organization continues to replace the former classical process organization. In-patient treatment is changing from "medical art" into a treatment process which can be completely managed. Clinical pathways are one key concept in this discussion [15].

A clear definition on clinical pathways has not been found yet. In general a core definition of clinical pathways includes statements about patient-care management of a well-defined group, the goals and key elements of patient-treatment, sequences on multidisciplinary activities and recommendations about communication, documentation and monitoring [2].

Several aspects need to be included in the communicational and knowledge organization: all kind of training and education, knowledge management as well as internal and external quality management. Further and advanced education are important factors facing the continuous development of technical, medical and nursing advances. Further education implies continuing medical education and increasingly continuing nursing education whereas advanced training implies residency for medicals and similar offerings for nursing staff [2]. The informational organization can be divided into three parts of verbal, written and IT-based organization. Combined, these parts form the socio-technical information system of an organization with all functions on information processing and storage. In hospital environments these systems are socio-technical hospital information systems [5] including electronic patient records, subsystems such as radiology information systems or laboratory information systems, all kind of archives such as picture archiving and communication systems, learning management systems, employee magazines etc. At least, communicational, knowledge and informational organization form the organizational memory [16].

5 Organizational Learning and EMS in German Hospitals

The key concept in learning health organizations is the idea of clinical pathways (for details see [13]). The idea behind is a structured patient treatment assisted by a continuous improvement process. The basic concepts of structured and continuous improvement processes are similar to EMS.

It can be supposed that both concepts (clinical pathways and EMS) will occur in similar ways but with different contexts.

5.1 EMS and learning levels

Individual learning appears in several forms. Regular, further and advanced education is the most visible one and is completed by individual learning experiences in quality circles, environmental management systems and project groups on clinical pathways. At least, environmental management systems provide individual experiences and suggestions for sustainably behaviour to the organizational member [12].

The project groups on EMS, clinical pathways and quality circles themselves are part of the second category. Especially research and rule modifying circles meet the requirements of organizational learning. Research quality circles work on new guidelines, whereas rule modifying quality circles improve these guidelines. Group learning was proven to be an important factor for organizational effectiveness in South Korean hospitals [7].

And at least, EMS occurs on the organizational learning level by improving the organizational environmental awareness in general. Similar to the concept of clinical pathways, EMS appear in individual, group and organizational learning level. The fourth learning level, inter-organizational learning, could be represented by highly integrated health care groups but are not realized yet.

5.2 EMS and learning types

Adjustments on EMS can be associated with single-loop learning. Examples are modifications during the continuous improvement process in existing environmental guidelines. The same applies for nursing standards and guidelines as well as adjustments in context of clinical pathways [15]. Double-loop learning is associated with the integration of completely new departments like energy or waste management [12]. The implementation of an environmental management system or the introduction of the clinical pathway concept itself can be seen as deutero learning. These concepts (as well as nursing standards and guidelines) improve the organizational ability on environmental awareness [11].

5.3 EMS and learning determinants

Organizational members support the learning hospital with their different qualifications and skills such as subject-competence, social competence, method competence, personal competence, entrepreneurial competence [3].
EMS aim on method competence, personal competence and entrepreneurial competence.

In context with the organizational structure, several instances are involved in EMS. At first, there is the environmental management representative similar to the quality management representative. He is the coordinator for all tasks regarding the EMS. Also typical is an environmental committee which is directly subordinated to the management board (e.g. [8]). Finally, the handbooks on EMS documenting the relevant processes are part of the organizational memory.

At least, an EMS can be interpreted as an artefact in organizational culture. The EMS represents the organizations' intention on environmental issues and is visible to all organizational members and non-members.

6 Conclusion

This theoretical-driven approach supplies a basic overview on the field of EMS in context of learning health care organizations. Indicators for EMS as a factor for organizational learning in hospitals were shown in all areas (learning levels, learning types, learning determinants). So EMS seem to be a possibility to extend the capability of a health care organization for environmental awareness and to improve their own learning processes.

Next steps should be a detailed empiric survey involving an analysis of implemented EMS in health care organizations, mainly hospitals. Hospitals in learning health care networks can be supposed to comprise another research field. Emerging regional and nationwide health care groups will strengthen the inter-organizational cooperation and thus the inter-organizational learning processes, probably based on EMS.

References

[1] Regulation (EC) No 1221/2009 of the European Parliament and of the Council of 25 November 2009 on the voluntary participation by organisations in a Community eco-management and audit scheme (EMAS)

[2] De Bleser L, Depreitere R, De Waele K, Vanhaecht K, Vlayen J, Sermeus W (2006) Defining pathways. J Nurs M, 14:553–563, 2006.

[3] Delamare-Le Deist F, Winterton J (2005) What is Competence? Hum Resource Dev J, 8(1):27–46

[4] EMAS-Register (2010) Gemeinsame Stelle der EMAS-Registrierungsstellen in Deutschland

[5] Haux R, Winter A, Ammenwerth E, Brigl B (2004) Strategic Information Management in Hospitals: An Introduction to Hospital Information Systems (Health Informatics). Springer

[6] Hislop D (2009) Knowledge Management in Organizations. A critical Introduction. Oxford University Press: New York

[7] Jeong SE, Lee T, Kim IS, Lee MH, Kim MJ (2007) The effect of nurses' use of the principles of learning organizations on organizational effectiveness. J Adv Nurs, 58(1):53–62

[8] Klinikum Oldenburg gGmbH (2010) Umwelterklärung 2010. http://www.klinikum-oldenburg.de/files/umwelterklaerung_2010.pdf. Accessed 12 Dez 2010

[9] Melnyk SA, Sroufe RP, Calantone R (2003) Assessing the impact of environmental management systems on corporate and environmental performance. J Oper Manag, 21:329–351

[10] Niemeyer M (2004) Entwicklung und Implementierung innovativer Qualitätstechniken zur Effektivierung von Managementsystemen. PhD thesis, Fakultät fuer Maschinenbau , Otto-von-Guericke-Universität Magdeburg

[11] Picot A, Reichwald R, Wiegand R (2008) Information, Organization and Management. Springer

[12] Rölker L (2007) Das Krankenhaus als lernende Organisation: Unterstützungsmöglichkeiten durch eLearning und Lern-Management-Systeme. Diploma thesis, Carl von Ossietzky Universität Oldenburg

[13] Rölker-Denker L (2010) Hospitals as learning organizations. Proc IADIS Int C e-Health

[14] Schein EH (2004) Organizational culture and leadership. John Wiley & Sons

[15] Vanhaecht K (2007) The Impact of Clinical Pathways on the organisation of care processes. PhD thesis, Katholieke Universiteit Leuven

[16] Virani T (2009) Clinical Practice Guidelines: Sustaining in Organizational Memory. PhD thesis, University of Toronto

[17] Wengelowski P (2000) Entwicklung organisationalen Lernens. Ein Lenkungsmodell. Deutscher Universitätsverlag

ProPlaNET – Collaborative Sustainable Project Planning - A Comparison with Existing Approaches

Nils Giesen[1], Daniel Süpke[1]

[1]University of Oldenburg, Business Informatics

giesen@wi-ol.de, suepke@wi-ol.de

Abstract. In this chapter, we present a web based software system, which aims at integrating decision support and multi-criteria analyses (MCDA) based on sustainability indicators and geographic information systems (GIS). The main innovative aspect of this system is found within its general approach, suitable for a large number of different planning projects. In order to support social i.e. participatory elements of project planning, the inclusion and interaction of the general public is a major focus in designing the planning process. Current project planning systems will be presented within this chapter, to give an overview of state-of-the-art planning systems and to demonstrate that there is currently no single solution available for general-purpose, participatory planning software systems. The goal is to base the software on a modern, open-source architecture and to extend the first implementation, based on experiences made in previous approaches. This includes greater flexibility, e.g. by allowing any number of MCDA methods to be plugged in, and primarily to enable participatory decision making on all levels by means of social software as found in e.g. the Web 2.0. Based on a concrete example, the underlying methodology and its realization within the prototype will be presented. The focus will be made on how to enable participation for the general public, especially when affected by regional projects. Finally, the general approach will be evaluated, including the advantages and disadvantages of indicator based sustainability assessment, in order to compare with existing project planning systems.

Key words: Sustainability Reporting, Sustainability Reporting Software, Sustainable Management, Environmental Information System, Web 2.0, Social Software, Dialog oriented

1 Introduction & Motivation

Sustainable development is the most important concept for long-term planning of any project, concept, or even society. The most prominent definition by the Brundlandt commission, stating it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [3], is clear enough to outline the need for sustainability. However, when confronted with its real world application, the concept remains vague. In all

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_31,

projects of reasonable size, there will be a multitude of possible planning processes, with no certainty which promises to be the most sustainable concept. This is mainly because of a) complex interdependencies, having simultaneous effects on economical, ecological, and social aspects and b) different views and interests of people affected by projects.

To ensure long term survival for projects, not only in terms of economy, but ecological and social aspects as well, a sustainable solution needs to be found. Moreover, the affected persons and population, i.e. the stakeholders, need to be able to understand decisions coming from a transparent process. Thinking of the possibility of massive protests coming from intransparent planning processes (in Germany e.g. recently the planning of a new train station in Stuttgart), such considerations should play an important role. Additionally, companies are more and more legally obliged to consider environmental impacts when planning projects and to include local communities (e.g. Planungsfeststellungsverfahren §§ 72-78 (VwVfG)). To deal with this, complex planning projects oftentimes use specifically designed tools and methods. A general, reusable and standardized, hence efficient planning platform is not available.

In a business informatics project group consisting of twelve students and three supervisors at the University Oldenburg, we developed a software tool over the course of one year to provide a solution for sustainable, transparent project planning. This tool provides a standardized procedure to create and compare scenarios, using expert knowledge and multi-criteria-decision-analysis (MCDA) to find the optimal solution. A further novelty is to include the public interest along every step of the process, having access to individual reports and the possibility to provide feedback. The idea for this tool is based on the redesign and improvement of an earlier implementation [7].

The scientific exploitation of this tool will be conducted by publishing three papers. The first one focused on the methodology [9], the second one on the eparticipation aspects [8]. This final chapter in the series will provide a comparison with similar approaches. Of course, aspects of the previous papers will be included. The chapter is structured as following: After this introduction, a comparison of similar solutions will be drawn. The third Chapter will present the software, along with an example. Finally, conclusion and outlook will present further development and practical applications being planned.

2 Comparison of similar approaches

As for the moment, there is no similar software solution, which is directly comparable to the approach of ProPlaNet. As a direct comparison is not feasible, an overview of related approaches and systems for the core functionality will be given. The identifiable core functionalities for the system can be separated into the following areas:

- eParticiaptive functionality

- Sustainable planning (of projects)
- Integrated decision support / multi-criteria decision analysis

As far as eParticipation is enjoying ever-greater public interest and attention, it is still very uncommon in the use of planning systems. The integration of participatory aspects in such software systems is often not wanted or implemented ineffectual. Motivator of the development of eParticiaptive functionality are often based among interest groups, associations, clubs or companies that create both information and free as well as billable services for the use and implementation of such services.

The combination of service providers and organization that provide conceptual and technical solutions for the participation process can be found in a network like the "Initative eParticipation" [10]. This solution and its software realizations are giving an emphasis on electronic public participation as method of conflict management for existing problems. This approach is motivated by the fact that the methodology, technology or social demands are often present, but are lacking the political conviction to be used. The simultaneous offering of various services, represented by a large amount of case studies and a variety of individual solutions shows the commercial factor in this initiative, whereby the objective approach is somewhat limited.

Other, strictly commercial offers, of guided participative support systems are specialized in internet-based processes for regional planning. The target group of such systems [1], are municipalities, which have certain construction or restructuring planned and are trying to move towards final decision, seeking the views of the citizens and giving the possibility of leaving comments or suggestions into the planning project. The principle which lies behind these online services is to be regarded more as a form of electronic consultation than electronic participation.

A third example for eParticiaptive approaches is the project DEMO-net (Demo-Net 2009), which is financed by the European Commission up to 2011. This project is seen as a European-wide network, that is based on interaction and information exchange between experts in the fields of methods, techniques and appliance of eParticipation. In this context, four basic objectives where defined:

- Achieving a sustainable integration of the currently fragmented research in eParticipation
- Joined research in agreed fields of research to encourage and motivate DEMO-Net
- Spread the DEMO-Net research among the target group of eParticipation
- Provide an indicator to measure effectively of research in the field of eParticipation in Europe, by collecting lessons-learned resources and project results

In the analysis of systems, initiatives or services dealing directly with eParticipation, it is revealed that the objectives of such programs can often be of a more diverse nature. It has to be mentioned, that the concept of eparticipation is used very extensive and therefore includes a large number of associations. It can, however, initially be classified into social and political forms of participation, under consideration of the current offers for possibility of electronic participation. The examination of the different forms of participation and differentiation of established and less successful offerings shows that the active participation of the electronic participation of the public in the social but also in the political environment is not self-evident and subject to several critical factors.

Supporting systems or approaches for sustainable planning are very scarce, and often are not applicable directly for large-scale regional projects. Transferring from the field of sustainable design, urban planners are interested in achieving a sustainable development by using several principles when designing new rural areas like cities or the corresponding infrastructure [4]. These approaches (e.g. Smart Growth, urban intensification, transit-oriented development…) are giving guidelines to a specific goal that should be reached under the idea of a fixed sustainable development rather than giving the possibility to measure activities or planned projects under a sustainable viewpoint. The main focus of urban and rural planning gives little to no room for the sustainable planning of individual projects of large-scale, demolition or comparison of alternatives. Some approaches focus in addition on the construction and design points of the sustainable planning [13], not considering an alternative pre-project phase as a central element of decision making.

Other software approaches, like the GEMI Tools (Global Environmental Management Iniative (GEMI 2010)) are focused on the business aspects and values, not setting regional or geographical references. The identification of the critical sustainable development issues for given business activities are in the focus of the SD Planner from GEMI, which represents an internal tool to systematically consider environmental and economic development with the goal to archive the most value for the users' business, by this being only partly sustainable. Other conventional project management software tools (e.g. MS Project, Trac, Redmine…) are more focused on the management aspects of the project (as the name implies) like scheduling, cost control, resource allocation or quality management than to external effects of the project.

Beside all these general approaches an unknown number of individual specialized solutions exist, which are strongly focused on given projects and thus cannot be transferred into other regions, use cases or plans. Examples for such sustainable planning oriented projects are all different types of integrated coastal zone management [11] projects like NOKIS [15] or regional and specialized projects like the development of a sustainable planning tool for Australian tourism destinations under the Topic of Tourism Destination Modeling [12].

To review the field of decision support systems (DSS), which include multi-criteria decision aiding, first a limitation of examined systems has to be done. Even if many individual approaches for software supported decision support systems exist, most of the offered solutions are strongly integrated into a given focus of the integration software system (like executive dashboard or business performance software). These systems cannot be adapted (easily), or transferred to a more sustainable point of view, as they are in the appliance mainly focused on one field of criteria. The available open-source solutions for a multi-criteria decision support are more flexible, but lack good usability and are often connected to proprietary third-party tools [16].

In addition, the usage of a DSS as a promoting method for sustainable development has been researched only partly [2], but it has been identified earlier as an elementary approach to solve sustainability conflicts on different levels of analysis [14].

All core functionalities within ProPlaNET can be found in different, separate solutions, but not combined into a single free available software system. In addition, not all functionalities have been set into relationship to sustainable development. Even if the core functionalities (e.g. sustainable planning) have been used in the field of sustainable development, the field of application has been limited to given project boundaries and cannot be chosen easily. Followingly, the ProPlaNET software will be presented, which aims at providing a more generalized and holistic approach compared to other existing software.

3 ProPlaNET – The software

ProPlaNET defines a process every project has to follow in order to find the optimal, most sustainable solution among a set of given approaches. Within this process, ease of use as well as transparency of decision are the main focus. The specific implementation is depending on the project, while the overall process is the same (see Fig. **1**). The first step, after the project idea has been made clear, is the definition phase wherein the project and its objectives are described. The evaluation scheme needs to be defined (all steps will be presented in more detail later). After the goals and evaluation process of the project have been defined, project alternatives – concrete realization options – are entered, possibly by external providers or agencies. The alternatives' influences on the indicators specified in the evaluation schema are estimated. In the next phase, the definition process is closed and all alternatives are evaluated with an MCDA system based on promethee to find the best solution for the given schema. The decision is finalized and the result published. The entire process is supported by a GIS system for visualization and is being transparent to the public, which can participate.

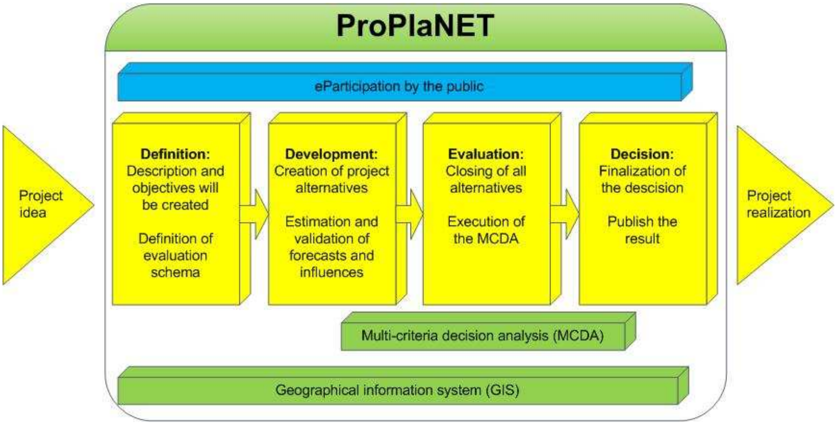
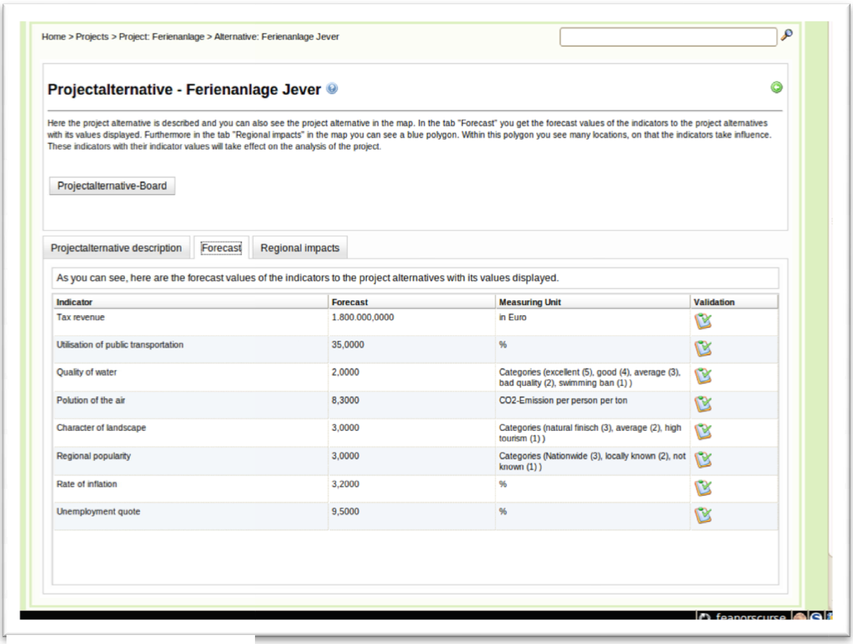


Fig. 1. Procedure for evaluating a project in ProPlaNET

Given the overview, the phases will be presented in more detail along with the responsible user roles. The first phase is assigned to the project manager, who enters descriptive information about the project, its goals and the region. A very important step here is the definition of the evaluation schema, upon which decisions will be made.

In order to have a transparent and valid evaluation of different project alternatives (realization options), a set of indicators is used to determine the effects of such alternatives. While these effects are defined in another phase, the indicators upon which the evaluation is based needs to be given in the very first phase, to allow a fair comparison of different alternatives. Indicators selected here should be taken from different areas of sustainability and give a well-balanced view of economic, ecologic and social issues. Each indicator can be given a different weight; in Fig e.g. the unemployment quote is the foremost concern. This schema is public and can be discussed with the public, once again to achieve a more transparent and participatory approach.



Home > Projects > Project: Ferienanlage > Alternative: Ferienanlage Jever

Projectalternative - Ferienanlage Jever

Here the project alternative is described and you can also see the project alternative in the map. In the tab "Forecast" you get the forecast values of the indicators to the project alternatives with its values displayed. Furthermore in the tab "Regional impacts" in the map you can see a blue polygon. Within this polygon you see many locations, on that the indicators take influence. These indicators with their indicator values will take effect on the analysis of the project.

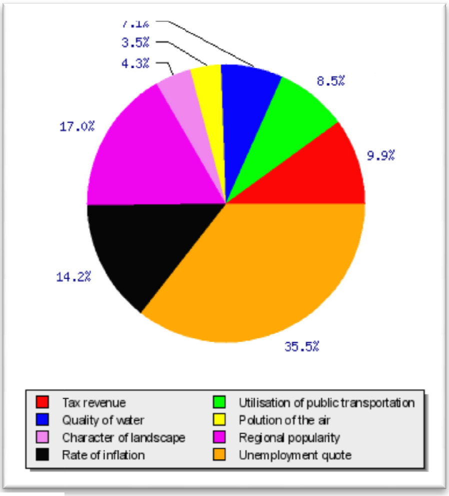
Projectalternative-Board

Projectalternative description | Forecast | Regional impacts

As you can see, here are the forecast values of the indicators to the project alternatives with its values displayed.

Indicator	Forecast	Measuring Unit	Validation
Tax revenue	1.800.000,0000	in Euro	
Utilisation of public transportation	35,0000	%	
Quality of water	2,0000	Categories (excellent (5), good (4), average (3), bad quality (2), swimming ban (1))	
Polution of the air	8,3000	CO2-Emission per person per ton	
Character of landscape	3,0000	Categories (natural finisch (3), average (2), high tourism (1))	
Regional popularity	3,0000	Categories (Nationwide (3), locally known (2), not known (1))	
Rate of inflation	3,2000	%	
Unemployment quote	9,5000	%	

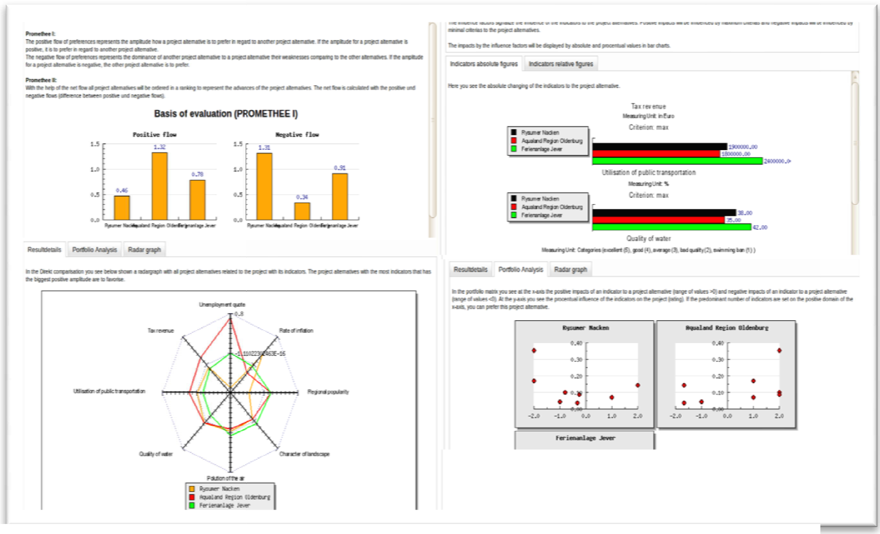
cts of a project alternative



Once the goals and evaluation basis for the project has been finalized, the second phase concerning possible realization options begins. There are different possibilities on how to conduct this phase. One of the most intriguing ones is to make a public call for e.g. architects providing options to realize a project, e.g. where and what type of building to create in order to achieve the goals of the project. Now, different companies can easily compete and be compared within the systems, with understandable goals. All information provided for a project alternative need to be in such detail, that independent experts can evaluate their impact on the indicators specified in the evaluation schema (see Fig). Once the phase for supplying project alternatives has been closed and the forecasts have been made, the evaluation phase can begin.

The evaluation is supported by a multi-criteria-decision-support tool (MCDA) based on Promethee[1]. Promethee takes into consideration the selected indicators, the forecasts of project alternatives for these indicators and the weight these got in the initial evaluation schema. The results of this evaluation can be easily expressed in various diagrams (see **Error! Reference source not found.**).

On the top left, you can see the overall positive and negative flows of three suggested project alternatives. On the top right and lower left, a pair-wise comparison of indicator changes in the alternatives can be seen. Especially the radar plot



(however, the weight is not considered in here). On the lower right, the impact of

[1] Another option could e.g. be to use MacBeth, a comparison of both methods will be part of future work.

indicators towards positive and negative flow is visualized. Based on such diagrams, a decision can be made in the finale phase, providing reasonable and transparent process leading to the conclusion. A pdf report can be created automatically (at any time), providing all the information about the projects, indicators, alternatives and evaluation available in the system.

4 Conclusion & Outlook

As of today, there are no well-known and widespread applications for integrated collaborative sustainable project planning. Even if there are several individual solutions for specific parts of the problem, the combination of these solutions is often not possible or accompanied by huge effort and lacking usability. There will be a future development for integrating sustainability concerns into given software systems, but as far as this process is only starting in the enterprise software system sector (e.g. Sustainability Reporting), a transformation to planning and decision support software will not be a near term event.

The sustainable planning and implementing of a regional project will never be able to reach the theoretical optimum, as there are too many factors to consider, too many different viewpoints and unknown effects. But especially in complex projects (only) software support can contribute to carry out the “optimal planning”, at least as to the extend possible. The use of PROMETHEE, the use of expertise knowledge and external consulting reinforced this process. By choosing a universal approach not bound to a specific project, many different project types can be effectively treated with this standard software.

For the further improvement of ProPlaNET two major activities are currently in progress. The first activity is the extension of the current ProPlaNET software framework with a component for the analysis and the modeling of regional and interregional sustainable supply chains. Beside a graphical modeling and design phase the developed supply chains will be usable for the integrated decision support as well as connectable to geographic information systems. By creating such a solution, the current regional project oriented ProPlaNET process will be extended with a valuable method to design, develop, examine and adapt supply chains under sustainability issues. The development of this extension will be integrated into the sustainable supply chain analysis of the enercoast (Enercoast 2010) project, giving a large field of application and validation in real life scenarios.

As second activity it is envisaged that an on-field implementation of ProPlaNET is carried out, for evaluating different alternatives of a planned highway route. This implementation will be evaluated to improve the current usability as well as to get an insight into the usage of the participative functionality of the system.

By implementing and further developing the ProPlaNET software system, an ongoing improvement of the software as well as a further distribution of sustainable project planning can be achieved.

References

[1] Beteiligung online.com. Internetgestützte Bürgerbeteiligung - e-Partizipation. www.beteiligung-online.com/ - last access 03. Dec 2010

[2] Blanquart, S. (2009) Role of multicriteria decision-aid (MCDA) to promote sustainable agriculture: heterogeneous data and different kinds of actors in a decision process. In: International Journal of Agricultural Resources, Governance and Ecology, Inderscience Enterprises Ltd, vol. 8(2), pages 258-281

[3] Bruntland Comission (1987) Our common future: The World Commission on Environment and Development. Oxford, Oxford University Press

[4] Bullard, Robert (ed.) (2007) Growing Smarter. Achieving Livable Communities, Environemntal Justice and Regional Equity. MIT Press, ISBN 978-0-262-52470-4.

[5] Enercoast – Bioenergy in the North Sea Region - http://www.enercoast.eu – last access 24. Dec. 2010

[6] GEMI 2009, http://www.gemi.org – last access 25. Nov. 2010

[7] Giesen N, Chen L, Dahlem N, Finke J, Hornischer O, Lederer A, Süpke D, Vogel U, Yang J, Zurhorst N, Sonnenschein M (2006) Ein Informationssystem zur Bewertung regionaler Projekte unter Berücksichtigung nachhaltiger Entwicklung. In: Müller M (ed), Simulation in Umwelt- und Geowissenschaften. Workshop Leipzig 2005- ASIM-Mitteilung AM 106, ISBN 3-8322-5132-4, pp. 99-108

[8] Giesen N, Jürgens P, Marx Gómez J, Omumi H, Rieken M, Stepanyan H, Süpke D (2010): ProPlaNET – Web 2.0 based Sustainable Project Planning. In: Greve K., Cremers A B (eds): EnviroInfo 2010 - Integration of Environmental Information in Europe; Shaker, Aachen. pp. 436-445

[9] Giesen N, Süpke D (2010): ProPlaNET - Webbasierte Projektplanung für eine nachhaltige Entwicklung. In: Wittmann J (ed): Simulation in Umwelt- und Geowissenschaften. Workshop Osnabrück 2010. Shaker, Aachen. pp.193-202

[10] Initiative Eparticipation (2010) www.initiativeeparticipation.de/index.html last access: 21. Dec. 2010

[11] Integrated Coastal Zone Management, European Commission Environment, http://ec.europa.eu/environment/iczm/home.htm, last access 06.Dec. 2010

[12] Jones T, Wood D, Hughes M, Pham T, Pambudi D, Spurr R, Dwyer L, Deery M, Fredline L (2010) Tourism destination modelling : building a sustainable planning tool for Australian tourism destinations, CRC for Sustainable Tourism Pty Ltd, Australia, ISBN 9781921658495

[13] Kehagia F (2009) The implementation of sustainability in highway projects, in International Journal of Sustainable Development and Planning

[14] Munda G. (2005) Multiple Criteria Decision Analysis: State Of The Art Surveys. In: International Series in Operations Research & Management Science, Volume 78, VII, 953-986, DOI: 10.1007/0-387-23081-5_23

[15] NOKIS: Offenes Informationssystem für die Nord- und Ostseeküste, http://www.nokis.org/, last access 05. Nov. 2009

[16] Tong T: Free Multi-criteria decision aiding (MCDA) Tools for Resarch Students, http://sites.google.com/site/mcdafreeware/, last access 30. Dec. 201

Reporting Models for Corporate Sustainability in SMEs

Frank Medel[1], Lourdes García[1], Saumel Enriquez[1], Maybel Anido[2]

[1]Industrial Engineering Department Central University of Las Villas,
[2]Center of Software Development University of Informatics Sciences Camajuaní

Abstract. Sustainability is one of the biggest challenges in our industrialized societies. It has become an important strategic objective for all companies over the world, trying to keep a dynamic balance of the organizations' economic, environmental and social performance. Transparency about the organizations' activities is of great interest for a range of stakeholders. For that reason organizations should maintain a continuous stakeholder dialogue that allows tracking the organizations' impact along the dimensions of sustainability. The Sustainability Balanced Scorecard and the Global Reporting Initiative provide frameworks that help to identify current shortcomings of financial reports and to recognize the value of intangible assets of the companies. These frameworks have several points in common, they can be supplemented and they support organizations' efforts to report their performance in terms of sustainability. The objective of this chapter is to present a new approach to handle the integration of these frameworks, allowing organizations to better manage strategies, provide communication with stakeholders, and made clear by the case of Small and Medium Sized Enterprises (SMEs).

Keywords: corporate sustainability; reporting; frameworks integration.

1 Introduction

Nowadays the Corporate Sustainability (CS) is the main objective in all kind of business. There is an increasing trend and demand for organizations to demonstrate transparency and accountability beyond the domains of financial performance. Create long terms consumers and employee value, taking into consideration every dimension of how a business operates in the social, cultural, and economic environment. Besides the opportunities sustainability unlocks, being a leader in implementing sustainable strategies can strongly improve perceptions of the business among customers.

Transparency about the sustainable activities is of interest to a diverse range of stakeholders, including customers, suppliers, regulators, neighbors, employees, shareholders, and many others. Stakeholder dialogue is an important element to achieve the CS because the performance of the company can be tracking in the three pillars of sustainable development, establishing a feedback among business sustainability performance, internal and external stakeholders.

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*,
Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_32,

Reporting is a good way for a company to communicate openly about its values, objectives, principles and performance in relation to sustainable development. This makes it easier to build trust between a company and its stakeholders. According to a 2008 KPMG survey, approximately 80% of the world's largest 250 corporations engage in some form of sustainability reporting. This is up from 50% just three years ago. The literature is replete with reasons why companies should engage in and report on social responsibilities. According to [1] the Small and Medium Sized Enterprises (SMEs) are hesitant about becoming "Green" and including sustainability reports as part of their overall corporate reporting. The process to reach the sustainability involves two key components:

1. Adjusting business model.
2. Reporting the results.

The existence of different business reporting models tested in all kind of business can help to the organizations specially SMEs to make effective the sustainability reporting process in order to inform the interest parts the business performance.

Two business reporting models have special characteristics but fortunately there is a large overlap between them, the Sustainability Balanced Scorecard (SBSC) and Global Reporting Initiative (GRI), both characterized by their criticism of a traditional public reporting model in which historical financial statements play a central role recognize the importance of the non-financial, forward-looking information, and the importance of intangibles.

The aim of this chapter is present how these businesses reporting models can be used as a framework for traduce CS strategies into actions and communicate it to stakeholders. The integration and complementation of these frameworks can help SMEs to tracking and inform the transparency of their sustainable activities.

2 Corporate Sustainability

The concept of corporate or business sustainability has therefore grown in recognition and importance. Corporate sustainability can be defined as:

"adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining and enhancing the human and natural resources that will be needed in the future"[2].

A strategy for CS must meet the needs of a firm's stakeholders without compromising its ability to also meet the needs of future stakeholders [3].

The capability of an organization to continue its activities indefinitely, taken into account their impact on financial, social and environmental capitals [4].

The Dow Jones emphasizes that CS constitutes a business approach which creates long term shareholder value by embracing opportunities and managing risk deriving from economic, environmental and social development.

Business sustainability refers the incorporation of the objectives of sustainable development, namely social equity, economic efficiency and environmental performance, into company's operational practices.

According with [4] Corporate Sustainability is a multi-dimensional concept which includes the following aspects:

- *Strategy.* Integrating long-term economic, environmental and social aspects in their business strategies while maintaining global competitiveness and brand reputation.
- *Financial.* Meeting shareholder demands for sound financial returns, long-term economic growth, open communications and transparent financial results.
- *Customer & Products.* Fostering loyalty by investing in customer and supplier relationship management products and service innovation that focuses on technologies and practices which use financial, natural and social resources in an efficient, effective and economic manner over the long term.
- *Governance and stakeholder.* Setting the highest standards of Corporate Governance and stakeholder engagement, including corporate codes of conduct and public reporting.
- *Human factor.* Managing human resources to maintain workforce capabilities and employee satisfaction through best-in-class organizational learning, knowledge management, practices, remuneration and benefit progress.

In general CS is the triple-bottom line strategies define by the business, to generate a long-term economic growth based in costumers' satisfaction with products and services, reinforcing stakeholder's engagement with a motivated human capital assuring long-term sustainability business success.

3 Business Reporting Models

The continual demand for an improved a general reporting framework has been a long-running debate, with increased concerns over the inadequacy of different models for reporting balancing qualitative and quantitative, past-oriented and future-oriented information. The new reporting models containing various elements and critical connection points, can support enhanced business understanding and help to create a more sustainable enterprises. A connected and integrated reporting model would [5]:

- Be centered on the *sustainable strategy* and market context within which the business is operating and how this may change over time.
- Provide clarity on how the business is led and governed and how employees are incentivized and remunerated to deliver *sustainable business outcomes*.
- Provide *transparency* around the dynamics of the *business model* and the associated risks and opportunities that emerge, including environmental and social factors.

In the last decades many reporting models have arisen but the chapter is centered in two: The first is the SBSC a derivation of the traditional balanced scorecard (BSC) is one of the more developed and applied instruments in the late years, around the world, it's consider an important strategic management tool and sustainability issues can be integrated inside. The second is GRI; advocates 'triple bottom line' reporting that measures economic, environmental and social performance. The objective of GRI is 'to assist reporting organizations and their stakeholders in articulating and understanding contributions of the reporting organizations to sustainable development.' The broader objective is 'to help direct private sector activity toward outcomes that are socially and environmentally, as well as economically, beneficial [5].

These are two great opportunities for businesses specially SMEs to meet, reach and report environmental, social and economic issues and achieve an even balance among these three dimensions of sustainability.

3.1 The Sustainability Balanced Scorecard

The Balanced Scorecard is one of the most influential management ideas of the past 18 years. This measurement system was proposed for the first time in 1992 in the article The Balance Scorecard – Measures that Drive Performance written by Robert S. Kaplan and David P. Norton and published in the Harvard Business Review.

The evaluation of an organization must not be restricted to traditional financial evaluation rather it should be complemented with measures related to the satisfaction of costumers, internal processes and the capability to innovate. These additional measures should guarantee the financial companies future and lead the company toward their strategic goals while it maintains these four perspectives equilibrated and balanced [6].

Several authors have approached how the traditional balanced scorecard can contribute to the sustainable development, defining the Sustainability Balanced Scorecard it is develop for the “Business Case” “Fig. 1” where the environmental and social topics are used to generate economic value, without committing future generations.

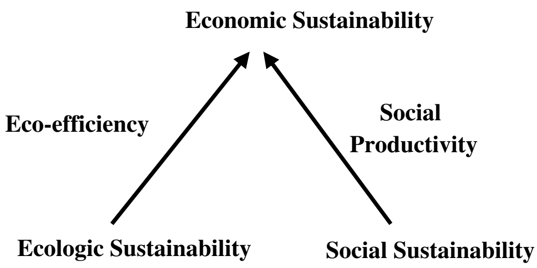


Fig 1. The "Business Case", *Source: [3]*

A SBSC is a type of BSC specifically designed to reflect the issues and objectives of corporate sustainability. In order to clarify appropriate sustainability strategies and translate them into action, it is generally recommended that managers first design a separate SBSC. This must then be integrated into the traditional BSC in order to ensure a holistic view of sustainability. This process will help to overcome the distinction between a traditional financially oriented management approach and emphasizing sustainability or environmental management concerns [3].

According to [7] (Gminder, 2005)the SBSC is based on the traditional BSC, but provides a broader scope, integrating the three dimensions of sustainability. So, it has a different content and possibly a different structure (“architecture”). In addition to the four perspectives of the traditional BSC, it is possible to include a fifth perspective in order to explicitly address stakeholder issues. Another definition was given for [8],

which outlines that the SBSC can help to detect important environmental and social strategic objectives in the company, in a strategic business unit or department, illustrating the causal relationships, among the intangible factors and the finances of the company.
Literature about SBSC has identified basically four possible approaches of integrating Corporate Sustainability into the BSC according [4]:

1. Sustainability aspects can be *integrated* in the existing four standard perspectives of the traditional Balanced Scorecard.
2. Sustainability issues are *integrated* into one of the Balanced Scorecard Perspectives.
3. An additional perspective, the sustainability perspective, can be *added* to the existing Balanced Scorecard.
4. The *development* of an *overall* Sustainability Balanced Scorecard.

The inclusion into SBSC of stakeholders' interest is very important according to [9] "All stakeholder interests, when they are vital for the success of the business unit's strategy, can be incorporated in a Balanced Scorecard", for that reason a different architecture is shown in the "Fig. 2".

The stakeholders' perspective permits: 1) list the main interest parts of the business who can affect the value chain, 2) the inclusion into the core management of the business of key topics and concerns that have been raised, and 3) how the organization responds to those key topics. The social and cultural perspective allows addressed important issues difficult to integrate into a traditional BSC without compromising the functional idea proposed masterfully by Kaplan and Norton (e.g. public policy, anticompetitive behavior, corruption, cultural respect to the community or region and others can be included).

The SBSC allows making a balance between past- and future-oriented, quantitative and non-quantitative, financial and nonfinancial information [11] and include the triple bottom line into the core management of the business. Contemplate the acting of the organization from fives possible perspectives: Learning and Growth, Internal Process, Stakeholders, Financial and Social & Cultural.

The sustainability strategy, as every strategy, has to be continuously developed, implemented, and controlled. This implies according [12].

- (Re) formulating the strategy.
- Forming a consensus with respect to the strategy.
- Communicating the strategy.
- Launching strategic initiatives.
- Adjusting the aims of particular groups and the objectives of the strategy.
- Linking strategic objectives with medium and short term aims.
- Providing resources for the implementation of the strategy.

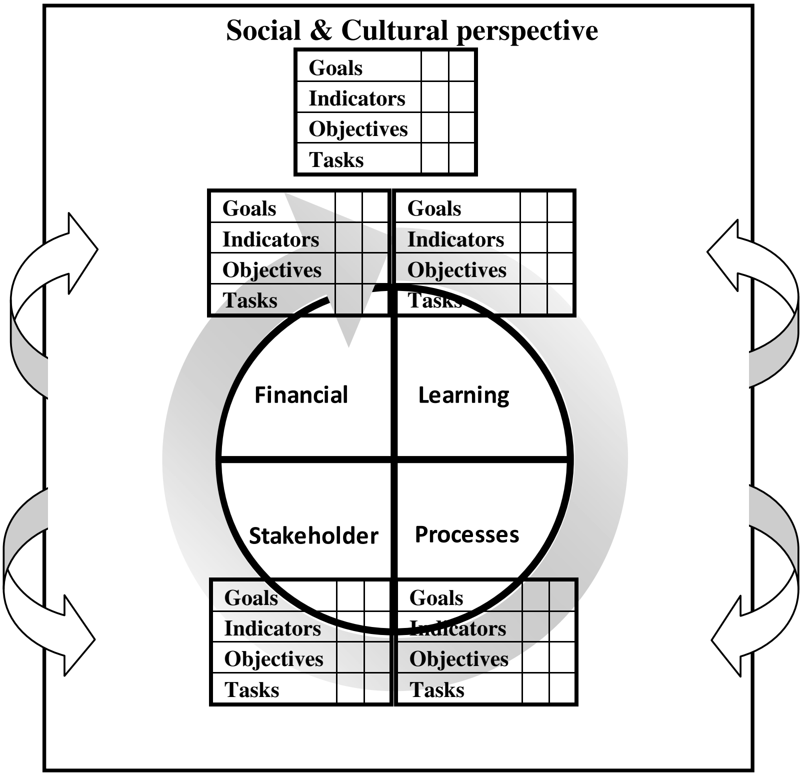


Fig. 2. Sustainability Balanced Scorecard enhanced by stakeholders and social and cultural Perspective, *Source: Adaptation of [10]*

- Periodically review the strategy.
- Organize feedback and learning.

The SBSC supports the management processes which are necessary to deal with these challenges. SBSC facilitates the development in an active way, of a new dynamic control in organizations impelling the coordination and the complementarities among the different areas of the company and allowing the sustainability strategy of the business. The SBSC is considered as a sustainability strategic management system and can be used to manage the CS strategy of the business.

3.2 Global Reporting Initiative

The GRI is a reporting framework that intended to serve as a generally accepted framework for reporting on an organization's economic, environmental, and social performance. It is designed for use by organizations of any size, sector, or location [14]. This pattern is for voluntary use by organizations wishing to report on the triple bottom line impacts of their activities, products and services. The GRI sets out principles and specific content to help guide the development of sustainability reporting at the organizational level. In this way, it helps the institutions to present a "balance" and reasonable view of their economic, environmental and social comparison promotes memory and facilitates interaction and communication with a big range of stakeholders.

The GRI framework “Fig. 3” describes the results that a report must be obtained and delivery guidelines for decision making in the reporting process (defining the content and coverage) and to verify the quality of the final product.

Fig. 3. The GRI Reporting Framework ,*Source: [13]*

A company that reports under GRI’s Sustainability Reporting Guidelines should include the following elements in a report that complements and only draws selectively from the financial statements:

- Vision and strategy.
- Profile.
- Governance structure and management systems.
- Performance indicators.

These four elements are including in three types of Standard Disclosures according [13]:

- Strategy and Profile: Disclosures that set the overall context for understanding organizational performance such as its strategy, profile, and governance.
- Management Approach: Disclosures that cover how an organization addresses a given set of topics in order to provide context for understanding performance in a specific area.
- Performance Indicators: Indicators that elicit comparable information on the economic, environmental, and social performance of the organization.

In table 1 are shown the main elements of GRI Guidelines, divided in categories, types and elements.

Table 1. Main Elements of GRI Reporting Guidelines (

GRI Sustainability Reporting Guidelines		
Category	***Type***	***Components***
Principles	Defining Report Content	Materiality, Stakeholder inclusiveness, Sustainability context, Completeness
	Ensuring Report Quality	Balance, Comparability, Accuracy, Timeliness Clarity, Reliability
Standar Discluoser	Profile (Context)	• Strategy and Analysis • Organizational Profile • Report Parameters • Governance, Commitments, and Engagement
	Performance Indicators (Results)	Environmental, Human Rights, Labor Practices and Decent Work, Society, Product Responsibility, Economic, Guidance for using Indicators
	Management Approach (Drivers)	Goals and performance, Policy, Organizational responsibility, Training and awareness, Monitoring and follow up, Additional contextual information

Source: adaptation of [14](GRI, 2006)

The principal advantages of GRI according [15] are:

1. GRI provides a common framework for companies to report their achievements towards sustainability, which raises awareness and promotes business accountability.
2. The standardized format and indicators allow for comparisons between companies and thus promote external benchmarking.
3. GRI measures the elements of business sustainability that have not been addressed before, such as product reparability, activities in developing countries and community technology transfer, among others. In addition, GRI addresses key issues of global concern, such as greenhouse gas emissions, persistent organic pollutants, and the gap between developed and developing countries.

Other advantages could be:

4. GRI include various stakeholder-oriented specifications and that provide a guide on what content should be included in sustainability reports permitting an effective communication of interest issues.

GRI would become a platform for a broadly participative societal dialogue on what constitutes sustainability performance by companies and other organizations [16].

4 SBSC and GRI, Complementary Frameworks

The sustainability Balanced Scorecard and Global Reporting Initiative are frameworks that permit the inclusion of sustainability issues in the core management of the business and report it. Each company has to make decisions on what data to collect and how to report it. This requires the development of new internal management processes.

Before report the performance of the business is necessary measure and tracks the strategies in the three pillars of sustainability. For that reason SBSC comes to be an important complement in sustainability reporting process especially of GRI framework, using the same elements to achieve different objectives but complementary between them. SBSC offer a method to translate the CS strategies into actions, it allows introducing the topics related to the sustainability, including stakeholders issues on board, helping to detect strategic objectives, selecting the derived indicators of the objectives, permitting measure execution level of the CS goals, achieving the integration of sustainability inside the core management of the business. While the GRI report the performance of general activities of the organization related economic, environment and social topics based in three key elements: principles, standards of discloser and protocols. In the table 2 can be appreciated how these framework fulfill the same criteria to achieve different objectives but complementary between them.

Table 2. Common elements between Sustainability Balanced Scorecard and Global Reporting Initiative framework.

	Frameworks	
Criteria	***Sustainability BSC***	***GRI Reporting Guidelines***
Sustainability issues	Can be included into the SBSC	Provide a great scope of integration
Function	Is a tool to track and evaluate the strategy accomplish level	Their main function is communicate the activities and sustainable performance of the organization
Corporate strategy	Start with a strategically analysis: mission, vision and objectives	Is part of one standard disclosure helping the understanding of business performance
Stakeholders	Permit the stakeholders inclusion into the business strategy	Try to make clear the most relevant topics of the main interest parts to communicate the achievements of the organization
Orientation	External orientation to the stakeholders satisfaction as a key for the organization	To stakeholders communication of relevant topics
Financial and non financial information	Balance financial information and non-financial information.	Combine financial and non-financial information to report
Types of indicators	Environmental, economic, social, leading and lagging indicators	Environment, economic, society, product responsibility, human rights, labor practices and decent work

The SBSC could be an important tool in sustainability reporting process in conjunction with GRI, because reporting is more about management than reporting. Management in this case refers to aspects like business strategy/systems with regards to sustainability issues; to company values and culture; to information; and to gaps and shortcomings in performance. The integration of these frameworks can offer benefits to the companies in the long race of corporate sustainability.

5 SMEs and Corporate Sustainability Frameworks Integration

The challenge is to develop solutions for SMEs on corporate sustainability from an SME perspective, demonstrating the link between sustainable business practice and business benefit.

The importance of SMEs to sustainability cannot be understated. The cumulative impacts of small to medium-size enterprises are considerable. SMEs make up more than 90 percent of businesses worldwide. They also account for 50 percent of GDP[1] of all countries and for 60 percent of their employment, on average [17].

The dissemination of Corporate Sustainability has been a particularly challenging task to SMEs since there are a number of constraints such as a lack of expertise, time and resources. Independently of this SMEs can absorb different frameworks like SBSC and GRI and put it to work, to have improved performance and stakeholder's communication. GRI offer different manuals and templates to report in SMEs and the SBSC is not limited at enterprise size, it should work better in SMEs. The principal idea is synchronize them trough the corporate strategy guaranteeing the inclusion of organization key issues and stakeholders interest topics, assuring at the same time business profit and sustainable behavior.

General ideas to integrate those frameworks:

- The *sustainability strategy* analysis is the first step of the integration. The strategy should cover the organizations good performance commitments and promote the stakeholder's dialogue trough the communication and feedback.
- Clarify the main *objectives*, *critical success factors* and the main interest topics of *stakeholders*, to bring it on board.
- *Sustainability indicators* as a key of mensuration and evaluation process. The indicators of SBSC should respond to GRI performance indicators and strategically objectives.
- Support SBSC and GRI data in *Sustainability Management Information Systems*, using this as primary and basic information; maintain on *information technologies*.

A common base has to exist and should provide a great range of integration; information technologies and Internet play a fundamental role. It will be discussed in further publications.

6 Conclusions

1. Corporate sustainability is one of the more complex and fuzzy concepts in order to develop in the organizations, for that reason the integration of different reporting models consider as frameworks can facilitate the execution,

---

[1] Gross Domestic Product: is the amount of goods and services produced in a year, in a country. It is the market value of all final goods and services made within the borders of a country in a year.

tracking, transparency and communication of corporate strategies in order to achieve a sustainable performance of the organizations.

2. The ability of the SBSC framework to integrate sustainability issues into the core management, aligning and balancing strategic social and environmental goals with the operation of the organization, to communicate the importance of these initiatives and to measure the impact of these programs on corporate sustainability.
3. The GRI framework as sustainability reporting model for the companies of whole world generally accepted for reporting on organization's economic, environmental, and social performance. This promote external benchmarking measure elements that have not been addressed before and taking into account stakeholders interest.
4. The integration of Sustainability Balanced Scorecard and Global Reporting Initiative frameworks can offer benefits to the companies connecting two key processes: strategy management and sustainability reporting making these frameworks complementary between them, to improve sustainability performance and effective stakeholder communication, The integration of these frameworks in the SMEs can contribute significantly to improve the ability of these organizations in the long race of sustainability and take competitive advantages of sustainable performance. General ideas are exposed to take in mind when we try to synchronize these frameworks

Acknowledgments. F.M.G thanks to Professor Ralf Isenmann for your help and cooperation during the elaboration of this chapter.

References

[1] Newell, C., & Moore, W. B.: Creating Small Business Sustainability Awareness. International Journal of Business and Management , 5 (9), (2010)

[2] Deloitte & Touche.: Business strategy for sustainable development: leadership and accountability for the 90s, IISD (1992)

[3] Bieker, T., Dyllick, T., & Gminder, C.-U.: Towards A Sustainability Balanced Scorecard Linking Environmental and Social Sustainability to Business Strategy, (2002)

[4] Esterhuyse, W. P.: The Sustainability Blanced Scorecard: It´s Theory and applications to companies operating within the South Afrcan fishing industry. University of Stellenbosch. (2008)

[5] ICAEW.: New reporting models for business. Consulted on 28 of August of 2010, Web of Institute of Chartered Accountants in England & Wales: www.icaew.co.uk/bettermarkets

[6] Kaplan, R., & Norton, D.: Having trouble with your strategy? Then map it (Vols. September-October), (1996)

[7] Gminder, C.-U.: Environmental Management with Balanced Scorecard. A case study of Berlin Water Company, Germany. In J. Chenoweth, & J. Bird, The business of water and sustainable development, pp. 53—54, Greenleaf Publishing, (2005)

[8] Bieker, T.: Sustainability management using Balanced Scorecard. International Summer Academy on Technologies Studies-Corporate Sustainability, (2003)

[9] Kaplan, R., & Norton, D.: The strategy-focused organization: How balanced scorecard companies thrive in the new business environment. Boston: Harvard Business School Press, (1996)

[10] Figge, F., Hahn, T., Schaltegger, S., & Wagner, M.: The sustainability balanced scorecard. Linking sustainability management to business strategy. 11 (5), 269–284, (2002)

[11] Schaltegger, S., & Dyllick, T.: Sustainability Management Using the Balanced Scorecard. Wiesbaden Germany: Glaber (2002)

[12] Blazejczak, J.: The Balanced Scorecard Approach to Integrating Sustainability Policies. Conference on the Human Dimensions of Global Change, Berlin (2004)

[13] Global Reporting Initiative.: Sustainability Reporting Guidelines. http://www.globalreporting.org

[14] Global Reporting Initiative.: Sustainability Reporting Guidelines— Reference Sheet, http://www.globalreporting.org

[15] Kinderytė, L.: Analysis and Comparison of Methodologies for Corporate Sustainability Assessment. Environmental Research, Engineering and Management, 66-75, (2008)

[16] Brown, H. S., Martin J., Levy D.: Building institutions based on information disclosure: lessons from GRI's sustainability reporting, Elsevier, Journal of Cleaner Production, (2009)

[17] Global Reporting Initiative. Small, Smart and Sustainable. GRI Research and Development. Amsterdam: http://www.globalreporting.org

Decision making model in integrated assessment of business-environment system- a case study

Lukasz Hadas[1], Agnieszka Stachowiak[1], Piotr Cyplik[1]

[1] Poznan University of Technology,

lukasz.hadas@put.poznan.pl, agnieszka.stachowiak@put.poznan.pl, piotr.cyplik@put.poznan.pl

Abstract. The goal of the chapter is to present a business model developed to confront efficiency of processes and their influence on natural environment, combining economic reasons for process reengineering and environmental aspects of business activity. The economic reasons presented are based on the assumption that processes should be cost-efficient to be competitive. Environmental aspects on the other hand assume that limitation of negative influence on natural environment should not result in decreasing enterprises' competitiveness. The assumptions introduced are integrated in the model developed thanks to analyzing complex relations between assortment, lot size, releases, set ups, energy use, waste, quality providing costs and related processes.

Keywords: environmental management, efficiency assessment, decisions making

1 Introduction

Development of technologies and science, except from facilitating many areas of economic and everyday life, has brought some negative results. Increase in production (thanks to using new technologies) resulted in increased pollution of environment around us with excessive wastes. In the XIX and the second half of the XX century enterprises were striving to increase their profit [1]. The pace of industry development and increased production of wastes, together with common belief that landfills are the only way to dispose wastes has led to growing degradation of natural environment. One of the most important challenges of our times is the problem of wastes management and disposal [11].

Contemporary enterprises should take the fact that their activity influences environment into consideration. Except from monitoring their competitors they should be involved in environment protection and remember that final products and wastes as well are results of processes they perform. The waste problem is of a large scale as it concerns all the enterprises, both, manufacturers, and service providers, large, globally competing businesses and SME sector representatives.

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_33,

A steady increase in the amount of waste generated has been noted in Poland in the last 30 years. Of the approximately 145 million tonnes of waste produced currently every year, industrial waste account for 133 million tonnes and the amount of industrial waste has decreased over the last 10 years. The decrease and subsequent stabilization in waste generation is caused mainly by the changes in the structure of national industrial production, including the reduction in coal reduction level (mining wastes) and improvement in its calorific value (power station wastes) [6]. The reason for continuous decrease in the amount of industrial waste generated, except form improved quality of industrial processes realized, is also caused by more and more strict law regulations, systematically updated to meet European standard and requirements according to sustainable development idea, and continuously increasing ecological awareness of both, entrepreneurs and customers.

Sustainable development idea is one of the most often discussed and analyzed contemporary approaches to economy and business. One of the firsts, and the most popular explanations and definitions of the term "sustainable development" is the statement from the WECD report from 1987 (also called Brundtland Report) – "at the present stage of civilization development sustainable development, which is development thanks to which needs of today's generations can be met without decreasing chance of future generations for meeting their needs, is possible". The report proves, that contemporary civilization has reached the level of welfare which can be maintained only when properly managed. The model of such economy assumes, that relation between economic growth, care for environment and human health should be created [13]. With other words, to reach sustainable development, a process of changes in necessary so that exploitation of natural resources, investments, technology development and institutional changes were realized in full harmony with the present of future potential to be used to meet human needs and aspirations [10].

The idea of sustainable development should not be treated as a demand to stop economic development but as a demand to improve life quality instead of increased expansion of industrial production [14]. Modern approach to the idea of sustainable development starts exactly where three ideas: natural environment, society and economic results meet. The idea refers to J. Elkington's theory, in which he suggest simultaneous analysis and balancing of three crucial dimensions (the Triple Bottom Line): economical, ecological and social (fig.1).

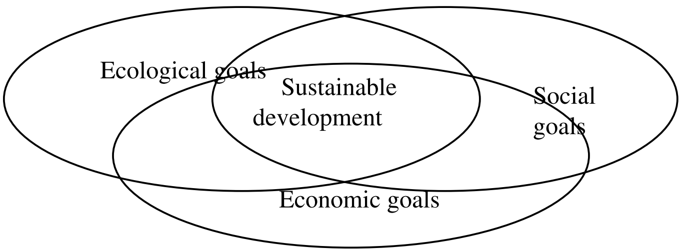


Fig. 1. The three crucial factors creating sustainable development, *Source: [6]*

With such approach, sustainable development is "not only the matter of good corporative citizenship, which is collecting points for reduction of harmful emissions from the factory or providing health protection program, but a fundamental principle of intelligent management" [13]. Managers start to see ecological issues as an integral part of business strategies, despite solving global problems connected with environment pollution is not a core activity of an enterprise. The strategies enable enterprises creating positive image, and gaining competitive advantage as well [8]. Sustainable development idea proves, that taking environmental aspects into consideration is not only ecological, but also cost-efficient. The approach to be accepted is the one formed by H. Rodham Clinton, according to which "economic development and clean environment are not contradictive goals – actually these goals are harmonized as life quality and economic activity depend on care for environment".[9]

The approach presented above is reflected in strategies and operations of numerous businesses, trying to benefit from waste generated. Though in Poland landfilling is still the cheapest and most common of method of industrial and municipal waste management, businesses start to understand that waste is not only the source of cost, negative but necessary result of materials processing, but it can be limited, minimized, re-used or even sold bringing extra profits. More than half of the industrial waste are re-used, mostly wastes from coal mining and processing, the power and metallurgical industries. The highest degree of utilization is noted for metallurgical slag, fly ash from bituminous coal combustion in power stations, waste lime from carbide production and mining wastes [6]. The company analyzed in the following chapter generates various kinds of waste and performs processes, which are highly resources consuming. To meet requirements defined in law regulations concerning energy use limits and follow the guidelines defined for waste generators, the Enterprise decided to develop decision making model based on ecological and environmental criteria, and to stay competitive it also included economical criteria to the model to be developed.

The following chapter introduces the idea of the business developed as a result of a larger project developed for the Enterprise. The framework and some details are presented. The conclusions and further research assumptions are presented as well.

2 Research framework

Business process perspective

The research works were carried out in industrial engineering in complex environmental conditions of production. This was an specializing in technology, multi-departments environment, with multiple streams of values. The work was carried out under the transformation of the production system from the "push" logic of flow to the "pull" logic of flow and building a dedicated system [7,8] based on the lean management approach. Works on the production planning and shop floor control system were started by looking at the current functioning mode of the enterprise. This is a traditional enterprise, with a hierarchical and centralized planning structure, supported by MRP II / ERP system. Long-term planning (1 year) involves drawing up annual forecasts, intended to verify income and expenses and roughly balance machine and worker production capacity. In medium-term planning (1 - 2 months) production and supply schedules are prepared based on sales plans and confirmed orders. In short-term planning production launch orders are sent to the foundry (a division where the production process is initiated). Orders are "pushed" through subsequent levels (the "push" logic) up to the assembly (product ready for marketing) or processing level (orders to partners in the supply chain). Machine workload plans are rough and workstations are allocated according to the technical specification.

An analysis of planning and shop floor control revealed a number of problems. In short- and medium-term planning:

- low level of plan integration, both vertical (management board - managers) and horizontal (supply - production),
- low level of MRPII/ERP implementation (ranked as C in ABCD checklist),
- poor planning discipline (no explicit processes).

In short-term planning and current production control the following observations were made:

- no total value stream vision,
- frequent conflicts about resources,
- chaotic „spaghetti " flow,
- waste of large batches,
- changeability of performance priorities.

The total image of the planning system shows the enterprise as an organization with poor management decisions (no holistic view), significant decision-making inertia (many management levels) and local optimization activities (production unit level), adversely affecting Work-In-Progress (WIP) and the logistics service level.

Research perspective

The aspect of decision model building (including execution procedures and flow management and control) presented below is connected with the lowest level of manufacturing system transformation. It is operations level and it completes the work concerning management system on finished products level realized before. Enterprise[2], doing business on international market has to cope with intensive and strong competition, not only within European Union, but also in the Asia. These competitive environments have to be discussed separately as they are completely different and the differences result in necessity to implement two different business models, which are difficult to combine in business practice. Enterprises doing their business in European Union have to meet numerous environmental standards and bear costs emerging from environment-friendly polices their governments develop. On the other hand, competition platform of enterprises coming from countries such as China is based on low costs, which are result not only of low payments for employees of almost all levels (cheap workforce), but also of low costs of natural environment exploitation.

The Management, because of difficulties company is facing, has decided to build the model of process management based on competitive costs and minimizing environmental impacts.

[2] The name and branch is not revealed because there is no Management permission

3 Framework of the solution developed

The first stage of the project was analysis of the factors influencing the decision model to be developed. The first factor, identified as fixed one is the existing technological system. In the first stage of production process, there are the following units identified: cores department, forming department, melting department and two casting lines. The further analysis led to the conclusion that the system should also include grinding department which is the bottleneck of the entire production system (including processes of chemical processing and final assembly, which are not discussed in the hereby chapter). After analysis of the technological aspects, connected with the enterprise, factors related with its environment should be analyzed, including dynamic market environment and relatively fixed law regulations. The relation between enterprise and natural environment should be analyzed as well, with special regard to energy and resources use and waste generation. The idea is presented in the figure below (fig. 2), which also includes the implementation stage, translating decisions made into management procedures.

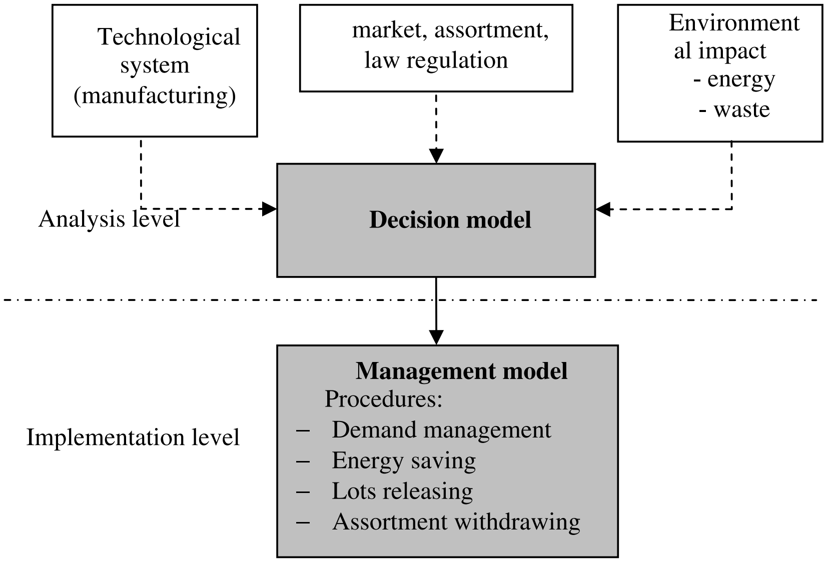


Fig 2. Business model: process efficiency – environment al impact, and its implementation

According to the Theory of Constraints, critical resources should be fully loaded [3,4] and downtime costs in their case are very high [16]. According to analysis prepared by the Authors, the main reason for downtime of critical resource (bottleneck – precise grinding department) is not a lack of jobs to complete (as the previous process has capacity higher by about 40%), but time wasted on processing faulty casts and the need to frequently set up the system because of the lot size (small batches).

Faultiness of products is a result of casting process characteristics, which for small batches, under 100 casts, is characterized with rejects level ranging from 10% up to 40%.Small batches are a consequence of various customers orders and completing lots necessary when rejects level is higher than the indicator used for lot correction in the primary release. The reasons listed above caused that grinding department had to be considered in optimization procedures for technological system.

The second aspect of analysis was (as presented in the figure 1) a market, including market demand and law regulations defining CO_2 emissions, acceptable noise level, waste management and others. Market demand influences directly on assortment to be manufactured. During research, negative influence of excessive variety of demand on efficiency of process realized has been identified. It means, wide variety of assortment makes benefiting from scale effect and production sequencing difficult.

These are the main reasons for taking demand management aspect and assortment withdrawal into consideration in optimization procedures.

The third aspect of analysis is influence on natural environment. The literature on the subject shows that casting process is not the most environment polluting one [15]. The most important aspects identified are the following: electric energy use, waste generated during casting process and regeneration of casted materials and dusting. Energy use influences natural environment not directly, but by demand on energy production, which in Poland is based on coal and charcoal. In the casting analyzed energy use is an important part of its operating costs.

After analysis and definition of the model components, the next stage of the project realized in the Enterprise was developing manufacturing process management model.

4 Details of the solution developed

The first step of the project at this stage was optimization of technological system of melting department (H1, H2), forming department (F), cores department (C), casting lines (L1, L2) and grinding department (S). The scheme of the system is presented in the figure below (fig.3).

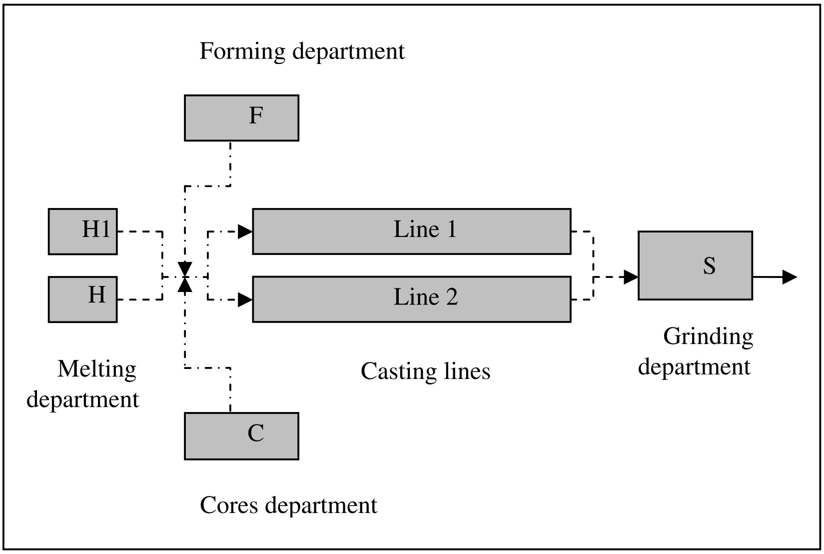


Fig 3 Analyzed elements of technological system

Analysis of the technological system, has led to the conclusion that it requires synchronization of planning and controlling. Hence, business practices used in this areas were analyzed and discussed with reference to specific processes and market condition typical for the branch the Enterprise is doing its business. The conclusion was that the most common solution is local plans optimization, which is a classic approach (plans are optimized for identified production units), though relations between plans in this case are not considered. New planning and releasing procedures were developed for month, week and day time horizon and assumed that the whole technological system is organized to limit influence of the bottlenecks identified.

There were three types of bottlenecks identified from the process efficiency point of view:

- type 1 - limiting production capacity,
- type 2 - setups sequence and lot sizing,
- type 3 – lot sizing and products type.

Type 1 bottleneck is limitation of production capacity and is located in grindery department. It was used in planning procedure applied to balance manufacturing orders.

Type 2 bottleneck is casting system (casting lines), which requires large lot sizes because of quality requirements and setups sequence connected with assortment variation. It required procedure defying setups for technological families and between them.

Type 3 bottleneck is melting department, which requires predefined lot size and metal types. Melting department requires creating relation between procedure of combining orders with responding metal types with other planning procedures.

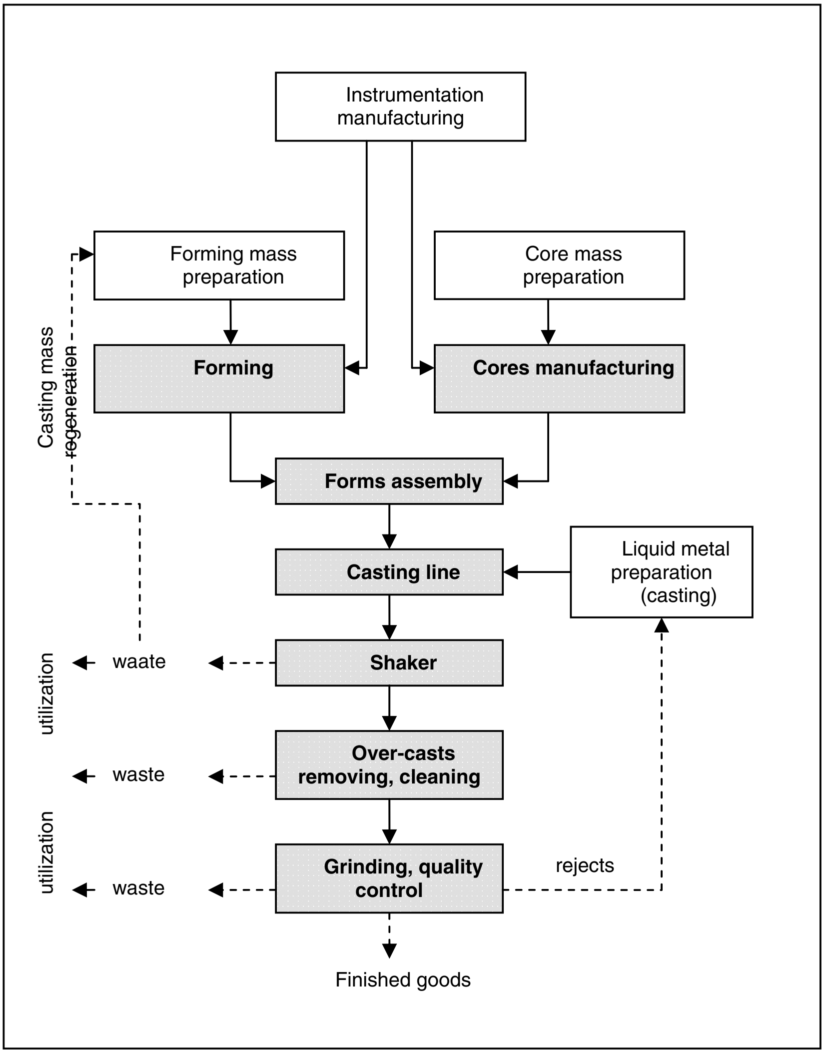


Fig 4. Scheme of production process and identification of material inputs

Source: Own study

The next step taken was analysis of developed planning procedures used for process outcomes planning. There were the following outcomes identified: finished products, waste, rejects to be re-used. Analysis proved that production lot size has the highest impact on rejects percentage. Too small lot size generates losses connected with launching and finishing the process. To stabilize percentage of rejects, casting process was supplemented with stabilizers. The minimum lot size, accepted from the quality point of view and work-in-process size was introduced.

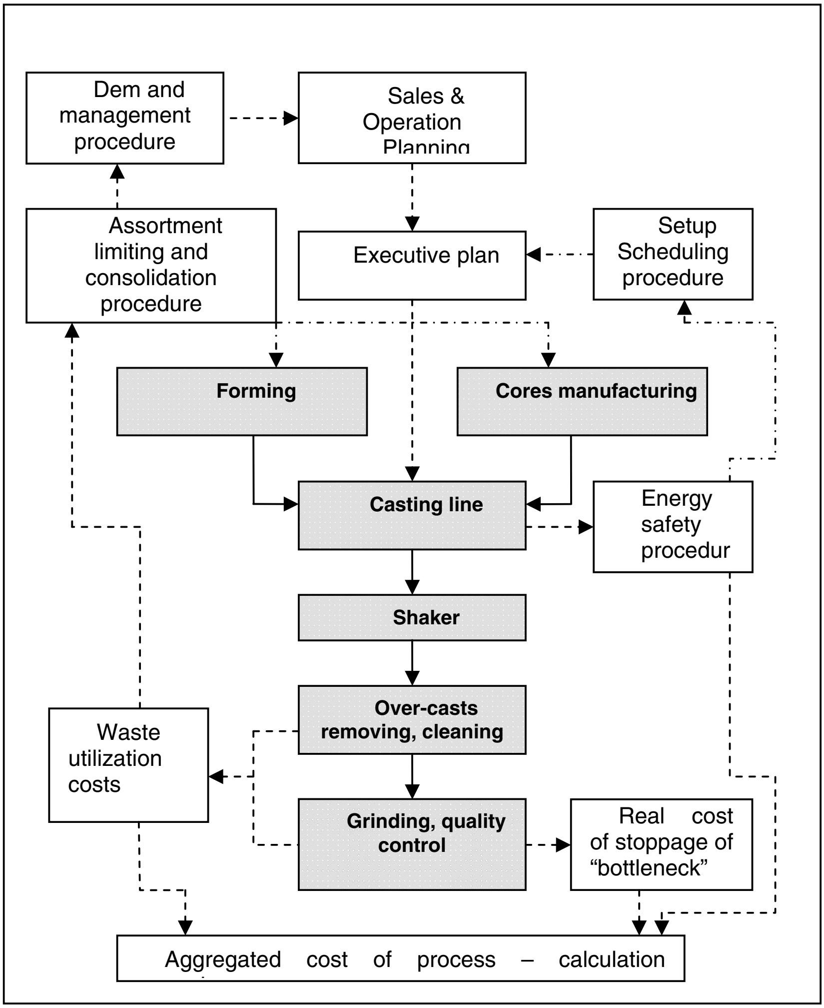


Fig 5. Process management procedures at planning and operations level

Combination of technological guidelines influencing efficiency of process and environment al impact costs was realized as a complex management system development. The system developed includes:

– level of Sales & Operation Planning, moving 18 moths time horizon,
– level of weekly manufacturing plans,
– jobs sequencing – operational level.

At the highest level, procedure of limiting assortment not meeting production size criterion and technological criterion showed to be the most important. At the level of production planning and controlling, (Executive plan), management procedure was completed with the following procedures: Setup Scheduling procedure, Energy safety procedure. Calculation of production process with reference to total costs (Aggregated cost of process – calculation procedure), was to include waste utilization costs, electric energy costs and critical resources downtime costs.

Aggregated procedure of cost calculation and environmental impact allows for assessment of both Management decisions and of operating managers, striving for decreasing environmental impact and maintaining competitiveness of market offer.

5 Conclusion and further research

The research conducted show that it is possible to achieve difficult goals such as building efficient production process management system and minimize environmental impact at the same time. Competitiveness on international market is the basic element providing success of sustainable development concept. Loss of competitiveness eliminates companies from the market and results in high social costs because of losing precious workplaces. Poor society is not interested in bearing costs of ecological policy, neither in everyday life, nor in work-life, which additionally leads to worsening ecological situation of the region or the whole country.

The case study analyzed above does not give universal solution, but detailed procedures developed (though not presented in great detail) are typical for management in the specific conditions of the analyzed Enterprise. The Authors, basing on the case analyzed want to validate the model developed and prove its efficiency in various business conditions. The complex model can be used as a tool for analysis and building solutions implementable in various business functioning in different branches.

References

[1] Berny J.S., 2008, „Ekologistyczne problemy przedsiębiorstwa", Dworecki S.E. (red.), Usprawnianie zarządzania logistyką przedsiębiorstwa, Wydawnictwo Akademii Podlaskiej, Siedlce, ss. 157 – 181
[2] Bendkowski J., Wengierek M., 2002, Logistyka Odpadów, Tom 1. Procesy logistyczne w gospodarce odpadami, Wydawnictwo Politechniki Śląskiej, Gliwice
[3] Edwarczyk N., Stachowiak A., 2009, „Koncepcja zamkniętej pętli łańcucha dostaw", [w:] Logistyka, 1, ss. 74 – 76
[4] Goldratt E., Cox J., Cel. Doskonałość w produkcji, WERBEL, Warszawa 2000.
[5] Goldratt E., Łańcuch krytyczny, WERBEL, Warszawa 2000.
[6] Grodzińska-Jurczak M., Management of industrial and municipal solid waste in Poland, Resources, Conservation and Recycling 32 (2001) 85-103
[7] Hadaś Ł., Cyplik P., Adamczak M., The theory and practice of building MRP/JIT hybrid systems - case study, Applications of information technologies in management, Poznan University of Technology, Poznan 2010

[8] Hadaś Ł., Cyplik P., Hybrid production planning system in make-to-order company – case study, LogForum 2010
[9] Karmańska A., 2007, Zarządzanie kosztami jakości, logistyki, innowacji, ochrony środowiska a rachunkowość finansowa, Wydawnictwo Difin, Warszawa
[10] Kowalski Z., 2005, „Zagrożenia środowiska naturalnego. Modele zrównoważonego rozwoju", Tabora A. (red.), Gospodarowanie odpadami i substancjami niebiezpiecznymi. Tom 1. Ustawodawstwo, składowanie odpadów, transport towarów niebezpiecznych, dokumentacja, Centrum Szkolenia i Organizacji Systemów Jakości Politechniki Krakowskiej im. Tadeusza Kościuszki, Kraków, ss. 277 – 308
[11] Kozłowska B., Manczarski P., Zabawa S., 2005, Gospodarka odpadami, w tym odpadami niebezpiecznymi. Informator, Futura Grzegorz Łuczak: na zlec. Polskiego Zrzeszenia Inżynierów i Techników Sanitarnych. Oddział Wielkopolski, Poznań
[12] Perzyk M., Waszkiewicz S. Kaczorowski M., Jopkiewicz A., Odlewnictwo, Wydawnictwo Naukowo-Techniczne, Warszawa 2000
[13] Rutkowski K., 2008, Najlepsze praktyki w zarządzaniu łańcuchen dostaw. Wyjść naprzeciw wyzwaniom społecznej odpowiedzialności biznesu, Szkoła Główna Handlowa w Warszawie, Warszawa
[14] Szołtysek J., 2009, Logistyka zwrotna, Wydawnictwo Biblioteka Logistyka, Poznań
[15] Szołtysek J., 2009, „Ewolucja logistyki zwrotnej. Odpady i sposoby ich zagospodarowywania na przestrzeni wieków oraz co z tej lekcji wynika współcześnie", [w:] Logistyka, 5, ss. 8 - 11.
[16] Woeppel M. J., Manufacturer's Guide to Implementing the Theory of Constraints, The St. Lucie Press, Boca Raton London New York Washington, D.C. 2001.

Pro-ecological solutions applied in hotels – examples

Joanna Oleskow-Szlapka[1], Agnieszka Stachowiak[1], Paulina Golinska[1]

[1] Poznan University of Technology,

joanna.oleskow-szlapka@put.poznan.pl, agnieszka.stachowiak@put.poznan.pl, paulina.golinska@put.poznan.pl

Abstract. Tourism is recognized to be the one of the world's largest industries and continues to expand at a rapid rate. Many enterprises and institutions pay attention to such issues as environment protection, corporate social responsibility (CSR) and "green" image. Solutions for sustainable development of natural environment are also developed and implemented in tourism domain. Public is increasingly concerned about environmental issues, hence green management is rapidly becoming a strategic tool that can enhance a company's competitive advantage. The most convincing indicator of consumer activation with regard to green management is the growing number of people who are willing to purchase environmentally friendly products. Along with growing concern of both enterprises and consumers about environmental issues, developing tourism, and one of its most important branches, which is the hotel industry turn to the "green" side and implement more and more environmentally friendly solutions. The chapter is to introduce world standards for environmentally friendly hotels and the solutions applied in the Polish hotel industry. The goal of the chapter is to assess solutions applied and suggest some further opportunities of going green.

Keywords: green hotels, sustainable environment, corporate social responsibility

1 Introduction

Tourism is recognized as a one of the world's largest industries and continuous to expand at a rapid rate. The hotel industry forms a large part of the tourism industry and if not managed properly, it has the potential to be detrimental to the social and natural environments within which it functions. As hotels are also resource intensive, in order to reduce their impact, it is contemporary imperative to go green and benefit from green management. Green management is defined as "the processes and practices introduced by an organization for reducing, eliminating and ideally preventing negative environmental effects arising from its undertakings" [6]. The hotel should develop green management strategies into overall development policies, including green marketing, green maintenance, green operational procedures. It should analyze its operating procedures and operational activities in terms of being

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_34,

green and develop suitable countermeasures. Nowadays all environmentally friendly hotels are those that provide tourists with the products and services in line with the full use of resources, environmental protection requirements and the hotels harmless to human body. The concept of a green hotel is well articulated by the Green Hotels Association [10], which states that "Green Hotels are environmentally friendly properties whose managers are eager to institute programs that save water, energy and reduce solid waste – while saving money – to help protect our one and only Earth!" this statement include key green management practices in the hotel industry, such as saving energy and water, managing waste and educating guests about the environment [17]. This environmental concern has translated into a movement for green management in the hotel industry that aims to mitigate the environmental effects of excessive nondurable goods consumption, energy use, water wastage and the release of pollutants into air, water and soil [15].

Table 1 The enviromental impacts of a hotel

Service/ Activity	**Description**	**Environmental Impacts**
Administration	Hotel management Reception of clients	Energy, water and materials (mainly paper) Generation of waste and hazardous waste
Technical services	Equipment for producing hot water and heating Air conditioning Lighting Swimming pools Green areas Mice and insect extermination Repairs and maintenance	Energy and water consumption Consumption and generation of a wide range of hazardous products Air and soil emissions Generation of waste water Pesticides use
Restaurant / bar	Breakfast, lunch, dinner Beverages and snacks	Energy, water and raw materials consumption Packaging waste Organic waste
Kitchen	Food conservation Food preparation Dish washing	Consumption of energy and water Packaging waste Oil waste Organic waste Generation of odors
Room use	Use by guests Products for guests' use Housekeeping	Energy, water and raw materials consumption Use of hazardous products Generation of waste packaging Generation of waste water
Laundry	Washing and ironing of guests clothes Washing and ironingn of hotel linens	Consumption of energy and water Use of hazardous cleaning products
		Generation of waste water

Source:[24]

For the growing number of tourists an important factor influencing on the choice of the hotel is the fact that it actively contributes to environmental protection. Consequently many participants of the lodging industry realize that a sustainable development rules in the strategy are necessary. On account of their specificity, hotels utilize a substantial amount of energy, water and other products [21].

It has been estimated that 75 per cent of all environmental impacts created by the hotel industry can be attributed to the excessive consumption of local and imported non-durable goods *FMCG – fast moving consumer goods*, energy and water, followed by emissions released to air, water and soil (APAT, 2002) [15].

Many greening initiatives are not expensive to implement and provide substantial benefits to the business. Unfortunately, few studies have investigated ecological initiatives within the hotel industry, including these presented in [IHEI 1993, Stabler and Goodall 1997, FEMATOUR 2000, Despretz 2001,APAT 2002, Bohdanowicz 2003].

2 Water and energy consumption – actual numbers and guidelines how to reduce them

The hotel industry is one of the most energy-intensive subsectors of the tourism industry, with about 50% of the overall energy consumption due to space conditioning.

Among commercial buildings, lodging facilities are unique with regard to operational schemes, the type of services offered, as well as the resulting patterns of natural resource consumption. Many of the services provided to hotel guests are highly resource intensive, whether it concerns energy, water or raw materials. As a consequence, hotels have been found to have the highest negative impact on the environment of all commercial buildings, with the exception of hospitals [20].

In view of the globally growing environmental degradation, the need for effective measures is being increasingly endorsed by both guests and industry. Approximately 40 percent of more than 3000 respondents to a hotel industry survey confirmed using different quantitative measures of environmental performance, including those relevant to energy use and water consumption, waste disposal, as well as volume and treatment of wastewater [23].

The majority of hotels with a significant position on market promote pro-ecological operations related with minimizing water and energy consumption, efficient waste management and the utilization of renewables as well as acquiring of diverse ecological certificates confirming a green company image.

The one factor without doubt influencing the work of hotels is an aspiration for pulling down the prime costs.

From assumption a good level of hotel staff, a high work efficiency and a proper remuneration should not depend on the increase of personal costs and all other costs.

The customer service level shall continuously grow and costs shall continuously fall down [11].

The process of constructing hotels through promotion of sustainable construction industry and renovation of buildings give many capabilities to limit a negative influences on the environment. Basic questions in this sector are economies: water, energy and material ones. They must be expanded on three different planning levels: architectural-technical planning of the building, implementation and utilization and, the enforcement. Each of above stages require different remedial measures to be prepared with reference to the environmental protection [16].

Business model of the hotel sector should take into account the new expectations of the customers but they should not be forced to bear an additional costs. Growing meaning of engagement in environmental protection is still limited by a height of additional costs that customers are willing to bear. Environmental protection programs in a hotel sector ought to offer a competitive advantage, reduce costs of working, increase the satisfaction of guests and employees as well as conduct actions in aid of expanding the brand dealing responsibly with environment protection.

According to hotel industry statistics, utilities makes up 30% of the average hotel's operating cost – a huge percentage with a major impact on the bottom line and the environment. Inefficient use of lights, heating and air conditioning is one of the major culprits in the waste of resources. The potential savings are impressive: according to one EnergyStar[1] estimate, cutting energy usage by just 10% could save nearly $300 million for the industry as a whole [1]. The table below introduced the minimum requirements of the HVAC-system for hotels. The rating enables identification of energy standards used in hotels.

Table 2. Minimum HVAC-system requirements for hotels according to World Tourism Organisation (as cited in Lawson 2001)

Hotel rating	Service provided
*	Heating or fan cooling when necessary
**	Heating or fan cooling when necessary. Central heating and comfort cooling seasonally available.
***	Heating or fan cooling when necessary. Central heating and comfort cooling seasonally available. Individual heat control in bedrooms. Temperature maintained within the range of 18-25 degree.
**** and *****	Central heating and comfort cooling available in entire premise. Individual heat and air conditioning control in all rooms. High quality equipment with very low noise emission level

Source: [3]

There are many factors that influence energy consumption in the hospitality industry. Therefore, it is very important to compare properties to facilities in similar

[1] EnergyStar program is a voluntary program for businesses. It promotes manufacturers and sellers of office equipment which is highly energetically efficient.

climates and with similar features. The following features, in particular, can have a sizable impact on the energy consumption of hospitality properties.

- Laundry – In-house or outsourced?
- Swimming pool(s) – Indoor or out? Heated or not?
- Health Club – Hours of operations? Open to the general public?
- Meals – Full dining services? Serving non-guests? 24-hour room service?
- Meeting Facilities – Number and size? Ballroom? Exhibition space?
- Central HVAC or through the wall units?
- Single rooms or suites?
- Family vacation or business guests?
- Other activities – Casino, theater, retail, etc.? [8]

To be awarded with the highest number of stars (the option most comfortable for consumers) and in the same time achieve cost efficiency reducing an energy consumption the following sequence of actions must be kept [8]:

1. Reduce an energy consumption in manufacturing processes (providing services process) till the lowest possible level
2. Optimize an efficiency of the whole hotel systems
3. Utilize a heat excess

Lighting is not always the biggest energy consumer in hospitality facilities but it is usually one of the best opportunities for reducing energy costs. And, as a bonus, most lighting upgrades also result in improved lighting quality. New lighting technologies often produce energy reductions of 40- to 80-percent and paybacks less than three years. These lighting improvements generally fall into two categories – more efficient lighting fixtures and improved lighting controls [8].

It has been estimated that seventy-five percent of hotels' environmental impacts can be directly related to excessive consumption [3]. This is wasteful in terms of resources and it creates unnecessary operational costs.

According to Gössling et. al. [9], "the average energy consumption per bed per night in hotels might be in the order of 130 Megajoules. Hotels generally use more energy per visitor than local residents, as they have energy intense facilities, such as bars, restaurants, and pools, and have more spacious rooms". Studies have determined that a hotel emits an average 20.6 kg of carbon dioxide per night.

Tourist accommodations can have large, expensive energy requirements, especially for space heating and cooling systems. However, there are many options for conserving energy. Strategies from designing for passive solar heating to something as simple as providing good insulation can help reduce or eliminate the need for costly heating and cooling. Simply changing thermostat settings can make a big difference.

Hotels worldwide are recognizing opportunities to implement energy-efficient projects in space heating and cooling systems.

Water-efficient practices use improved technologies that deliver equal or better service using less water. Water conservation encourages hotels to better manage how and when water is being used, addressing both the technical and human side of water management issues. It is estimated that by 2010, water use will increase to approximately 475 gallons per day for each room in high luxury facilities. However, in other accommodations, water use is still a cost and an important stress on the local environment [1].

In many cases water conservation can be a matter of purchasing and using the proper systems and tools. Choose products that have standardized replaceable components for the best long-term performance. Factors to include when considering water sources may include renewability, potential impacts on the environment and water supplies as well as the economic benefit. In many developing countries hotel water use may impact the water supplies of the local people.

A pro-ecological activity introduced to the hospitality facilities is the utilization of natural sources of energy. In Poland it is not very popular but this trend is strongly evolving in hotels in Germany, France.

The possible renewables are as follows:

- solar energy,
- wind energy,
- water energy,
- and in considerably smallest degree a biomass and biogas [21].

The benefits of renewables can be following [21]:

- Lack of emission of greenhouse gas
- Renewables are accessible in most places
- Technologies are reliable, check and they require minimal maintenance
- Systems do not require continuous supplying of commodities (motor oil, filters etc.)
- The costs of life cycle of wind or water energy production can be very attractive
- Some
- Cost of cycles of lives of products of winds or there can be very attractive water energy
- Some systems can be built on place
- Long die life (15-25 years)

Table 3 Typical life cycle cost of electricity generation systems in off-grid locations.

Electricity generation system	**Life cycle cost of the energy (US$ per kWh)**
Small-scale hydroelectric system	0.05 to 0.15
Wind turbine	0.04 to 0.15
Diesel generator	~0.25

Source: Pam Baldinger, Energy and Sustainable Tourism: Energy Supply and Use in Off-Grid Ecotourism Facilities, 22.02.2006, USAID EGAT/Energy Team

The hotel industry has been pursuing green practices since the 1990s due to fluctuating economic levels and a strong focus on customer service [5].

There are many green practices that hotels can implement as preventative measures to save unnecessary costs. Examples of these practices are [5]:

- Pollution prevention such as waste discharge into waterways:
- Energy consumption;
- Recycling;

- Other popular cost cutting measures for the short-, mid- and long-term include:
- Use of compact fluorescent lights - saves energy.
- Reuse of linens - saves water, detergent, energy and greenhouse gases.
- Low-flow shower systems - saves water and energy.
- Local products - save transportation costs.
- Installation of green roofs - saves energy.
- Installation of solar heaters or other renewable energy source - saves energy.

The ultimate result of these actions is a win-win situation; to reduce hotel operational costs and harmful environmental impacts.

3 Waste management in hotels

Responsible waste management is one of environmental activities the easiest to be brought into effect, where results are at once visible and generally appreciate, therefore the majority firms starts just from it.

The number of wastes is collected in guest rooms, restaurants, bars, gardens, corridors, swimming pools' vicinity, hall and the kitchen. They can be pressed immediately in the place of their generation or after transportation in a central special area. There is also possible combination of both above solutions [19].

Hotels should provide and implement the following:

- Recycling program (materials to be recycled: paper, glass, aluminum cans, cardboard and grease),
- Clearly marked recycling containers in common areas, including lobby and hotel guest Rooms, unless hotel sorts and recycles,
- Towel and sheet reuse program,
- Consumable amenities will not be replaced daily unless they are gone. Use of soap and shampoo dispensers would be optimal,
- Hotel housekeeping staff instructed to shut blinds and turn down heat / air conditioning during the day in rooms while attendees are gone
- Use of glass or china (nondisposable) catering plates, cups and glasses
- No Styrofoam used
- Condiments (including sugar, cream, butter, cream cheese etc) served in bulk containers, not individual servings
- Shade-grown coffee served at conference functions
- Sloth napkins used when possible coasters used instead of cocktail napkins
- All leftover food donated to a local food bank
- All table scraps donated to a local farm or composted and
- Use of cleaning products that do not introduce toxins into the air or water [23].

An effective action in the scope of waste management in hotels shall comprise also among others:

- mark off the areas where wastes can be limited,
- carry out a cost analysis paying special attention to the kind of packaging to be used.

- elaborate recycling programs
- reduce a number of booklets for customers, printing on recycled paper
- Use of e-mail.[2]

4 Eco-certificates

There is many eco-certificates that can be applied for lodging facilities such as Eco-friendly hotels, Ecotel, Environmental Squirrel, Grean Leaf, Green Key, Green Hotelier, Nordic Swan, EU Flower etc.

The global environmental certification program for the travel and tourism industry was developed in 1996 by three international organizations: the World Travel & Tourism Council, the World Tourism Organization and the Earth Council. These organizations jointly launched an action plan entitled “Agenda 21 for the Travel & Tourism Industry: Towards Environmentally Sustainable Development.” Subsequently, “Green Globe,” a benchmarking, certification and performance-improvement program based on the Agenda 21 principles, was created. This program identifies the environmental and developmental issues which threaten the economy and ecological balance, and presents a strategy for transition to more sustainable development practices. Hotels receive “Green Globe” certification by addressing major environmental issues in key areas including: greenhouse emissions, energy efficiency, management of freshwater resources, ecosystem conservation, and waste water and solid waste management. In addition to Green Globe and Agenda 21, the hospitality industry has an array of regional certification programs and initiatives developed by governments and private hotel companies

There are several eco-label programs around the world, and they are generally designed to promote products that reduce environmental damages during the use and disposal phases of the products. A distributed sample of such programs includes [13]:

- Japan's Eco Mark,
- Nordic Swan Eco-label,
- Korea's Environmental Labeling Association,
- India's Ecomark Scheme,
- Singapore's Green Label Scheme,
- Sweden's Good Environmental Choice,
- France's NF Environment,
- Australia's Environmental Choice,
- United States' Green Seal,
- International Organization for Standardization (ISO).

Worldwide "green labels" work to reduce environmental degradation by helping consumers make more informed choices about the products they buy. The challenges are worth facing and overcoming to help standardize the information conveyed by green labels. If green label information means the same thing around the world,

[2] Based on Majewski J., Proekologiczne rozwi zania w obiektach hotelarskich, Warszawa 1999, s. 125 oraz Kasprzak K., Ochrona rodowiska w hotelach – wybór problemów, Zeszyty naukowe Południowo-Wschodni Oddział Polskiego Towarzystwa In ynierii Ekologicznej, Rzeszów 2006, zeszyt 7, s. 42

consumers can make informed decisions regardless of where they are or where the product comes from. The lodging industry is a major consumer of resources and products. Consumption includes land, construction materials (carpet, paint and wood), fixtures and furnishings, cleaning supplies, food, and equipment (air conditioners, computers, elevators, furnaces). Then there is the daily consumption of water and power. Hotels are active 24 hours a day, seven days a week, year in and year out, using water and power throughout the day for general operations, cleaning, and guest use. With this massive ongoing use of products and resources there is a need for environmental action to preserve the environment and conserve resources for future generations.

Environmental action needs to be with purchased products and daily operations. The ideal is the products brought into the hotel operation will have been produced with environmental care, both at the source and for the guests' health. And the resources consumed daily like water, power, newspapers, and cleaning supplies, are minimized to reduce the strain on the environment. Just as consumers want to buy products according to their environmental sensitivities, they also want to buy their hotel "product" and experience according to their preferences and needs; they want to choose hotels that have an environmental awareness. There are several voluntary regional, national, and international eco-labeling programs for the hotel industry. Some of the programs are verified and others are on the honor system. Some of the certification programs include [13]:

- international standards for lodging properties to follow for certification - ISO
- lodging certification programs
  - U.S.'s Green Seal,
  - Canada's Green Key,
  - Key to Costa Rica;
- hospitality property certification
  - Europe's Green Tourism,
- U.S. building certification
  - U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED).

Environmentally Friendly Hotels is one non-certification program available to hotels. Some of certification programs apply a green rating to their members, helping consumers focus their purchasing behavior.

The more and more common policy among companies and corporations is choosing hotels which are environment-friendly. In this case the role of eco-labels is crucial, as they directly prove that hotels perform pro-ecological activities, and what is more influence positively not only ecologizing touristic facilities, but also educating both, hotel staff and tourists benefiting from services provided by the hotels [7]. Ecolabel is one of the most well-known ecological certificates. It a label introduced in 19992 in the European Union and given to the hotels according to regulations presented in the directive by the European Parliament developed in 2000.

The European Commission has taken all the necessary efforts to develop one unified and reliable eco-certificate for all the touristic facilities. In April, 2003 European Commission made the decision and published the document identifying ecological criteria for giving eco-label named European Union Flower for hospitality services in tourism [4]. One of the product lines which can be labeled with this certificate are hotel services and environmental criteria which should be considered are defined in the given Commission's decision [7]. The criteria were divided into two groups: obligatory and facultative. The last group do not have to be fully met. The criteria were defined to limit use of water, energy and waste generation and support using renewable resources and provided information and ecological education [18].

Another Eco-certificate well-known in Europe is the Swan Label – Eco-label given by the Nordic Council of Ministers.

The Nordic eco-label swan (presented in the figure 2) has been given by the Nordic Council of Ministers – an association of ministers from all the Nordic countries including: Sweden, Finland, Norway, Island an since 1997 Denmark as well. The criteria for the label are verified and updated if necessary every three years. The assumption is to adjust the criteria to the current technological level. The label meets requirements of the ISO 14024 standard –Labels and environmental declarations – Environmental labeling of the I type – Rules and procedures [4].

Swan eco-label is given only after precise analysis of the characteristics of the product to be labeled and its manufacturing process done by an independent research institute. Ecological requirements are gradually increased along with the growing technical and scientific opportunities, the level of meeting the requirements defined is checked during license period.

Fig 1 Nordic ecolabelSwan, ***Source:***
http://www.abena.pl/Default.aspx?ID=11659&M=News&NewsID=1169&pid=7343

Hotels can be also awarded with EnergyStar label (mentioned in the previous chapter). Hotels involved in the program are obliged to provide staff and resources to achieve continuous improvement in terms of environment protection. To achieve this, energetic manager is appointed and energetic group is defined to realize energetic policy. Collecting and monitoring the data is a very important step of this program as it requires developing documentation for all the energy sources. EnergyStar hotels define parameters used to measure the level of improvements. According to the research, there is about 247 hotels all over the world, including f.ex. Hilton Group, Starwood and Hyett [11].

The next eco-certificate is LEED and it proves that the hotel awarded with it is the "green" one. LEED comes from the Leadership in Energy and Environmental Design. The certifying institution in this case is the U.S. Green Building Council (USGBC), which awarded more than 400 hotels with this prestigious label.

Although some consumers see environmental labels as a sign of quality, the quality judgments made by these customers are not based uniquely on environmental attributes. Nevertheless, quality is a widely acknowledged antecedent of satisfaction (Iacobucci et al., 1995) [3].

5 Pro-ecological activities in hotels

According to the research results, about 35% of hotels worldwide benefits from programs connected with environment protection. In Poland though only few facilities realizes environmentally friendly projects and they are not complex ones, like f.ex. heating modernization, but implementations of selected solutions only [16].
One of the examples of ecological hotels in Poland is Starwood. Sheraton Hotel in Poznan was awarded internationally as one of the most ecological hotels in Europe, Africa and in the Close East. Sheraton Poznan does not only follow initiatives common for the corporation and spread all over Poland, but also it introduced two innovative projects. Together with Remondis, waste management company working in Poznan agglomeration area it implemented program of waste sorting and managing to enable guests waste segregation. What is more, the hotel cooperates with Philips Lightning Poland to benefit from energy saving lighting systems. The system used in Sheraton Poznan includes LED lighting sources (Philips Master LED[3] – presented in the photo below) and ecological lamps.
Ecological initiatives implemented by Starwood Hotels&Resorts include, among others:

- Green patrols – teams responsible for implementation of green solution in hotels,
- Segregation of hazardous waste (batteries, electronics etc.), such waste is also collected from employees,
- Recyclable materials collecting (paper, glass, plastic),
- Water saving thanks to modernization of water distribution equipment (it has been proved that water use decreased by 40% after implementation of before mentioned facilities),
- Saving energy thanks to using energy-saving lighting sources,
- Monitoring and scheduling ventilation systems with respect to demand level,
- Using environment-friendly detergents,
- Green Room program, developed to suggest guest reusing their towels and sheets.

Fig 2 Philips MasterLED used in Sheraton in Poznan
Source: http://www.philips.swiatlo.pl/MASTER_LED, derieved on. 2.06.2010

[3] Philips MASTER LED is a combination of a high quality light with low exploitation costs. Providing 45 000 hours of high quality light, Philips MASTER LED is an innovative solution providing efficient and cost effective lighting system.

Another hotel is LIM Center/Marriott in Warsaw, which modernizes its infrastructure to save energy and increase comfort of guests and become greener (more ecological). The Hotel, as well as the office building were awarded with Trane Energy Efficiency Leader Award[4]. The infrastructure improvements implemented has led to 30% electric energy use decrease, noise level decrease and greenhouse gases emissions reductions. Modernization of the HVAC system included implementation of four new cooling aggregates of high efficiency (1650hW), automatic and equipped with "free-cooling" towers. Preventive maintenance service was implemented as well.
All the improvements listed above were necessary to make the facility more ecological and energy-saving, and, what is the most important to provide the highest customer service level possible. Other benefits emerging from improvements discussed above include the guarantee of continuous work, increased energetic and operational efficiency, increased reliability and decreased greenhouse gases emission.

6 Summary

There are numerous areas for ecological improvements in the processes and services provided by hotels as they are resources consuming and have a large impact on natural environment. However, it is crucial that "greening" hotels should not decreased customer service level as efficiency and economic condition of hotels is directly connected with customer service level provided and depends customers satisfaction.

However not only achieving ecological requirements is important, but also proving the level of meeting green standards. The most reliable proof for meeting the standards is a certificate.

There are green hotel certification opportunities and benchmarking tools available to help hotels to become a green hotel. Hereunder are listed some of them[1]:

- Benchmark Hotels - This site contains a Web-based tool specifically intended to help hotels assess their environmental performance.
- International Hotel Environmental Initiative (IHEI)- The IHEI promotes improvements in the hotel industry. It provides a benchmarking tool and a has a variety of suggestions from recommended products to environmental hotel magazines. IHEI is a non-profit group founded in 1993 that now represents 11 000 hotels on five continents. It is difficult, given differences in cultures and attitudes, to develop guidelines that work for such a diverse range of accommodations, but IHEI has published hand-books, purchasing manuals and user-friendly action packs as well as Green Hotelier magazine [45].
- CERES Green Hotel Initiative- This organization provides an online best practice survey checklist. This is a great way to assess or monitor your progress in becoming a green hotel. Questions vary from water conservation

[4] The award is given to the buildings which show initiative towards improving their energetic and operational environments and actively Take action towards using ecological solutions.

and energy efficiency practices. And, like the IHEI, they provide suggestions for product purchasing and a step-by-step process in starting a green hotel.

- Green Hotel Association- The Green Hotels Association provides more information on green hotels and some general steps for greening your hotel. It also provides suggestions for less-toxic product substitutions. It provides the hotelier with an opportunity to receive a catalog on greening lodging facilities, and become a member.
- Green Leaf Program - The Hotel Association of Canada's Green Leaf Eco-Rating Program uses a 1-5 scale to help a hotel track its progress toward becoming green.

References

[1] Alexander S., Green hotels: Opportunities and resources for success, Zero Waste Alliance, September 2002, Portland, http://www.zerowaste.org/publications/GREEN_HO.PDF

[2] Application Solution - Reducing Energy Consumption in Hotels, 2008 Spinwave Systems, Inc., http://www.spinwavesystems.com/Applications/Energy%20Usage%20in%20Hotels.pdf. Retrieved on 1.06.2010

[3] Bohdanowicz, P 2006, 'Environmental Awareness and Initiatives in the Swedish and Polish Hotel Industries - Survey Results' International Journal of Hospitality Management, vol. 25, no. 4, pp. 662-668.

[4] Borkowska M., Kochmann H., Ewolucja podej cia ekologicznego w ocenie jako ci wyrobów elektronicznych, II konferencja naukowo-techniczna „Ekologia w elektronice”, 5-6.12.2002 Warszawa

[5] Claver- Cortes, E., Molina-Azorin, J.F. Pereira-Moliner, J., Lopez-Gamero, M.D. 2007, 'Environmental Strategies and Their Impact on Hotel Performance' Journal of Sustainable Tourism., vol.15, no.6, pp. 663-679.

[6] Cooper, I. (1998). Emerging issues in environmental management. In K. Alexander (Ed.), Facility management: Theory and practice (pp. 111–119). London: Spon Press.

[7] Commission Decision of 14 April 2003 establishing the ecological criteria for the award of the Community eco-label to tourist accommodation service” – 2003/287/EC

[8] Fedrizzi R. and Rogers J., Energy Efficiency Opportunities – The lodging industry, A Division of The Global Environment and Technology Foundation, June 2002,

[9] Gossling, S, Paul Peeters, Jean-Paul Ceronc, Ghislain Duboisd, Trista Pattersone and Robert B. Richardson. 2005, 'The Eco-Efficiency of Tourism.' Ecological Economics, vol. 54, no.15, pp. 417-434.

[10] Green Hotels Association. (2008). What are green hotels? Retrieved October 10, 2008, from http://www.greenhotels.com/whatare.htm.

[11] Gworys W., Kornak A.S., Szeremeta R., Jak kierowa hotelami i innymi obiektami noclegowymi, wyd. II, ‚Wy sza Szkoła Hotelarstwa i Turystyki w Cz stochowie, Cz stochowa 2003

[12] Hasek G., Energy Star for Hospitality Successfully Earning its Keep, Green Lodging News, December 2007, http://www.greenlodgingnews.com/Energy-Star-Hospitality-Successfully-Earning-its-Keep, retrieved on 4.06.2010

[13] Instytut Rynku Hotelarskiego, Biuletyn inwestycyjny, nr 04/2010, Ekologia w hotelu czy to kogo obchodzi?, http://www.irh.pl/biuletyn/04-2010, ci gni te dn. 27.05.2010

[14] Italian National Agency for the Protection of the Environment and for Technical Services. (2002). Tourist accommodation EU eco-label award scheme – Final report. Rome.

[15] Kasprzak K., Ochrona rodowiska w hotelach – wybór problemów, Południowo-Wschodni Oddział Polskiego Towarzystwa In ynierii Ekologicznej z siedzib w Rzeszowie, zeszyt 7, 2006,

[16] Kotler, P., Bowen, J., & Makens, J. (1999). Marketing for hospitality and tourism (2nd ed). UK: Prentice-Hall.; Middleton, V.T.C., & Hawkins, R. (1998). Sustainable tourism: A marketing perspective. Oxford, UK: Butterworth-Heinemann., Jin-Soo Leea, Li-Tzang (Jane) Hsub, Heesup Hanc∗ and Yunhi Kimd. Understanding how consumers view green hotels: how a hotel's Green image can influence behavioural intentions, Journal of Sustainable Tourism Vol. 18, No. 7, September 2010, 901–914

[17] Nierzwicki W., Etykietowanie rodowiskowe w hotelarstwie, Wy sza Szkoła Turystyki i Hotelarstwa w Łodzi, Turystyka i Hotelarstwo 11(2007), s.94-95

[18] Orwak, Bardziej opłacalna gospodarka odpadami dla hoteli i restauracji, www.orwak.opakowania.com.pl/pdf/ORWAK_HoReCa.pdf, retrieved on 5.06.2010

[19] Rada J., 1996: Designing and Building Eco-efficient Hotels, Green Hotelier, Magazine of the International Hotels Environmental Initiative, Issue 4, September 1996

[20] Robinot E., Giannelloni J.L., Do hotels' "green" attributes contribute to customer satisfaction?, Journal of Services Marketing 24/2 (2010) 157–169

[21] Strojny J., Odnawialne ródła energii, ELektroPlus Nr 4/2008 (13)

[22] Tyra W. H. Environmentally friendly hotels, Primedia Business Magazines and Media, July/August 2004

[23] http://www.environmentallyfriendlyhotels.com/eco-label.html

[24] Graci, S. 2009, Can Hotels Accommodate Green? Examining What Influences Environmental Commitment in the Hotel Industry, VDM Verlag, Frankfurt

Towards sustainable tourism: Utilizing E-Commerce Applications for minimizing impacts of Climate change

Masele. J.J[1]

[1]Universität Oldenburg

masele2000@yahoo.com

Abstract. The impact of climate change caused by human activities in the course of transacting business threatens tourism sector. This paper reviews literature on areas of sustainable tourism, e-commerce, and climate change with the aim of identifying how e-commerce can be used for climate change combating for sustainable tourism. Commuting and deforestation are ranked high as the cause of climate change due to production of Carbon-dioxide, and eliminating the carbon-dioxide sink respectively. The impacts are particularly more significant in developing countries with growing economies than the developed countries. That, unlike developed countries, developing nations are less reliant on fossilized fuels - accordingly they have the ability to change and adapt to this escalating concern. Firstly, because their economies are just emerging. Secondly, it appears that developing countries will be the most affected by the consequences of global warming, such as droughts and the spread of infectious diseases. This paper advocates use of web technologies and mobile technologies as a way of reducing carbon emission that would otherwise contribute to global warming. The paper, tries to establish a link between use of e-commerce and/ m-commerce technologies in carbon emissions reduction and its potential to sustainable tourism. However the paper stresses that using technology alone does not fully reduce the problem, the technology itself needs to be used in an energy conserving manner. From content analysis, the paper proposes a conceptual framework of Climate combating through e-commerce for sustainable tourism which further studies may follow in implementing use of e-commerce for sustainable tourism development.

Keywords: e-commerce, sustainable tourism, climate change

1 Introduction

1.1 Background information

Tourism has been acknowledged to have a high potential for growth in the economy [21]. The major benefit of tourism for a region or country is economic as it provides an opportunity for job creation and generation of revenue at international, national, and local level. The money resulting from tourism comes into urban and rural areas which in turn stimulates new business enterprises and promotes a more positive

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_35,

image in an area. Jobs generated by Travel & Tourism are spread across the economy - in retail, construction, manufacturing and telecommunications, as well as directly in Travel & Tourism companies. These jobs employ a large proportion of women, minorities and young people; are predominantly in small and medium sized companies; and offer good training and transferability. Tourism can also be one of the most effective drivers for the development of regional economies. These patterns apply to both developed and emerging economies.

Tourism sector is significant in many poor countries and is already affecting the livelihoods of millions of poor people, positively. In developing countries, for example, it offers huge opportunities to increase incomes from the growing number of arrivals that land their destinations. It is growing rapidly and is the most significant source of foreign exchange after petroleum [38]. Characteristically, tourism makes growth potentially pro-poor, being a diverse industry, which increases the scope for wide participation; the customer comes for the product, providing important opportunities for linkages (e.g., souvenir sales); and it is highly dependent on natural capital (wildlife, scenery) and culture, assets that some of the poor have in abundance. Unlike their counterparts in developed countries, rural majority of developing countries are often rich in natural assets, scenery, climate, culture, and wildlife that can form the basis for appropriate tourism enterprises capable of sustaining local livelihoods and lifestyles as well as generating alternate sources of income that ease the pressure on the natural environment. Such assets lend themselves to the development of local tourism and can be exploited for poverty alleviation. Moreover, tourism can be more labor intensive than manufacturing; and a higher proportion of benefits (jobs, trade opportunities) go to women and youth [26 ; 34; 32]

Comparatively, tourism has a comparative advantage in that its start up and running costs can be low compared to many other forms of industry development. It is also often one of the few realistic options for development in many areas. What makes tourism special is that, many of these different products and services are often supplied by different operators: usually small or medium sized businesses in local ownership. This makes tourism a highly fragmented and diverse industry and so coordinated, industry-wide action is difficult to achieve. The influence of Travel & Tourism's demand also extends far beyond traditional tourism companies, into upstream suppliers like aircraft manufacturers or food producers and into the downstream service providers for travelers, like retail shops [40].

Despite the fact that tourism sector is a potential sector to the economy of any given country, worries exist that its future may not be sustainable. Climate change probably constitutes the greatest contemporary environmental challenge to tourism sector. The adventure tourism industry in particular, with its reliance on natural resources and its multitude of businesses offering trips in extreme environments – polar, marine, mountain, tropical - is experiencing the effects of climate change well before many mainstream tourism businesses, and as a result is facing policy and business development challenges sooner. There is substantial evidence that, human activities requiring commuting and tree cutting are the main causes of these changes producing carbon dioxide which in turn are highly responsible to global warming.

There are a number of initiatives in place to improve the environmental management of Travel & Tourism businesses towards reducing emission of green house gases (GHG). Such initiatives as cruise liners practicing marine conservation, hotels implementing energy consumption and waste disposal programs, and investing in increasingly fuel efficient fleets though likely, have little impact to GHG emissions. Although, it is often thought that using bio-fuels rather than fossilized fuels would reduce carbon emissions, however, using bio-fuels could have an unexpected side effect, where staple foods could become unaffordable and in developing countries this could lead to mass starvation [23]. This means, reducing the number of commuters' activities is one of the best ways of reducing the level of carbon emissions and hence, climate change. The use of e-commerce applications has recently being thought as a means of conducting business without actually commuting [28] hence reducing the number of commuters on the road. Efficient use in E-commerce, would not only minimize commuting, but also eliminate necessity for paper works hence reducing cutting trees for paper making. However, literature shows limited studies that looked into the links between e-commerce use, climate change effects minimization and sustainable tourism. This paper, reviews literature on the three aspects and proposes a model that can be used for more understanding of the *nexus between e-commerce use, climate change combating and sustainable tourism.*

1.2 Objectives of the paper

This chapter reviews literature on areas of sustainable tourism, e-commerce, and climate change with the aim of identifying how e-commerce can be used for climate change combating for sustainable tourism. From content analysis, the paper will propose a conceptual framework of Climate combating through e-commerce for sustainable tourism.

1.3 Definition of key terms

1.3.1 Tourism

According to Mathieson and Wall [43] tourism is defined as "the temporary movement of people to destinations outside their normal places of work and residence, the activities undertaken during their stay in those destinations, and the facilities created to cater to their needs". Macintosh and Goeldner [42], consider tourism as "the sum of the phenomena and relationships arising from the interaction of tourists, business suppliers, host governments and host communities in the process of attracting and hosting these tourists and other visitors". The dimensions of tourism may include: 1. attractions (e.g., natural resources, culture, ethnicity, entertainment, and high adventure), 2. facilities (lodging, support services, and other necessary infrastructure), transportation (time and money required), and hospitality. Thus, Tourism product is not produced by a single business, nonprofit organization, or governmental agency; rather, it is defined as "a satisfying visitor experience." This definition encompasses every activity and experience that a tourist encounters during his or her entire trip away from home.

1.3.2 Sustainable tourism

Chris Butters [5], broadly defines, sustainability as a positive social and economic development on a long-term basis within the framework of the carrying capacity of the earth's ecosystem." Sustainable tourism is that tourism that is committed to making a low impact on the environment and local culture, while helping to generate future employment for local people. The aim of sustainable tourism is to ensure that development brings a positive experience for the local people, tourism companies and the tourists themselves.

1.3.3 Climate change

The United Nations Framework Convention on Climate Change (1992) defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." The Intergovernmental Panel on Climate Change (IPCC), [15] defines climate change as the impact of an ever warmer planet brought by increased levels of greenhouse gases such as carbon dioxide, methane and nitrous oxide that are trapped in the atmosphere. In the latter sense climate change is synonymous with global warming.

Climate change is a normal part of the Earth's natural variability, which is related to interactions among the atmosphere, ocean, and land, as well as changes in the amount of solar radiation reaching the earth. The Climate change may be limited to a specific region, or may occur across the whole Earth.

1.3.4 E-commerce

The Pan Africa E-commerce Initiative (2001) defines e-commerce as doing business electronically. This study uses the term to mean many diverse activities including electronic trading of goods and services, online delivery of digital content, electronic funds transfer, electronic share trading, electronic bills of lading, commercial auctions, online sourcing, public procurement, direct consumer marketing, and after-sales services.

E-commerce also covers internal processes such as production, inventory management, product development, risk management, finance, knowledge management, and human resources.

2 Factors for destination selection

The attractiveness of a given tourist destination implies the state of the physical environment, thus the variety of activities and the resultant cognition [7]. Most tourism products and destinations are connected to certain physical and environmental factors therefore any changes in these may lead to a decrease in the popularity of and the demand for the given product as well as maintaining the quality of the product may be a special challenge for the tourism sector [44]. Climate and local natural conditions are significant factors in the choice of many visiting destinations are expected to affect the choice of destinations and where expenditures will occur. This means climate change, and the implications these changes have for destinations will have significant economic impacts in the coming years. Natural environments such as snow- and glacier capped mountains, coastal and island environments, beaches, forests, rivers, lakes, deserts and many other beautiful landscapes are already experiencing the impact of climatic changes in varying degrees.

3 The causes of climate change and/global warming

Although scientists divide the causes of climate change into natural and human causes, it has been demonstrated beyond reasonable doubts that the climate changes occurring today have been speeded up by man's activities [39;45]. The Royal Society [45] adds that, there is strong evidence that the warming of the Earth over the last half-century has been caused largely by human activity, such as the burning of fossil fuels and changes in land use, including agriculture and deforestation."

Carbon dioxide is undoubtedly, the most important greenhouse gas in the atmosphere [45], [10; 11; 35; 19]. Changes in land use pattern, deforestation, land clearing, agriculture, and other activities have all led to a rise in the emission of carbon dioxide. Others gases are methane, water vapor, and Nitrous oxide, though in a relatively small rates. Gases in the atmosphere behave like the glass on a greenhouse, allowing sunlight to enter, but blocking heat from escaping. Long-lived gases, remaining semi-permanently in the atmosphere, which do not respond physically or chemically to changes in temperature, are described as "forcing" climate change whereas gases, such as water, which respond physically or chemically to changes in temperature are seen as "feedbacks."The net result of this process and the re-emission of long-wave back to the Earth's surface increase the quantity of heat energy in the Earth's climatic system.

Carbon dioxide (CO_2) is the most important greenhouse gas, accounting for an estimated 60% of the warming caused by emissions of greenhouse gas emissions [34]. The UK Government (2001) noted manmade causes as the main contributors of climate change categorizing into: 4% of carbon emissions come from industrial processes; 7% come from agriculture – for example methane emissions from livestock and manure, and nitrous oxide emissions from chemical fertilizers; 21% carbon emissions from transport; and 65% come from the use of fuel to generate energy (excluding transport)

Boko, et al., [4] asserts that the biggest sources of emissions for most people are likely to be: energy use in the home causing deforestation (the main use is heating); driving cars; and air travel travels. Besides, he (ibid) noted that there are other small elements of people's homes that contribute to climate change indirectly. Everything from furniture and papers to computers; from clothes to carpets; all use energy when it is produced and transported causing carbon emissions to be released. People burn fossil fuels to create energy, which is used for many things including: heating homes and buildings; growing, transporting and cooking food; travelling (for example, by car, plane, bus and train); treating water to make it drinkable, heating it and piping it into homes; manufacturing, using and transporting products, from clothes to fridges, from plastic bags to batteries

To this extent, over the past three centuries, the concentration of carbon dioxide has been increasing in the Earth's atmosphere [22]. According to Neftel et al [22] there has been increase in carbon dioxide from 280 parts per million from the early 1700s, to 380 parts per million in 2005(See also figure 2). Most computer climate models suggest that the globe will warm up by 1.5 - 4.5° Celsius if carbon dioxide reaches the predicted level of 600 parts per million by the year 2005.

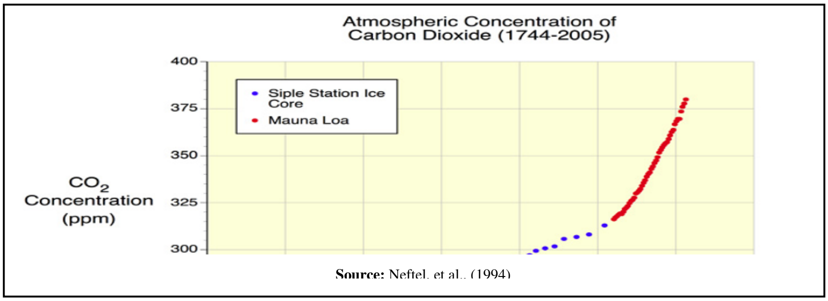


Fig 1. Atmospheric cincentraton of Carbon – dioxide (1744-2005)

4 How climate change affects tourism?

There are four complicated interactions between tourism development and climate change, ranging from natural, external phenomena to those resulting from human behaviors [10; 11]. Climate change is likely to impact disproportionately upon the poorest countries and the poorest persons within all countries, exacerbating inequities in health status and access to adequate food, clean water and other resources. Impacts can be being worse in many areas that are already flood and drought prone. The impacts include: (1) Direct impact from weather phenomena caused by warming: destruction wrought by floods, storms, fires and drought, glacial lake overflows, the disappearance of beaches and so on; (2) Indirect, long-term impacts resulting from a substantial and lasting alteration of the environment of a tourist destination that reduces its attractiveness (polluted waters, receding forests, decreased biodiversity, retreating glaciers and snow caps, etc.); (3) Lifestyle changes, causing, for example, the reorientation of tourism flows both in winter and summer; and, (4) Induced impacts, which include the efforts of individuals and public policies aimed at attenuating the effects of warming that produce a series of consequences for tourism activity: for example, the adoption of new, more energy-efficient technologies, increased transport costs, product-diversification efforts aimed at prolonging a season and reducing vulnerability, etc.

For example, what the IPCC 4th Assessment Report [14] found in Tanzania (one of the touristic country in East Africa and where the author comes from) and documented by WWF [37], found a number of effects that climate change may in long run affect tourism sector:

- Kilimanjaro glaciers and snow cover have been retreating 55% of glacier loss between 1962 and 2000. Debate over past and current climate change and ice cap coverage, however, persists. Over the 20th century, the spatial extent of Kilimanjaro's ice fields has decreased by 80%. It is suggested by some, that if current climatological conditions persist, the remaining ice fields are likely to disappear between 2015 and 2020 (for the first time in 11 000 years)
- Along with warming surface waters, deep water temperatures (which reflect long-term trends) of the large East African lakes (Victoria, Malawi) have warmed by 0.2 to 0.7°C since the early 1900s.
- The 1997-1998 coral bleaching observed in the Indian Ocean and Red Sea was coupled to a strong El Niño / Southern Oscillation -ENSO (an indication of the potential impact of climate-change induced ocean warming on coral reefs). In the western Indian Ocean region, a 30% loss of corals reduced tourism in Mombasa and Zanzibar and resulted in financial losses of about US$ 12-18 million.
- Mangroves and coral reefs, the main coastal ecosystems in Africa, will likely be affected by climate change. Endangered species associated with these ecosystems, including manatees and marine turtles, could also be at risk, along with migratory birds.

On top of that, a four 4-days workshop on Sustainable Tourism Peer Exchange held in February 2009, in Dar es Salaam-Tanzania on Climate change, anticipated a number of climate change impacts in coastal regions of Tanzania. They included: higher rainfall, stronger storms, larger waves, and rising sea levels that may lead to erosion, salt water intrusion and declining rice paddy yields. All these changes are expected to obstruct destination physical environment, activities therein and the resultant cognition hence affecting the choice of destinations and where expenditures will occur affecting future development of tourism. A need for urgency efficient and sustainable mechanism thus becomes urgent and essential.

5 Ways towards combat climate change

There have been a number of moves towards counteracting climate changes and effects to the tourism sector. One the most important ones is the Davos Declaration of 2007 on Climate Change and Tourism, which set the goals among others to reduce these emissions to enable the sector to grow in a sustainable manner through the adoption of carbon-neutral strategies. Among others they laid strategies, policies and action plans to reduce GHG emissions in the transport, clerical, accommodation and related tourism activities. There was encouragement on customers/tourists to opt for environmentally-friendly activities that reduce their carbon footprint as well as contribute to the preservation of the natural environment and cultural heritage in their choices of activities before and at the destination.

According to the declaration, individuals and organizations are argued to reduce their carbon footprint including switching appliances off standby or walking short journeys instead of using the car, and reducing paper work use in various business transactions (called e-commerce).

6 The role of e-commerce in combating climate change for sustainable tourism

Commuting is responsible for about 25% of carbon-dioxide emissions [41]. Although it is often thought that using bio-fuels rather than fossilized fuels would reduce carbon emissions, using biofuels could have an unexpected side effect, where staple food could become unaffordable. In Tanzania and South Africa for example, it is anticipated that a poorly considered biofuel development path could bypass smallholders and severely compromise the food security of the poor. Biofuels can impact on food security through triggering increases in the food prices [29] leading to mass starvation [23]. The World Wide Fund for Nature Tanzania Programme Office [36] reports emphasizes that until more is known about the relationship between biofuels and food security and production within Tanzania increases, the potential consequences remain uncertain. E-commerce thus remains the only rational alternative for reducing level of carbon emissions as it minimizes need for long and frequent commuting. E-commerce and e-business -used interchangeably for this case remains the means of conducting business without actually commuting [23].

E-commerce as it was defined in the preceding section refers to the digital enablement of transactions and processes within a firm. It may include keeping the workforce informed of new issues, managing customer information online, keeping track of projects, managing sick and vacation days, placing orders, and many other business tasks. In order to be able to explain how e-commerce can minimize the effects that could be caused by climate change to the tourism industry, business activities are categorized into two: that is ‘tourism related activities’ and ‘non tourism related activities’.

The tourism related activities as per value chain presented in figure 2.

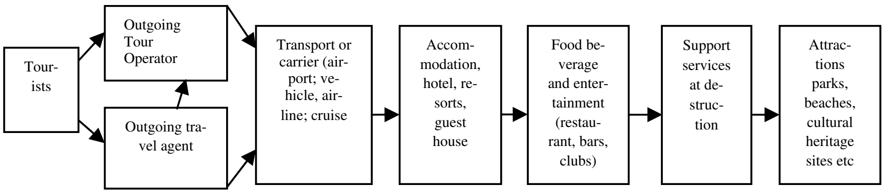


Fig 2. Tourism value chain, *Source: [40]*

From figure2 as narrated by Kamuzora [40], customers or tourists can purchase tourism product with or without the help of tour operators or outbound travel agents (package travel) or arrange it themselves (individual travel). Incoming travel agents can be used to make transfer arrangements from/to the airport (minicab, minibus, train station, harbor, etc.), to/from the hotel, and for daily excursions and other activities at the destination. Transportation (airline, train, etc.) between hotel and destination is also an important part of the tourism value chain. There may require pre-delivery support activities such as handling visa requirements, giving detailed information about the destination and any other things that the consumer may need to know before departure. Post-delivery support customers departure to his/her home country.

From the chain, we can below see that e-commerce is applied in most tourism activities. E-commerce will not only enhance and simplify the process, but also minimizes commuting and use of paper works- processes which would emit tons of GHGs. For example, (1) in destination selection; e-commerce through the web provides option which customers can browse to multiple sites from different countries and destinations before reaching a judgment of where to visit. Regarding the ubiquitous nature of e-commerce this can be done at 24/7/365 anywhere - in office, home or internet café provided that there is internet connection. (2)Bookings can be simply done through the web offering tourists options to book bus, train or air ticket online. This saves a quantifiable amount of gases that could have been emitted in the process of buying this ticket. (3) Payments are also possible electronically through credit card, debit card and/or bank transfer. (4) Pre-delivery support activities including handling visa requirements, detailed information about destination and many others, a tourist may be required to present before departure can all be done electronically, through scanning and electronically sending documents by email or fax. (5) Transfer arrangements from/to the airport using minicab, minibus, train station, harbor etc. to/from the hotel and daily excursion and other activities at the destination. All these can be electronically conducted to minimize commuting and use of paper works.

The non tourism related activities may include all day to day organizational and /or individual activities apart from tourism business operations which contribute to green house gases emission. They may include: (1) Interaction using emails which are poster systems whereby everybody sending it electronically, leading to air, cooling long routes. These could otherwise require long route physical delivery of letters and documents from one place/ country/ continent to another, a process that could lead to a quantifiable amount of gases emitted. (2) Building contracts for business, jobs, and tender could require documents which without e-commerce would require delivery over long drives/travels. (3) Conferencing where members from different parts come together could instead be conducted through the so called 'teleconferencing' hence minimizing long car or train or air travels. (4) Window-shopping and brochure requirements are simplified through e-commerce which is not only convenient to a customer, but also enables a customer to choose the best from multiple providers. (5) Communication with the organization-using intranet, extranet and/or internet hence saving cost of not only papers but also printing and photocopying costs. (6) Invoicing can as well be done electronically, hence saving greenhouse gases emissions, and; (7) Payments-done electronically using credit cards, debits cards, and bank transfer arrangement.

It has been estimated that 209 million tons of CO_2 could be saved through Business-to- Consumer e-commerce [31]. Initiatives like e-Commerce, e-Government could have a significant impact on reducing Green House Gas (GHG) emissions through the dematerialisation of public service delivery - particularly in countries where government constitutes a large share of the overall economy" For example, many paper-based services can be moved into the digital environment and situations where face-to-face interaction has been previously required (e.g. to prove identity) can be done electronically.

Businesses can engage in telecommuting programs to Reduce carbon footprint and Improve Staff Morale. According to Wikipedia (2010), telecommuting or telework is a work arrangement in which employees enjoy flexibility in working location and hours. In other words, the daily commute to a central place of work is replaced by telecommunication links. Human resources are another area where businesses can reduce their carbon footprint. Employees can connect to the organization's computer network and works from home rather than coming into the office, hence reducing the pollution from employee commutes and decrease the energy used by the business. Nonetheless, telecommuting programs can also increase staff morale as they allow a greater flexibility in work practices.

Instead of arranging conferences and conventions, the environmentally sustainable option is to utilize the technology provided by Web 2.0 and hold video and web conferences. Using internet based technology enables businesses to have all the advantages of face to face communication without the carbon load of air or vehicle travel.
Introduce ICT Services that reduce climate change impact such as Flexi-working and conferencing. This can stimulate flexible working through broadband access and wireless communications. For example as Andriessen, [1] posits, that if 10% of the EU 25 workforce were to become flexi-workers, this could save 22.17 million tonnes of CO_2 a year. Web-based video and teleconferencing capabilities can help to reduce the greenhouse gas emissions by replacing business travel and daily commutes with Voice over IP (VoIP) services. If 20% of business travel in the EU 25 was replaced by video conferencing, this would save 22.3 million tonnes of CO_2.

Wikipedia (2008) cited in Mpogole (n.d) reports that over 8 million Tanzanians own a mobile phone with a penetration rate of about 21 per cent. A recent study in 2010 commissioned by Vodafone indicates that mobile phone use in Africa is growing faster than anywhere else in the World, and that 97% of people surveyed in Tanzania said they could access a mobile phone, while just 28% could access a land line phone. Asian countries have the highest mobile phone penetration of developing nations, helped by their proximity to Japan and South Korea and the fact that many mobile factories are located there. The telecommunications companies prefer mobile technology because there are fewer infrastructures to install, so in many cases citizens can afford mobiles when they can't afford (or get) land lines.

Moreover, the arrival of mobile banking and [1]M-pesa in Tanzania and Kena and South Africa is currently done using Short Message Service (SMS). Unlike fixed line internet access, these wireless mobile devices are ubiquitous, affordable, and portable and have location awareness [16]. Online media, e-Commerce, e-Paper, telecommuting replacing face-to-face meetings – could play a substantial role in reducing emissions. Teleconferencing and videoconferencing could replace between 5 and 20% of global business travel. Advanced videoconferencing applications in the early stage of adoption could have a very significant impact in highly distributed service industry environments in both the private and public sectors.

Besides, moving to a paperless society would greatly reduce deforestation and the consequential delivery that would mean CO_2 emissions. On this fact, there are several ways in which digital transfer of information could be useful. Typically billing and advertising are paper-based where marketers has to physically hand out paper flyers. This can be avoided using blue tooth technologies and web technologies. Pedayachee [23] emphasizes that billing statements can be sent via SMS or emails. Moreover, aero-plane booking can be purely 'ticket less', operate by sending tickets via e-mails

[1] M-PESA is a branchless banking service, meaning that it is designed to enable users to complete basic banking transactions without the need to visit a bank branch. 'Pesa' is a Swahili word meaning money.

to customers avoiding not only cost of printing tickets but also the GHGs that could be emitted. In turn this reduces costs of operations but at the same time saves customers as well no longer have to pay for the operating costs of businesses. To this extent the commuting distance are shortened from supplier to the final customer. Expensive packaging could be used and and reused by the service provider.

7 Utilizing E-commerce and Mobile Technologies More Efficiently

It should however be noted that, e-commerce will only rationally assist combating climate change for sustainable tourism if the technologies to be used are actually relatively energy efficient [28]. For example, although computers and associated technologies are advocated, they use energy too. They should actually be used efficiently. This paper presents good news for users if the following are taken into consideration: Rosenfeld and Herrman [25] found that using 'average PC and monitor with at most 150 watts of power dips to 50 watts or less in energy-saving modes. They (ibid) noted that although, printers and peripherals tend to be spread over a great many users do not increase this average very much. Low energy users Laptop computers with at most 30 watts should be advocated. Besides, more energy-efficient Laptop computers are coming up every year because of steady improvements in technology driven in part by the growing market for portable equipment (and by the IT sector's desire to reduce its environmental impact)' [25].

Since the use of technology does have a cumulative negative impact on the environment more energy efficient and more recyclable products including hand held cellphone operators-a process known as "green" computer design [12] should be advocated. "Energy Star" computers and monitors can be programmed to automatically "power down" to a low power state when they are not being used [6]. To this extent, user training is also encouraged on basic issues relating to computer use such as turning off computers when they are not in use.

Colorado [6] further comments that waste products produced through e-commerce need to be recycled to further protect the environment. For example, printer toner and ink jet cartridges and batteries could be reused. Instead of tossing these in the garbage, they can be recycled, saving resources and reducing pollution and solid waste.

Taking into account of the above named consideration, considerable amount of saving can be realized with using e-commerce hence avoiding endangering the tourism natural resources and attractions a thing that could in long-term deny the community from the benefits that could be reaped if GHG emission were avoided.

8 Conceptual framework

This chapter comes up with a conceptual model (figure 3) for E-commerce for Climate Change Avoidance for Sustainable Tourism Development.

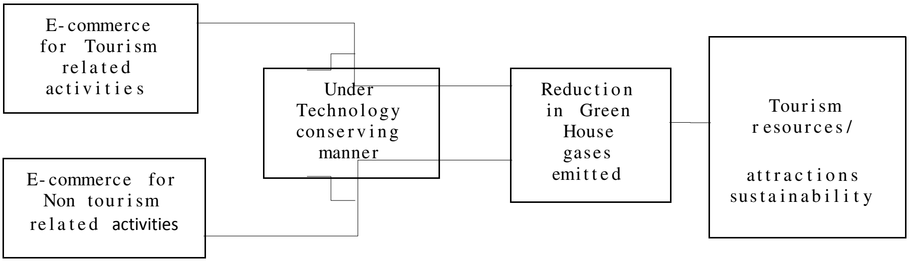


Fig.3. E-commerce for Climate Change avoidance for sustainable tourism development, *Source: Author' Literature review*

From the model, it is hypothesized that if e-commerce is efficiently used in both tourism and non-tourism related activities will offer a considerable amount of savings in GHG emission. This in turn will positively bring to sustainable tourism development.

9 Conclusion

It should be stressed that, sustainability of tourism business depends very well on how users can balance profit against reducing carbon emissions by embracing strategies for reducing its cause. As more organisations go online there is the potential to share business strategies and resources and thereby further increasing the incentive to go online. Developing countries in which tourism sector is actually offering them comparative advantage are argued by this paper to advocate the use of e-commerce and M-commerce to reap not only the competitive advantages accrued from e-commerce but also those relating to diminishing the effect of global warming resulting from climate change. Although, obstacles like speed of internet connection, power reliance and bandwidth problems, still show up, promising trend to e-commerce and m-commerce in most developing countries is manifested by the literature. Speed of Internet access and more specifically lack of affordable access to broadband problems, there are getting narrower day after day. Nonetheless, with wireless protocol the gap of the digital divide is getting lesser and lesser. However, there must be close public-private partnership cooperation. This means governments have to prepare conducive environments for e-commerce usage to be optimized for sustainable tourism development.

References

[1] AndriessenLess,. J.H. Erik (2007). Less mobile, more virtual: Learning remote communication to save costs and the climate. Talk & Vision-www.videoconference.nl

[2] AnnRowe, John D Smith and Borein, Fiona (2002). Travel and Tourism. Cambridge University Press

[3] Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tenn. U.S.A. and Keeling, C.D. and T.P. Whorf. 2006. Atmospheric CO_2 records from sites in the SIO air sampling network. In Trends: A Compendium of Da-

ta on Global Change. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A.).

[4] Boko, M. et al., (2007): Africa. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge UK, 433-467

[5] Chris Butters (2010) GAIA International Sustainable Planning and Architecture Energy Planning and Sustainable Development: The issues of climate and energy can pose a threatto cultural heritage. But what is real sustainability ? KULTURAS MANTOJUMS - MUSDIENU IZAICINAJUMSRiga, Ceturtdiena 9.sept 2010

[6] Colorado(Boulder). T.U.o., The Green Computing. Guide http://ecenter.colorado.edu/energy/projects/green_computing.html. Last, Accessed 1 August 2007.

[7] Dávid, L., Baros, Z., Szilágyi, Zs. (2006) Dimensions and environmental problems of sport tourism (in Hungarian). Tájökológiai Lapok, Vol. 4, No.2, pp.395-405

[8] de Silva, H. & Zainudeen, A. (2007) Poverty Reduction through Telecom Access at the Bottom of the Pyramid. Centre for Poverty Analysis Annual Symposium on Poverty Research in Sri Lanka, Colombo, December 6 -7

[9] Donald Mitchell (2010) Biofuels in Africa: Opportunities, Prospects, and Challenges

[10] Garnaut, R. (2008a) Garnaut Climate Change Review: Synopsis of Key Points. Australian Government.

[11] Garnaut, R. (2008b) The Garnaut Climate Change Review, Final Report. Commonwealth of Australia. www.garnautreview.org.au/index.htm, accessed in December 2008.

[12] Goldberg, L. (1998). The Advent of Green Computer Design. Computer.31(9): 16-19.

[13] Goldstruck Report, Online Retail in South Africa 2006 - Broadband and experience the keys to online retail, http://www.theworx.biz/retail06.htm, Last Accessed 1 August 2007. 2006.

[14] Intergovernmental Panel on Climate Change (2001). Climate Change 2001. Synthesis report. Cambridge University Press. Cambridge.

[15] Intergovernmental Panel on Climate Change twenty-FIFTH SESSION Agenda Mauritius, 26-28 April 2006 Concerning new IPCC emission scenarios) IPCC-XXV/INF. 25.IV.2006)

[16] Kurkovsky, S. and Harihar, k (20069. Using ubiquitous computing in interative mobile marketing. Persojal and Ubiquitous Computing. Vol 10(4) 227-240.

[17] Lean, Judith (2010) "Cycles and trends in solar irradiance and climate," Wiley Interdisciplinary Reviews: Climate Change, vol. 1, January/February 2010, 111-122.

[18] Lockwood, Mike (2009) "Solar Change and Climate: an update in the light of the current exceptional solar minimum," Proceedings of the Royal Society A, 2 December 2009.

[19] Metz, Bert, et al, eds., Climate Change 2001: Mitigation: Contribution of Working Group III to the third assessment report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press, 2001. SL QC 981.8 C5 C511343 2001.

[20] Mpogole, Hosea; Usanga, Hidaya and Tedre, Matti (n.d) Mobile Phones and Poverty Alleviation: A Survey Study in Rural Tanzania

[21] Naude, W., and Saayman, A. (2005). The determinants of tourism arrivals in Africa: apanel data regression analysis. Tourism Economics, 11(3), 365-391.

[22] Neftel, A., H. Friedli, E. Moore, H. Lotscher, H. Oeschger, U. Siegenthaler, and B. Stauffer. 1994. Historical carbon dioxide record from the Siple Station ice core. pp. 11-14. In T.A. Boden, D.P. Kaiser, R.J. Sepanski, and F.W. Stoss (eds.) Trends'93: A Compendium of Data on Global Change. ORNL/CDIAC-65.

[23] Padayachee, Keshnee (2008) Utilizing E-Commerce and M-Commerce Applications to Address the Effect of Global Warming. E-leader, Krakow.
[24] PLUS Peer Exchanges (2009). Sustainable Tourism: Coastal Management, Climate Change. Dar es Salaam, Tanzania February 2009
[25] Romm, J; Rosenfeld, A; and Herrman, S(1999). The Internet e-conomy and Global Warming, in a Scenario of the Impact of E-commerce on Energy and the Environement. Annandale, V.A: The center for Energy and Climate Solutions.
[26] Rose, J. (1998). Multipurpose Community Telecentres as support for population and development policies. Paper presented at ICPD Advocacy in the Global Information and Knowledge Management Age: creating a New Culture, UNFPA, Ankara, 1–4 December 1998.
[27] Samuel, J., Shah, N., & Hadingham, W. (2005). Mobile Communications in South Africa, Tanzania and Egypt. Intermedia, 33(3), 32-42
[28] Siikavirta, Hanne e al, 2003 Effects of E-Commerce on Greenhouse Gas Emissions: A Case Study of Grocery Home Delivery in Finland Reprinted with permission from Journal of Industrial Ecology 6, No. 2, pages 83-97. MIT Press, Helsinki.
[29] Sosovele, Hussein (2010), Policy Challenges Related to Biofuel Development in Tanzania,´in: Africa Spectrum, 45, 1, 117-129.
[30] Sustainable tourism CRC (15th December 2008). The Impact of Climate Change on Australian Tourism Destinations – Developing adaptation and response strategies.
[31] The association of European Telecoms Network Operators and the World Wildlife Fund (2005). Saving the climate at the speed of light: ICT for CO2 reductions, May 2005
[32] Whyte, A. (1998). Telecentres Research Framework for Acacia. IDRC study/Acacia Initiative, June 1998.
[33] TOURISMOS: AN INTERNATIONAL MULTIDISCIPLINARY JOURNAL OF TOURISMVolume 2, Number 2, Autumn 2007, pp. 141-152
[34] UNESCO (2001). Public service Applications of the Internet in Developing Countries, Paris. UNWTO and UNEP and WMO (2008), Climate Change and Tourism: Responding to Global Challenges, (prepared by Scott, D., Amelung, B., Becken, S., Ceron, JP., Dubois, G., Gössling, S., Peeters, P. and Simpson, M.C.), UNWTO, Madrid,and UNEP, Paris.
[35] Wagner, Marcus (2004). Firms, the Framework Convention on Climate Change and the European Union Emissions Trading systems: Corporate Energy management Strategies to address Climate Change and GHG emissions in the European Union.
[36] WORLD WIDE FUND FOR NATURE TANZANIA PROGRAMME OFFICE (WWF-TPO) (2009) Biofuel Industry Study, Tanzania: An Assessment of the Current Situation
[37] World Wildlife Fund WWF (2006) Climate Change Impacts on East Africa: A Review of the Scientific Literature
[38] WTO. (2008). World Tourism Barometer.
[39] Garnaut, Ross (2008) Climate Change Review Final Report. Cambridge university press. Cambridge
[40] Kamuzora, F. (2006). Interpretation of Tourism Sector Contribution in the Tanzanian Economy: A Need for New Methodological Approach. Bradford Centre for International Development Seminar. Bradford, UK. 14 February 2006.
[41] King, D. (2005). Climate change: the science and the policy. Journal of Applied Ecology. 42(5): 779-783.
[42] Macintosh, R. W. and Goeldner, C. (1986). *The Tourism Industry*. New York: Harper Press.
[43] Mathieson, A., and Wall, G. (1982). Tourism, economic, physical and social impacts Essex:Longman Group Limited.
[44] Rátz, T. (2006). The role of climatic and weather factors in influencing travel behaviour (in Hungarian). *Turizmus Bulletin*, Vol. 10, Special Edition, pp.42-53.

[45] Royal society (2010) new Climate change guide http://www.dailymail.co.uk/sciencetech/article-1316469/Royal-Society-issues-new-climate-change-guide-admits-uncertainties.html#ixzz1LqrntANJ retrieved on 2nd March 2011
[46] The Pan-African Initiative on e-Commerce (2001). State of Ecommerce in Africa 2001
[47] The UK Government (2001). Summary for Policymakers, Climate Change2001-Impacts, Adaptation and VulnerabilityIntergovernmental Panel on Climate Change (IPCC), Third Assessment Report (TAR), "ClimateChange 2001" http://ipcc-ddc.cru.uea.ac.uk/
[48] Wikipedia (2008) cited in Mpogole et al., (n.d) Mobile Phones and Poverty Alleviation: A Survey Study in Rural Tanzania
[49] Wikipedia (2010) Telecommuting or telework (http://en.wikipedia.org/wiki/Telecommuting) retrieved on 23rd March 2011.

Introduction to Strategic Eco-Controlling to Support Strategic Decision Making

Miada Naana, Junker Horst

naana@wi-ol.de, horst.junker@imbc.de

Abstract. During the last years it was indicated the concept (environment-oriented enterprise guidance) because of the consideration to the environmental issues about the scarcity or destruction of natural resources. This ecological enterprise policy looked at the connections between the mutual effects from economic actions and ecological consequences and that required constant supervision and correspondence with the enterprise targets. Due to this situation, enterprise management shows its interest in resource management. That can be realized through applying the strategic planning and controlling systems to supporting decision-making concerning sustainable development and environmental protection. In addition, business intelligence plays also the role to support decision-making. In this contribution I will describe, how it can be used BI system to support Strategic Eco-Controlling.

Keywords: strategic Eco-Controlling, strategic environmental management, decision-making support, environmental indicators

1 Introduction

Environmental effects of production are coming from the application of raw materials on the input side of a production process and on the output side by waste and undesirable by products [16]. This has substantially positive as well as negative consequences to the environment. For this reason, the main focus in the environmental domain is resource reduction as well as a continuous decrease or avoidance of environmental impacts in all areas in producing enterprises [10]. For that, management is required to analyze the environmental impacts of its products as well as production processes and to improve them [13]. Consequently, these environment-related perspectives receive the importance of corporate environmental management as a necessary area in enterprise. Moreover it promotes environmental management to an appropriate level coming from the rising importance of environment protection.

1.1 Corporate Environmental Management

To reach the enterprise goals, successful potentials are built up and used for the supply and the application of suitable resources [15]. In addition, it is avoided

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_36,

damage or failure potentials. For that, application of corporate environmental management supports realization of the enterprise purposes indirectly and directly, because it encloses the planning, control, supervision and improvement of all operational environment protection actions, as well as employee's management [8]. It is applied exactly like the enterprise management at different planning levels for environment-related decision support for realizing the added value activities as well as the environment protection strategy. Therefore, corporate environmental management can be defined as a subsystem of the top management and can be specified afterwards.

The matters of corporate environmental management are environmental impacts as well as financial impacts. There are possibilities for using the available potentials for the environmental discharge and at the same time cost reduction, which can be fulfilled by the reduction, optimization and reorganization of operational material usage. Therefore environmental achievements originate concretely through active environmental management by the recognition of the weak points which results in early-stage influence of environmental-relevant enterprise activities [16]. Accordingly the environment-oriented achievement improvement generates various tasks to improve on the supervision and management of the ecological environment along the product life cycle. These tasks are concretized by application of Eco-Controlling.

1.2 Corporate Eco-Controlling

Because the operational activities are always connected with undesirable outputs, the compensation of this situation requires measurement applications and control systems for reducing the material and energy consumption as well as protection of natural resources. Hence, the concept of "Eco-Controlling" has picked up since the middle of the 80s to detect and improve the effects of economic action.

The tasks of the strategic as well as tactical and operative management have led together with controlling to the formation of a specified management function [5]. Moreover, Weber stated that controlling is understood as ensuring management rationality [17]. With regard to the corporate environmental management, eco-controlling concentrates upon the relevant environment protection aspects of the enterprise management and shows as a subsystem of the corporate environmental management as well as the enterprise controlling [5], as in Figure 1.

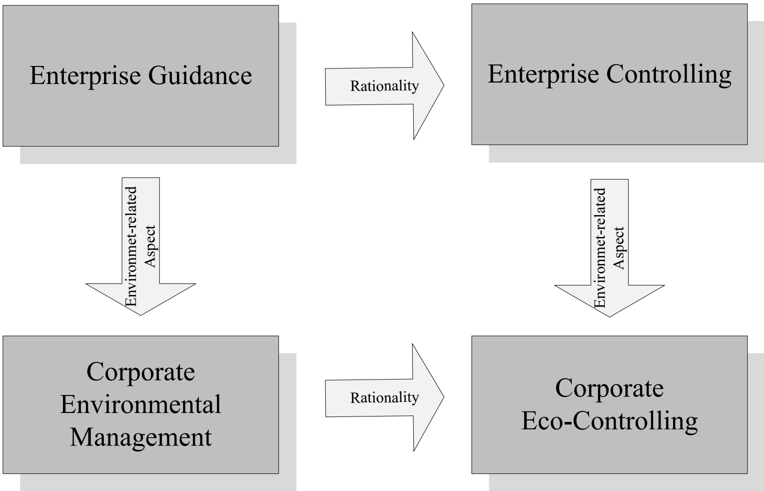


Fig 1. Two Stage Deduction of Eco-Controlling, *Source:[5]*

Hence, it is an environment-related subsystem of enterprise controlling and has a specific structure und functions for operationalizing the tasks of corporate environmental management. Moreover, it has responsibility for many tasks and also implements many targets to record and assess the ecological impact of economic activities in order to [13]:

- Reduce the negative ecological effects of existing products,
- set benchmarks for product development,
- Enable the creation of an ecologically orientated product range on a rational basis.

1.2.1 Goal of Eco-Controlling

The objective of eco-controlling is derived of enterprise controlling goals which support the enterprise management [5]. Due to this situation, eco-controlling can be seen as a management support system and coordination system of the corporate environment protection.

In this case, it is seen as the difference between the exogenous and endogenous real target: the exogenous target covers merely adaptation to legal regulations. But endogenous target considers environmental protection and provides as a possibility for reaching an adequate investment program. Hence, an endogenous target is a necessary condition for Eco-Controlling.

1.2.2 Tasks of Eco-Controlling

The tasks of eco-controlling represent all the activities need for the realization of real targets [3]. This means that it tries to find out the information to provide a basis for decision-making. According to the definition of Bauermann et al1, the tasks of eco-controlling consist of the coordination and adaptation abilities, which are shown with system-building and system-coupling functions. The first one, the system-building function includes creation of an organization as well as process structure which contributes to the coordination of the tasks [6]. The second one, the system-coupling function, exists in forming up and compression of information for a basis to be used in decision-making [3]. Hence, the system-building function can be seen as supposition to successful realizing the system-coupling tasks of the eco-controlling.

The coordination and adaptation tasks serve the solution of problems which arise from the increasing complexity, dynamism and discontinuity of the environment [6]. On the one hand, coordination task ascribe the coordination and exchange of information by different management subsystems (especially, planning, control and information care system) [6]. That is to avoid the deficits between interfaces of the organization. Hence, the coordination area can be seen as the head of eco-controlling. On the other hand, the adaptation task refers to the possibility of adapting in environmental change [3]. Due to anticipation ability, it can provide additional information about changes of the environment. Consequently, it is always possible to fix occurred environmental damages and to anticipate subsequent correction and certain interaction.

1.2.3 Modules of Eco-Controlling

Schaltegger et al [12] stated that eco-controlling envisages a strategic approach to environmental issues and proposes a systematic management procedure with various steps from target and strategy formulation to data management, decision support, control, implementation and communication [14]. The structure and tasks setting of eco-controlling are described as phase modules in figure 2.

[1] Eco-Controlling is an additional subsystem that extends the overall controlling consisting of each planning, management, controlling and information supply components by both system building and system coupling coordination. These additional features support the system by means of an increased adaptability and coordination [2].

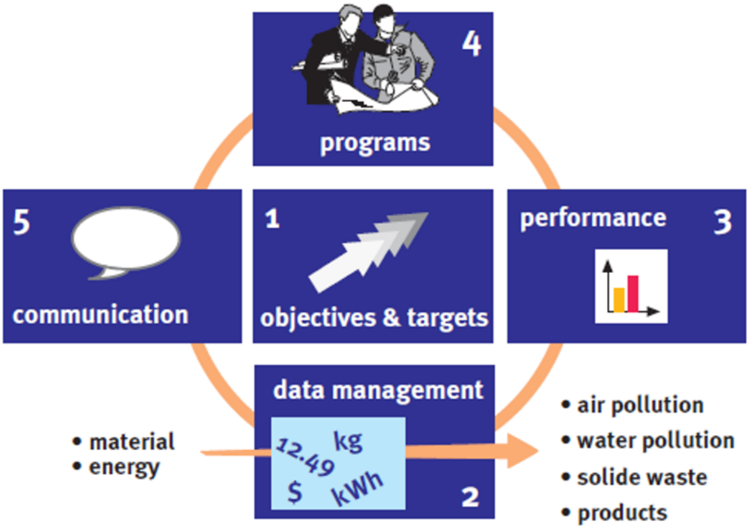


Fig 2. Modules of Eco-Controlling, *Source: [11]*

Objectives and Targets: It is already mentioned that the controlling goal is found the covering and sustainment of reaction, coordination and adaptation abilities in management. That is needed in order to realize the real purposes of the enterprise [7]. Moreover, that has to be clear for a company to be a credible and an efficient environmental performer and to reap the benefits of being an environmental leader.

The formulation of environmental objectives and targets starts with a commitment to comply with all relevant environmental regulations and to continuously improve environmental performance [11].

Data Management: The recording of environmental data and environmentally induced financial information is necessary as a basis for effective decision making [11]. Both the financial and environmental data are imaged in information systems. These systems can gather the information in physical as well as in monetary units.

Performance Management & Control: In this stage the actual progress is compared to the goals set, with strong and weak points being identified. Hence, management and control processes coordinate the distribution of all information in order to support the decision-making.

Decision Making Support: Many of the existing environmental management tools fail to consider the importance of the implementation process [11]. The controlling function is basically understood as a support function for decision makers in view of purpose reaching [3]. The task of eco-controlling lies in finding out environment-related information to support the basis of decision-making.

Communication: At the communication stage deals with the information exchange between the areas in enterprise, especially for strategic and operative decisions concerning ecological consequences. This is necessary for considering the requirements of internal and external stakeholders in the enterprise.

Consequently, eco-controlling is assumed as a suitable help system in corporate environmental management to realize the environmental targets. However, one question comes to mind: to enable a long-term saving of resources and to keep the production ability continuously high, how can eco-controlling be improved in order to generate effective and concrete effects?

2 Introduction to Strategic Eco-Controlling in BI Landscape

Due to the ecological challenges (especially: damage by emissions on earth, water and air.) as well as the economic requirements for increasing margins and profits, this requires to support strategic decisions about the long-term balance between economic and ecological dimensions in the corporate environmental management. This situation needs to harmonize between environment-related strategic measures planning and control of the operative activities.

2.1 Requirements and Conditions

The support of strategic decision-making can be realized through using business intelligence tools and technologies in the field of environmental controlling. That can achieve many targets in the corporate environmental management. The implementation of BI solutions does not differ in this field from common applications. It can generally benefit in the following features:

Complexity, defined as the number and, respectively, the variety of relevant environmental stocks within various environmental segments. Applied to a system, this means that a large number of objects and dimensions as well as numerous interdependencies among the objects have to be taken into account [1].

Dynamics, defined in terms of each frequency, speed, strength, regularity and predictability of changes of environmental resources relevant for the company, in various environmental segments. As a consequence, systems need to be adjusted often.

The basics of holistic and integrated approaches can provide assistance, as these are used for both economic and ecological goals. A technology is available for the company that can identify and remove the environmental risks and vulnerabilities prematurely.

2.2 Strategic Environmental Management

Strategic environmental management receives a growing significance through the ecological and economic sustainable development in enterprises. That is not only because of increased legislations concerning environmental risks, but also the growing scarcity and costs of natural resources at the world market [16]. This generates, actually, the importance of strategic environmental management which leads to strategic tasks in the following aspect [16]:

- Warning the enterprise for ecological long-term dangers,
- Supporting the objective of long-time survival of the enterprise,
- Ability to maximization of long-term profit,
- Identification of long-term social enterprise responsibility.

For that, the tasks of strategic environmental management include the consideration of: continuous sustainable development, ecological and economic futuristic added value activities, definition of social and environmental responsibility as well as environment-related strategic decision support through planning and management of enterprise activities. These tasks help avoiding and decreasing environmental impacts as well as long-term protection of the enterprise purposes. Moreover, it can appreciate ecological successful dimensions through the economic effects.

2.3 Strategic Eco-Controlling

With regard to concretizing and controlling the enterprise strategy, especially long-term environmental management strategy, the Strategic Eco-Controlling concept can be used. Due to significance of ecological and economical balance by application of voluntary or legal measures, this situation produced needs to fulfilling and condensing the Information. For that, strategic Eco-Controlling is a good method to detect a suitable basis for long-term decision-making. Moreover, it can especially serve concretizing the sustainable strategy and its realization in enterprise action.

This system needs at first to improve the adaptation area which can ascertain early-stage recognizing for strong and weak points as well as futuristic chances and risks. Hence, the adaptation area is an engine of Eco-Controlling, because it gives new suggestions, new knowledge of chances and risks, particularly being at hand from the ecological domain [3]. Additionally, it reports the coordination area with important changes of the indicators or recognize about weak signals.

In order to improve the functions of adaptation and coordination in Eco-Controlling, BI system can be used. This is relatively a new approach to using the benefits of business intelligence in environment area. It is capable to recommend the best decisions of actions (based on past data), but it does so in a very special way.

2.4 Abstract Business Process Model

For establishing the long-term environmental strategies rationally in the enterprise management, the economic and ecological requirements must be fixed as well as organizational and technical bases must be created. This requires the following considerations: definition of social, legal and environmental responsibility, clean production and recycling technologies, laws and orders as well as perception of environmental impacts and costs.

On the base of the generated information, the strategic environmental management can define the long-term purposes, which have to take into consideration the enterprise strategy. The actual realization of the operational, ecological and economical purposes can be handled by planning and control instruments, such as increasing of material efficiency and reduction of impacts and emissions. These purposes should be structured completely and presented to all stakeholders in the enterprise. In addition, the measures are formulated, structures are defined and new trends and their enterprise-related consequences are derived. Furthermore, it should be not only fixing the measure planning and achieving the activities, but also continuing the processes and avoiding negative impacts. Therefore, the rationality processes is taken extensively into consideration by the function of strategic Eco-Controlling. This exists in the condensation and aggregation of information for finding out the basis of long-term decisions. With business process modeling the sequence of strategic decision-making and decision support can be introduced into the strategic environmental management (figure 3).

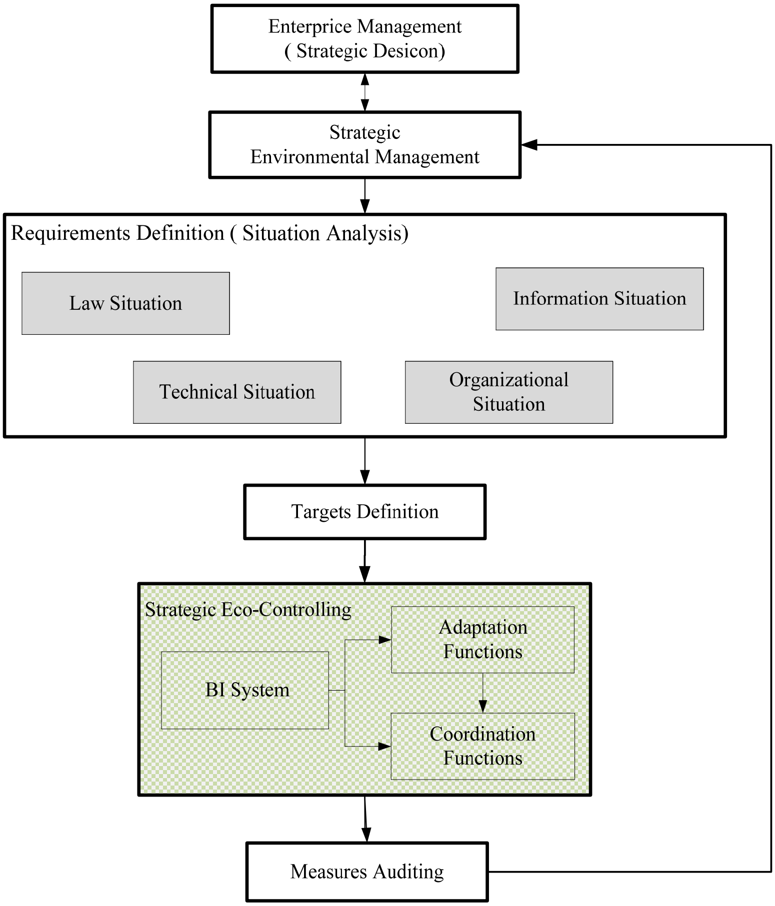


Fig 3. Abstract Process Model for Realization of Strategic Targets

In this process model, strategic Eco-Controlling tries to achieve the goal of strategic environmental management. It is used as a "supervision and correction instrument". Hence, it concentrates clearly upon the adaptation and coordination tasks.

Within the scope of the adaptation task, the recognizing for new enterprise-relevant trend is understood as well as matching the adaptation decisions [3]. To fulfill the adaptation function, it requires suitable instruments. Early warning functions and prediction functions are suitable to recognize prematurely critical, economic and ecological developments and to timely generate suitable counter measures. On the one hand, early warning functions can give signals about the weak points in production process and measures. On the other hand the prediction function gives information about new chances or ideas, which can bring better value and result. Therefore, the adaptation system improves above all the forecasting of continuing changes in natural, technical, social, political, legal and economical domains. Moreover, Michalewicz et al stated: "the discipline of using prediction and optimization techniques to build self-learning (decisioning system)" [9]. Due to this situation, it carries out advances in relation on decision support. This situation leads to use BI to applying strategic Eco-Controlling, which is shown in figure (4).

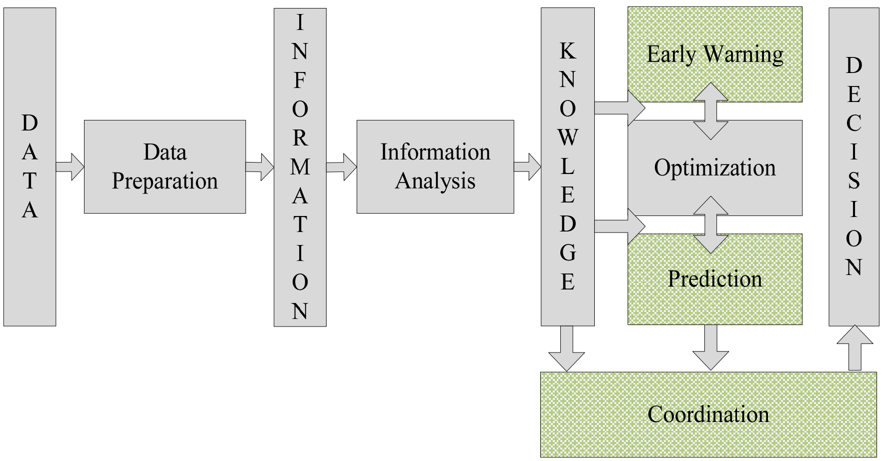


Fig 4. Efficient Eco-Controlling through Using BI System, *Source: based on [9,pp.5]*

A business intelligence system is defined as “a broad category of application programs and technologies for gathering, storing, analyzing, and providing access to data” [9]. For that, this system can help controlling functions through: the aggregation and integration of environmental data with many dimensions in a data warehouse for particular purposes, and then analyze the integrated data concerning the environmental issues. Such being the case, an analyzed information system serves the information supply and functional support for operational professional specialists for analysis purposes [4]. As result of analyzed data, specific performance indicators are produced.

Hence, those performance indicators can create environmental knowledge, which help applying the early warning, prediction as well as coordination functions of Eco-controlling, especially regarding strategic targets. By using BI, some functions of strategic Eco-Controlling can be realized. It incorporates alerting, predication and optimization modules through many indicators for improving future decision. That can make signals for weak points, and then predicate a new chance and solution.

In all cases, the knowledge and predicated Information are transferred to the coordination function. In this stage, they can be managed and controlled. Consequently, this function can detect weak points and provide a suitable decision basis for managers.

3 Conclusion & Outlook

The strategic Eco-Controlling concept can specifically be used in the industrial company. That can support the environmental decision-making in the environmental management to realize the company targets. In this situation it can practically be designed a reference model for business process model and strategic decision-making model.

With regard to business process model the company targets can be defined starting from the problem definition to schedule all the requirements, and then the measures are planned. Afterwards, the strategic decision-making model can be realized through using strategic Eco-Controlling, which uses BI system as well as the adaption and coordination functions. In environmental data warehouse environmental indicators are generated about using the material and energy as well as the amount of wastes and emissions for a product. Moreover, the environmental indicators can principally give a lot of signals and contrasts, which help to the decision support, for example in the following points:

- Reducing the usage of raw material,
- Reducing the CO2 emission,
- Ability to reproduce the waste of product,
- Ability to investment a new product or usage an alternative material.

References

[1] Bergnd M, Buxhner H, Weigand A, (2000) Identifikation strategischer Schlüsselbereiche durch Messung der Turbulenz im Unternehmensumfeld am Beispiel der Festo AG & Co. In: Horvàth & Partner (Hrsg.): Früherkennung in der Unternehmenssteuerung, Stuttgart. P.79-103

[2] Beuermann G, Halfmann M, Böhm M (1995) Ökologieorientiertes Controlling, In: wisu, 24. Jg. H. 4, P. 335-343
[3] Bleis C (1995) Öko-Controlling (betriebswirtschaftliche Analyse zur systematischen Berücksichtigung von ökologischen Aspekten durch Unternehmenscontrolling). Frankfurt am Main
[4] Chamoni P, Gluchowski P (2006) Analytische Informationssysteme (Business Intelligence- Technologien und Anwendung). Berlin
[5] Dyckhoff H (2000) Umweltmanagement (Zehn Lektionen in umweltorientierter Unternehmensführung). Berlin
[6] Faßbender-Wynands E, Seuring S, Nissen U (2008) Grundlagen des Umweltcontrollings (Aufgaben, Instrumente, Organisation). In: Baumast A, Pape J (Hrsg.): betriebliches Umweltmanagement (Nachhaltiges Wirtschaften im Unternehmen), pp. 103-115, Regensburg
[7] Horvath P (2009) Das Controlling-Konzept (Der Weg zu einem wirkungsvollen Controllingsystems). Darmstadt
[8] Kamiske G.F, Butterbrodt D, Dannich-Kappelmann M, Tammler U (1995) Umweltmanagement (Moderne Methoden und Techniken zur Umsetzung). München
[9] Michalewicy Y, Schmidt M, Michalewicy M, Chiriac C (2007) Adaptive Business Intelligence. Berlin
[10] Rautenstrauch C (1999) Betriebliche Umweltinformationssysteme (Grundlagen, Konzepte und Systeme). Berlin
[11] Sturm A, Müller K (2000) Eco-Controlling (a tool to implement value based environmental management). Maastrich
[12] Schaltegger S, Sturm A (1990) "ökologische Rationalität". die Unternehmung, Nr. 4, pp. 117-131, Stuttgart
[13] Schaltegger S, Sturm A (1993) Eco-Controlling (an integrated economic and ecological management tool). Great Britain
[14] Schaltegger S, Sturm A (1995) Öko-Effizienz durch Öko-Controlling. Zur praktischen Umsetzung von EMAS und ISO 14001. Schäffer- Poeschel/vdf, Stuttgart/ Zürich
[15] Souren D (2008) Nachhaltige Unternehmensführung. Berlin.
[16] V. Lang C (2007) Ökonomisch-ökologische Zielsysteme als Herausforderung für das Ressourcenmanagement. In: Pietsch T & V. Lang C (Hrsg.): Ressourcenmanagement (Umsetzung, Effizienz und Nachhaltigkeit mit IT). Berlin
[17] Weber J (1999) Einführung in das Controlling, 8 Aufl., Stuttgart

Corporate Social Responsibility in approach to business reality- case study with Cuban enterprises

Yaima Yiri Antelo González[1], Daniel Alfonso Robaina[1],
Desislava M. Dechkova[2], Jorge Marx Gómez[2]

[1] CETDIR (Study Center of Management Techniques), Technical University of Havana (CUJAE),
[2] Department für Informatik Abt. Wirtschaftsinformatik I Very Large Business Applications, Carl Von Ozziestky Universitat.

yaima@ind.cujae.edu.cu, dalfonso@ind.cujae.edu.cu
desislavamd@yahoo.com jorge.marx.gomez@uni-oldenburg.de

Abstract. Corporate Social Responsibility (CSR) represents the way companies achieve enhanced ethical standards and a balance of economics, environmental and social imperatives addressing the concerns and expectations of their stakeholders. At present a predominant attitude of rejection, which rules towards social responsibility is still observed. This research aims to determine if CSR is a part of the business strategy implemented by Cuban companies. The research shows that, theoretically, the studied Cuban enterprises interpret CSR as taking responsibility for the impact of their activities on the stakeholder. Practically, they try to fulfill the expectations of only two of the stakeholder-groups. It was also determinate that there is coherence between corporate values and the action taken by companies. Although the knowledge about the CSR is scarce, and the often interpretation of the CSR is as a concept that helps them be more competitive, CSR is included only on a very basic level in their business strategy.

Keywords: Corporate Social Responsibility, Stakeholders, Strategic Management, Corporate Values.

1 Introduction

Corporate Social Responsibility (CSR) is a phenomenon of management that is prevailing in the organizations during the past few years. The importance of this phenomena goes beyond the simply consideration of the performance of an enterprise. Its development is based on the idea that the companies must have in all possible dimensions and means a responsible behavior towards the stakeholders.

At present rules still a predominant attitude of rejection, towards social responsibility. However, the entrepreneurial sector can no longer continue to neglect the need of embracing this commitment as a means for achieving both internal and external benefits.

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*,
Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_37,

The increasing sensitization of organizations to utilize entrepreneurial practices that satisfy the worries of the society, strengthens their wish to assume CSR as a management position; taking into consideration the trust granted by the stakeholders [7; 24; 6; 30; 33; 23] and the strategy in that direction - the organization chooses itself. The organizations have an important role in the contribution to sustainable development and therefore it is perceived by the society.

In this sense, it is fundamental that the entrepreneurial structure incorporates real strategical steps towards a socially responsible conduct and realizes that the performance results will determine a long-term survival (OCDE, 2000; 19; 15; 9; 32; 31; 1; 18; 14; 30; 17; 29].

The managers today must try to obtain creatinging value for the society organizations and to keep the golden middle; this can happen only with a society, which recognizes this leadership; therefore, enterprises must be transparent in the steps and the process and communicate the new developments and the way to achieve them with the public. In the present moment a strong conviction from every organizations that acts socially responsible is demanded. It is not a subject of the purely entrepreneurial motives, but rather an interrogation to be more than enough sufficient and to forge the own structures according to the demands of the society [25]. To reveal this, will be the task of this paper.

Cuba undergoes a process of significant changes, which will continue advancing. It aims facing the present-day defiance and vanquish it on efficiency bases, implying the best usage of resources, together with the alignment to the corporate purposes like, mission and responsibility for future generations (vision), as strategic elements of the targeted entrepreneurial system.

2 Corporate Social Responsibility (CSR)

CSR is generally understood to be the way a company balances the economic, environmental and social aspects of its operation, addressing the expectations of its stakeholders. However, the idea of corporate social responsibility is not new. Business has demonstrated through the time varying degrees of responsibility towards the society. However, the concept of CSR today, covers a wide spectrum of topics, issues, methodologies, tools etc. What can generally characterize the development is, on the one hand, that companies are increasingly expected to take into consideration other aspects of running a business than only productivity and profits. On the other hand, the ways in which companies show their relations to society are changing. The growing importance of intangible assets implies that companies have an interest in being in synchronized to the views and norms of key stakeholder groups. However, policy and practice within the field differ and it is important to adopt a critical approach in order to distinguish between the 'finish' and the 'substance', i.e. companies involved in CSR, which adopt a step-by-step approach in order to integrate responsible policy and practice throughout the organization.

CSR definitions have proliferated in the literature particularly since the 1980s. Turning to like predecessor of the CSR, Davis (1975) that considered as "company contribution to sustainable development and the articulation is to convert the economy based in more knowledge competitive and dynamic worldly, capable to grow economically of sustainable manner with more and better jobs and with bigger social cohesion" to the present time for Alfonso et.al (2009) where they present that in the last years a special attention has been rendered, so far in the academic space, to conception and practice of the social responsibility. The youngest scientists' majority supposes that it is cheaper to run a company in an environmental and social way. Nevertheless, common ground between CSR concepts and definitions is widely acknowledged and evident from representative definitions given below.

"CSR involves the conduct of a business so that it is economically profitable, law abiding, ethical and socially supportive. To be socially responsible then means that profitability and obedience to the law are foremost conditions when discussing the firm's ethics and the extent to which it supports the society in which it exits with contributions of money, time and talent" [5].

"CSR is defined as a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis' as they are increasingly aware that responsible behavior leads to sustainable business success" [16].

"CSR means open and transparent business practices that are based on ethical values and respect for employees, communities and the environment" (CSR Forum, 2002)

"CSR is the continuing commitment by business to behave ethically and contribute to economic development while improving the quality of life of the workforce and their families as well as of the local community and society at large" [32].

"CSR is defined as operating a business in a manner that meets or exceeds the ethical, legal, commercial and public expectations that society has of business. CSR is seen by leadership companies as more than a collection of discrete practices or occasional gestures, or initiatives motivated by marketing, public relations or other business benefits. Rather, it is viewed as a comprehensive set of policies, practices and programs that are integrated throughout business operations, and decision-making processes and are supported and rewarded by top management" [4]

"CSR is about how companies manage the business processes to produce an overall positive impact on society" [3]

However, in the practice a lot from the connected with the CSR is done to obey the material profit. The development through the years is to be seen in Figure 1.

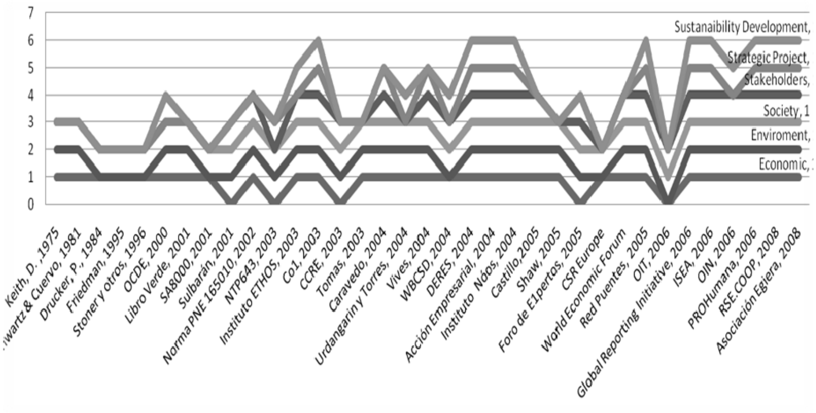


Fig 1. CSR trends, *Source: data analysis*

To summarize, a CSR practicing corporation should strive to obey the law, make a profit, be ethical and provide societal value and accountability. CSR is a company's positive impact on society and the environment through its operations, products or services and through its interaction with the key stakeholders.

Many companies today, especially Small- and Middle-sized Enterprises (SMEs), are still in an early phase of CSR implementation. Companies are struggling with considerations such as 'what issues to engage in' and 'how to develop responsible policies and practices within different areas of CSR'. The methodological development within the field has provided companies with useful guidelines and tools. However, the fragmented rather chaotic supply of codes of conduct, guidelines, charters etc has also complicated the picture and raises a number of concrete and operational questions such as: How to approach the field? Which products to pick? It raises also some more essential questions such as - How much should companies cover? or What is the level of ambition? These are essential questions, especially in regard to SMEs, which have limited time and resources.

CSR standards are used to describe a written document striving influencing behavior so that it is recognizable and reproducible in order to improve the social performance of the organizations, to which it is applied. This includes auditable standards as well as broad guidelines, codes of conduct, charters, investment screening mechanisms and benchmarking. Standards by which organizations can be measured make it possible to compare and contrast levels of performance. Initially, the function of standards is to establish minimum levels of performance. They also help organizations to manage the quality of their processes or systems designed to manage impacts and processes. Over the course of time, the use of standards encourages, facilitates and mandates best practice. Within the field of CSR, most standards are of a voluntary nature. CSR standards have a wide variety of organizational homes and governance structures. These range from old institutions initiating new standards (e.g. the EU Eco-label) to new institutions and multi-sector alliances being set up to develop CSR standards and codes of practice. Such alliances bring together individuals and organizations from across public, private and voluntary sectors to negotiate, implement, monitor and review emerging standards.

3 Case study of Cuban enterprises

3.1 Research Context

In the conditions of Cuban model, socialist development and taking into account a governmental law/order-paper to the business organizations, it proves to be necessary to identify the premises and basic conditions for the practice of socially responsible organizations, as well as the core elements that acquire this conception in our context. Essential is to take into considering that the Cuban State is the first guarantor of the satisfaction of the needs of the Cuban society. This is all is to be coherent to the Decree-Laws 252 and 281 established in the 2007 where a continuity and strengthening according to characteristics and requirements of the Management System is given.

The legal frame does not set yet an obligatory standard for CSR. At first, once out of courtesy, CSR postulates were partly being established, and they are present in functioning laws, decrees, resolutions and standards integrating the elements fully or fragmentarily in the economic order in Resolution No.297/2003 and Resolution No. 13/2006; regarding the environment ISO 14000, 14001 and ISO 9000 and of social way NC 3000, 3001, 3002; Resolution No.8/2005 and Decree-Law 283/2009.

Our country is challenged to cope on the one hand, with the confrontation of the negative impacts in the Cuban economy and rural life caused by the difficult internal and external conditions and on the other, with the development of Social Projects delineated by the maximum direction of our Revolution. It is directed to the improvement of the society's life quality; it constitutes a new scene that imposes the re-sizing, as form of a theoretic foundation for the CSR and the role of organizations in general. This will lead to a realization of an effective social responsibility that contributes to the improvement of the life-standard in our communities and consequently to the sense of belonging of the workpeople, and their identification with the results of the companies they are working for, in the dimensions of productivity of work and rational use of resources.

The essence of our revolutionary process has driven our entrepreneurial system to assume responsibility to the society through the commitment that supports the government in e.g. the equal and partly subsidized distribution of goods. From this perspective, the companies' contribution affects the well being of the society through fulfilling the general objectives of the economic policy, which are an expression of the grade of national social and economic achievements. Such conception aims to reinforce the commercial character of the company and at the same time to underline the need to achieve height level of efficiency in its production processes and/ or offered services, in order to support the government persuasion in development of the social programs. Cuban legislation postulates protection of the society and guaranties the human rights of the entire population and it is the companies' obligation to work with these rules.

3.2 Methods

This is an exploratory study, which obtained information on the CSR at the companies applying SDGEC. It includes descriptive and comparative components. The descriptive component is focused on the definition of a socially responsible company and the importance of the CSR concept. The comparative aspect includes knowledge of current practices and attitudes towards CSR. The fact-finding design is experimental, since it didn't control any of the variables and the questionnaire was applied over a short period of time.

The methods of data collection included a manual of self-evaluation according CSR [14] and CSR questionnaire [32]. These are tools that enable the companies to take an introspective look at their own performance in distinct areas of CSR, regarding their business as a vision. This vision integrates entrepreneurial steps with the respect of ethical and moral values, the people, the community and the environment. It intends to respond to the question, which is the grade of development that the company has to have in order to achieve CSR. Further step in the determination of the commitment grade of a company towards CSR, gives the possibility to evaluate its advances in terms of social responsibility in the following five areas: Values and Ethical Principles, Responsible Marketing, Environment Protection, Employment and Labor Conditions and Community Support.

Once every area of the manual is answered, the evaluation is to be done the following way: average of the same one will have to calculate itself the as the total scored according to the option (3, 2 ó1) dialed in each question obtains addend itself dividing it enter really load of questions answered (the ones that were answered Must Not Take Into Account Themselves N/C). The averages obtained in each of the areas will have to be transferred to the distinct axes of the Pentagon graphic. All of them together make possible creation of a figure, which illustrates will permit implementation the result in individual shape (area), moreover, it intends to illustrate the global situation of the company in terms of RSE.

The questionnaire [32] aims principal answers from the direction management and even though it covers up some aspects regarded as elementary, it is just to say that the same one faces up to companies of middling and great transport with true structure and for them as the concept of CSR as such is not new. The questionnaire can be useful for future stock- and processes-base. It was self-administered, carried out through anonymous letter and confidential; the quantitative data obtained from the study was analyzed using Minitab software. An open-ended question about socially responsible practices of enterprises was analyzed manually using the method of inductive content analysis.

3.3 Results

At present, 27 companies were investigated for CSR since the first condition for threat is to have established SDGEC and having a favorable performance in agreement with the established Decree-Laws 252 and 281 (2007). According to the different Cuban ministries, the enterprises' distribution appears in Figure 2.

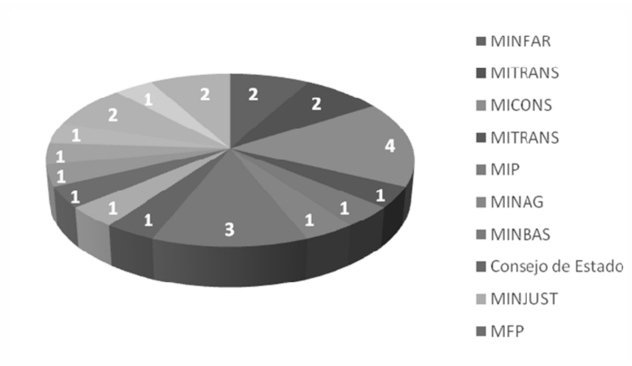


Fig. 2. Distribution according to Cuban Ministries, *Source: data analysis*

Basing on the strategic projects of these 27 companies a general evaluation of 209 strategic objectives was obtained and formulated for the period 2007-2010. Figure 3 gives the Status Quo, regarding the CSR's dimensions, described as follows: economic [160/209] – a thematic prevailing tendency can be observed, which corroborates Alfonso et.al (2009); social [54/209] - with a lower number and on last place - environment [36/209] (Figure 3).

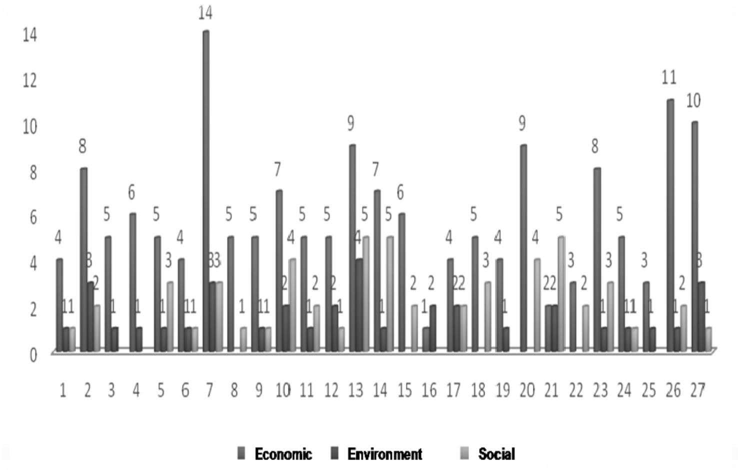


Fig 3. Analysis of strategic objectives according to CSR's dimensions,
Source: data analysis

Within the elaboration of the own strategic project 2007-2010 for the organizations examined, the corporate-shared values appear in the conceptualization with the following parameters: the companies consider the Responsibility (11/27) like one shared value - fact that in a way would be able to be linked to the commitment of the workpeople to the work and to the quality that is a crucial parameter for the obtainment of the customer's satisfaction. Another most frequently found values were: Professionalism (12/27), Possession sense (11/27), Discipline (10/27), Teamwork (7/27).

Regarding the results of the questionnaire for own evaluation (WBCSD, 2004) was gained the following information:

- 93 % recognize the vision spread out in the organization just like the corporate shared values and the conception (89 %) that find aligned to the processes (85 %);
- 81 % present that stakeholders are identified;
- 85 % have social and ethical impact's evaluation of products/services the same way that operations come true;78 % of the indicators are identified as measuring performance of objectives.

Regarding to the analysis of the manual of own evaluation, which is part of the CSR's manual for SME [14] the obtained information is shown in the Table 1.

Table 1. Descriptive Statistics of variables

Variables	Mean	SE Mean	StDev	Variance	Coef Var	Minimum	Median	Maximum	Median
ELC	2,5382	0.0782	0.3224	0.1039	12.70	1.78	2.59	2.95	2,59
RMK	2,5694	0.0850	0.3504	0.1228	13.64	1.69	2.67	3.00	2,67
EP	2,514	0.102	0.420	0.177	16.72	1.69	2.61	3.00	2,61
CS	1,271	0.195	0.806	0.649	63.40	0.30	0.92	3.00	0,92
VEP	2,7353	0.0631	0.2604	0.0678	9.52	2.00	2.84	3.00	2,84

Source: data analysis

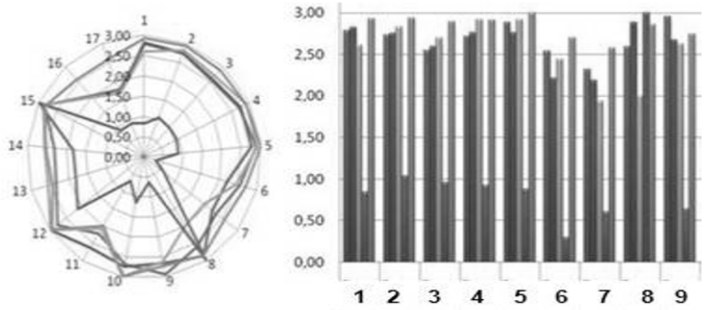
Analyzing the information gathered, it is to be mentioned (compare with Table 1) that the highest result variable was "Values and Ethics Principles" (VEP= 2.73). It shows how a company integrates a principled group in the decision making in its processes and strategic objectives. These bases refer to the ideals and beliefs that suit their purposes like referential frame for the decision making organizational them. This is known as focusing the business on the moral values and their reflection in general on the Mission and Vision of the company, thus it has main part in Ethics Codes.

n a similar way reveals the "Responsible Marketing" (RMK= 2.56), which implicates company's group of decisions, related fundamentally with its consumers and it is linked up with the integrity of the product, the customary business practices, the pricing, the distribution, the divulgation of characteristics of the product, the marketing and the publicity.

Respect to Environment Protection (EP=2.51) - shows the commitment of the business organization to the Environment and the sustainable development. This is today self-evident and involves a permanent and conscious evaluation from the business' side of the environmental impact.

According to the Employment and Labor Conditions (ELC=2.53) – is made a reference to the policies of human resources that affect the employees. Some of them are: clearings and gaining, administrative race, capacitating, working environment, diversity, balance - work/free time and work/family, health, occupational safety and others.

On last position comes out the Community Support (CS=1.27) that has an ample range in the company's portfolio, and accomplishes the maximization of the company's impact and contribution, in the Community. It can be measured in money, time, products, services, knowledge or another resource that are once the communities that operates on were aimed at. Support includes the enterprising spirit aiming at a bigger economic growth for the entire society. The complete gathered data from Cuban companies is visualized in Figure 4.



	1	2	3	4	5	6	7	8	9
Employment and Labour Conditions	2,79	2,73	2,55	2,72	2,88	2,54	2,32	2,59	2,95
Responsible Marketing	2,82	2,75	2,59	2,76	2,76	2,21	2,19	2,88	2,67
Environment Protection	2,61	2,83	2,70	2,92	2,92	2,44	1,94	2,00	2,63
Community Support	0,84	1,04	0,96	0,92	0,88	0,30	0,61	3,00	0,64
Values and Ethics Principles	2.93	2.94	2.89	2.91	3.00	2.70	2.57	2.86	2.74

Fig. 4. Fragment of representation of the Cuban companies according to CSR's dimensions , *Source: data analysis*

In a general way which reflex that a conscious exercise in the organizations makes of corporate purpose and the compliance with laws, decrees and resolutions that become established and the Figure 4 permitted to see similar behavior between all of the enterprises respect to CSR's areas.

4 Conclusions

In this paper we have described an approach based on the development in the Cuban case towards to CSR. The existent international references establish important directive-ideas requiring for the organization to be socially responsible, emphasizing that the materialization of concepts and ideas demand continual and persevering work in the (future) years, in addition to the combination of methodologies and tools that can adequately enrich these experiences for the needs of our country. A CSR practicing corporation should strive to obey the law, make a profit, be ethical and provide societal value and accountability. CSR is a company's positive impact on society and the environment through its operations, products or services and through its interaction with key stakeholders.

Cuban organizations contribute for the emphasizing on the social development. Their principal mission in that sense is to generate products and services that bring with own self the employees creation, the salaries and the fiscal revenue but is not sufficient but the dimensions related with the environment and the society sit up. Yet, when it comes to count on the powerful juridical support in Cuba for answering the needs of the society according CSR there are no obligatory juridical arrangements that are demanding to plan, to control, to search, to measure, to evaluate and to inform about the extent of the institutions' CSR measures.

Theoretically, the studied Cuban enterprises interpret CSR as taking responsibility for the impact of their activities on the stakeholders. Practically, they try to fulfill the expectations of only two of the stakeholder-groups: suppliers and clients. This analysis enables comparison between statements and deeds of the companies; it allows recognition of the stakeholders' influence in order to diminish performance lacks, and to determine the coherence between corporate values and the action taken by companies. Although the knowledge about the CSR is scarce, the often interpretation of the CSR is as a concept that helps be more competitive, never the less, CSR is included only on a very basic level in their business strategy.

Finally, CSR should be understood as a long-term profit carrying development tool, therefore it should not only being implemented for the purpose of image improving, or advertising business moral. A major part of our countries' future, especially in emerging economies, lies in the ability of the organizations to recognize their social responsibilities, and realizing, that acting social responsibly is far from being a burden, but a tool for competitiveness.

Acknowledgments My sincere gratitude to the 27 Cuban companies that took the participation in this investigation, seeing it as a chance and opportunity for the better performance, and incorporating new modus operandis inside the enterprises.

References

[1] Acción Empresarial (2004) “Análisis de la Responsabilidad Social Empresarial en las organizaciones”, Chile.

[2] Alfonso et. al (2009) “Responsabilidad Social Empresarial: sus particularidades en las empresas cooperativas” Revista Avances-CITMA Vol.11 No.1 CIGET Pinar del Río ISSN 1562-3297

[3] Baker, M. (2008) “Why CSR reporting is broken and how it should be fixed: Sustainability reporting will undergo a revolution in the next few years. This can only be a good thing” Margues Mallen Baker. Accessed June 30, 2009 from http://www.ethicalcorp.com/content.asp?ContentID=6224&ContTypeID

[4] BSR (2007) “Beyond Monitoring: A New Vision for Sustainable Supply Chains” Business for Social Responsibility.

[5] Carroll, A.B. (1999). Corporate social responsibility: Evolution of a definitional construct. Business & Society, 38(3): 268–295

[6] Castillo Clavero (2005) “La Responsabilidad Social de la Empresa y los consumidores”. Presentado en el Encuentro Nacional de Organizaciones de Consumidores: 31 de Marzo y 1 de Abril de 2005. [Online] Buenos Aires, Argentina. Consejo Consultivo de los Consumidores (Accessed February 17 2009) at available: http://www.mecon.gov.ar/secdef/basehome/comision7.pdf

[7] CCRE, (2001) “Qué es La Responsabilidad Social Empresarial”, Bogotá D.C., Colombia. (Accessed January 10, 2009)Available: http://www.ccre.org.co

[8] Confederación de la Producción y el Comercio (2006) “Manual de RSE para PYMES” Registro de Propiedad Intelectual Nº 158.819, ISBN: 956-8046-01-1 Santiago, Chile
[9] Cox, J. (2003) “De la Responsabilidad Social Empresarial en Chile y en el Mundo Acción Empresarial” Registro ISBN: 956-8305 02-5, Chile.
[10] Davis, K. (1975) “Can Business Afford to Ignore Social Responsabilities?” California Management Review, No. 2, EUA
[11] Decree-Laws 252 (2007), Cuba
[12] Decree-Laws 281 (2007), Cuba.
[13] Decree-Law 283/2009, Cuba.
[14] DERES (2005) “Algunos beneficios de ejercer la RSE” (Accessed Febraury 23, 2009). Available: http://www.deres.org.uy
[15] ETHOS Institute (2003). (Accessed January 12, 2009) at available http://www.iarse.org
[16] EU (2001) “Green paper on CSR” España (Accessed Febraury 15, 2009)
[17] Global Reporting Initiative (2006) “Sustainable Reporting Guidelines” (accessed July 15, 2008) at Available: http://www.globalreporting.org/ReportingFramework/ReportingFrameworkDownloads/
[18] Hollenhorst and Jonson (2004) “Herramientas Sobre Responsabilidad Social Empresarial” Autores del Relevamiento: (www.ifpeople.net) Informe Preparado para: Red Puentes Argentina (Accessed January 12, 2009) at available http://www.redpuentes.org
[19] Ibase Institute (2002) Instituto Brasileiro de Análisis Sociales y Económicos de Brasil
[20] ISO 9000 (2000) Sistemas de Gestión de la calidad –Fundamentos y vocabulario. Cuba
[21] ISO 14000, 14001, Cuba.
[22] NC 3000, 3001, 3002, Cuba.
[23] OIT (2007) “Guía de recursos sobre Responsabilidad Social de la Empresa” Uruguay.
[24] PNE Standard 165010 (2002) “Ética. Sistema de gestión de la Responsabilidad Social Corporativa” España
[25] PNUD (2005) “Hagamos de la competitividad una oportunidad para todos” Sinopsis del Informe sobre Desarrollo Humano Revista de la facultad de ciencias económicas de la UNMSM, año X nº 27. September, Perú
[26] Resolution No.297 (2003),Cuba.
[27] Resolution No.8/2005, Cuba.
[28] Resolution No. 13 (2006), Cuba.
[29] Ruiz et.al. (2007) “Manual de Responsabilidad para PYMES” (Accessed March 5, 2009) at available http://www.prohumana.cl
[30] Sulbarán, Juan Pedro, (2005) “El concepto de Responsabilidad Social de la Empresa” Revista Economía No. 10 p 225-248 Facultad de Ciencias Económicas y Sociales Universidad de Los Andes, Chile
[31] Urdangarin and Torres (2004) “Responsabilidad social y estrategia empresarial” Nóos Institute – Estudios estratégicos de patrocinio y Mecenazgo.
[32] WBCSD (2004) “Sustainable Development Reporting: Striking the Balance”. Geneva: World Business Council for Sustainable Development.
[33] World Economic Forum. (2005) Global Competitiveness Report.

Part V
New Models and Tools for Sustainable Transports

Reference model for stimulating cooperation between group of manufacturing and transport enterprises in the sphere of transport processes

Marcin Hajdul[1]

[1]Institute of Logistics and Warehousing,

marcin.hajdul@ilim.poznan.pl

Abstract. In the age of rapid economic changes, companies are forced to continuously search for ways of transport and logistics processes rationalization. For manufacturing and distribution companies reduction of logistics costs and in particular transport ones is the most important. The aim of the chapter is to present concept of cooperation between group of manufacturing and transport enterprises in the sphere of transport processes` implementation in supply chains. Author is going to describe new business reference model for the entire supply chain that would cause positive effect on enterprise`s activity in the short and long term (load factor) and also on the region in which the enterprise operates. Presented model will be validated in real business cases with participation of the industry.

Keywords: sustainable transport cooperation, co-modality, load factor in freight transport, e-freight, congestion

1 Current situation in organisation of transport processes

1.1 Introduction

Current business transport models suffer from problems such as: short term planning, over-reliance on road transport, low level of load factor in freight transport, lack of cooperation among companies from the same region, different standards in data exchange, lack of a common solution for monitoring of transport processes and insufficient amount of cargo to use intermodal haulages. Furthermore, the current trend within the supply chains for frequent and small deliveries results in increasingly high transport costs, increased traffic congestion and, as a

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_38,

consequence, longer delivery times. In addition to this, small, medium and even big enterprises have no access to the tools enabling cooperation among them in order to eliminate mentioned problems.
It must be also highlighted that transport processes in a company function within a big organism, i.e. the national or regional transport system. Thus, inefficiency of one element of a certain system can have a negative impact on the other one.

1.2 Traditional model of transport processes organisation

In traditional organization models of the transport process, manufacturers or distributors concentrate on fulfilling everyday orders from customers and ordering goods from their suppliers. Delivery and distribution of finished goods can be carried out with the use of own transport means or a specialized transport/forwarding company [19]. Details are presented on figure 1.

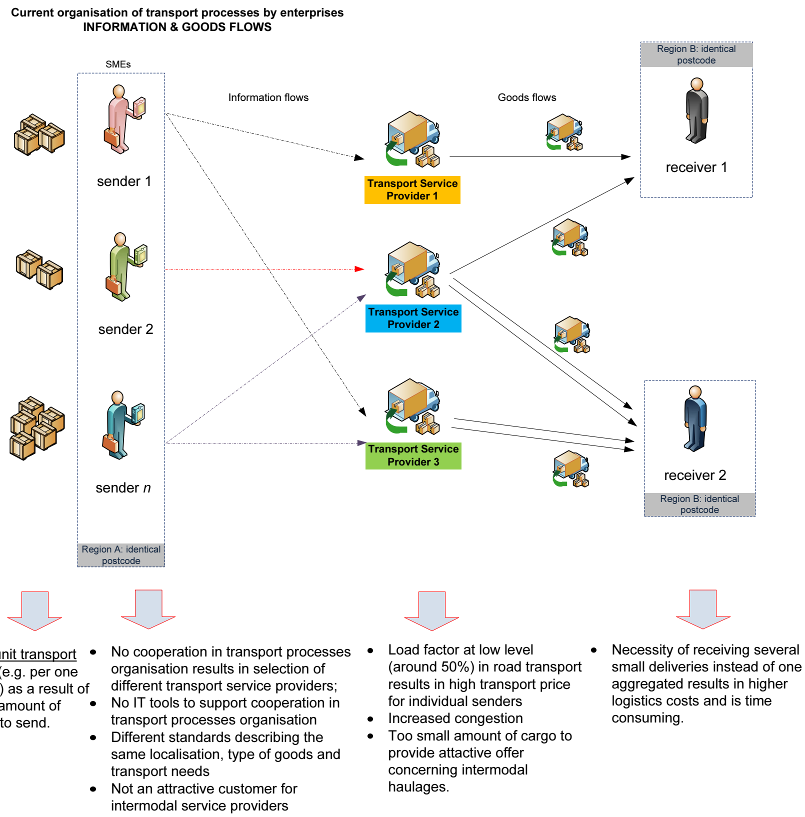


Fig. 1. Traditional way of organizing transport processes

In case of own fleet companies plan and optimize delivery routes from suppliers and distribution routes to customers on their own. Delivery fulfilment and distribution are in many cases handled together with the use of one vehicle, although they are two different parts of the supply chain [Kordel 2002]. Such actions aim at transport cost rationalization and effective usage of available transport means. Thus, many times the distribution of finished goods within a region is realised first and only then are goods picked from the supplier. After that, the goods are transported to the company warehouse/plant. The actions aim at maximum truck loading capacity utilization, which results in minimization of transport costs.
In case of lack or insufficiency of own fleet of trucks the company orders transport/forwarding services. It is favourable since the company only places transport orders and it is the forwarder or transport service provider that is responsible for organizing the process in the optimal way [Załoga, Milewski 2005]. The contact could be done either by traditional way or with support of electronic platforms – freight and vehicle exchange – figure 2 (e.g. Timocom truck & cargo, Wtransnet, Teleroute, European freight exchange TRAN, Benelog, OCX).

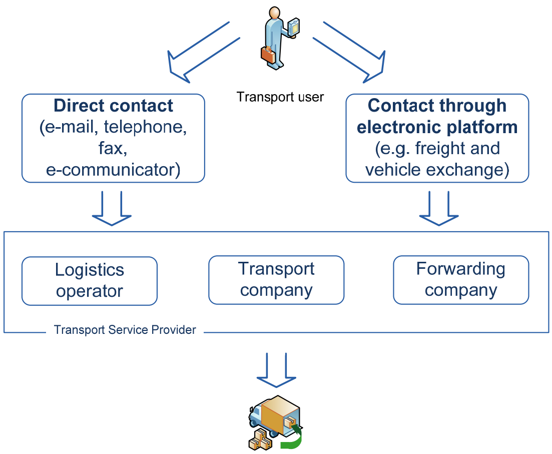


Fig. 2. Way of communication with transport service providers

Presented model of organization of transport processes has one significant disadvantage. The transport rate or the own transport cost depends directly on the size of load and our expectations regarding delivery time. The general rule is that transport companies have lower unit price for larger delivery quantities (figure 3). Both in own transport and the ordered one the cost per weight unit declines with the increase of delivery weight [3].

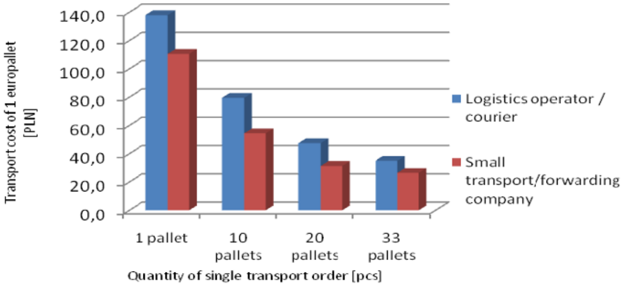


Fig. 3. Analysis of transport costs for selected transport orders on the route from Poznan to Świnoujście , *Source: Own study based on data from DHL, OPEK, Siódemka, Schenker, Raben, FM Logistics, Wincanton, Delta, Masterlink, Agatrans, Spedimex*

Unfortunately, the current trend, i.e. frequent and small deliveries results in growing high transport costs. Furthermore, the number of delivery trucks is also raising which increases traffic congestion and, as a result, longer delivery times is another disadvantage.

1.3. Major problems in transport processes organisation

Most companies have already noticed that effective transport process organisation has a great influence on their current performance, which determines total company costs [19]. It has resulted in creating many methods of business process realization and reengineering. Such methods as: DRP, JIT, TQM, ECR, CPFR, TOC, Business Process Reengineering (BRP), Business process management (BMP), Trillium Model, Change management, Capability Maturity Model Integration (CMMI), Benchmarking, Six Sigma, Process Improvement and Management (PI&M), Rational Unified Process (RUP), Zachman Framework.

The described methods show how logistics processes including transport, warehousing and inventory management can be improved by companies. The methods, however, do not consider the correlation between logistics processes. Customer requirements are always in the first place and the whole rationalization process should be designed to meet them. This conclusion seems to be obvious since this is the customer that brings profits to company. Moreover, there is no information about detailed practical implementation, e.g. what type of processes should be changed and how.

Additionally, all methods recommend focusing on internal company processes, and strictly within a particular range (e.g. transport or warehousing). A short-term economic account and customer requirements are becoming a leitmotiv of any business activity. Nevertheless, there are no methods, algorithms or tools that solve the above described trade-off relations problem comprehensively. Moreover, the methods do not take into consideration the relationships between transport organisation effectiveness and effective regional transport activity either.

Furthermore, according to the author's research in such project as Different (6 Framework Programme), Corelog (Interreg III B Cades), Kassetts (Interreg Central Europe), DiSCwise (DG Enterprise & Industry), companies try to fulfil orders often and quickly, mainly with the use of road transport. Obviously, keeping transport costs at a reasonable level. However, this approach causes that improving processes and customer satisfaction in the short-term by manufacturing and distribution companies can worsen their long-term activity. Frequent ,quick and small deliveries require more transport means to be involved, which makes traffic congestion bigger and road safety worse. Growing traffic congestion decreases the average technical speed of vehicles, which makes delivery time longer. Longer delivery time can cause customer dissatisfaction and, in the worst case, loss of some orders. Additionally, increased demand for transport services makes transport service providers increase their transport rates, because of low level of load factor. So, in the long-term companies worsen their financial results.

Seriousness of situation for the whole European transport system resulting from low load factors in freight transport is also confirmed by research carried out by European Environment Agency. According to the EEA report, load factors are generally far below the theoretical maximum (figure 4). While it is relatively easy to achieve full load on an outward trip, it is a complex puzzle to find return loads. Therefore, empty return trips are frequent. Transport of certain goods requires specialized vehicles that makes it impossible to find return loads – a gasoline tanker can neither bring milk nor pallets as a return load.

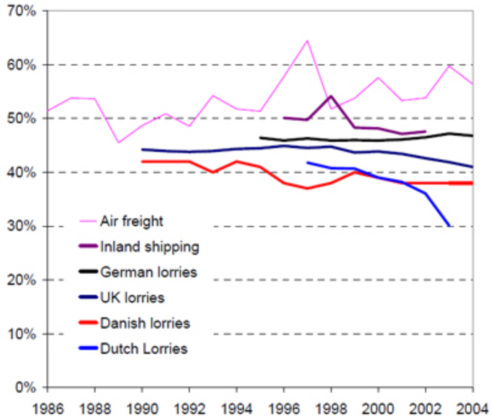


Fig 4. Load factors in freight transport

Source: TERM 2005 Load factors for freight transport, European Environmental Agency, 2005.

Load factors for road and inland freight transport have declined in most of the member states surveyed, indicating that vehicles are being less efficiently used. For road transport, the slow decline in load factors hides more marked developments in opposite directions: on the one hand a decline of empty haulage as result of better fleet management, and on the other hand a decline in load factors for laden trips. Companies are often more concerned with efficient time-management than efficient transport, resulting in an increasing number (more vehicle-kilometres) and a decreasing size of shipments (TNO, 1999), thereby contributing to lower efficiencies. 'Just-in-time' deliveries may stimulate this development. On the other hand, increased use of IT has contributed to better fleet management and may have compensated. An alternative explanation for the decline in load factors could be that loads are being increasingly constrained by volume or deck space, or a shift in the goods market away from bulk or bundled cargo and towards palletized goods1.

Moreover, there are limited policy options that directly address load factors, there may be more to be gained by focusing on objectives more directly related to environmental pressures.

As a results of carried out desk research major problems resulting from current approach to organisation of transport processes were identified:

- Short term planning - concentrating on the customers' needs and quick profits.
- Usage mainly of road transport.
- Inefficient use of means of transport – load factor at low level.
- Lack of cooperation among companies from the same region/cluster in organizing common logistics processes (e.g. transport).
- Companies (transport users) associated in organisations (clusters) are co-operating with several different transport service providers.
- Different standards in data exchange – no global language in use.
- Lack of business models of cooperation in the field of transport and logistics. No information about potential benefits.
- Poor education concerning joint transport and logistics processes.
- Co-modality does not exist.
- Increasing congestion.
- Inefficient use of mobile technology. Lack of a common system for monitoring of transport processes.

2 Reference model for stimulation cooperation in transport processes organisation

The objective of the reference model is to stimulate vertical and horizontal co-operation between logistics service clients (consignees, consignors) and transport service providers (SMEs), with the aim of increasing the load factor, reducing transport costs and exploiting co-modality concept (use of different modes on their own and in combination in the aim to obtain an optimal and sustainable utilisation of resources).

This cooperative business model requires sharing knowledge and information along the supply chain, according to the reference architecture, which has been further developed within the DiSCwise project. To achieve this, the information and communication systems and/or decentralized e-logistics platform used for managing transport and logistics operation need to interact efficiently and share

[1] TERM 2005 Load factors for freight transport, European Environmental Agency, 2005.

information. They must be interoperable and the actors must be able to share that information according to their own business rules.

Cooperating entities shall exchange information electronically, dedicated electronic platforms. In the reference model three groups of players are defined (see Figure 5):

- Users of transport services – companies that are engaged in the production and/or selling of the products. Transport is not their main source of business. These companies may have their own means of transport or they cooperate with the providers of transport services. They issue the demand for transportation. They order the execution of transport operations in most of the cases by issuing order to providers of services. In presented model, they are acting as a buying group of transport services.
- Provider of transport services – companies whose core business is the provision of transport, logistics and forwarding services. Their task is the coordination of orders issued by transport users. In the case where one of the cooperating firms has its own means of transport and is able to provide transport services for the other transport users, then it performs also the role of transport services providers.
- Coordinator – represents the transport users, deals with the coordination of transport processes (e.g. analysis of the possible aggregation of the transport orders issued by the different users, price negotiations, the choice of modes of transport), cooperation with suppliers of transport services, monitoring of the aggregated processes of transport, the carrying out of analyses in the micro and macro. The role of the coordinator may be performed in several ways. Coordinator might by financed by cooperation companies in the network, when a coordinator is their employee. The coordinator may be an independent entity supporting coordination of transport processes, which charges the users on the basis of the number of orders being executed. Finally, this may be the shipping company, acting exclusively for companies that have decided to collaborate in the organization of the transport processes.

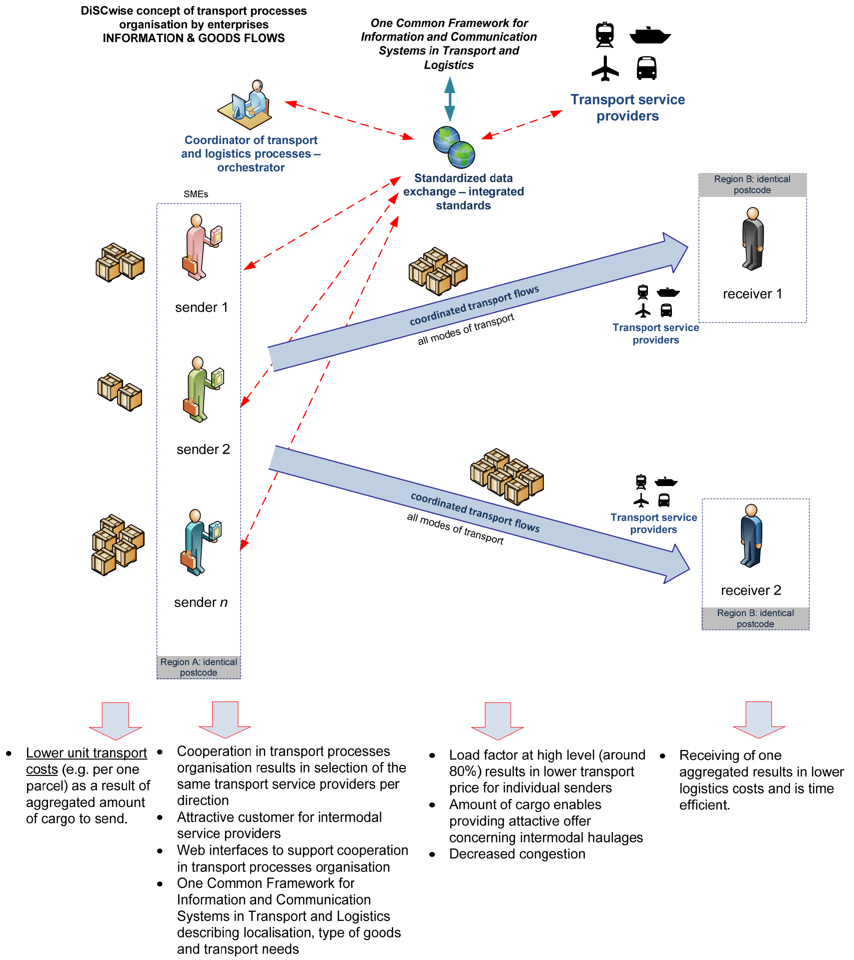


Fig 5. Reference model idea

As it was stated, vertical and horizontal cooperation and data exchange, cannot be done without support of dedicated web-accessible tools allowing dynamic data exchange between all involved parties. However, most of the enterprises got used to their own standard of data exchange. Nevertheless. to achieve project objective, the information and communication systems and/or decentralized e-logistics platform used for managing transport and logistics operation need to interact efficiently and share information. Actors must be able to share that information according to their own business rules. Therefore, presented mode is interoperable through implementation concept of interfaces, based on one common standard in transport and logistics data exchange.

Developed reference model takes into consideration:

- concept of the balanced development and assumptions for the European transport policy development,
- co-modality of transport processes,
- one common standard in transport & logistics data exchange which has been developing by several EU research projects such as FREIGHTWISE, e-Freight, INTEGRITY, Smart-CM, SMARTFREIGHT, EURIDICE, RISING, DiSCwise,
- correlation between strategic planning in enterprise and current processes realization,
- correlation among logistics processes in the enterprise,
- correlation between transport system of the enterprise and the regional/national/continental transport systems,
- requirements of enterprise's clients,
- possibility of using particular computing tools and information exchange techniques,
- particular processes' impact on effectiveness of enterprise transport system.

Within the framework of the model the following instruments stimulating cooperation between enterprises need to be addressed during implementation phase:

- methodology enabling estimation of potential savings and profits that derive from cooperation among enterprises in transport processes organization,
- legal framework for cooperation between shippers, transport service providers and co-ordinator (orchestrator),
- methodology that assure common planning of transport processes in a group of enterprises taking into consideration relation of a trade-off with inventory management as well as warehousing processes,
- methodology that assures common planning of transport processes in a group of enterprises in compliance with a trade-off relation between micro scale (enterprise) and macro scale (region),
- exploitation of existing e-platforms (Kassetts, EPL, Logit d2d) that support interoperability and harmonizing logistics processes in group of enterprises and as a result allows joint organization of haulages. Furthermore the e-platforms is to support standardized data exchange process thereby enabling cooperation between users and transport service provider for all modes.

The model can be applicable in the following variants:

- within the framework of selected supply chains,
- within the framework of particular transport modes,
- within the framework of cooperative enterprises' business profile,
- within the framework of type of product.

3 Example of cooperation in pharmacy sector

Developed model was implemented in group of enterprises from pharmacy sector in Poland. Several companies decided to start cooperation within common organisation of transport & logistics processes. Institute of Logistics and Warehousing together with small and medium enterprises located in Wielkopolska and Kujawsko-Pomorskie regions has started pilot tests in May 2010. First results were very optimistic from economic point of view, as well as environmental and social.

First tests were carried out on a small sample representing group of four distributors in Poznan, Poland. Before implementation of new organisational solution, companies did not cooperate at any level, but had deliveries to the same clients or clients located very close to each other.

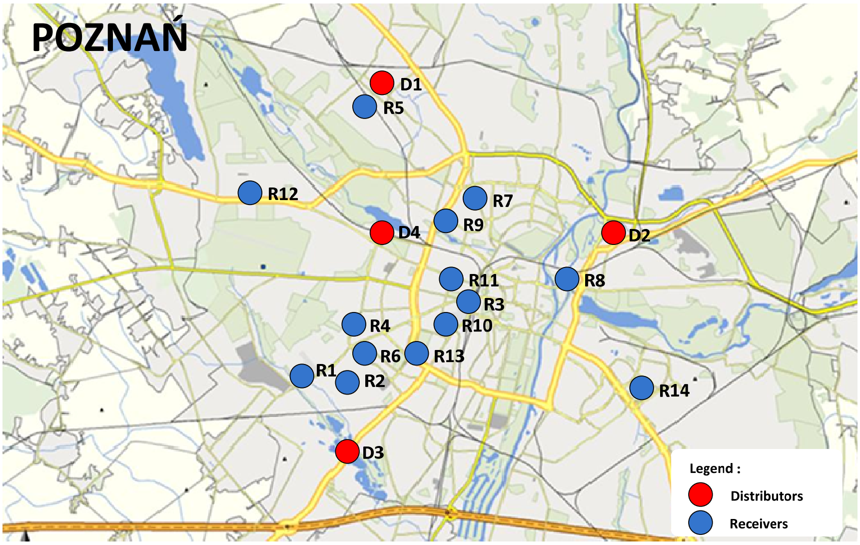


Fig. 5. Localisation of distributors and delivery, *Source: ILiM's own study*

In analysed case illustrating average day, each of the chemists ordered selected amount of products, which were delivered in special boxes (ca. 30 l), dedicated and standardized for pharmacy sector. Below implementation results are presented.

Table 1. Simulation results for two analysed options

Distrib-utors	Lack of cooperation			Cooperation (new model implemented)			
	Transport cost KTn (1 tkm = 1,08 PLN)	Average transport cost of single box [PLN]	Number of used trucks [PCS]	Trans-port cost KKTn (1 tkm = 1,08 PLN)	Average trans-port cost of single box [PLN]	Percen-tage costs savings [%]	Number of used trucks [PCS]
D 1	19,7	6,57	1	15,1	5,02	23,6	1
D 2	34,3	6,87	1	26,6	5,32	22,6	
D 3	26,3	5,26	1	18,5	3,70	29,5	
D 4	49,7	8,29	1	40,4	6,73	18,7	
To-tal	130,1	6,85	4	100,6	5,29	22,7	1

Source: Own study

The table above shows precisely the profits from the implemented solution. What is also worth paying attention to is that one truck is used instead of four ones which decreases road traffic congestion. Therefore, the solution eliminates disadvantages of the traditional method of transport process organization.

4 Summary

Presented reference model shall have a significant impact on transport and logistics systems on all levels: company, regional, national and European ones. The overall impact on the business side can be reflected not only in better economic indicators of the logistics chain participants. Better performance of supply chains will have a positive impact on the on the level of service offered to the customers. This, in turn, might create opportunities for improvements of their performance.

The reference model have a positive impact on the way that manufacturing companies cooperate with logistics service providers, as well as distribution sector (wholesalers and retailers). In addition to this, the model, is able to serve as a kind of a bridge, helping fill the gap between numerous tools, internet platforms, optimisers already available and their practical and effective implementation and exploitation. The developed approach focuses on the whole package of issues related to cooperation between business partners in a complex way, addressing not only organisational, technical and information based aspects, but also all soft measures (mental, cultural, social, environmental), equally critical for successful implementation of various concepts, methods and supporting tools.

In this way the wider implementation of presented solution can have an impact on cooperation in many more dimensions than only the business one. The outcome of the project will have a positive impact in few dimensions:

- Direct improvement of business, increased efficiency and effectiveness of transport and logistics operations in supply chains, achieved by all partners – IMPACT ON ECONOMICAL ASPECTS.
- Better communication and cooperation between logisticians on operational level – better understanding of culture diversity (which manifests in different approach and performance in certain business scenarios), use of common operational language, promotion of commonly recognized framework of standard logistics competencies – IMPACT ON SOCIAL/HUMAN ASPECTS.

- Environmentally friendly (green) transport and logistics solutions leading to: lower energy consumption, less pollution, less congestion, less noise and fewer accidents – IMPACT ON ENVIRONMENTAL ASPECTS.

References

[1] A sustainable future for transport: Towards an integrated, technology-led and user friendly system, Commission of the European Communities, Brussels, 2009

[2] Atkinson G., Dietz S., Neumayer E., (2007), Handbook of Sustainable Development, Edward Elgar Publishing Limited, Massachisetts.

[3] Coyle J., Bardi E., Langley C., (2003), The management of business logistics: a supply chain perspective, South-Western

[4] Doumpos M., Zopunidis C., (2002), Multicriteria Decision Aid Classification Methods, Kluwer Academic Publishers, New York.

[5] Energy, transport and environment indicators, Office for Official Publications of the European Communities, Luksemburg, 2008

[6] Fjørtoft K. E. (2009), Recommendations for Standardization, Deliverable 13.4, Freightwise project, Trondheim.

[7] French L. W., (1987), The Personnel Management Process, Houghton Mifflin Company, Boston.

[8] Ghani G., Laporte G., Musmanno R., (2004), Introduction to Logistics Systems Planning & Control, John Willey & Sons, Ltd., Chichester.

[9] Hajdul M, Cyplik P., Trade-off relations between the production plan and the transport organization in production company, International Symposium on Logistics and Industrial Informatics, LINDI 2007, IEEE 2007, s. 50-55.

[10] Hajdul M., Guszczak B., Knowledge transfer as an element of streamlining transport processes in business activities, w: Fertsch M., Grzybowska A, Stachowiak A.: Modelling of modern eneterprises logistics, Wydawnictwo Politechniki Poznańskiej, Poznań 2009.

[11] Hajdul M., Cyplik P., Efficient planning of transport processes which takes into consideration trade-offs relations with inventory management, w: Fertsch M., Grzybowska A, Stachowiak A.: Modelling of modern eneterprises logistics, Wydawnictwo Politechniki Poznańskiej, Poznań 2009.

[12] Hajdul M., Rydzkowski W., Factors influencing modal split and construction of intermodal chains, w. Innovative perspective of transport and logistics, red. Burnewicz J., Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk 2009.

[13] Hajdul M., Rydzkowski W., Price differentiation as way to increase intermodal transport in Europe, Logistikwürfel, red. Pfohl H. Ch., Gabler Verlag, Berlin 2010.

[14] Hajdul M., Kawa A., Golińska K., Pawlewski P., Cooperative Purchasing of Logistics Services among Manufacturing Companies based on Semantic Web and Multi-Agent System, W : Y. Demazeau (et al.) (Eds.): 8th International Conference on Practical Applications of Agents and Multiagent Systems, Advances in Intelligent and Soft Computing, Vol. 71, Springer-Verlag, Berlin Heidelberg 2010

[15] Hajdul M., Model of coordination of transport processes according to the concept of sustainable development, LogForum, No. 3(21) 2010, s. 45-55

[16] Hall W. R. (red.), (2003), Handbook of transportation science, Kluwer Academic Publisher, New York.

[17] Hugos M., (2003), Essentials of Supply Chain Management, John Wiley & Sons, Inc., New Jersey.

[18] Pidd M., (2003), Tools for Thinking. Modelling in Management Science, John Willey & Sons, Chichester.

[19] Rydzkowski W., Wojewódzka-Król K. (red.), (Transport), Transport, Wydawnictwo Naukowe PWN, Warszawa.

[20] Ulieru M., Brennan R.W., Walker S.S., The Holonic enterprise: A model for Internet-enabled global manufacturing supply chain and workflow management. Integrated Manufacturing Systems, vol. 13, no. 8, 2002

[21] Watson-Manheim M. B., Chudoba K.M., Crowston K., Discontinuities and Continiuities: A New way to under stand virtual work, International Technology and People vol. 15, no 3, 2002

[22] Wüstenhagen R. (2008): Sustainable innovation and entrepreneurship, Edward Elgar, Northampton.

One Common Framework for Information and Communication Systems in Transport and Logistics – case study

Marcin Hajdul[1], Marta Cudzilo[1]

[1]Institute of Logistics and Warehousing,

marcin.hajdul@ilim.poznan.pl, marta.cudzilo@ilim.poznan.pl

Abstract. Supply chains are becoming more and more global and responsive. The drive for more environment-friendly, decongested and secure logistics has led to the introduction of such concepts as Co-Modality, Motorways of the Sea, Secure Trade Lanes and Green Corridors. A number of EU funded research and development projects have been addressing the issues of information and communication technologies in transport and logistics. Traditionally, these projects have been quite autonomous and there has been little coordinated contact between the projects. This following projects: FREIGHTWISE, eFreight, INTEGRITY, Smart-CM, SMARTFREIGHT, EURIDICE, RISING, DiSCwise together developed one Common Framework for exchange of information between ICT systems in transport and logistics.The aim of the chapter is to present how the Common Framework supports interoperability between commercial actors and communication to authorities and transportation network responsible. Presented framework was validated in real business case with participation of the industry.

Keywords: co-modality, supply chain, sustainable development, data exchange, information and communication systems

1 Introduction

Transport is one of the most important sectors for the European economy. Perceived in a broader context as freight and passenger transport logistics, it can be seen as: a critical facilitator of trade and economy, significant cost driver and finally – what has become particularly important in the recent years – a factor having considerable impact on all environmental and social issues [14]. Certainly, the influence exerted by transport sector on these areas does not come from trucks only, and thus solutions can't be reduced to technological improvements of vehicles and road/rail infrastructure only. There are much more complex interdepend-

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_39,

encies between transport operations, economical issues, as well as managerial decisions, giving way to development and implementation of innovative solutions.

It is worth mentioning, that instead of condition of European economy, results of world financial crisis from 2008, increase in the volume of cargo and passenger transport has been observed, especially with usage of road transport. This reflects in increasing traffic congestion on major transport routes. Recent trends in freight and passenger modal split in Europe illustrate the dominant role of road transport. This dominance has increased in the last decade. When only inland goods movements were taken into consideration (i.e. excluding sea), road's share of tonne kilometres in Euro27 rise to 76% despite low figures in some individual countries1.

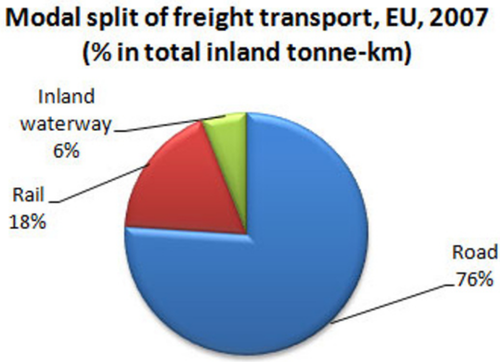


Fig 1. Modal split of freight transport in EU 27 - 2007 (% of tkm)

Source: Own study based on energy, transport and environment indicators, European Commission, edition 2009.

EU members states, have been trying to solve problems which results from described situation (e.g. congestion, COx emissions, accidents, increasing prices for transport services, decreasing of customer service level, etc.) by implementing measures defined, by European Commission, in numerous strategic documents as White Paper, Keep Europe Moving, Keeping Freight Moving, Greening Transport, Maritime Transport and Future of Transport [10]. Growth of intermodal transport, as well as co-modality approach to organizing haulages, both for passengers and goods, are the most important challenges in recent years. This require, effective logistics and supply chain management requires sharing knowledge and information along the supply chain. In this context, efficient cooperation between actors in integrated supply chains becomes more and more important. To achieve this, the information and communication systems used for managing transport and logistics operation need to interact efficiently, share information – they must be interoperable – and the actors must be enabled to share that information according to their own business rules. Similar exchange of information is necessary between private stakeholders and authorities.

[1] Based on recent available data published by European Commission – Eurostat.

Despite the fact that standards exist, industry representatives have realised that a paradigm shift in interoperability is needed if logistics efficiency is to be improved and political goals of reducing the environmental impact of transport are to be met. One example of an industrial initiative in this direction is the development of a new Logistics Interoperability Model (LIM) by GS1. Behind the LIM proposal are large manufacturers and logistics service providers [12].

Moreover, the importance of transport sector and its problems has made it a subject of numerous work programmes and particular calls within all research programmes either coordinated by the European Commission or by the national units. Traditionally, these projects have been quite autonomous and there has been little coordinated contact between the projects. This has, however, now changed. The partners in a number of ongoing EU funded projects (Freightwise, Euridice, Integrity, Rising, DiSCwise, SMARTFREIGHT, eFreight) have realised that there are project benefits that may be exploited from better cooperation. This view is also shared by the EU Commission [12].

As industrial developments and the research community have reached similar conclusions, a joint initiative has been taken to improve interoperability considerably by developing one Common Framework for exchange of information between ICT systems in transport and logistics.

2 One Common Framework for Information and Communication Systems in Transport and Logistics

The Common Framework developed by DiSCwise, as well as several other EU projects, supports interoperability between commercial actors and communication to authorities and transportation network responsible – to make the best possible use of the available transportation infrastructure, provide appropriate supply chain security, and support compliance requirements. To drive the required paradigm shift, the Common Framework addresses interoperability issues at two main levels in a technology-independent way. At the process and information level, the Common Framework is developed to ensure that only necessary and sufficient information is being exchanged, that the number of messages and their complexity is kept to a minimum, that the messages are unambiguous and that there will essentially be no need for business process harmonisation. At the architectural level, the framework builds on open services platforms and self-configuring logistics networks and devices - to support Intelligent Cargo, Single Windows and other mechanisms for collaboration and monitoring.

The Common Framework approach lowers the cost for companies to electronically connect in transport and logistics, without forcing those who already have invested much in the area to stop using what they have. Close cooperation has been established with standards organisations. In addition to being deployed in industry, the Common Framework will provide a mechanism for current and new research and development project to provide interoperability of relevant results [12].

On the basis of the projects already mentioned, a list of requirements for a Common Framework has been identified:

- Support multimodality (co-modality),
- Be stable and easy to refine and expand,
- Be future-oriented (independent of current solutions),
- Provide a total picture (supporting transparency, management, and security),
- Facilitate hiding of complexity (abstraction, simplification),
- Focus on interoperability (not on inner parts of systems),
- Independent of technology,
- Facilitating interaction with existing standards (to help protect investments already made in legacy and other systems).

Further requirements that have been extracted in the process leading up to the development of this document are as follows:

Different stakeholders have their own strategies and objectives and will have to be given the possibilities to continuously develop these. As a consequence, the Framework needs to:

- Assist in making the European transport and logistics system more efficient and environmentally friendly
- Provide interoperability without constraining business process development and improvements
- Lower barriers to improve business processes and develop new business models. The document "CO3: Collaboration Concepts for Co-modality" [3] expresses a situation where the transport and logistics industry needs to develop business processes over time until the goal of ensuring the best possible use of all transportation resources has been reached.
- Simplify interaction with authorities and compliance. For the time being there are different requirements for compliance and reporting for different modes and different geographies.
- Unlock access to services that would not be available without it.
- Enable market leaders and SMEs to interact at a low cost, and this should emerge as a standard endorsed and adopted by major freight ICT systems providers and logistics operators. Stakeholders that already have invested significant in existing ICT systems and associated technologies should be able to further exploit these investments and not replace them.

The ambition of the Common Framework is that it shall be able to communicate necessary and sufficient information between the stakeholders involved in freight transport management.

Figure 15 shows the elements of the Common Framework [7; 12]:

- TSD Transport Service Description – a standard description of transport services suitable for automatic detection
- TEP/TI Transport Execution Plan/Transport Instruction – describing all the information needed related to the execution of a transport service.
- GII Goods Item Itinerary – providing information about the movement of the goods (possibly through a chain of services)

- TES Transport Execution Status – providing information about the progress of the transport and of the cargo condition
- TOS Transport Operation Status – assisting in establishing the best possible arrival time estimates
- SDM Security Data Message – providing information about the security of a sealed load unit.
- STD Standard Transport Document – providing a unified way of informing authorities about transport such that compliance may be verified.
- TNS Transportation Network Status – nor suggested as a new standard, but a pointer to messages providing such information for the different transport modes.

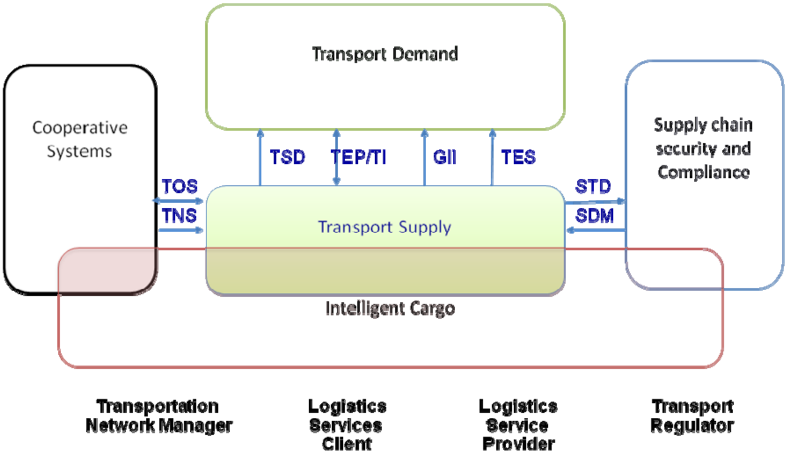


Fig. 2. Common Framework summary, *Source: [12]*

The figure 3 shows detailed profile of the Transport Service Description (TSD), one of the data exchange standards from the Common Framework.

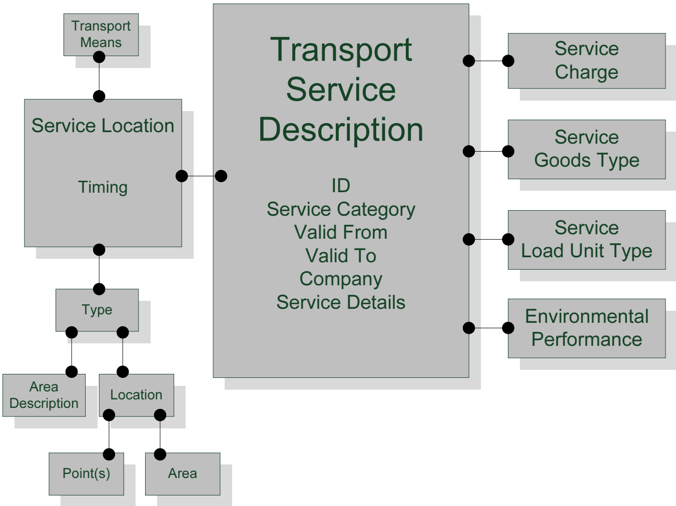


Fig. 3. Transport Service Description, *Source: [12]*

When the Framework is developed, it is important that the information that is exchanged enables all stakeholders to perform well. Hence, information needs to be necessary and sufficient. Figure 4 presents additional example of Goods Item Itinerary (GII). All door-to-door transport operations using more than one mode of transport, and many of those that use only one mode, are not direct services being provided without transshipment. Hence, it is necessary to be able to describe the complete itinerary for a given goods item. The Goods Item Itinerary provides this capability and the planned, estimated, and actual times for departure and arrival for each service, or segment is included. This means that information in the GII may later be used to trace the exact movement of goods through a supply chain. It is communicated from the Logistics Services Provider to Logistics Services Client when the Transport Instruction is marked “Ready for Execution”.

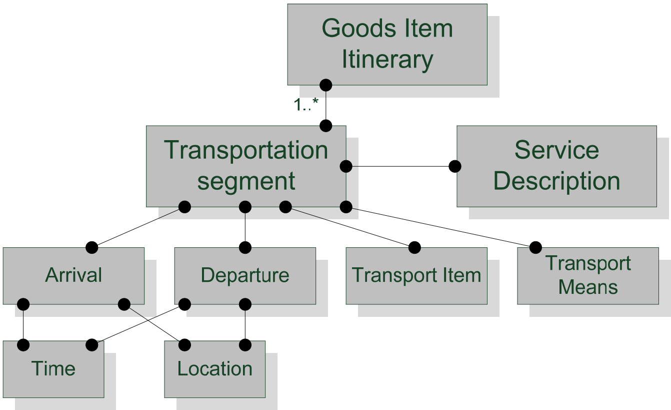


Fig 4. Goods Item Itinerary, *Source: [12]*

Figure 5 shows, as an example, how data that are relevant for planning purposes are being exchanged between providers and users of so-called Transport Services.

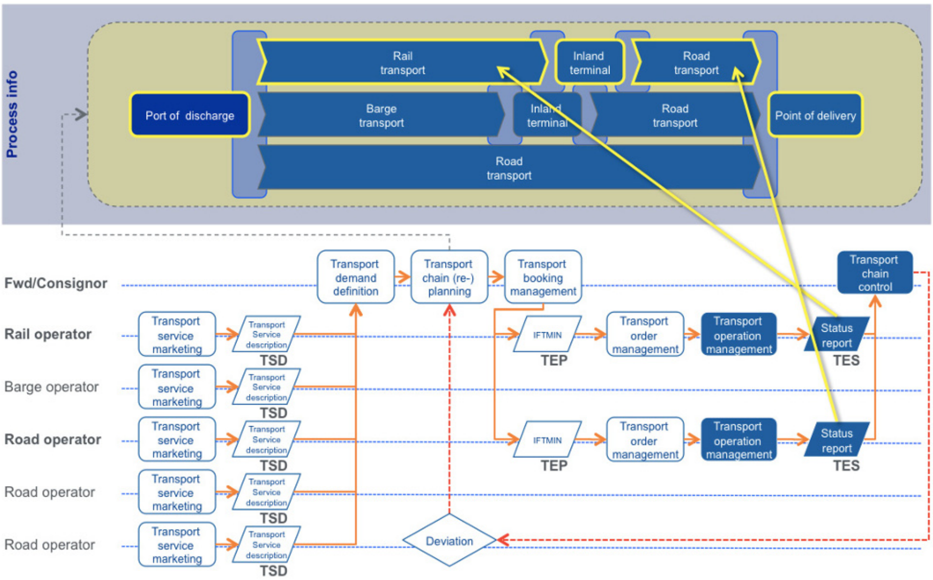


Fig 5. Data exchange in selected transport processes based on Common Framework, *Source: [12]*

Figure 5 also presents that several providers of transport services to connect the port of discharge to the hinterland are able to electronically publish their service offering using the Transport Service Description (TSD). The forwarder responsible for organizing the transport to the hinterland can plan this hinterland operation – either as a single road leg, or as an intermodal transport chain that exists of multiple legs combining rail or barge with road for the 'last mile'. After planning the forwarder communicates the booking and transport instruction to the operators. The latter are able to report back on the status of the transport execution. Based on feedback received from the individual legs, the forwarder is able to monitor the status of the transport chain up to the point of delivery. In case of deviations he might be forced to re-plan the hinterland transportation.

3 Practical implementation of One Common Framework

One Common Framework has verified in case focusing on stimulation the cooperation between logistics service clients (consignees, consignors) and transport service providers (SMEs) in view of increasing the load factor, reducing transport costs and exploiting co-modality concept. This cooperation model required efficient exchange of data, according to the reference architecture. Pilot in Poland, carried out by the Institute of Logistics and Warehousing, involved small, medium and big enterprises and focus on FMCG sector. Demonstration in Poland has been carrying out with support of ECR Poland Shared Supply Chain Workgroup.

ECR Poland is a non-profit association focused on optimising value chains in order to deliver better value for consumers/shoppers. ECR Mission is Working together to fulfil consumer/shopper needs – better, faster and at less cost in a sustainable way. ECR Poland gathers large, medium and small companies representing Fast Moving Consumer Goods sector in Poland:

- retailers and wholesalers,
- manufacturers (suppliers),
- service providers (including logistics and IT services).

ECR Poland Shared Supply Chain Workgroup was sanctioned by the ECR Poland Supply Forum earlier this year with the goal – to initially assess needs and value of sharing supply chains initiatives, build the business case and furthermore – to develop possible cooperation schemes and best practices for ECR Member companies and other FMCG organisations.

Many of the FMCG key players struggle with high distribution costs. Some of the LSP provide more complex service – including warehousing, transportation and stock management, allowing for more flexible ordering arrangements between manufacturers and retailers, however at premium price for the customer. At the same time, there are many FMCG companies with fully standalone distribution networks and/or using singular services from LSPs.

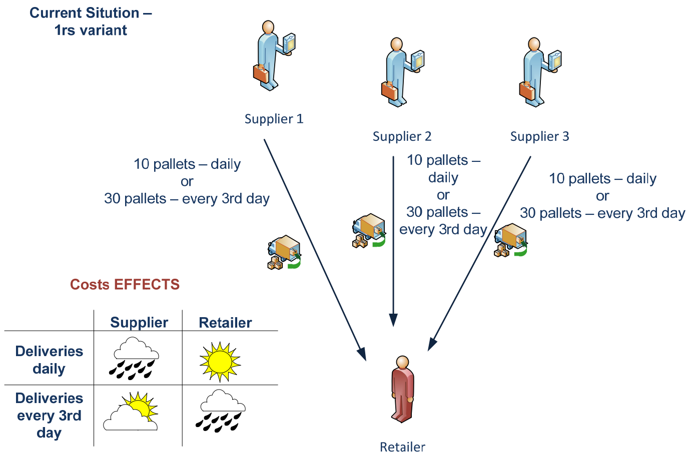


Fig. 6. Current situation visualisation

Unfortunately, the current trend, i.e. frequent and small deliveries results in growing high transport costs. Furthermore, the number of delivery trucks is also raising which increases traffic congestion and, as a result, longer delivery times is another disadvantage [11]. The main objective of the pilot was to ensure efficient exchange of information between cooperating logistics service clients (consignees, consignors) and transport service providers (SMEs) in order to rationalize organization of transport processes.

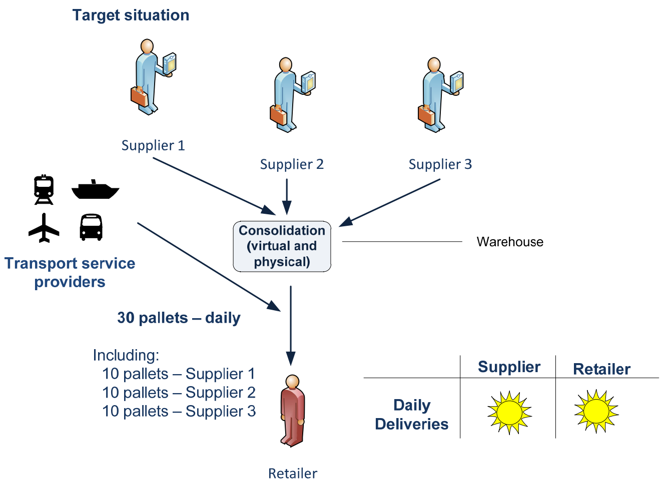


Fig. 7. Possible example of expected situation

Source: Own study

The whole work have been divided in three stages.

- STAGE I Data analysis, preparing data for simulation
- STAGE II Simulation – costs analysis for 3 variants of supply
- STAGE III Results analysis, conclusions – feedback to reference architecture

Stage I consist of the following tasks:

1. Verifying data bases
2. Selecting common cities by clients
3. Limiting supply points – supplies to clients from common cities only
4. Removing general cargo (Energizer – parcels)
5. Verifying supplies to common cities
6. Defining distance from the warehouse in G dki to particular cities
7. Defining common localisations within the cities – 2 variants:
   - city, street, number
   - city, street
8. Ordering supplies day by day for both lists of common localisations – basis of the simulation

Within the confines of stage II the following activities were carried out:

- Costs of supply in three variants were calculated for common localisations:
  - variant 1: costs of supply for company X
  - variant 2: costs of supply for company Y
  - variant 3: costs of supply for common localizations of both companies (combining volumes)

- 2 types of price lists were used:
  - LTL (Less then Truck Loaded) → pallets price list (price per 1 pul depending on transported volume and distance)
  - FTL (Full Truck Loaded) → price list per vehicle (price per kilometer: 2,9 PLN/km/32 pul),

Moreover, both companies carried out deliveries on EUR pallets (1,2m x 0,8m x 1,2m).

As a result two independent databases were unified. Figure 8 presents common delivery points of two companies.

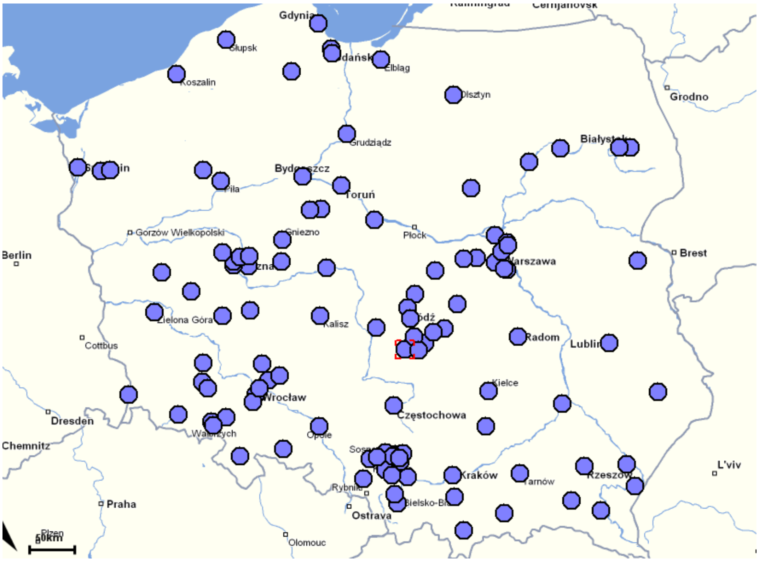


Fig 8. Common cities according to the clients databases

Analyses in stage III were made based on the following assumptions:

- Referred period of transport flows – full year.
- Costs were calculated for each day with supplies to the common localisations.
- Only supplies which carried out deliveries in the same day, to the same localisation (regarded common) were combined in first attempt of the simulation. In second attempt delivery dates were rationalized and unified in selected samples.

Stage III provided preliminary results and proved that the concept has a huge potential in terms of cost and time savings, as well as increasing competitiveness. Based on the achieved results the following conclusions were made:

- First simulation proved that cooperation in organisation of transport processes by transport users can bring financial, quality and organisational benefits.
- Standardisation of two independent databases contribute to transport cost reduction by 6-7% (of total transport costs) – without reducing customer service level.
- Implementation of One Common Framework for Information and Communication Systems in Transport and Logistics is essential for further optimisation of transport & logistics processes within supply chains.
- For more than two enterprises there is a need for a electronic , web-accessible, communication platform (like D2D, EPL, Kassetts), which allows efficient information exchange.

4 Summary

It can be noticed on presented example proved benefits of One Common Framework for different actors directly or indirectly involved in the supply chain. Firstly, profits are achieved by companies which reduce transport costs without reducing customer service level. Furthermore, the solution reduces the number of used trucks which contributes to reduction of truck traffic. It is noticeable that such an approach brings benefits companies from increased effectiveness both in the long- and short-term. Therefore, the approach complies with the sustainable development concept.

Another group that is indirectly involved in the supply chain are road users that have more and more problems with moving on the roads due to the growing traffic congestion. So, transport process organization improvement in companies resulting in reduction of delivery trucks is also profitable for the users of passenger cars.

The transport process organization strategy presented in the paper is also compatible with the current European Commission transport policy promoting transport process co-modality. The term describes separate or joint effective utilisation of various transport means in order to make the utilisation of the resource optimal and sustainable [11]. „Optimal" should be understood in terms of both economic, financial, service level and environment protection aspects [11]. However, there is a need to raise awareness of all actors, involved directly and indirectly in the transport chains, about strong relations between micro and macro scale and the potential benefits from implementing suggested solution in terms of economy, environment and society.

To sum up, real financial advantages and a perspective of a long-term business development is a great added value of presented solution. Achieved results allow to start implementing concept in wider group of small and medium enterprises.

References

[1] A sustainable future for transport: Towards an integrated, technology-led and user friendly system, Commission of the European Communities, Brussels, 2009

[2] Atkinson G., Dietz S., Neumayer E., (2007), Handbook of Sustainable Development, Edward Elgar Publishing Limited, Massachisetts.

[3] Barbarino S., T'Hooft D., Cruijssen F., Verstrepen S., Fumuso A., (2010), CO3: Collaboration Concepts for Co-modality, Transport Research Arena Europe, Brussels.
[4] Coyle J., Bardi E., Langley C., (2003), The management of business logistics: a supply chain perspective, South-Western.
[5] Communication from the Commission - The EU's freight transport agenda: Boosting the efficiency, integration and sustainability of freight transport in Europe, Brussels, 2007.
[6] Energy, transport and environment indicators, Office for Official Publications of the European Communities, Luksemburg, 2008.
[7] Fjørtoft K. E. (2009), Recommendations for Standardization, Deliverable 13.4, Freightwise project, Trondheim.
[8] Ghani G., Laporte G., Musmanno R., (2004), Introduction to Logistics Systems Planning & Control, John Willey & Sons, Ltd., Chichester.
[9] Hajdul M., Rydzkowski W., (2009) Factors influencing modal split and construction of intermodal chains, w. Innovative perspective of transport and logistics, red. Burnewicz J., Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk.
[10] Hajdul M., Rydzkowski W., (2010) Price differentiation as way to increase intermodal transport in Europe, Logistikwürfel, red. Pfohl H. Ch., Gabler Verlag, Berlin.
[11] Hajdul M., Model of coordination of transport processes according to the concept of sustainable development, LogForum, No. 3(21) 2010, s. 45-55.
[12] Pedersen T. J., Paganelli P., Knoors F., (2010), One Common Framework for Information and Communication Systems in Transport and Logistics, DiSCwise project deliverable, Brussels.
[13] Pidd M., (2003), Tools for Thinking. Modelling in Management Science, John Willey & Sons, Chichester.
[14] Rydzkowski W., Wojewódzka-Król K. (red.), (Transport), Transport, Wydawnictwo Naukowe PWN, Warszawa.
[15] Soubbotina P. T., (2004), Beyond economic growth. An introduction to sustainable development, The World Bann, Washington.

Global influence of multi-area integration of logistic processes

Marta Cudzilo[1], Karolina Kolinska[1]

[1]Institute of Logistics and Warehousing

marta.cudzilo@ilim.poznan.pl, karolina.kolinska@ilim.poznan.pl

Abstract. This chapter presents the rationale behind the need of cooperation of companies making up the supply chains and integration of logistics processes carried out in them. Realization of cooperation was confirmed by the analysis of trade-off relationship occurring at the crossroads of logistics, such as transport, warehousing, inventory control. Particular attention in the article devoted to aspects related to the impact of local solutions to optimize the market environment. The chapter presents optimization solutions to the potential impact on traffic congestion and verified their correspondence to the concept of sustainable development. An important element of the article provides an overview of methods and tools available on the market and used in the process of multi-territorial optimize logistics processes. Identified solutions (both substantive and information technology) in different ways capture the issue of optimization of logistics processes, but their common feature is that they do not include interaction between large-scale logistics processes, and optimization activities are carried out only within individual functional areas.

Keywords: transport, logistics processes, trade-off, inventory management

1 The need for multi-area integration of logistic processes

It can be observed that there are more and more mergers on the market and competition and customers' expectations are rising. Companies start to notice that generating profit and building a strong position and predominance on the market is possible by means of an effective organisation of logistic processes. Many companies have understood that their market success depends on the competitive strength of the whole supply chain in which they participate. It is very important to offer high quality products to realize orders fast and effectively and to make sure that the products are available. All this has an impact on a product's price and the level of Customer's Service. Logistics in supply chains has started to be seen systemically as a compilation of elements and processes which depend on one another. Due to this fact there have been initiatives which aim at rationalising the

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_40,

way of organising transport processes, processes connected with managing the stock and warehouse processes which are a key element of a logistic system of productive and distributive companies.

Rationalisation of the logistic processes in supply chains is difficult because of strong trade-off relations between the aforementioned areas. Often improvement of one part of the system generates deterioration of another area. An example of a trade-off relation taking place on the verge of an area of supplies management and transport management is settling the size of the purchase portion and, consequently, the frequency of the purchase. Reducing the size of the purchase portion is beneficial from the point of view of forming supplies as it decreases their level also in the cost aspect. However, it needs to be remembered that frequent deliveries of small amounts increase transport costs. In addition, generating numerous orders from suppliers increases purchase costs (purchase costs of smaller portions are usually bigger not only because of higher prices of the products but also because of higher cost of handling many orders) and has a direct impact on a substantial number of orders which causes lowering the effectiveness of realised warehouse processes. Trade-off relations between the area of managing the supplies and managing the warehouse are mainly dependent on a physical form of goods [24]. Optimisation of warehouse processes requires activities which allow for a hierarchy of packaging of individual goods, especially the size of summary packaging, which can negatively influence the costs connected with supplies maintenance. On the other hand, such action has positive effect on the rationalisation of transport processes (optimisation of transport portion and, at the same time, lowering transport costs).

Nowadays, as the studies done by the Institute of Logistics and Warehousing show, the integration level of companies which constitute individual links of a supply chain is very low. Each company usually realises its own tasks and logistic aims. The reason for such a situation is that the market lacks suitable methods and tools which would allow for multi-criteria optimisation of logistic activities and starting an effective cooperation between the partners in supply chains. The result of the lack of integration is a substantial decrease in the effectiveness of the flow of information and products, lengthening the time of reaction to changes and increase in logistic costs. The way to change the present situation is ensure a suitable level of integration of a supply chain. This can be done through implementing methodical and IT solutions which facilitate the cooperation of individual links and optimisation of logistic processes realized in them. Implementing an integrated attitude towards managing supplies, transport and warehouse's work would enable companies to gain dominance or keep the stable competitive position. The companies could also develop systems of quick reaction to customers' needs for supplies and, at the same time, optimise logistic costs and stick to the rules of a balanced development. As a result, a company can gain the following benefits:

- a substantial rationalisation of the information flow among the supply chains with a simultaneous increase in credibility and reliability of the data,
- synchronising transport with supplies management, which would allow for setting an optimum size of a supply portion and a safe frequency of deliver-

ies while keeping the expected level of goods' availability and optimum exploitation of means of transport,
- ensuring that the deliveries are on time and keeping good quality, which optimises the size of supplies and decreases costs of warehousing,
- ensuring the quality of products and services through their delivery readiness, better quality of parcels, flexibility of reactions to changes as well as reliability and availability of means of transport,
- development of strategic and operational planning of logistic processes in the whole supply chain.

For these reasons it is necessary to search for solutions which will allow for optimising the area of transport, supplies management and warehouse management.

2 Methods and tools of multi-area integration of logistic processes

2.1 Methods of multi-area integration of logistic processes

Nowadays the market offers a wide range of methods and tools which enable companies to increase their effectiveness in realising logistic processes. Companies have realised that effective organisation of logistic processes has an enormous influence on their present functioning, which affects the level of company's overall costs [5]. For a few years the market has been offering many methods which imply the way of organising logistic processes so as to achieve optimum functioning of the area of managing the supplies, transport and/or a warehouse. Among the aforementioned methods there are the most popular concepts such as [8; 9; 14; 21]: Distribution Requirement Planning (DRP) [28], Just-in Time (JIT) [6], Total Quality Management (TQM) [16], Efficient Consumer Response (ECR) [19], Collaborative Planning, Forecasting and Replenishment (CPFR) [26], Theory of Constraints (TOC) [11], Business Process Reengineering (BRP) [23], Change management [2], Capability Maturity Model Integration (CMMI) [25], Benchmarking [10], Six Sigma [20], Process Improvement and Management (PI&M) [27], Rational Unified Process (RUP) [4], Zachman Framework [22]. Popularity of these methods is more a consequence of their dissemination in industry literature than their real implementation by companies in European markets [17]. Companies which try to implement these methods are not able to achieve rationalisation of logistic processes in the form of expected measurable results such as, for example, increase in the availability of goods, decrease of transport costs, etc. It is probably caused by the complexity of those methods and difficulty with turning them into real action steps as well as the fact that they do not take into consideration the relations between logistic processes (they do not include the trade-off relation). It often happens that implementing methodical solutions leads to the so-called sub-optimisation, which means that only one subsystem of logistics, treated as a whole, is reformed and it does not lead to improving the functioning of the whole logistic system and its global optimisation. An example of sub-optimisation can be implementing the algorithm of replenishment which lead to optimisation of the purchase portion so that the demand can be met. It helps to decrease the level of supplies but, at the same time, increases transport costs (the whole vehicle size is not included).

Another disadvantage of the aforementioned methods is that they do not take into consideration relations between companies and correlations taking place in the supply chains. They are only dedicated to one company's needs. Moreover, the methods which are on the market do not bring up the issue of the influence which the recommended solutions can have on a company's environment and they do not include the aspects of global optimisation.

To summarise the analysis of the methodical solutions supporting logistic activity of companies, it needs to be stated that on the market there are no methods which can solve the problem of trade-off relations and deal with the issue of the influence of local optimisation on a company's environment [7].

2.2 An analysis of IT possibilities of supporting the integration of logistic processes

IT solutions offered by the market also do not include correlation between logistic processes and optimisation activities are usually realised in individual functional areas or processes. IT support of individual activities such as managing supplies, warehouse or transport does not solve the problems connected with global optimisation of logistic processes. There are no solutions which would have the functionality integrating all piecemeal optimising solutions (modules).

Meanwhile, market studies show that companies are interested in solutions which would employ methodology and IT technology to optimise complex logistic processes in a multi-criteria and complex way. Such solutions could be a supplement to companies' IT systems which do not have the functionality in this area.

IT systems used by companies can be divided into two groups:

- Systems which support Enterprise Resource Planning (ERP) which are composed of many modules aiming at controlling economic activity of the whole company,
- Dedicated systems which function in one/a few areas, for example transport systems, warehouse systems, etc.

Analysis of ERP systems available on the European market has shown that the tools have modules supporting the area of transport and storing but there is no a separate module which would support managing the supplies. In most of ERP systems individual functions dealing with supplies are dispersed in the whole system and made available on screen forms in a place where they should be used in a given moment and recording supplies is done through registering special documents of the warehouse turnover.

Apart from integrated ERP systems, European market also offers area-oriented applications which means that they support managing the warehouse or transport, sporadically they support managing the supplies. Examples of such applications are Trans-Sped, Shipper, Transport Company, QGUAR WMS PRO, MaGS1, FERRODO. These applications have a very wide functionality in the area which they are designed for. However, their implementation does not allow for holistic approach towards managing logistic processes.

IT tools which are available on the market have also been analysed in search for new technologies, compatibility with the standards and the possibility of supporting the policy promoted by the European Commission (in the area of the so-called co-modality). A substantial disadvantage of most available on the market IT solutions is the lack of traceability of the products. Meanwhile, traceability is required when it comes to food1 and it is very important in other industries, such as pharmaceuticals, para-pharmaceuticals, and cosmetics. What is more, most existing IT tools do not support European transport policy (co-modality, balanced development) and operative regulations. As studies show, there is a growing demand on the market for alternative means of transport. Such solutions are more beneficial not only for economic reasons but also for environmental and social reasons. An example can be intermodal transport on some routes [12]. Intermodal transport is used not only to reduce the time the shipment of goods, or reduced transportation costs, but also in to reduce emissions of CO2 to the atmosphere [18].

3 Influence of logistic processes on environment

Global optimisation of logistic processes is justified not only because of its positive influence on the condition of companies which create supply chains but also because of its positive influence on the environment and community. The aforementioned influence is a consequence of a strong correlation between realisation of transport processes in individual companies and the transport system of a country. The fact that companies transport their goods mainly by road causes congestions, is a threat to road safety and makes the transport slower. This fact has been noticed by the European Commission which promotes the rule of co-modality (effective organisation of transport processes with the help of one or a few transport branches) in many documents, such as White Paper, Keep Europe Moving, Keep Freight Moving, Greening Transport and Future of Transport. This effectiveness should include economic, social and environmental aspect.

Integrated approach towards realisation of logistic processes and implementing solutions from this area in economic practice will allow for decrease in road congestion in the region. As mentioned earlier, such action is in accordance with the co-modality promoted by the European Commission. Methodology of integrated optimisation of logistic processes is also in accordance with the theory of a balanced development. This theory assumes that balanced development makes it possible to cater for current needs in a way which does not eliminate the possibility of catering for the same or different needs in the future [1; 3].

A detailed research has been carried out to present the influence which realising the actions mentioned in this manuscript has on a transport system of a given

[1] it is specified by the new European dietary law which is legitimized by regulation no. 178/2002 valid from 01.01.2005.

region where individual companies work. The results of this research are presented in Table 1 which shows the results of rationalising a transport system of a chosen company. An analysis of the data included in Table 1 shows that after rationalising transport processes in a given company the number of vehicles performing deliveries has fallen down and, similarly, transport costs have decreased.

Table 1. Results of a transport system rationalisation in the analysed company for a 5-week period

No.	Parameter	Condition before rationalization	Condition after rationalization
1	Total number of full supply of the vehicle	106	128
2	Total number of partial deliveries	43	21
3	Total number of vehicles carrying supplies	149	128
4	Reduction of vehicles carrying supplies	0%	14%
5	Total transport costs	100%	91%

Source:[13]

Table 2 shows the results of congestion measurements in a company's surroundings before and after implementing rationalising actions. It can be seen that the number of vehicles on the analysed road section has fallen down by 1%. Additionally, the consequence of lowering the number of vehicles will be a lowering the emission of CO2.

Table 2. Traffic congestion in a company's surroundings before and after rationalisation

Route number	Name	Before rationalization		After rationalization		Reduction rates of heavy traffic
		Total Vehicles	Total Trucks	Total Vehicles	Total Trucks	
		SDR	SDR	SDR	SDR	[%]
196	POZNAN-MUROWANA GOŚLINA	13580	2160	13576	2156	0,2

Source: [13]

Analysing the results presented in Table 2 one needs to remember that the research was carried out on the example of one company which is considered to be a medium company and only transport processes were rationalised. Optimising the model of managing the supplies was not included in the research. Nevertheless, due to this analysis one can conclude that integrated optimisation of logistic processes has an enormous influence on reducing traffic congestion in a given region.

To sum up, it needs to be stated that the methods of optimisation that are nowadays used do not take into account the relation between operational activity of a company and its influence on the environment and social relations. The influence of sub-optimum decisions on the whole transport system of a given region is also not included. Integrated rationalisation of logistic processes which supports operational activity of a company (micro scale) should be expanded to include the influence of integrating logistic processes in a supply chain on the environment (macro scale). Each time one realises rationalising actions, they should remember about a strong two-way correlation between logistic processes on a micro and macro scale. It mainly applies to transport system.

Due to multi-area integration of logistic processes companies can achieve the following results:

- Economic - on the level of a company: Minimising all-in costs in the area of transport, storing and keeping the supplies; Shortening the time of realising deliveries; Improving the process of information flow in a company as well as with the partners who directly and indirectly participate in a logistic chain; The possibility to determine the frequency of deliveries from the point of view of minimising transport costs, keeping the set level of supplies on individual indices and rationalising the work in a warehouse; Effective organisation of transport processes with the use of one or a few branches of transport and including economic aspects (co-modality); Support in company's strategic decisions such as identifying the number and location of warehouses/ factories or exploiting one or a few transport branches (e.g. road transport, inter-modal transport, rail transport).
- Environmental - Reducing emission of fumes; Reducing emission of greenhouse gases; Optimisation of the number of vehicles performing transport processes, which will reduce road congestion; Limiting the number of paper printouts of palette labels and computer printouts due to using electronic mobile terminals.
- Social - Improvement of the safety on the roads due to lowering traffic congestion; Ensuring traceability of goods in the whole system- a guarantee of consumer's safety.

4 Summary

Multi-area integration of logistic processes is a difficult subject as there are many processes which should be interrelated [15]. It is also difficult due to many trade-off relations which take place between individual processes. These relations take place on the highest general level (e.g. the area of transport- the area of managing the supplies) as well as in the frames of a given area. Nevertheless, integration of the logistic processes discussed is vital for productive as well as distributive companies.

A missing element, which would certainly made companies' actions more effective and which is presently not available on the market, is a IT system which, in its functionality, would have interrelated transport, warehouse and managing the supplies modules. Additionally, such a system should have the function of generating solutions which would take into consideration different edge conditions and user's expectations, e.g. generating the size of orders- filling the means of transport.

At present the market lacks solutions which would include trade-off relations between individual areas as well as the influence of local optimisation solutions on the environment.

There is also lack of methods thanks to which a company could integrate its logistic processes. Most methods are dedicated to individual areas of functioning (transport, storing and management) and there is no common method for these areas. Implementing such a method would surely make logistic processes more rational.

References

[1] Atkinson G., Dietz S., Neumayer E., (2007), Handbook of Sustainable Development, Edward Elgar Publishing Limited, Massachisetts.

[2] Balogun J., Jenkins M., (2003), Re-conceiving Change Management: A Knowledge-based Perspective, European Management Journal, Volume 21, Issue 2, pp. 247-257

[3] Bozarth C., Hanfield R. B., (2006), Introduction to operations and supply chain management, Pearson Prentice Hall, New Jersey

[4] Cooper K., Abraham S.P., Unnithan R.S., Chung L., Courtney S., (2006), Integrating visual goal models into the Rational Unified Process, Journal of Visual Languages & Computing, Volume 17, Issue 6, pp. 551-583

[5] Coyle J., Bardi E., Langley C., (2003), The management of business logistics: a supply chain perspective, South-Western

[6] Cua K. O., McKone K. E., Schroeder R. G., (2001), "Relationships between implementation of TQM, JIT, and TPM and manufacturing performance", [in:] Journal of Operations Management, Vol. 19, Issue 6, pp. 675-694.

[7] Cudziło M., Hajdul M., (2010), Metody i narzędzia wspierające wieloobszarową integrację procesów logistycznych z wykorzystaniem nowoczesnych technologii [Methods and tools supporting multi-area integration of logistics proceses], [in:] Technologie informacyjne w logistyce [Information technology in logistics], Golińska P., Stajniak M. (ed.), Publishing House of Poznan University of Technology, Poznan, pp. 69-81

[8] Cyplik P., Przegląd metod sterowania zapasami [A review on inventory control methods], Logistyka [Logistics] 1/2003, pp. 23-27.

[9] Doumpos M., Zopunidis C., Multicriteria Decision Aid Classification Methods, Kluwer Academic Publishers, New York, 2002.

[10] Fertsch M., (2008), Supply Chain Assessment – selected methodological issues, [in:] LogForum, Vol. 4, Issue 3, No 1, pp. 1-6

[11] Goldratt E. M., (1990), What is this thing called Theory of Constraints, North River Press, New York
[12] Hajdul M., Fechner I., Kubiak P.: Przewozy intermodalne – realne korzyści dla firm oraz użytkowników dróg [Intermodal transport - real benefits for businesses and road sers], Logistyka [Logistics] 2/2008, pp. 27-30
[13] Hajdul M.: Racjonalizacja systemów transportowych przedsiębiorstw szansą na zmniejszenie ruchu pojazdów ciężarowych w Wielkopolsce [Rationalisation of transport systems to reduce the chance of enterprises of heavy traffic in Wielkopolska], Logistyka [Logistics] 4/2007
[14] Hamid Mollach A.: Application of Failure Mode and Effect Analysis (FMEA) for Process Risk Assessment, BioProcess International 12/2005, pp. 12-20.
[15] Harrison A., van Hoek R. I., (2008), Logistics Management and Strategy: Competing Through the Supply Chain, Pearson Education, New Jersey
[16] Heizer J., Render B., (2008), Operations Management, Pearson Prentice Hall, New Jersey
[17] Keep Europe Moving, Brussels: Commission of the European Communities, 2006.
[18] Kolińska K., Koliński A., (2009), Rozpoznanie możliwych alokacji przyszłych powierzchni magazynowych w województwie pomorskim [Possible future allocation of warehouse space in the Pomorskie region], Gospodarka Materiałowa i Logistyka [Materials Management and Logistics], (7), pp. 2–6.
[19] Kotzab H., (2001), European developments in Efficient Consumer Response, Food Supply Chain Management, pp. 268-280
[20] Kwak Y. H., Anbari F. T., (2006), Benefits, obstacles, and future of six sigma approach, Technovation, Volume 26, Issues 5-6, pp. 708-715
[21] Mike Jacka J., Keller J. P., Business Process Mapping, John Wiley & Sons, New York, 2002.
[22] Noran O., (2003), An analysis of the Zachman framework for enterprise architecture from the GERAM perspective, Annual Reviews in Control, Volume 27, Issue 2, pp. 163-183
[23] O'Neill P., Sohal A. S., (1999), Business Process Reengineering A review of recent literature, Technovation, Volume 19, Issue 9, pp. 571-581
[24] Pfohl H.-Ch., (2010), Logistiksysteme: Betriebswirtschaftliche Grundlagen, Springer Verlag, Berlin
[25] Pooley R., Wilcox P., (2004), The Capability Maturity Model for Software, Applying UML, pp. 151-159
[26] Sari K., (2008), On the benefits of CPFR and VMI: A comparative simulation study, International Journal of Production Economics, Volume 113, Issue 2, pp. 575-586
[27] Schiefer G., (2002), Environmental control for process improvement and process efficiency in supply chain management – the case of the meat chain, International Journal of Production Economics, Volume 78, Issue 2, pp. 197-206
[28] Wang W., Fung R., Chai Y., (2004), Approach of just-in-time distribution requirements planning for supply chain management, International Journal of Production Economics, Volume 91, Issue 2, pp. 101-107

Automatic generation of transshipment and loading plans through a linear programming model in railway terminal

José Ángel González Manteca, Eva Ponce-Cueto

Industrial Engineering, Management and Statistics Department.
Universidad Politécnica de Madrid (UPM)

jagonzalez@etsii.upm.es, eva.ponce@upm.es

Abstract. Before the aggressive consequences of European merchandise transport modes imbalance, which results from excessive use of roads and highways, increasing railway transport can make an evolution to a sustainable model easier. The hypothesis of this chapter consists in the possible contribution of quantitative models for operations improvement that take place in railway stations. Their contributions can help to improve service levels of combined transport modes, increasing their competitiveness and providing a more sustainable mobility system. This investigation has developed a model that provides trains' automatic transferring plans generation. Particularly, the developed model for transferring containers between trains shows improvement in time response and in solutions quality related to classic manual systems used to deal with this task. The comparison among the given solutions by this model and the ones given by the traditional methods of railway companies shows without doubts improvements provided by the developed computer application.

Keywords: Combined transport, freight transport, transhipment and load planning, lineal programming, railways terminal

1 Context[1]

In the same way the term "sustainable development" is most often found in production systems as a way of considering the importance of future consequences of each specific activity, the term "sustainable transport" is repeated in studies, reports and analysis, which proceed from places ranging from public administrations to scientific and academic communities. The present, and possibly future, consequences of different transport mode use on the lives of many citizens are signifi-

[1] This paper stems from author´s participation in an european proyect INTERFACE (Improvement of Intermodal Terminal Freight Operations at Border Crossing Terminal) developed while years 2002-2005 in the V Framework Programme, European Commission, ref: GRD-2-2000-30249 SI2.339954 (2005)

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_41,

cant. This makes it inevitable to consider sustainability as a fundamental criterion in any evolution of present transport systems.

2 Freight transport in the European Union

The changes in industrial production processes, with more adjusted productions and lower inventories, trends new distribution systems and current customers consumer habits decisively influence the increase in demand for freight transport. In fact, the increase in transportation exceeds, in percentage, the growth of the economy. According to data from the European Union [3], the growth of intra-Community transport of goods has been, during the period from1995 to 2005, of 32%, while economic growth, in the same period, was 25%.
On the other hand, the current modal split of freight in Europe presents a strong imbalance. The road transport dominates widely to the rest of the modes, and exaggerated way more direct competitors, so, the rest of modes of land transport. The trend in recent years has also intensified this domain. Table 1 can be seen the evolution of the modal split of freight transport in the European Union in recent years. The year 2005 data include countries incorporated into the European Union on 1 May 2004, while the data for the year 2006 and 2008 include those current 27 members.

Table 1. Goods transport in the European Union

Year	Road	Railway	Inland waterway	Gas and oil pipeline	Transport by sea (intra-UE)
1.970	34,6	20,1	7,3	4,5	33,5
1.980	36,2	14,7	5,4	4,3	39,4
1.990	41,8	11,0	4,6	3,0	39,6
2.000	43,8	8,1	4,1	2,8	41,3
2.005*	44,2	10,0	3,3	3,4	39,1
2.006**	45,6	10,5	3,3	3,2	37,3
2.008**	45,9	10,8	3,6	3,0	36,6

2.005*: Including 10 countries into the EU in 2004

2.006 ** and 2008 **: Whereas the 27 countries comprising the European Union currently

Source: Directorate-General for energy and transport in the European Community (COM, 2010)

The impact of the strong imbalance between European transport modes are daily environment elements in the life of millions of people in the European Union. Among the most prominent problems and, consequently, more worrisome highlights: congestion, accidents and environmental impact. By way of example, one can cite, during 2008, killed by road accidents 38.875 people in the European Union, while rail accidents only 83 people [4].

The persistence of this situation can be explained, at least partially, by the fact that users do not pay the costs generated concrete transport used mode. The pricing structure does not usually reflect full costs of infrastructure, congestion, accidents and environmental impacts. This idea leads to the concept of external costs as a cost generated by the activity of transport and is not paid by the corresponding user. The statement Infras, report by the University of Karlsruhe, compared the external costs of transport of goods by road and rail in year 2000. In the conclusions, the report quantifies were 82.0 • external costs per 1000 tonne in the case of road to 18.6 • railroad.

On the other hand the rail freight presents great advantages, such as transport, high capacity the great suitability large distances, high energy efficiency, great adaptation to new technologies and the low rates of accidents. In fact, other markets, such as the United States market show very different in their modes of transport distributions. During 2008, the share of use of rail transport of goods was 42.9% in the internal market of the United States.

The lack of adaptation of the rail to the demands of the market is the source of its current decline. The European Commission for transport and energy has pointed out, in its white papers [6.], some of the causes of this lack of adaptation. Among them the fragmentation of the railway, since the design of the rail network in Europe was made when their States sought to cover mainly national and local transportation needs. This fragmentation has resulted in lack of support of the European network; understand support the capacity of a train to circular by any stretch of the rail network of the European Union.

In particular, the passage of a national railway network to another implies, in many situations, a place of strangulation in the flow of trains, due to the different characteristics of the two national networks that converge.

The research presented in this document focuses on the rail terminals between Spanish and French networks of the two rail corridors crossing the Pyrenees: the Mediterranean corridor and the Atlantic one.

3 The border of the Pyrenees rail terminals

Different researches [1; 10] brought the great impact of the border of the Pyrenees in Spain rail traffic terminals. The main problem for transit trains has been produced by different track gauge on both sides of the border. While the classic track gauge of the Iberian Peninsula is 1,676 m, elsewhere in Europe, with some exceptions, trains circulate on track width UIC (1,435 m).

On the other hand, precarious border terminals for the realization of transshipment facilities lengthened shape exaggerated employed times necessary to ensure that containers become a network to another.

In the context of the INTERFACE project, researchers from the Technical University of Madrid analysed, over a period of 24 hours, the times of permanency of the containers transported in Port Bou's terminal, as well as the different tasks undertaken during this period. These tasks were divided into three phases:

– The first, T1, since the arrival of the train until the beginning of transhipment. Includes checking and transition information platforms and containers as well as planning for manoeuvre and transfer operations.
– The second, T2, brings together all of transfer operations. To do this, it is necessary to chop the train, because length of transfer zone is lower than the own train.
– The third, T3, since the end of transshipment at the exit of the train. Includes necessary manoeuvres for their composition, as well as monitoring and checks.

With regard to containers terminal dwell times, varied between three hours with twenty minutes to 14 hours 8 minutes. Table 2 shows the results obtained, differentiating the sense of trains and the three aforementioned key phases. As you can see, the average time spent on this terminal to transfer a container is seven hours and a half.

Table 2. Analysis of transit times representative day

TRAIN	North – South				South – North				All the trains			
	T1	T2	T3	*Total*	T1	T2	T3	*Total*	T1	T2	T3	*Total*
Minimum	0:29	1:15	0:45	*3:23*	0:20	1:00	0:50	*3:45*	0:20	1:00	0:45	*3:23*
Average	0:38	2:02	4:02	*6:43*	2:57	2:23	2:45	*8:06*	1:57	2:14	3:18	*7:30*
Maximun	0:50	2:30	6:00	*8:38*	7:55	4:20	5:17	*14:08*	7:55	4:20	6:00	*14:08*

Unit: hours.

In relation to the tasks figure 1 lists the set of tasks on a train travels in North-South direction.

In a sense, as in another, transhipment planning is a key element in goods transshipment terminal dwell time. It is included in the T1 phase and time average duration, in research conducted at the terminal of Port Bou, is slightly more than half an hour. As this task doesn't overlap with any other process, any savings in execution time is going to affect directly the goods terminal dwell time. Also its influence on other tasks is very large, especially in the movements of cranes and work inspection and control of outbound train.

Transhipment planning is done manually by railway undertakings responsible for the transhipment operators. One of the lines open from INTERFACE project has been the realization of this planning of a model of linear programming, to obtain better quality solutions in less time than that used currently.

Although the model developed use Port Bou terminal features, it is easily applicable to any terminal that transfer container train to another. On the other hand, the Port Bou terminal is very representative of the situation of the Iberian Peninsula, since 60% of all goods entering or leaving the peninsula used such a terminal.

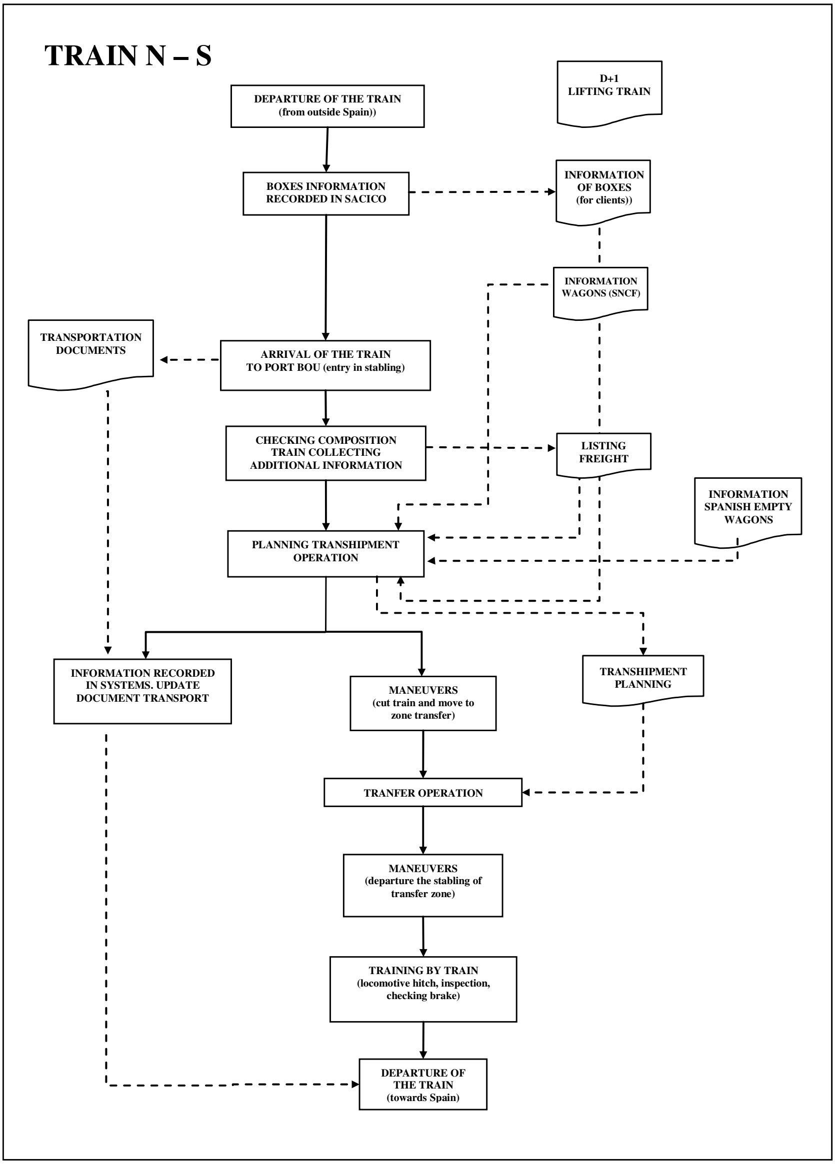


Fig. 1. Process of transfer terminal Port Bou in direction North - South Railway

4 Automatic generation of transfer plans model

The generation of transhipment between trains planning has been addressed by various authors. Linear programming models proposed by Bostel and Dejax [2] consider the possibility of storage, but do not include differences of two rail networks that converge in the terminal. With a model simulation Marin et al [9] yes consider different railway networks, do not provide a concrete solution planning of transhipment, but modes of operation of the bridge crane.
The model presented in this document integrates the different restrictions affecting the transhipment of containers between trains. In particular, the source of these restrictions can be:

- Terminal conditions

Two characteristics influence directly the problems of the transhipment:
  - The dimensions of the transhipment zone
  - The possibility or not of storage containers

- The characteristics of the containers and platforms

There is a set of constraints that limits the final composition of the outgoing train. If any of them were not respected, the train would be regarded as bad loaded, and consequently, could not move the rail network. Some are so basic that the sum of the lengths of containers loaded on a platform cannot exceed its own platform length. Others are related to the load or the transport of dangerous goods. In summary, these restrictions are six types:
  - Length
  - Maximum load
  - Load per linear meter
  - Load per axis
  - Balance of the loads
  - Incompatibilities among hazardous materials

- Destinations of containers

To reduce operations with containers in subsequent terminals need to meet two conditions:
  - No platform can have two or more containers with different destinations.
  - Containers with the same destination must be located in consecutive platforms.

The objective of the model is twofold: on the one hand decrease the time needed by the crane for transhipment of containers and on the other hand, use efficient rail resources, which means, using the fewest possible platforms.

4.1 Structure of the model

Initial data can be basically divided into two large groups. One of them is the incoming train and integrated data of all cargo units that make up this train. The other refers to the outgoing train and is composed of data platforms that have been located in transhipment zone to receive the incoming train containers.

Initial data are grouped in particular, two arrays. The array A of dimension $(n \times 6)$, with n the number of cargo units transported in the incoming train, groups the containers initial data. Table 3 lists the structure of this array. Of equal form the counterfoil B groups the information of the platforms.

Table 3. Array: Each container or unit load data

Concept	Format	Term
Denomination	Alphanumeric: 11 characters (4 letters and 7 digits)	a_{i1}
Destination terminal	Numeric: 5 characters	a_{i2}
Length	Numeric: 2 characters Unit: Feet	a_{i3}
Weight	Numeric: 4 digits, of which 2 integers and 2 decimals Unit: Ton	a_{i4}
Load material	Binary: 1: Dangerous goods 0: Non dangerous goods.	a_{i5}
Position	Numeric: 2 digits	a_{i6}

The developed model consists of three phases. The first addresses the situation of the destinations on a worksheet. Later programmed in AIMMS, linear programming model introduces all the constraints resulting from the features of the platforms and containers. This model provides the optimal solution, which is finally returned to the worksheet for export to the databases of the railway companies. Figure 2 shows this structure.

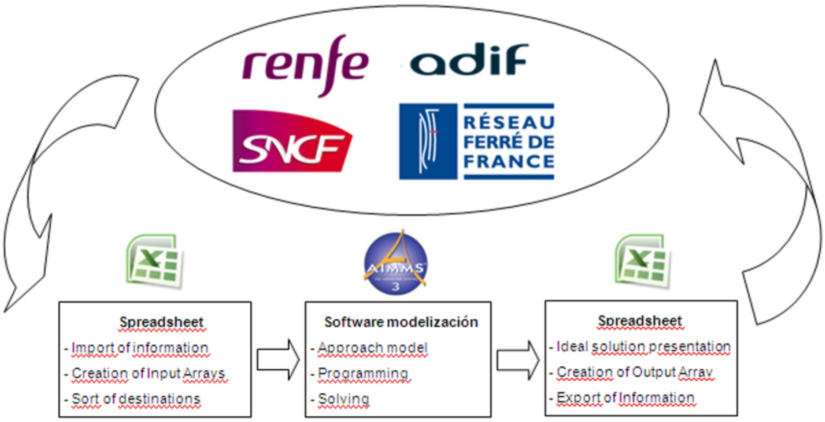


Fig. 2. Structure of the programming model of automatic generation of transhipment plans

Detailing this process, the railway enterprises data are imported by an Excel spreadsheet that groups containers by destinations. This grouping considers the physical location of each destination, to thus facilitate its downloading and decomposition of the train. This sort of destinations is very important to reduce management and subsequent terminals download tasks.

Programmed in AIMMS linear programming model uses eleven variables, whose characteristics are:

- Seven matrix of dimension $(n \times m)$,
- An array of dimension $(n \times r)$,
- A variable dimension $(n \times m \times r)$,
- Two variable scales.

Being n, the number of containers, m the number of platforms and r the number of destination.

Between defined variables, we have:

x_{ik}: Indicates whether the load unit i is transfer to the platform k (0 in the case of do not be transfer, 1 in the front position, 2 in the average position and 3 rear position).

d_{ik}: Binary variable that indicates whether the load unit i is transfer to the platform k.

The restrictions are grouped together into eighteen sets, some inherent to the problem and others are the product of the combination between platforms and containers.

For example, the axle load has be equal to or less than the maximum allowable in each platform, as well as it must not exceed, in either case, the limit of the road infrastructure is 22,5 metric tons.

In the case of a two-axle platform and a load in the rear position, as shown in Figure 3, restrictions take the following form:

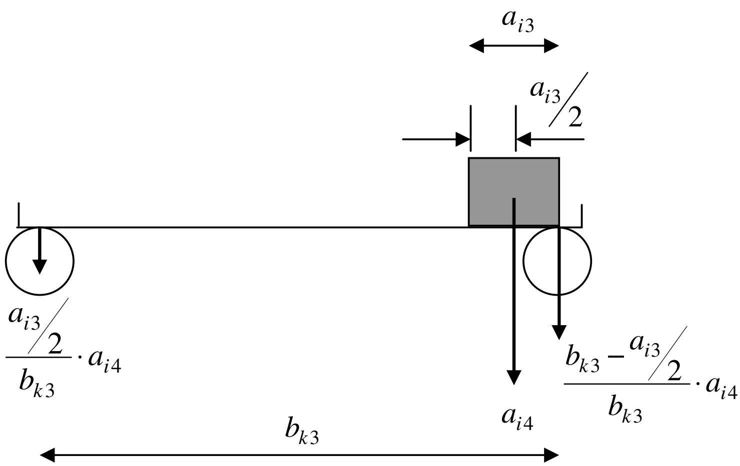


Fig. 3. Distribution of axial loads in a container placed in the first end of the platform

$$\sum_{i=1}^{n} \frac{b_{3k} - {a_{i3}}/{2}}{b_{3k}} \cdot a_{i4} \cdot d_{ik} \leq b_{k6}$$

$$\sum_{i=1}^{n} \frac{{a_{i3}}/{2}}{b_{3k}} \cdot a_{i4} \cdot d_{ik} \leq b_{k6}$$

$$\sum_{i=1}^{n} \frac{b_{3k} - {a_{i3}}/{2}}{b_{3k}} \cdot a_{i4} \cdot d_{ik} \leq 22{,}5$$

$$\sum_{i=1}^{n} \frac{{a_{i3}}/{2}}{b_{3k}} \cdot a_{i4} \cdot d_{ik} \leq 22{,}5$$

The model has a multiobjective function, through the use of weights. In particular, its expression is of the form:

$$\min z = 10^{6} \cdot Y - \sum_{i=1}^{n} \sum_{k=1}^{m} a_{i6} \cdot d_{ik} \cdot b_{k8} + 10^{-3} \cdot \sum_{i=1}^{n} \sum_{k=1}^{m} d2_{ik}$$

With:

$10^6 \cdot Y$: Minimizes the number of platforms.

$-\sum_{i=1}^{n}\sum_{k=1}^{m} a_{i6} \cdot d_{ik} \cdot b_{k8}$: Minimizes the movement of their transhipment cargo units.

$10^{-3} \cdot \sum_{i=1}^{n}\sum_{k=1}^{m} d2_{ik}$: Avoid placing loading units in Central positions.

4.2 Results of experimentation

González [7], in his doctoral thesis, presents the methodology used for the verification and validation of the model, including tests for consistency between the results provided by the model and the rules of operation of the system which is intended to represent.

With regard to experimentation, testing has lumped into five groups varying in each of them certain input parameters, so parsing the response from the model. Particular groups have been:

A: Consistency across platforms and loading units
B: Variation of load units
C: Variation across platforms
D: Introduction of dangerous goods
E: Variation in loads destinations

For each of these groups the response of the model has measured up, in seconds, when the amount of load units varies between 10 and 70. In particular, the quantities used in Port Bou terminal transfers vary between 30 and 45 units.

Figure 4 shows the results of this experimentation.

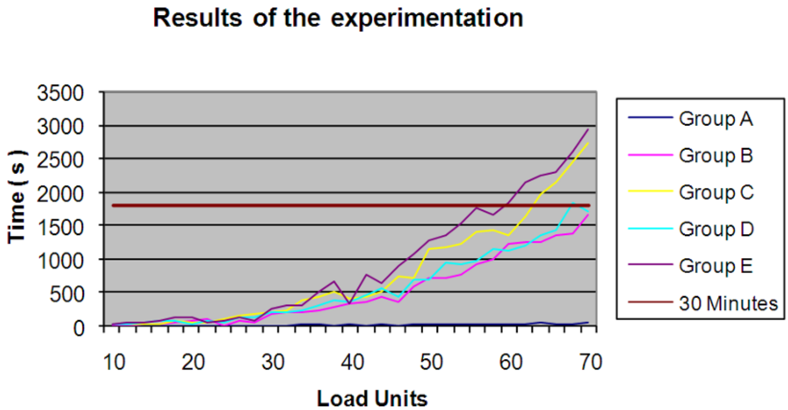


Fig. 4. Results of the experimentation

The reference time currently used on the border of the Pyrenees, which is 30 minutes, terminals is also indicated in Figure 4. This figure shows only for large amounts of load units close to 60, the model answer exceeds the reference for 30 minutes.

5 Conclusions

Some of the findings obtained from this work are:

- Both the scientific community and Governments agreed influence border terminals in European network compatibility issues and the need for investment in infrastructure and organizational improvements.
- The linear programming is a convenient tool to address the planning processes of transhipment and loading units load on rail terminals.

Using references Spanish border terminals of the Pyrenees, this work provides an analytical model of transhipment between train operations planning automation. This model allows the most efficient use of resources in response times lower than the current employees.

References

[1] Arnold, P.; Peeters D.; Thomas, I. Modelling a rail/road intermodal transportation system, Transportation Research Part E 40, 2004.

[2] Bostel, N.; Dejax, P. Models and Algorithms for Container Allocation Problems on Trains in a Rapid Transshipment Shunting Yard. *Transportation Science* Vol 32, No. (4), pp. 370-379, 1998.

[3] COM, EU (2007) Energy and Transport in Figures, Statistical pocketbook 2006. European Communities, Luxemburgo, 2007.

[4] COM, EU (2010) Energy and Transport in Figures, Statistical pocketbook 2010. European Communities, Luxemburgo, 2010.

[5] Drongelen, W. Cerbère – Port Bou, Rail Passion 75, November 2003. http://www.bueker.net/trainspotting/stations_cerbere.php. En Internet: 16/05/07.

[6] EC (European Commission), White Paper. European transport policy for 2010: time to decide. Office for Official Publications of the European Communities, Luxembourg, 10-11 (2001).

[7] González, J.A. Desarrollo de una metodología para la mejora de los procesos de trasbordo y carga en transporte combinado mediante programación lineal. Tesis Doctoral, Universidad Politécnica de Madrid, 2010.

[8] INFRAS, External costs of transport (accidents, environmental and cosgestion costs) in western Europe, Paris, Infras Zurich, Institut für Wirtschaftspolitik und Wirtschaftsforschung, Universität Karlsuhe, 2000.

[9] Marín, F.; García, I.; Ortiz, A.; Arreche, L.M. Gantry crane operations to transfer containers between trains: a simulation study of a spanish terminal. *Transportation Planning and Technology*, Vol. 27, No. 4, pp. 261-284, 2004.

[10] Mataix, C.; Ponce, E.; González, J.; Carrasco, J. Metodología para la evaluación de alternativas para la mejora de terminales ferroviarias fronterizas de transporte de mercancías. *X Congreso de Ingeniería de Organización*. Valencia, 2006.
[11] US Bureau of Transportation Statistics, U.S. Departament of Ttransportation, http://www.transtats.bts.gov. En Internet 30/04/08.

Analysis of logistics processes according to BPMN methodology

Maciej Stajniak[1], Bartosz Guszczak[1]

[1]Institute of Logistics and Warehousing,

maciej.stajniak@ilim.poznan.pl, bartosz.guszczak@ilim.poznan.pl

Abstract. Nowadays companies are looking for recipes for greater effectiveness and get back to the idea of processes. The principle of a process approach is the optimization of actions taking into consideration processes, not functions. Therefore, it is a process that determines the growth of effectiveness of a company. The aim of a process approach to a company management is achieving a high level of reliability in a precise situation. Companies with process management possess identified business processes and their maps. It entails consistent improvements of these processes. Thanks to the use of process management employees focus more on the bottleneck, use their resources more effectively and reduce overcapacity.

Keywords: BPMN Methodology, logistics processes, logistics management

1 Description of process analysis

Nowadays companies are looking for recipes for greater effectiveness and get back to the idea of processes. The principle of a process approach is the optimisation of actions taking into consideration processes, not functions. Therefore, it is a process that determines the growth of effectiveness of a company. The aim of a process approach to a company management is achieving a high level of reliability in a precise situation. Companies with process management possess identified business processes and their maps. It entails consistent improvements of these processes [2]. Thanks to the use of process management employees focus more on the bottleneck, use their resources more effectively and reduce overcapacity.

It was first noticed that a process is an important part of analysing a company's performance by F. Taylor in his work "Principles of Scientific Management" published in 1911. At that time the process approach was used only to analyse manufacturing systems. This approach to the issue of process management in a company resulted from attractive for its creators prospect for building production systems in which an employee's work would be almost as reliable as a machine's

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_42,

work. That is why, processes are regarded as sequential actions describing consecutive tasks that a worker should perform [7]. A revival of the process approach in system analyses of a company took place at the beginning of the 1990s when M. Hammer, J. Champy and T. Davenport in their publications suggested reengineering, strictly speaking Business Process Reengineering, as an approach to the reorganisation of business activities.

Reengineering is defined as a technical reorganisation of processes and aims at introducing improvements [7]. The starting point of reengineering is the assumption that ways of managing a company do not meet needs of a company and as a consequence should be modified. Moreover, adjusting the introduction of improvements to the conditions of running a company is of great significance. From the historic point of view, we can distinguish two kinds of reengineering [7]:

- radical reengineering (also called classical) assumes rejecting reality in a company because it is believed that analysing the present state is a waste of time if we want to achieve our aim. There is an assumption that all processes to date are to be eliminated and replaced with newly – planned ones. It is radical as it simplifies the course of processes according to the principles of reengineering. The main aim of this action is making a breakthrough in an organisation system of a company. Its consequence is a rapid cost reduction caused by eliminating all unnecessary (taking into account a value added) operations in action processes. First of all, unnecessary course of decision processes is eliminated, which entails a new division of authorities in a company. It assumes rejecting the reality based on functional rules of behaviour and accepting a completely new one, the process reality,
- Business Process Improvement was created as an alternative to radical reengineering. Following all the rules of radical reengineering, the method of radical elimination of organisation reality as a starting point in designing processes was rejected. Existing processes are registered and then improved. Processes are constantly improved so that their course is changed gradually, not radically. It aims at getting the habit of continuous improvement of all the fields of a company by all its workers. Business Process Improvement extends the process of achieving new reality as it generates lower cost reduction, less quality, speed and efficiency improvement of processes. However, it allows gradual preparation of workers to the realities of process organisation and adjusts the speed of learning to the abilities of an average worker.

Creating a process concept of a company must be followed by understanding the structure and relationships between existing processes. Taking functions into account, processes in a company can be divided into two types [7]:

1. Primary processes:
   - this type of process creates a product (goods, services or information) directly connected with the principal business activity,
   - create a value added and take part in a value chain which is seen as the effect by the external customer,

- mainly processes that directly influence the market situation of a company , such as product design, sales, manufacturing, customer relationship, service, logistics.

2. Support processes:
   - support primary processes and improve their efficiency,
   - directly influence the value added as they enable its creation by primary processes,
   - directly influence the value for an internal customer (those who stimulate primary processes and other support processes),
   - most of them are indirect processes, for example human resources management, internal logistics, IT service, finance management, warehousing, market research, transport.

In a company there must be a proper model of a hierarchy of processes which should be divided into mega – processes, main processes and subprocesses. The model of a hierarchy of processes is presented in Figure 1.

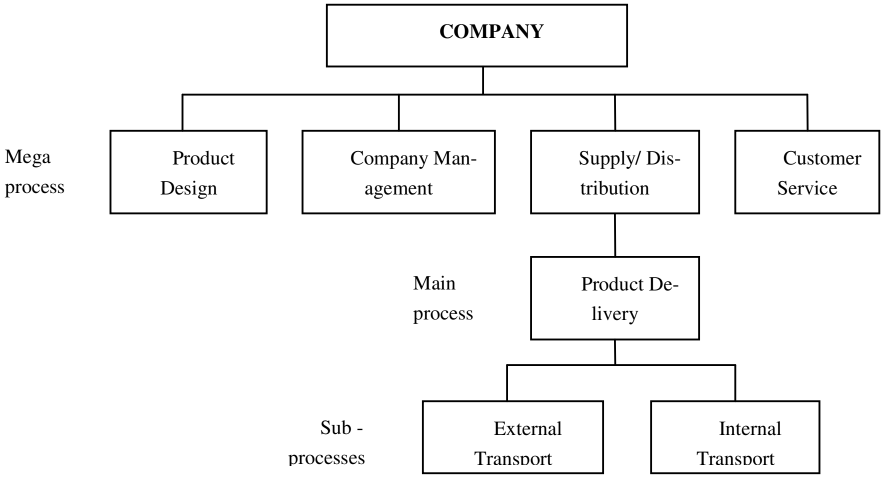


Fig 1. Model of a hierarchy of processes in a company;
Source: Own elaboration based on [3]

2 Process mapping

In order to carry out a process analysis of a company correctly and hence process reengineering the point of process activity mapping must be understood. Process mapping is a way of presenting the course of a process by means of maps. Business process maps that were created by mapping reflect the reality of a company. Process maps should be a document provided by teams responsible for improving the processes [3].

The main aim of process mapping is describing business processes in order to simplify them, eliminate unnecessary activities and improve some so that products and services are cheaper, better and achievable quicker [3]. Process mapping should include the following steps [4]:

- step 1 – a detailed record of every process action,
- step 2 – an analysis of actions in all stages of a process,
- step 3 – identification of spots where losses are incurred,
- step 4 – an analysis of possible process improvements,
- step 5 – choosing a better organisation of the course of a process and transport– suggested process map.

Here are some of the advantages of process mapping [18]:

- process mapping often tell more than words, therefore they should be commonly used in organizations and let us assess the work flow, the range of losses and situations to be improved,
- while creating maps the units that cooperate begin to understand tasks and problems of others and other workers' contribution to the whole process. The process of creating maps often makes workers look for some improvements while imperfections of organizations are revealed and get eliminated.

A company which is acquainted with its own logistics processes and their maps, knows their course and consistently strives after perfecting these processes. One of the methods leading to the improvement of processes, organisation connections and business process activities is their modelling.

3 Logistics process modelling

Modelling is a process reflecting the most important features of an object (process, system) in a simple manner. Models illustrate the work flow and a value added, which stimulates a better comprehension of functioning of an organisation. Logistics process modelling involves describing the functional architecture of individual subprocesses by symbolic reflection of the reality [22].

By modelling we look for the final shape of processes that should be conducted as well as possible. Logistics process modelling can take place thanks to redesigning the existing process which helps us find the answer concerning the unity of actions, costs, using the resources, etc. The problem may be discussed in a broader sense and after creating a model it can be verified paying special attention to its potential implementation. However, it must always start with identification and analysis of processes.

Process modelling involves complicated processes and going into details at different levels. It establishes connections and relationships between processes so that one can focus on a chosen level without going into subject in greater depth and allocate resources to logistics processes. Models reflect real systems that are studied to find out more about them [9].

When the desired model solutions are found they are compared to the existing processes paying special attention to modifications and improvements.

Models can be verified using information technologies to stimulate processes, which are very useful because making process maps is time - consuming.

Modelling can be treated in two ways:

1. diagnostic - focus on depicting the actual state, analysis of current solutions and making a diagnosis,

2. predictive – presenting a newly - adopted model process corresponding to the conditions of a company.

Models treated in a predictive way which uses processes based on many attempts, experiences and implementations of IT systems are called reference models. They take advantage of business solutions without creating new processes from the beginning. Such models usually refer to functional, organisation and information areas of logistics.

In practice in case of logistics process modelling, depending on the range and subject of works, either the diagnostic or the predictive approach can be used or even both of them (e.g. when the predictive approach is limited only to the design stage of logistics processes).

As for detailed rules in the stage of process modelling, we should follow the general rules. In literature there is a set of rules to obey during process modelling [21]:

1. Each process starts and finishes for a specified customer (receiver) who determines requirements and takes advantage of the effects of processes (process individualisation).
2. Each process consists of subprocesses, operations and other basic components (process structuralisation).
3. Each process has a party responsible for the process, its own "owner" (determining process responsibility).
4. In each process one object is transformed / produced (determining a process object).
5. Process components that do not provide a value added are eliminated (focus on creating a value).
6. For each process the best structure (taking time and other resources into consideration) is determined (shaping the course of a process).
7. Each process must be properly protected by the supplier (the input arrangement with the supplier).

While modelling there is a rapid transfer of information about performing a part of a task because it is the start of another part that determines the effectiveness of operations (eliminates unproductive time wasted on waiting for an order and the periods between tasks). It is easy to get statistics concerning how long individual tasks were performed and also a statistical analysis of the length of a work cycle. Process models not only make designing organisation structure easier but also provide a graphical visualization and simulation of the real process [10].

The results of process modelling must be documented. That is why, the name of a process, its starting and final points, aims, criteria, party responsible for a process, object of a process, input with a supplier, output with a receiver and other additional information should be provided on special templates. You cannot include too much information about a process because it may make the description illegible [23]. However, you can always distinguish 10 basic stages of creating a model, using it for simulation and implementing the results (Figure 2).

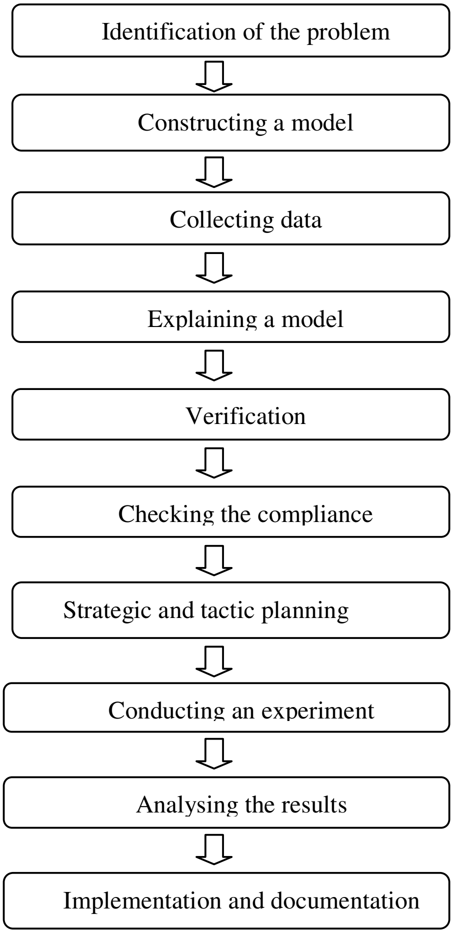


Fig. 2. Stages of creating a model and implementation of its results; *Source: [1]*

Many details of the logistics process management require the use of information technologies. In the market there are not fully- integrated tools dedicated to the needs of logistics process management. There are some IT tools facilitating a process analysis of a company and they serve well in improvement processes on a large scale and in the long term [15]. They are a part of the rapidly – developing concept called Business Process Modelling (BPM) and provide a graphical presentation of logistics processes.

Process modelling tools can be divided into three groups [8]:

- programs for creating diagrams are used in visualizations, process mapping by means of diagrams and documentations, e.g. MS Office Visio 2007, iGrafx FlowCharter (Corel), cheap and easily operated,
- CASE tools (Computer Aided Software Engineering) – for process modelling especially when they are to be integrated with IT solutions, e.g. Designer/2000 (Oracle), Select Enterprise (Select Software),
- advanced tools for designing and improving processes, for advanced analyses and simulations, such as iGrafx Process/ iGrafx Process for Six Sigma (Corel), ARIS Toolset (IDS Scheer) (Scheer, 1992, p. 41), Adonis (BOC GmbH), Workflow Analyzer (Meta Software) or process modelling tools in ERP systems (built in these systems), e.g. IFS Business Modeler. They are relatively expensive and difficult to operate.

Although there is a wide range of available IT tools facilitating process mapping and many consulting companies, MS Word and Visi still remain the most commonly used tools.

4 BPMN as a tool for mapping and modelling logistics processes

Transport, forwarding and logistics oriented processes gained popularity and intensified the search for efficient tools for process modelling, analyses, optimization and automatic creating of applications stimulating these processes in IT environments.

An example of a tool that got recognition is Business Process Modelling Notation, usually known as BPMN. It is accompanied with a special language BPEL (Business Execution Language for Web Services) based on XML (Extensible Markup Language) which creates a code of a program that stimulates a process described by BPMN.

BPMN became a graphical standard for business process modelling and a standard for service description. It offers semantics and syntax of a language of diagrams that describe processes. BPMN offers a range of advantages in business process modelling. First of all, BPMN offers the technique of modelling process flows and workflows. The technique is adjusted better to modelling ways used by business analytics. Secondly, reliable mathematical basis provides direct transformation into the execution languages of business processes.

Generally speaking, BPMN is process mapping and provides a graphical notation of a process or a complex of processes/operations and their interrelations. There are some special graphical symbols used to describe elements of a process map. The advantages of BPMN in logistics process mapping are:

- a user – friendly way of describing a logistics process helps experts and other users understand it better,
- symbols used in process mapping are well-known in many countries which makes it easier to compare standards between companies from many various countries,
- identification of key operations in a given process and specifying necessary inputs and outputs in a given operation,
- identification of unnecessary operations (that do not provide a value added) such as storing semi-manufactured products between operations, internal transport etc.

BPMN diagrams can be unambiguously translated to other standards - BPEL and XPDL (Process Definition Language). It is helpful in migration between tools of process implementation.

BPMN provides a detailed description of one business process diagram called BPD (Business Process Diagram) which was to serve two purposes. Firstly, it can be easily understood and used. It may be used for quick and easy logistics process modelling since even users without technical abilities will comprehend it. Secondly, with BPMN you can model complicated complex logistics processes and transform it into any execution language of business processes.

In logistics process modelling one has to model only operations starting the process, then operations which carry out the process and finally potential results of the process. Decisions and branched processes are modelled by means of decision nodes regardless of the kind of tool that models the process – the emphasis was put on a comprehensive description for all users irrespective of the used tools. However, to achieve the best possible results an approach should be supplemented by simulation of a process.

There are also plenty of limitations and drawbacks of BPMN [19]:

- can be used only for business process modelling,
- does not model data flow but only control flow (data can be additionally described),
- does not inform users about a structure and access to data (especially in a safety section),
- hardy describes dynamic groups and the hierarchy of users,
- the organisation of a company is poorly presented.

However, in spite of all the mentioned drawbacks BPMN remains the best tool for logistics process mapping, modelling and simulation.

Table 1. Basic functionalities in modelling in BPMN notation

No.	Functionality	Scope of operation
1	**Activity**	An element of a process diagram which represents only one step in a process. Activities differ from one another not only due to their places in the process but also their features (called attributes).Their main attributes are *time* (the time of performing an activity) and *cost* (fixed costs concerning performing an activity). Every activity is connected with other activities by connections that describe the direction of a transaction flow and are presented on a diagram as lines with arrowheads.
2	**Transaction/ Token**	It is an object that flows through a process and can be presented as a token moved according to a process flow from one activity to another one. Depending on the way of process modelling one transaction can be divided into many other transactions connected with one another. A lot of transactions can be connected or grouped into one 'pack' of transactions. Transactions may have various attributes which means that not all transactions in a process have the same features. There can be different courses of transactions. One of the ways of naming transaction attributes is defining them by a transaction generator while introducing them to the process. By means of the transaction generator we can also define the place in a process diagram where a transaction is introduced. It can be guessed that a transaction is introduced to a process in a starting point called *Start* but it is not the only possibility and various transactions may be introduced in various points of a diagram.
3	**Connections**	Sequence Flow is used to define the execution order of process activities. Message Flow is used to show information transfer between two independent units (participants) of a process that can send and receive information. Associations are used to combine information and artefacts with activities, events, gateways and flows.
4	**Transaction Flow**	The way that a transaction flows through a process consists of lines connecting certain activities. A transaction enters a given activity through a coming line and then is sent through a line going to another activity. It is a typical way of a transaction flow. However, it may differ from this example. One transaction can be divided into two or more transactions while leaving an activity. What is more, on reaching an activity many transactions coming to the same place can be combined into one transaction.

5	**Artefacts**	Artefacts are elements of a diagram used to provide additional information about a process. They are directly connected neither with the process flow nor the information flow.
6	**Resources**	To perform activities people, machines and other devices are usually needed. A designer modelling a process must define the sort and number of resources necessary to perform a given activity. Using resources entails their operating costs. The operating costs of resources are added to the total costs of a process. The allocation of resources is not usually determined for individual activities but for individual departments. iGrafx Process assumes that in every department there is one person who is able to perform all the activities in a given department and every activity needs such a person. Obviously, it is a supposed situation which usually differs from the reality and therefore can be modified. Reports of a process simulation are to answer the following questions: Is it right to assign resources to individual departments? How should allocation of resources be modified?
7	**Tasks**	Information defining the way of performing activities (the time of an activity, costs, the maximum number of transactions that can be processed at the same time, etc.) is called a task. There are three kinds of tasks: • Work – an activity is performer by resources and in case of every transaction takes a given amount of time and generates fixed costs. • Process – an activity joins a present process with another process which may be a parallel or subordinate process. Subordinate processes (subprocesses) are equivalent to subroutines in programming languages. Having completed a subordinate process, a transaction returns to an activity that caused a subprocess and then flows further in a process diagram. • Waiting – this activity marks that a transaction is waiting for a given period of time.

Source : Own elaboration

BPMN provides the notation and semantics of BPD (Business Process Diagram) which is an easy and adaptable notation enabling modelling very complex business processes. It bridges the gap between modelling processes of business analytics and the implementation of processes with techniques used by technical developers.

It is so simple that uncomplicated models can be made fast. More complex ones should be described and improvements of simulation of a modelled process are to be looked for. As there is more and more information new elements can be added, e.g. you can create a new department, specify the number of new employees and the manner of their work (working time, hourly rates), add new points of making decisions or modify parameters of some activities.

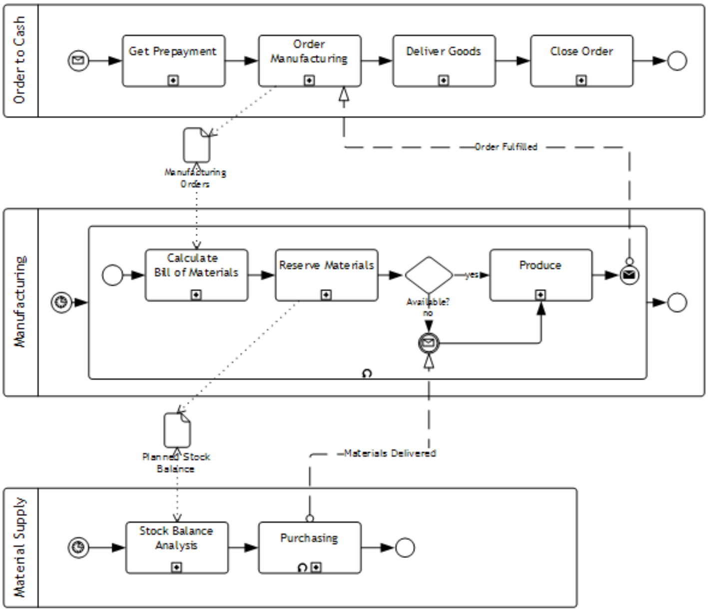


Fig 3. An example of transport process model in the BPMN notation
Source: Own elaboration in iGrafx Process for Six Sigma

iGrafx Process for Six Sigma is one the best well–known and the most widely-used programs for modelling and simulating processes. They are so general that they let users model processes of various structures and complexity (from so easy ones like a circulation of documents to so complex ones like a logistics centre). Since we can change the parameters of processes and use a wide range of simulations we can make decisions aiming at process optimization.

Logistics process modelling helps to find optimal solutions and answer the following questions:

- what are the necessary data (inputs) and results (outputs) of activities?
- how much time do individual stages take?
- what is the availability and usage of resources?
- what should the schedule of individual activities be?
- where are the bottlenecks?
- how much does the processing of one transaction cost?

Thanks to it a designer can:

- prevent mistakes before they really occur,

- improve the work in an organization,
- calculate and follow the statistical data concerning working hours, costs and resources.

Processes in computer programs are reflected very realistically and we can consider a lot of limitations as well as include random parameters which illustrate random factors. For instance, users can determine a legal number of working hours of an employee, such as the standard of working time of drivers, the average operating speed or the working hours of warehouses. The results of process modelling and a graphic representation of a scheme can be sent to everyone who is interested in it in a company. The advantage of modelling is getting results quickly. We can also change some parameters, repeat activities and then compare both solutions. These activities do not generate any costs so we can repeat them with edited parameters and experiment until we receive a satisfactory solution.

5 Conclusion

Logistics process mapping and modelling in BPMN notation is essential to comprehend and connect logistics processes with the business ones in the whole company and provide firm support for other modelling techniques like entity- relationship modelling, designing XML schemes and designing network architecture. All these methods of modelling help a company understand and work out functional architecture in such a way that it accelerates responses to changes in a safer manner. Due to the careful verification of efficiency and effectiveness before logistics process implementation there would not be expensive mistakes any more.

This tool may be successfully used both in process mapping in the fields of transport, supply, production and all other processes concerning physical and information flows in a company and between companies.

Process mapping provides a proven methodology that can be used in business enterprise for effective simulation, cost and schedule analysis and significant process improvement [14].

In conclusion, it may be stated that companies that have process management (that is possess identified processes and process maps) achieve a high level of reliability and growth of their own effectiveness. Therefore, the knowledge of processes results in continuous improvements of these processes.

References

[1] Alan A., Britsker B., (1989), Introduction to simulation and SLAM II, A Halsted Press Book, John Wiley& Sons, New York, Chichester, Brisbane and Systems Publishing Corporation, West Lafayette, Indiana.

[2] Anders A., (2008), Zarządzanie procesowe i mapowanie procesów biznesowych, PWE, Warszawa.

[3] Ciesielski M., (2009), Instrumenty zarządzania łańcuchami dostaw, PWE,Warszawa.

[4] Ciesielski M., (2006), Instrumenty zarządzania logistycznego, PWE,Warszawa.

[5] Davenport T., (1993), Process Innovation. Reengineering through Information Technology, Harvard Business School Press.

[6] Davenport T., (1995), Business Process Reengineering: Its Past, Present and Possible Future, Harvard Business School Publishing, Boston.

[7] Grajewski P., (2007), Organizacja procesowa, projektowanie i konfiguracja, PWE, Warszawa.

[8] Gruchman G., (1998), Rysować czy modelować, „ComputerWorld", nr 43.

[9] Jacyna M., (2009), Modelowanie i ocena systemów transportowych, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa

[10] Kasprzak T. (red.), (2005), Modele referencyjne w zarządzaniu procesami biznesu, Wyd. Difin, Warszawa.

[11] Hammer M., Champy J., (1993), Reengineering the corporation: a manifesto for business revolution, Nicholas Brealey, London.

[12] Hammer M., July-August (1990), "Reengineering work: don't automate, obliterate" [in:] Harvard Business Review, pp.104-112.

[13] Hollins B., Shinkins S., (2009), Zarządzanie usługami. Projektowanie i wdrażanie, PWE, Warszawa.

[14] Hunt D.V., (1996), Process mapping, How to Reengineer Your Business Processes, John Wiley & Sons, New York.

[15] Managanelli R.L., Klein M.M., (1998), Reengineering, PWE, Warszawa.

[16] Nowosielski S., (2008), Procesy i projekty logistyczne, UE, Wrocław.

[17] Pacholski L., Cempel W., Pawlewski P., (2009), Reengineering: reformowanie procesów biznesowych i produkcyjnych w przedsiębiorstwie, Wydawnictwo Politechniki Poznańskiej.

[18] Peppard J., Rowland P., (1997), Re-engineering, Gebethner & Ska, Warszawa.

[19] Piotrowski M., (2007), Notacja modelowania procesów biznesowych, Wyd. BTC, Warszawa.

[20] Scheer A. W., (1992), Architecture of integrated information systems, Springer Verlag, Berlin.

[21] Schmelzer H.J., Sesselman W., (2003), Geschäftsprozessmanagement in der. Praxis. Hanser Wien.

[22] Sussam J. E., (1995), Logistics modelling, Pitman, London.

[23] Tosun I., (2007), Modelling in transport phenomena, Elsevier Science & Technology Books, Ankara.

Declarative modeling of multimodal cyclic processes

Grzegorz Bocewicz[1], Zbigniew A. Banaszak[2]

[1] Koszalin University of Technology,
[2] Warsaw University of Technology

bocewicz@ie.tu.koszalin.pl, z.banaszak@wz.pw.edu.pl

Abstract. Cyclic scheduling problems arise in a variety of transportation applications and service domains. Within the class of those problems we can identify situations where there is need to make use of different modes of transportation. What is of particular interest in this paper is the design of a class of multimodal cyclic processes (MCP) for production engineering and supply chains. The paper presents a new modeling framework enabling to prototype and evaluate multimodal processes while comparing their cyclic steady states. A way in which the multimodal processes encompass the behavior of supporting them concurrently flowing cyclic processes (SCCP) is discussed in terms of constraints satisfaction problem. Possible implementations are illustrated on example of the flexible manufacturing system operation.

Keywords: cyclic processes, cyclic scheduling, concurrent processes, multimodal processes, state space, declarative modeling, dispatching rules.

1 Introduction

Operations in cyclic processes are executed along sequences that repeat an indefinite number of times. In everyday practice they arise in different application domains (such as manufacturing, time-sharing of processors in embedded systems, digital signal processing, and in compilers for scheduling loop operations for parallel or pipelined architectures) as well as service domains (covering such areas as workforce scheduling (e.g., shift scheduling, crew scheduling), timetabling (e.g., train timetabling, aircraft routing and scheduling), and reservations (e.g., reservations with or without slack, assigning classes to rooms) [6; 7; 8; 9; 15; 16; 17; 18]. Such systems belong to a class of so called systems of concurrently flowing cyclic processes (SCCP) [2; 4]. Subway or train traffic can be considered as an example of such kind of systems.

Assumption the subway trains following particular metro lines (due to the subway map, that can be seen as a kind of the transit map) can be treated as cyclic processes passing, due to a given timetable, the sequence of stations, allows one to state a question concerning a minimization of the total passenger travel time. So, if

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_43,

passengers travel between two distinguished locations in the transportation network for which no direct connection exists, i.e., transfers become inevitable, the relevant scheduling problem can be stated in the following way. Given a set of metro lines, each one treated as a repeating sequence of stations. Some lines may share the common stations. Given a headway time (interval between the trains), i.e., the fixed interval between the trips of a line sometimes called the period time. The question considered is: What is a transportation route between two designated terminal stations in the transportation network providing the shortest travel time subject to above mentioned constraints? In other words, a best transportation route of the so called multimodal process, i.e. sharing different lines, is sought.

Many models and methods have been proposed to solve the cyclic scheduling problem [10]. Among them, the mathematical programming approach (usually IP and MIP [18]), max-plus algebra [11], constraint logic programming [1; 2; 3; 4; 5] evolutionary algorithms [13] and Petri nets [14] frameworks belong to the more frequently used. Most of them are oriented at finding of a minimal cycle or maximal throughput while assuming deadlock-free processes flow. The approaches trying to estimate the cycle time from cyclic processes structure and the synchronization mechanism employed (i.e. rendezvous or mutual exclusion instances) are quite unique.

In that context our main contribution is to propose a new modeling framework enabling to evaluate the cyclic steady state of a given SCCP on the base of the assumed processes topology, dispatching rules employed and an initial state. So, the paper's objective is to provide the observations useful in the course of multimodal processes routing and scheduling in systems composed of concurrently flowing cyclic processes interacting between oneself through mutual exclusion protocol.

The rest of the paper is organized as follows: The problem formulation is stated in the Section 2, and then the state space modeling framework is presented in the Section 3. The main definitions clarifying the concept of state space of concurrently flowing cyclic processes and aimed at cyclic steady states evaluation are discussed. Illustrative example of multimodal processes declarative model implementation is then presented in Section 4. Final conclusions are presented in the Section 5.

2 The problem formulation

Consider the digraph shown in Fig. 1. The four cycles specifying routes of local cyclic processes P_1, P_2, P_3 and P_4, respectively are distinguished. Each process route is specified by a sequence of resources passed on among its execution. So, processes can interact each other through common shared resources. The process routes are specified as follows: $p_1 = (R_6, R_3, R_5)$, $p_2 = (R_2, R_3, R_4)$, $p_3 = (R_1, R_7, R_5, R_4)$, $p_4 = (R_5, R_6, R_8, R_7)$, where R_3, R_4, R_5, R_6, R_7 are so-called shared resources, since each one is used by at least two processes.

The resources R_1, R_2, R_8, are non-shared, i.e. are exclusively used by a unique process. Processes sharing common resources interact each other on the base of mutual exclusion protocol. The possible resources conflicts are resolved with help of priority rules determining the order in which processes make their access to common shared resources (for instance, in case of the resource R_4, the relevant priority dispatching rule $\sigma_4 = (P_3, P_2, P_2)$ determines the order in which processes can access to the resource R_4, i.e. the process P_3 as first, then P_2 as next, then and once again P_2, and P_3, and so on.

Consider two multimodal processes mP_1, mP_2 specified by the following routes: $mp_1 = (R_3, R_5, R_6, R_8, R_7)$, $mp_2 = (R_1, R_7, R_5, R_4, R_2)$. Since routes of multimodal processes consist of resources occurring in local process routes, hence multimodal processes can be seen as processes composed of sequences of local processes. In other words each multimodal process can be treated as a process executing itself along parts of locally executed elementary processes determined by relevant route sections. So, in case local processes encompass the subway lines network the relevant multimodal processes can be seen as passengers traveling between assumed destination points in this network. Similarly to local processes, the multimodal processes can be also considered as cyclic and/or serial ones.

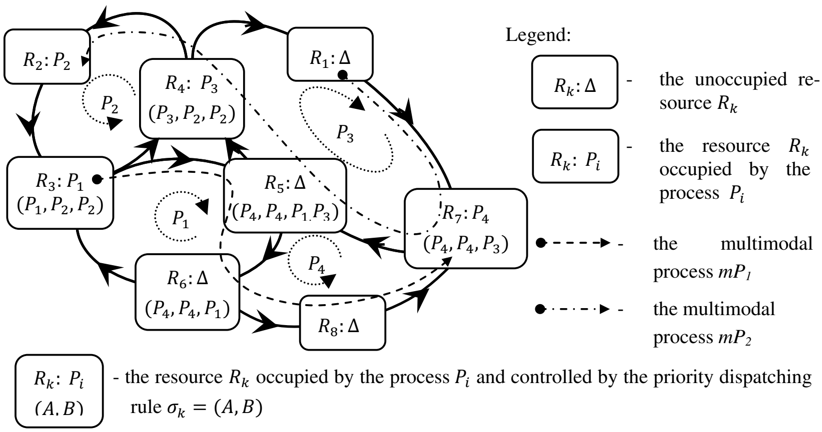


Fig. 1. The structure of multimodal process routes encompassing the routes structure of local cyclic processes

In general case, each local process $P_i \in P = \{P_1, P_2, \ldots, P_n\}$, where: n - is a number of processes, the sequence of operations using resources defined by the given process route $p_i = (R_{j_1}, R_{j_2}, \ldots, R_{j_{lr(i)}})$, $j_k \in \{1,2, \ldots, m\}$, where: $lr(i)$ denotes a length of cyclic process route, m - is a number of resources, and $R_{j_k} \in R$, where $R = \{R_1, R_2, \ldots, R_m\}$, executes periodically.

The sequence $T_i = \left(t_{i,j_1}, t_{i,j_2}, \ldots, t_{i,j_{lr(i)}}\right), t_{i,j_k} \in \mathbb{N}$ describes the operation times executed by P_i.

To each shared resource $R_i \in R$ the priority dispatching rule $\sigma_i = (P_{j_1}, P_{j_2}, \ldots, P_{j_{lp(i)}})$, $j_k \in \{1,2, \ldots, n\}$, $P_{j_k} \in P$ is assigned, where $lp(i) > 1$, $lp(i) -$ is a number of processes dispatched by σ_i. In general case the same processes can occur many times and in different orders so priority rule lengths are not limited. It means, in case of the following rule $\sigma_5 = (P_3, P_4, P_4, P_1)$ (see Fig.1) processes P_3, P_1 access uniquely while P_4 twice due to assumed order P_3, P_4, P_4, P_1.

Let $\{P_i | \ i \in \{1, \ldots, n\}\}$ be the set of cyclic processes determined by the set of process routes $\{p_i | \ i \in \{1, \ldots, n\}\}$. Consider the set of multimodal processes $MP = \{mP_1, mP_2, \ldots, mP_u\}$, where u- is a number of multimodal processes. Due to our earlier informal definition, each multimodal process mP_i is specified by the route mp_i which is a sequence of sub-sequences (sections) of local cyclic process routes:

$$mp_i = \left(mpr_j(a_j, b_j), mpr_k(a_k, b_k), \ldots, mpr_h(a_h, b_h)\right), \tag{1}$$

where: $mpr_j(a, b) = \left(crd_a p_j, crd_{a+1} p_j, \ldots, crd_b p_j\right)$, $crd_i D = d_i$, for $D = (d_1, d_2, \ldots, d_i, \ldots, d_w)$, $\forall a \in \{1,2, \ldots, lr(i)\}$, $\forall j \in \{1,2, \ldots, n\}$, $crd_a p_j \in R$.

By analogy to local cyclic processes the sequence $mT_i = \left(mt_{i,j_1}, mt_{i,j_2}, \ldots, mt_{i,j_{lm(i)}}\right), mt_{i,j_k} \in \mathbb{N}$ describes the operation times required by operations executed along mP_i (where $lm(i)$ length of i-th multimodal route mP_i).

In that context a $SCCP$ can be defined as a pair [4, 5]:

$$SC = (ST_{SCCP}, SB_{SCCP}), \tag{2}$$

where: $ST_{SCCP} = (R, P, T, \Pi, \Theta)$ – specifies the SCCP structure, i.e. $R = \{R_1, R_2, \ldots, R_m\}$ – the set of resources, $P = \{P_1, P_2, \ldots, P_n\}$ – the set of local process, $T = \{T_1, T_2, \ldots, T_n\}$ – the set of local processes operation times quences, $\Pi = \{p_1, p_2, \ldots, p_n\}$ – the set of local process routes, and $\Theta = \{\sigma_1, \sigma_2, \ldots, \sigma_m\}$ – the set of dispatching priority rules.

$SB_{SCCP} = (MP, M\Pi, MT)$ – characterizes the SCCP behavior, i.e.
$MP = \{mP_1, mP_2, \ldots, mP_u\}$ – the set of multimodal process, $M\Pi = \{mp_1, mp_2, \ldots, mp_u\}$ – the set of multimodal process routes, $MT = \{mT_1, mT_2, \ldots, mT_u\}$ – the set of multimodal process routes operations times.

Due to the earlier assumption every operation times (i.e. of local and multimodal processes) is equal to unit operation time (1 u.t. for short), i.e.:

$$\forall_{i \in \{1,\ldots,n\}} \forall_{j \in \{1,\ldots,lr(i)\}} \left(crd_j\, T_i = 1\right) \tag{3}$$
$$\forall_{i \in \{1,\ldots,u\}} \forall_{j \in \{1,\ldots,lm(i)\}} \left(crd_j mT_i = 1\right) \tag{4}$$

In that context the problem considered can be stated as follows:

The problem statement

Consider a $SCCP$ following the conditions (3). Given are initial allocations both the local and multimodal processes. The main question concerns of SCCP's periodicity, i.e. in case the SCCP behaves periodically the next question regards of the SCCP's period. Of course, the similar questions can be stated for multimodal process. To cope with such the problem let us consider its implementation in terms of a declarative model.

3 Model

The model considered enables to analyze a state space of SCCP systems as well as its extension encompassing behavior of multi modal processes

3.1 State space of local processes system

Consider the SCCP shown in Fig. 1. Since at each moment system resources are either occupied or not by local processes, hence the relevant **local processes allocation** can be specified by the following sequence:

$$A = (a_1, a_2, \dots, a_m), \tag{5}$$

where: m – is a number of resources occurring in the SCCP, $a_i \in P \cup \{\Delta\}$, $P = \{P_1, P_2, \dots, P_n\}$ – the set of processes, $a_i = P_k$ - the i-th resource R_i is occupied by the k-th local process P_k, and $a_i = \Delta$ - the i–th resource R_i is unoccupied.

In the case considered (see Fig. 1) the processes allocation is specified by the sequence: $A = (\Delta, P_2, P_1, P_3, \Delta, \Delta, P_4, \Delta)$.

Consider a **sequence of semaphores** Z (6) where the i-th semaphore z_i, assigned to the i-th resource R_i determines the process that could be allotted to resources at the moment (state) considered.

$$Z = (z_1, z_2, \dots, z_m), \tag{6}$$

where: $z_i \in P$ - means the name of the process (specified in the i-th dispatching rule σ_i, allocated to the i-th resource) allowed to occupy the i-th resource; for instance $z_i = P_k$ means that at the moment process P_k is allowed to occupy the i-th resource.

For the SCCP from Fig. 1 the sequence of semaphores Z has the following form: $Z = (P_3, P_2, P_1, P_3, P_4, P_4, P_4, P_4)$.

Consider a **sequence of semaphore indices** Q (7) determining the positions of the semaphores value in the priority dispatching rules [4]:

$$Q = (q_1, q_2, \dots, q_m), \tag{7}$$

where: q_i – the position of the semaphore z_i in the priority dispatching rule σ_i, $z_i = crd_{(q_i)}\sigma_i$, $q_i \in \mathbb{N}$. For instance $q_2 = 2$ and $z_2 = P_1$, means the semaphore P_1 regards to position 2 in the priority dispatching rule σ_2.

For the SCCP from Fig. 1 the sequence of semaphore indices Q has the following form: $Q = (1,1,1,1,1,1,1,1)$.

Consider the definition of **the SCCP's k-th state** (8) which consists from the sequence of processes allocations A^k, the sequence of semaphores (the processes rights access to individual resources) Z^k, the sequence of semaphore indices Q^k:

$$S^k = (A^k, Z^k, Q^k), \tag{8}$$

where: S^k – the k-th state, $A^k = ({a_1}^k, {a_2}^k, \dots, {a_m}^k)$ – the processes allocation in the k-th state, $Z^k = ({z_1}^k, {z_2}^k, \dots, {z_m}^k)$ – the sequence of semaphores corresponding to the k-th state, $Q^k = ({q_1}^k, {q_2}^k, \dots, {q_m}^k)$ – the sequence of semaphore indices, corresponding to the k-th state.

Note that introduced concept of the k-th state (8) constraints itself to ST_{SCCP} , i.e. to a system of local cyclic processes. So, consequently let us consider:

The state S^k is feasible only if for any of it's the i-th co-ordinate ${a_i}^k$ the following conditions hold:

$$\forall_{i\in\{1,2,\dots,n\}} \exists!_{j\in\{1,2,\dots,m\}} \left(P_i = crd_j A^k\right), \tag{9}$$

$$\forall_{i\in\{1,2,\dots,m\}} \left(crd_i\, A^k \in \left\{s_j \middle| s_j = crd_j\, \sigma_i\, , j = 1, \dots, lp(i)\right\} \cup \{\Delta\}\right). \tag{10}$$

where: $lp(i)$ - the number of processes dispatched by the rule σ_i.

It means in every feasible state each process is allotted to a unique resource due to the priori rule assigned.

Each feasible state S^k belongs to so called **the state space $\mathbb{S}l$ of local processes system** $\mathbb{S}l$, i.e., $S^k \in \mathbb{S}l$. Consider two feasible states S^k and S^l ($S^k, S^l \in \mathbb{S}l$):

$$S^k = \left(({a_1}^k, {a_2}^k, \dots, {a_m}^k), ({z_1}^k, {z_2}^k, \dots, {z_m}^k), ({q_1}^k, {q_2}^k, \dots, {q_m}^k)\right), \tag{11}$$

$$S^l = \left(({a_1}^l, {a_2}^l, \dots, {a_m}^l), ({z_1}^l, {z_2}^l, \dots, {z_m}^l), ({q_1}^l, {q_2}^l, \dots, {q_m}^l)\right). \tag{12}$$

The state $\boldsymbol{S^l}$ **is reachable directly from the state** $\boldsymbol{S^k}$ if the following conditions hold [4]:

$$\forall_{i\in\{1,2,\dots,m\}} \forall_{j\in\{1,2,\dots,n\}} \left[({a_i}^k = \Delta) \wedge ({a_{\beta_i(P_j)}}^k = {z_i}^k) \Rightarrow ({a_i}^l = {z_i}^k)\right], \tag{13}$$

$$\forall_{i\in\{1,2,\dots,m\}} \forall_{j\in\{1,2,\dots,n\}} \left[({a_i}^k = \Delta) \wedge ({a_{\beta_i(P_j)}}^k \neq {z_i}^k) \Rightarrow \left({a_i}^l \neq P_j\right)\right], \tag{14}$$

$$\forall_{i\in\{1,2,\dots,m\}} [({a_i}^k = \Delta) \Rightarrow [({z_i}^l = {z_i}^k) \wedge ({q_i}^l = {q_i}^k)]], \tag{15}$$

$$\forall_{i\in\{1,2,\dots,m\}} [({a_i}^k \neq \Delta) \wedge ({a_i}^l \neq \Delta) \Rightarrow [({z_i}^l = {z_i}^k) \wedge ({a_i}^l = {a_i}^k) \wedge ({q_i}^l = {q_i}^k)]], \tag{16}$$

$$\forall_{i\in\{1,2,\dots,m\}} \left[({a_i}^k \neq \Delta) \wedge ({a_i}^l = \Delta) \Rightarrow [({z_i}^l = crd_{({q_i}^l)}\sigma_i) \wedge ({q_i}^l = \gamma_i({q_i}^k))]\right], \tag{17}$$

$$\forall_{i\in\{1,2,\dots,m\}}\left[(a_i{}^k \neq \Delta)\wedge(z_{\alpha_i(a_i{}^k)}{}^k = a_i{}^k) \Rightarrow (a_{\alpha_i(a_i{}^k)}{}^l = a_i{}^k)\wedge(a_i{}^l = \Delta)\right], \quad (18)$$

$$\forall_{i\in\{1,2,\dots,m\}}\left[(a_i{}^k \neq \Delta)\wedge(z_{\alpha_i(a_i{}^k)}{}^k \neq a_i{}^k) \Rightarrow [(a_i{}^l = a_i{}^k)\wedge(q_i{}^l = q_i{}^k)]\right], \quad (19)$$

where: m – a number of resources, n – a number of processes,
$\beta_i(P_j)$ – the index of resource directly proceeding the resource R_i, in the j-th process route p_j, $\beta_i(P_j) \in \{1,2,\dots,m\}$,
$\alpha_i(P_j)$ – the index of resource directly succeeding the resource R_i, in the j-th process route p_j, $\alpha_i(P_j) \in \{1,2,\dots,m\}$,
$\gamma_i(q_i{}^k)$ – the function defined by (20):

$$\gamma_i(a) = \begin{cases} a+1 & for\ a < lp(i) \\ 1 & for\ a = lp(i) \end{cases} \quad (20)$$

where: $lp(i)$ - the number of processes dispatched by the rule σ_i.

Feasibility of the state S^l means that there exist the state S^k such that S^l is directly reachable from S^k, and is denoted by: $S^k \rightarrow S^l$. In general case, the states S^k and S^l can be linked by other states, e.g. S^r, S^w what leads to the following sequence of transitions: $S^k \rightarrow S^r \rightarrow \dots \rightarrow S^w \rightarrow S^l$, $S^k \overset{i}{\rightarrow} S^l$ in short, where: i means the number of states $S^r,\dots, S^w$ linking S^k, S^l. So, in the case $S^k \rightarrow S^r \rightarrow S^w \rightarrow S^l$ it means $S^k \overset{2}{\rightarrow} S^l$.

Property 1

Consider two feasible states $S^k, S^l \in \mathbb{S}l$ The transition $S^k \rightarrow S^l$ following conditions (13)÷(19) is a partial state transition function denoted by δ. The notation $S^l = \delta(S^k)$ will be treated as equivalent one to $S^k \rightarrow S^l$.

The set $Sc^* = \{S^{k_1}, S^{k_2}, S^{k_3}, \dots, S^{k_v}\}$, $Sc^* \subset \mathbb{S}l$ is called **a reachability state space of local processes system** generated by an initial state $S^{k_1} \in \mathbb{S}l$ if the following condition holds:

$$S^{k_1} \rightarrow S^{k_2} \rightarrow S^{k_3} \rightarrow \dots \rightarrow S^{k_v} \quad (21)$$

In case $S^{k_1} \xrightarrow{i-1} S^{k_i} \xrightarrow{v-i-1} S^{k_v} \rightarrow S^{k_i}$ the set $Sc = \{S^{k_i}, S^{k_{i+1}}, \dots, S^{k_v}\}$, $Sc \subseteq Sc^*$ is called **a cyclic steady state of local processes system** (a cyclic steady state of ST_{SCCP}**).** In other words a cyclic steady state contains such a set of states in which starting from any distinguished state it is possible to reach the rest of states and finally reach this distinguished state again. Each cyclic steady state is determined by so called period of the cyclic steady state Tl.

A cyclic steady state period $\boldsymbol{Tl}$ is defined in the following way: $Tl = \|Sc\|$. Of course, for any $S^k \in Sc$ the following property holds $S^k \xrightarrow{Tl-1} S^k$.

In that context, our former question regarding SCCP periodicity results in the question whether there exists an initial state S^0 generating the cyclic steady

state Sc. It means, that searching for a cyclic steady state Sc in a given SCCP can be seen as a reachability problem where the state S^kgenerated by an initial state S^0 such that following transitions $S^0 \xrightarrow{i} S^k \xrightarrow{Tl-1} S^k$ holds, is sought.
Property 1 implies that from a given initial state S^0 there exists a unique sequence of transitions leading either to so called deadlock state or to a cyclic steady state. In other words starting from any feasible state S^0 the SCCP behavior ends either with a deadlock o cyclic steady state.

3.2 State space of multimodal processes

In order to take into account the multimodal processes the considered so far the state space $\mathbb{S}l$ has to be properly extended. The extension assumes that to a given state S^k many different allocations of multimodal processes can be linked. It means the simultaneous sharing of the same system resources by different multimodal processes is allowed. So, the extended state definition enables to describe both the local and multimodal processes allocation:

$$mS^k = (S^r, MA^k), \tag{22}$$

where: $S^r \in \mathbb{S}l$ – the state of local processes, corresponding to the k-th state multimodal processes,
MA^k – the sequence of multimodal processes allocation: $MA^k = (mA_1^k, \dots, mA_u^k)$,
mA_i^k – allocation of the process mP_i, i.e.:

$$mA_i^k = ({ma_{i,1}}^k, {ma_{i,2}}^k, \dots, {ma_{i,m}}^k), \tag{23}$$

where: m – is a number of SCCP resources, ${ma_{i,j}}^k \in \{mP_i, \Delta\}$, ${ma_{i,j}}^k = mP_i$ means, the j-th resource R_j is occupied by the i-th multimodal process P_i, and ${ma_{i,j}}^k = \Delta$ - the i–th resource R_j is unoccupied by the i-th multimodal process P_i.

In that context, **the state $\boldsymbol{mS^k}$ is feasible** only if S^r is feasible and for any of its ${ma_{i,j}}^k$ the following condition hold:

$$\forall_{i\in\{1,2,\dots,u\}} \exists!_{j\in\{1,2,\dots,m\}} \left(mP_i = crd_j \; mA_i^k\right), \tag{24}$$

$$\forall_{i\in\{1,2,\dots,u\}} \forall_{j\in\{l|R_l\in\{r_l|r_l=crd_l mp_i, l=1,\dots,lm(i)\}\}} \left({ma_{i,j}}^k \in \{mP_i, \Delta\}\right), \tag{25}$$

$$\forall_{i\in\{1,2,\dots,u\}} \forall_{j\notin\{l|R_l\in\{r_l|r_l=crd_l mp_i, l=1,\dots,lm(i)\}\}} \left({ma_{i,j}}^k = \Delta\right), \tag{26}$$

where: $lm(i)$ – the length of multimodal process route mP_i.

It means in every feasible state each multimodal process is allotted to a unique resource due to relevant multimodal process route.
Similarly to $\mathbb{S}l$ the introduced concept of the k-th state $\boldsymbol{mS^k}$ enables to create a new expanded feasible states space $\mathbb{S}$. In general case $\|\mathbb{S}l\| \leq \|\mathbb{S}\|$ holds. Moreover, the transition linking directly reachable states can be also introduced.

Consider two feasible states $mS^k$and mS^l, i.e. $mS^k, mS^l \in \mathbb{S}$, such that:

$$mS^k = (S^{kr}, MA^k), \tag{27}$$
$$mS^l = (S^{kl}, MA^l). \tag{28}$$

The state $\boldsymbol{mS^l}$ **is reachable directly from the state** $\boldsymbol{mS^k}$ if the transition $S^{kr} \rightarrow S^{kl}$ holds, and the following conditions hold [4]:

$$\forall_{i\in\{1,2,\dots,u\}}\forall_{j\in\{1,2,\dots,m\}}\left[\left({a_j}^{kr} = \Delta\right) \Rightarrow \left({ma_{i,j}}^k = {ma_{i,j}}^l\right)\right], \tag{29}$$
$$\forall_{i\in\{1,2,\dots,u\}}\forall_{j\in\{1,2,\dots,m\}}\left[\left[\left({a_j}^{kr} \neq \Delta\right) \wedge \left({a_j}^{kl} \neq \Delta\right)\right] \Rightarrow \left({ma_{i,j}}^k = {ma_{i,j}}^l\right)\right], \tag{30}$$
$$\forall_{i\in\{1,2,\dots,u\}}\forall_{j\in\{1,2,\dots,m\}}\left[\left[\left({a_j}^{kr} \neq \Delta\right) \wedge \left({a_j}^{kl} = \Delta\right) \wedge \left({ma_{i,j}}^k = \Delta\right)\right] \Rightarrow \left({ma_{i,j}}^l = \Delta\right)\right], \tag{31}$$
$$\forall_{i\in\{1,2,\dots,u\}}\forall_{j\in\{1,2,\dots,m\}}\left[\left[\left({a_j}^{kr} \neq \Delta\right) \wedge \left({a_j}^{kl} = \Delta\right) \wedge \left({ma_{i,j}}^k \neq \Delta\right) \wedge \left(\alpha_j\left({a_j}^{kr}\right) = \alpha_j^*\left({ma_{i,j}}^k\right)\right)\right] \Rightarrow \left[\left({ma_{i,j}}^l = \Delta\right) \wedge \left({ma_{i,\alpha_j^*\left({ma_{i,j}}^k\right)}}^l = {ma_{i,j}}^k\right)\right]\right], \tag{32}$$
$$\forall_{i\in\{1,2,\dots,u\}}\forall_{j\in\{1,2,\dots,m\}}\left[\left[\left({a_j}^{kr} \neq \Delta\right) \wedge \left({a_j}^{kl} = \Delta\right) \wedge \left({ma_{i,j}}^k \neq \Delta\right) \wedge \left(\alpha_j^*\left({ma_{i,j}}^k\right) = \Delta\right)\right] \Rightarrow \left[\left({ma_{i,j}}^l = \Delta\right) \wedge \left({ma_{i,\lambda_j\left({ma_{i,j}}^k\right)}}^l = {ma_{i,j}}^k\right)\right]\right], \tag{33}$$
$$\forall_{i\in\{1,2,\dots,u\}}\forall_{j\in\{1,2,\dots,m\}}\left[\left[\left({a_j}^{kr} \neq \Delta\right) \wedge \left({a_j}^{kl} = \Delta\right) \wedge \left({ma_{i,j}}^k \neq \Delta\right) \wedge \left(\alpha_j\left({a_j}^{kr}\right) \neq \alpha_j^*\left({ma_{i,j}}^k\right)\right) \wedge \left(\alpha_j^*\left({ma_{i,j}}^k\right) \neq \Delta\right)\right] \Rightarrow \left({ma_{i,j}}^k = {ma_{i,j}}^l\right)\right], \tag{34}$$

where: m – the number of resources, u – the number of multimodal processes,
$\alpha_i(P_j)$ – an index of the resource directly succeeding the resource R_i, in the j-th local process route $p_j, \alpha_i(P_j) \in \{1,2,\dots,m\}$, in case the resource R_i is the last element in the sequence p_j, then $\alpha_i(P_j)$ states for an index of the resource beginning these sequence,
$\alpha_j^*(mP_j)$ – an index of resource directly succeeding the resource R_i, in the j-th multimodal process route mp_j, $\alpha_j^*(mP_j) \in \{\Delta,1,2,\dots,m\}$, in case the resource R_i is the last element in the sequence p_j, then $\alpha_j^*(mP_j) = \Delta$,
$\lambda_j(mP_j)$ – an index of the first resource in the j-th multimodal process route mp_j, $\alpha_j^*(mP_j) \in \{\Delta,1,2,\dots,m\}$.

Therefore, $mS^k \rightarrow mS^l$ linking two feasible states $mS^k, mS^l \in \mathbb{S}$ while following the conditions (29)÷(34) can be seen as a partial state transition function.

Property 2

Consider two feasible states mS^k, $mS^l \in \mathbb{S}$. The transition $mS^k \to mS^l$ following conditions (13)÷(19) and (29)÷(34) is a partial state transition function denoted by $m\delta$. So, the notation $mS^l = m\delta(mS^k)$ will be treated as equivalent one to $mS^k \to mS^l$.

Due to the earlier introduced assumption, considered are conflict-free executions of the multimodal processes (i.e. processes do not compete each other with the access to common shared resources). Moreover, since the executions of so called elementary subsequences (that each multimodal process is composed) depend on local cyclic processes, hence moments of their initiation also depend on local processes "availability" (i.e. the moments the local and multimodal processes are allocated at the same resource).

The set $mSc^* = \{mS^{k_1}, mS^{k_2}, mS^{k_3}, \dots, mS^{k_v}\}$, $mSc^* \subset \mathbb{S}$ is called a reachability state space of multimodal processes generated by an initial state $mS^{k_1} \in \mathbb{S}$. If the following conditions hold:

$$mS^{k_1} \xrightarrow{i-1} mS^{k_i} \xrightarrow{v-i-1} mS^{k_v} \to mS^{k_i} \tag{35}$$

where: $mS^a \xrightarrow{i} mS^b$ – the transition defined by (13)÷(19) and (29)÷(34),

the set $mSc = \{mS^{k_i}, mS^{k_{i+1}}, \dots, mS^{k_v}\}$, $mSc \subseteq mSc^*$ is called a cyclic steady state of multimodal processes (i.e., a cyclic steady state of SB_{SCCP}) with the period $Tm = \|mSc\|$, $Tm > 1$. In other words a cyclic steady state contains such a set of states in which starting from any distinguished state it is possible to reach the rest of states and finally reach this distinguished state again: $\forall_{mS^k \in mSc} \left(mS^k \xrightarrow{Tm-1} mS^k \right)$.

In that context, our former question regarding periodicity of multimodal processes executed in SCCP results in the question whether there exist an initial state mS^0 generating the cyclic steady state mSc. It means, that searching for a cyclic steady state mSc in a given SCCP can be seen as a reachability problem where for an assumed initial state mS^0 (i.e. determining local and multimodal processes allocations) the state mS^k, such that following transitions $mS^0 \xrightarrow{i} mS^k \xrightarrow{Tm-1} mS^k$ holds, is sought.

Property 1 implies that from a given initial state mS^0 such that $S^k \in Sc$ (Sc is cyclic steady state), there exists a unique sequence of transitions leading to a cyclic steady state both local and multimodal processes. In other words starting from the state mS^0 the SCCP behavior ends with a cyclic steady state.

Moreover, it can be shown that steady state mSc there exist if and only if there exist Sc. The quantitative relationship among two kinds of steady state expresses the following theorem.

Theorem 1

Consider SCCP and initial feasible state $mS^k = (S^{kr}, MA^k)$ such that $S^{kr} \in Sc$ and $mS^{kr} \in mSc$. $MOD(Tm, Tl) = 0$, where mSc – the cyclic steady state of multimodal processes, Sc – the cyclic steady state of local processes, Tm - the period of mSc, Tl - the period of Sc.

3.3 Constraint satisfaction problem

Considered reachability problems can be stated in terms of Constraint Satisfaction Problem (CSP) [5]. Because of discrete structure both the topology and dispatching rules of SCCP as well as discrete event nature of processes execution the CSP framework seems to be best suited. So, the considered problems of mSc and Sc delimitation can be modeled in declarative framework as follows:
Consider

$$CS = ((X, D), D) \tag{36}$$

where: $X = \{Tm, mSc^*\}$ - the set of decision variables (the cycle of multimodal processes, the set of states contained by the multimodal processes cyclic steady state), D – the family of decision variable domains: $Tm \in \mathbb{N}$, $mSc^* \subseteq \mathbb{S}$,
C – the set of constraints (37)÷(39).

It means, the set mSc^*, see $X = \{Tm, mSc^*\}$, has to follow the constraints C:

$$Tm + i = \|mSc^*\|,\ i \geq 0, \tag{37}$$

$$\exists_{mS^k \in mSc^*}\ (mS^0 \overset{i}{\rightarrow} mS^k \xrightarrow{Tm-1} mS^k), \tag{38}$$

$$\exists!_{mSc \subseteq mSc^*}\ \forall_{mS^k \in mSc}\ (mS^k \xrightarrow{Tm-1} mS^k), \tag{39}$$

where: mS^0 – an initial state, $mS^a \overset{i}{\rightarrow} mS^b$ – the state transition following the conditions (13)÷(19) and (29)÷(34).

Therefore, the problem stated above reduces to determination of the decision variables X that follow constraints C. In consequence, the declarative languages environment has to be employed.

Note, the problem considered is formulated in a straight way. However, within the modeling framework employed the opposite one, i.e. reverse problem formulation can be considered. In that case the variables $\{R, P, MP, \Pi, M\Pi, T, MT, \Theta\}$ are treated as decision ones, and Tm, mSc^* as well as conditions (37)÷(39) state for constraints.

4 Example

For illustration let us consider the SCCP, as shown in Fig.1. Initial allocation of the local cyclic process assumes (5) as well as the semaphore values (6). Consider two multimodal processes mP_1, mP_2 being specified by routes: $mp_1 = (R_3, R_5, R_6, R_8, R_7)$, $mp_2 = (R_1, R_7, R_5, R_4, R_2)$.
The processes mP_2 start their executions while being allotted to resources starting process routes. The response to the following question is sought: Does the SCCP cyclic steady state can be reached? What are Tl and Tm cycle times?
Assuming the following initial state the response to these questions results from CS (36): $mS^0 = (S^0, MA^0)$, where: $S^0 = (A^0, Z^0, Q^0)$ – an initial state for local cyclic processes,$A^0 = (\Delta, P_2, P_1, P_3, \Delta, \Delta, P_4, \Delta)$, $Z^0 = (P_3, P_2, P_1, P_3, P_4, P_4, P_4, P_4)$, $Q^0 = (1,1,1,1,1,1,1,1)$, $MA^0 = (mA_1^0, mA_2^0)$ – an initial allocation of multimodal processes, $mA_1^0 = (\Delta, \Delta, mP_1, \Delta, \Delta, \Delta, \Delta, \Delta)$, $mA_2^0 = (mP_2, \Delta, \Delta, \Delta, \Delta, \Delta, \Delta, \Delta)$.

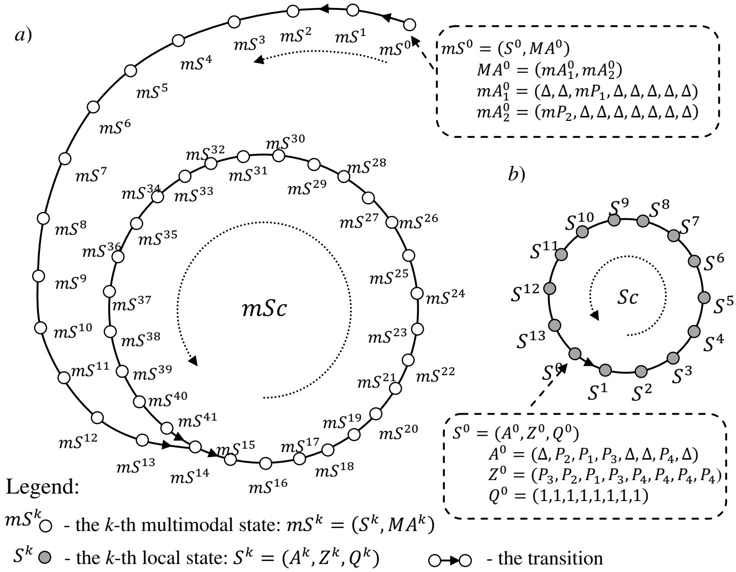


Fig. 2. Graphical illustration of steady states encompassing: a) multimodal processes execution, b) local cyclic processes execution

The problem has been implemented in Oz Mozart [12]. The solution has been found in ten steps, including both constraints propagation and variables distribution [12]. So, the cyclic steady state $mSc = \{mS^{14}, mS^{15}, \dots, mS^{41}\}$ of multimodal processes was reached after transient period including 14 states ($mS^0 \div mS^{13}$). Its graphical illustration is show in Fig. 2a). The corresponding steady state cycle time: $Tl = 28$ u.t. The cyclic behavior of multimodal processes follows from cyclic steady state of local processes system $Sc = \{S^0, S^1, \dots, S^{13}\}$. The corresponding cycle time is: $Tm = 14$ u.t. Graphical illustration is show in Fig 3. Note that the initial state S^0 belongs the cyclic steady state.

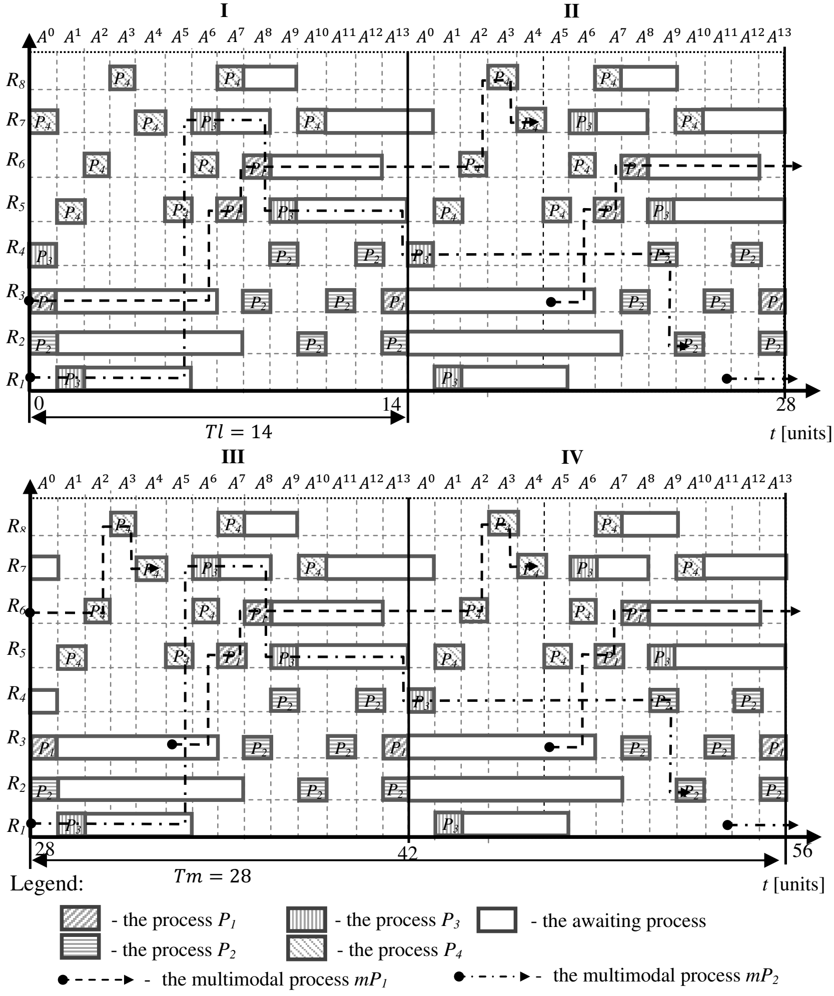


Fig 3. Gantt's charts illustrating execution of processes from. Fig. 2

Note that the transient period of multimodal processes execution takes just cycle time of the cyclic steady state Sc. Moreover, the transient period and cyclic steady state mSc are the multiplicity of cycle time generated by Sc (see the Theorem 1), see Fig. 3. It means the steady state Sc can be seen as mSc throw on $\mathbb{S}l$, see Fig. 4. So, both kinds of cyclic steady states depend on each other.

Therefore, the declarative modeling employed in course of multimodal processes scheduling can be seen as a quite attractive alternative in the face of computer simulation methods. So, providing well suited framework allowing one to prototype public communication routes along the urban and suburban transport processes (which can be seen as network of closed loop train, bus and subway lines) enable to reduce the level of the whole (mostly generated by personal cars) transport emission, i.e. contributes to the set of environmental engineering tools.

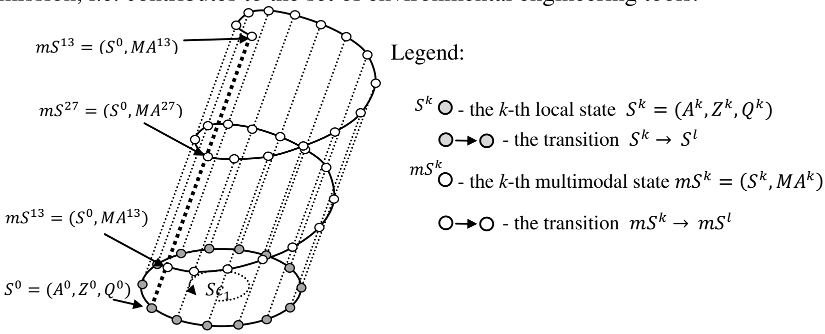


Fig. 4. mSc throw on $\mathbb{S}l$

5 Concluding remarks

The approach proposed is based on the system of concurrently flowing cyclic processes concept assuming its cyclic steady state behavior guaranteed by a given set of dispatching rules and assumed set of initial processes allocations. In the general case that means there exists a set of possible cyclic steady states encompassing potential cyclic behaviors of the SCCP at hand. Each cyclic steady state characterized by its cycle time specifies the local processes repeatability, i.e. their periodicity.

In that context, so called multimodal processes that can be seen as processes composed of local cyclic processes lead to two fundamental questions: Does there exist a control procedure (i.e. a set of dispatching rules and an initial state) enabling to guarantee an assumed steady cyclic state (e.g. following requirements caused by multimodal processes at hand) subject to SCCP's structure constraints? Does there exist the SCCP structure such that an assumed steady cyclic state (e.g. following requirements caused by multimodal processes at hand) can be achieved? Response to these questions determines our further works.

References

[1] Bocewicz G., Wójcik R., Banaszak Z., On Undecidability of Cyclic Scheduling Problems, In: Mapping Relational Databases to the Semantic Web with Original Meaning, Lecture Notes in Computer Science LNAI, Vol. 5914, Springer-Verlag, Berlin-Heidelberg, 2009, 310-321

[2] Bocewicz G., Wójcik R., Banaszak Z., AGVs distributed control subject to imprecise operation times. In: Agent and Multi-Agent Systems: Technologies and Applications, Lecture Notes in Artificial Intelligence LNAI, Vol. 4953, Springer-Verlag, Berlin-Heidelberg, 2008, 421-430

[3] Bocewicz G., Wójcik R., Banaszak Z., Cyclic Steady State Refinement. In: Proceedings of the 9th International Conference on Practical Applications of Agents and Multi-Agent Systems, 2011, (in print)

[4] Bocewicz G., Banaszak Z., Wójcik R., Design of admissible schedules for AGV systems with constraints: a logic-algebraic approach. In: Agent and Multi-Agent Systems: Technologies and Applications, Nguyen N.T., Grzech A., et al. (Eds.), Lecture Notes in Artificial Intelligence LNAI, Vol. 4496, Springer-Verlag, Berlin-Heidelberg, 2008, 578-587

[5] Bocewicz G., Banaszak Z., Cyclic processes scheduling. In: Applied Computer Science, Vol. 6, No. 2, 2010, 41-70

[6] Ernst A.T., Jiang H., Krishnamoorthy M., Owens B., Sier D., An annotated bibliography of personnel scheduling and rostering. In: Annals of Operations Research, 127, 2009, 21-144

[7] Fournier, O., Lopez, P., Lan Sun Luk, J.-D., Cyclic scheduling following the social behavior of ant colonies. In: Proceedings of the IEEE International Conference on Systems, Man and Cybernetics, 2002, 450-454

[8] Kats V., Lei L., Levner E., Minimizing the cycle time of multiple-product processing networks with a fixed operation sequence, setups, and time-window constraints. In: European Journal of Operational Research, Vol. 187, 2008, 1196-1211

[9] Liebchen, C., Möhring, R.H., A case study in periodic timetabling. In: Electronic Notes in Theoretical Computer Science, Vol. 66 (6), 2002, 21-34

[10] Levner E., Kats V., Alcaide D., Pablo L, Cheng T.C.E., Complexity of cyclic scheduling problems: A state-of-the-art survey. In: Computers & Industrial Engineering, Vol. 59, Issue 2, 2010, 352-361

[11] Polak M., Majdzik P., Banaszak Z., Wójcik R., The performance evaluation tool for automated prototyping of concurrent cyclic processes. Fundamenta Informatice. In: ISO Press, Editor-in-Chief, A. Skowron, Vol. 60, No.1-4, 2004, 269-289

[12] Schulte Ch., Smolka G., Wurtz J., Finite Domain Constraint Programming in Oz. DFKI OZ documentation series, German Research Center for Artificial Intelligence, Saarbruecken, Germany, 1998

[13] Slowik A., Steering of Balance Between Exploration and Exploitation Properties of Evolutionary Algorithms - Mix Selection, In: Artificial Intelligence and Soft Computing, L. Rutkowski et al. (Eds.): Lecture Notes in Artificial Intelligence, LNAI, Vol. 6114, Part II, Springer, Heidelberg, 2010, 213-220.

[14] Song J.-S., Lee T.-E., Petri net modeling and scheduling for cyclic job shops with blocking. In: Computers & Industrial Engineering,Vol.34, No.2, 1998, 281-295

[15] Soon-Ki Heo, Kyu-Hwang Lee, Ho-Kyung Lee, In-Beum Lee, Jin Hyun Park, A New Algorithm for Cyclic Scheduling and Design of Multipurpose Batch Plants. In: Ind. Eng. Chem. Res., 42 (4), 2003, 836-846

[16] Trouillet B., Korbaa O, Gentina J.-C.k Formal Approach for FMS Cyclic Scheduling. In: IEEE SMC Transactions, Part C, 37, Issue 1, 2007, 126-137

[17] Wang, B., Yang, H., Zhang, Z.-H., Research on the train operation plan of the Beijing-Tianjin inter-city railway based on periodic train diagrams. In: Tiedao Xuebao/Journal of the China Railway Society, Vol. 29 (2), 2007, 8-13
[18] Von Kampmeyer T., Cyclic scheduling problems, Ph.D. Dissertation, Fachbereich Mathematik/ Informatik, Universität Osnabrück, 2006

Part VI
Information Management for Reverse Logistics and Sustainable Supply Chain

Reverse Logistics in the Automotive Industry: Organizational Models for Waste Generated in Repair Shops

Ruth Carrasco-Gallego[1], Joaquín Delgado-Hipólito[1], Eva Ponce-Cueto[1]

[1]Technical University of Madrid (UPM)

ruth.carrasco@upm.es, joaquin.delgado@upm.es, eva.ponce@upm.es

Abstract. This chapter is the result of one of the research works carried out in the framework of the DOLI project (Analysis and development of techniques for Design and Operations of Reverse Logistics systems). The chapter focuses on the collection and treatment of waste generated during the use phase of automobiles' life-cycle. First, the different types of waste arising during vehicles' service life are characterized using data collected in collaboration with SIGRAUTO, the product stewardship organization in charge of vehicles' recovery in Spain. Next, three organizational models for collection and treatment of those residues are proposed. The three alternatives are benchmarked and assessed from a double organizational and operational perspective for the particular case of the Madrid region in Spain.

Keywords: reverse logistics, closed-loop supply chains (CLSC), end-of-life vehicles (ELV), waste management, automotive industry.

1 Introduction

Reverse logistics discipline has undergone an increasing development in the last 20 years. The main focus of the discipline has been centered on two aspects:

- The organization of reverse material flows in supply chain networks (returnable packaging, commercial returns, remanufacturing) and the integration of the reverse flow and the forward flow in the so-called closed-loop supply chain [6]
- The management of products' end-of-life phase (waste management, recycling), mainly from an environmental perspective [1].

Nevertheless, aspects related to the waste generated during the use phase of the product life-cycle have not been extensively dealt with neither by academics nor policy-makers. The legislation deriving from the principle of Extended Producer Responsibility (EPR) or product stewardship has focused on the waste generated at products' end-of-life phase. Waste generated throughout products' service life

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_44,

has been much less studied and regulated. For some particular parts or components, specific waste management systems have been developed, but those parts and components are considered like an end-product themselves rather than like waste generated during the use-phase in another product's lifecycle. Examples: toner cartridges, tires, batteries, vehicles' oils.

In Europe, the automotive sector is subject to the End-of-Life Vehicles (ELV) Directive [4]. The implementation of this norm has translated in the creation of country-specific Producer Responsibility Organizations (PRO), such as SIGRAUTO in Spain [3] or ARN in the Netherlands [7]. Nevertheless, to the best of our knowledge, legislation and research works to date consider the collection and treatment of end-of-life vehicles' waste [10; 11; 7; 2], while the waste generated during vehicles' service life is not considered with a holistic perspective.

In this research work, carried out in close contact with SIGRAUTO, the objective is to propose and to assess several alternatives for organizing the joint collection and treatment of different types of waste generated during vehicles use-phase. More specifically, three organizational models for managing those residues are proposed. In this multi-level logistic system four actors are included: "repair shops"; "specific waste managers"; "managers for waste managers"; and "control entity". The structure of the chapter is as follows. In section 2, we present an overview of reverse logistics systems in the automotive industry and justify the importance of waste generated during the vehicle use-phase. In Section 3, we characterize the data obtained during the field visits to a selection of official repair shops (service departments of car dealerships, typically linked to one particular Original Equipment Manufacturer (OEM)) located in the Region of Madrid. In Section 4, a series of selected possible alternative models to set out the collection and treatment of the waste generated during vehicles use-phase within those repair shops is characterized. In Section 5, those three models are assessed from a qualitative and quantitative point of view. Finally, in Section 6, the conclusions of this research work are presented.

2 Reverse Logistics in the Automotive Industry: End-of-Life Vehicles and Waste Generated Throughout Vehicles Use-Phase

Reverse logistics issues in the automotive industry have been focused until now in the so-called End-of-Life Vehicles (ELV). This is a consequence of the introduction in year 2000 of the ELV Directive, which made ELV recycling mandatory in the European Union (EU) countries, and the further extension of the spirit of this directive to other national legislations, such as the ones of Japan, South Korea, Taiwan or almost half of the states in the US.

Automobiles are complex products made up different materials. Though most of a car's weight is made up of metals (ferrous and non-ferrous), a vehicle also includes a wide variety of other materials, such as plastics (whose share in a vehicle's weight has been increasingly growing), glass, rubber, fluids, textiles, etc.

When a car service life comes to its end in an EU member state, such as Spain (Fig. 1), the vehicle is taken to an ELV collection point, a certified ELV dismantler, where the vehicle passes through a process of depollution (draining of the vehicle's fluids) and series of operations in order to promote reuse and recycling (removal of valuable parts, components and materials: battery, spare parts that can be reused or remanufactured, …). After that, the reminder of the ELV is taken to a shredder in order to regain the metal fractions. First, the ferrous metals are recovered, and next, a series of methods have been developed in the last decade for regaining the non-ferrous metals remaining (cooper, aluminum, etc.). After metal separation, the reminder is a mixture of glass, plastics, textiles and other components, the so-called shredder fluff. The fluff is first treated for energy recovery and then landfilled.

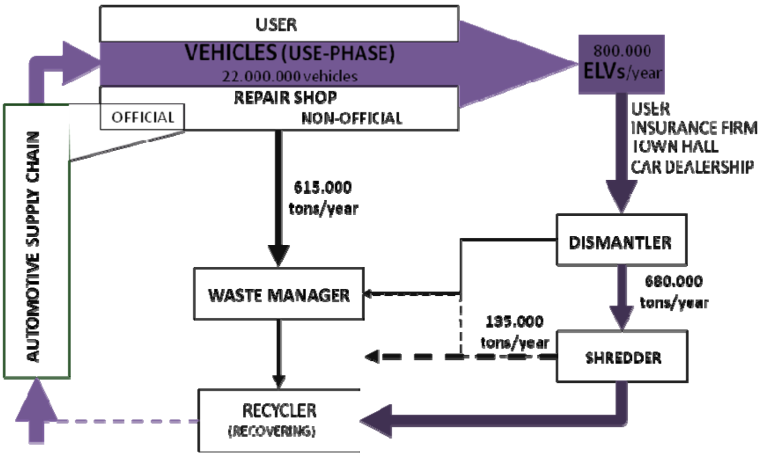


Fig. 1. Reverse Logistics in the Automotive Industry in Spain

Every year in Spain about 800,000 vehicles are declared ELV. Each ELV is considered to weight 1 metric ton (t). After depollution, parts reuse and metallic scrap recycling, approximately 135, 000 t of residues are generated and sent to be used as fuel (energy recovery) or directly landfilled.

Those figures from waste generated by end-of life vehicles can be compared with the waste generated by a vehicle during its service life. In a survey carried out in 2001 [3], more than 600 repair shops located in Spain provided information about the waste quantities generated in their premises by vehicles repair orders. The study was limited to residues that could be identified with those coming from ELV. From that survey, it was stated that every year in Spain 615,000 t of waste are generated by vehicles in the use-phase of their life-cycle. Given that the total number of cars in use registered in Spain is about 22 million cars, and that the average car lifetime is 15 years, we can assume that each vehicle in use generates about 28 kg of waste per year, and that at the end of its use phase (15 years), a car would have generated about 420 kg of waste throughout its life before it becomes an ELV.

Therefore, if the carcass effect is taken aside (most of a ELV weight is made up of metallic materials), the amount of waste generated in Spain every year by vehicles in their service life is almost 4 times the amount of non-metallic waste generated by ELV (615,000 t vs. 135,000 t). In that figures, the waste generated in the repair shops due to the regular activity of the facility has not even been taken into account.

3 Field study: data collection methodology and data characterization

According to SIGRAUTO (2009 data), there are about 50 000 repair shops in Spain. Of those, almost 20% are official repair shops, certified by one particular OEM. The Region of Madrid, where about 15% of the Spanish populations resides, accounts for 1073 (~11%) of those official repair shops. Those repair shops were classified depending on their size (number of Repair Orders (OR) performed) and on the type of activities carried out in the repair shop (just mechanics, paint and body shops, light or heavy vehicles, etc.). As a result, based on those variables and on SIGRAUTO's staff knowledge, six categories of repair shops emerged (A to F) for the Madrid region. Next, through a stratified random sampling process [5], a sample of 26 official repair shops belonging to 8 different OEM (Hyundai, Peugeot-Citröen, Fiat, Mitsubishi, Renault Trucks, Seat, Renault, BMW) was selected. Table 1 reflects the representativeness of this sample.

Table 1. Sample representativeness

Repair Shop Type	% of repair shops in the whole population	Nb. of repair shops in a sample of 26 elements	Nb. of repair shops visited
A	1.95	0.51	1
B	7.06	1.84	1
C	12.58	3.27	3
D	21.34	5.54	6
E	5.72	1.49	2
F	51.35	13.35	13
Total	100	26	26

Data collection was carried out between November 2008 and January 2009 through a field study. Each selected repair shop was physically visited 4 times in order to register the amounts generated for 39 different types of waste throughout 3 periods of time.

The waste generated in a repair shop has been classified in this research work in the following three categories: product waste, process waste and common waste.

Product waste includes all types of materials disposed in the repair shops coming directly from the vehicle. It includes a wide variety of materials, such as oils, batteries, different types of vehicle fluids (coolant- antifreeze, brake fluid, air-conditioning system fluid, fuels (petrol/diesel)), oil filters, tyres, glass, plastics (bumpers, dashboard, fluid containers in the vehicle, …), textiles and foams, air-bags, catalysts, etc. Besides all those non-metallic materials, an important part of product waste is made up of a metallic fraction that includes mechanics waste (recoverable components or spare parts that can be reused or remanufactured), ferrous metallic scrap that can be easily recycled into steel, and non-ferrous metallic scrap (aluminium, magnesium, zinc, copper, lead, …) such as the lead wheel counterweights used in tires balancing (that are being substituted by zinc ones).

Process waste refers to the waste generated during the repair process that does not directly come from the vehicle. This includes for instance: industrial wastewater (floor and car washes), solvents used in the mechanic area (non-halogenated solvents, mineral spirits), waste paints, paint strippers, paint thinners, waste paint-contaminated materials (such as paint booth filters, masking paper, overspray paper), paint chips from sanding, absorbent sepiolite.

Common waste refers to the waste that can be generated in any type of repair shop, regardless of the type of repair activities carried out in the shop. This category includes for instance: print cartridges, paper and cardboard, packaging materials (wood, metallic, plastic), strip light bulbs, electronic waste and so on.

Data collected during the field study were statistically treated with Statgraphics. In this statistical work, the average amount of waste generated by repair order (OR) was calculated. When possible, the confidence intervals of the average amount were also calculated. The data characterization process results are summarized in Table 2

Table 2. Average waste quantities per order of repair (OR)

	Average quantity per repair Order (OR)	**Confidence Interval**	**Unit**
Product Waste			
Oils	1,73	± 0,41	kg/OR
Batteries	0,05	± 0,013	kg/OR
Coolant	0,073	± 0,047	l/OR
Brake Fluid	0,02	± 0,01	l/OR
Fuels	0,059	± 0,026	l/OR
Oil filters	0,26	± 0,06	kg/OR
Tyres	0,13	± 0,03	units/OR

Glass	0,13	± 0,05	kg/OR
Bumpers	0,2	± 0,03	kg/OR
Metallic scrap	0,57	± 0,11	kg/OR
Process Waste			
NH Solvents	0,091	± 0,019	kg/OR
Masking paper	0,048	± 0,016	kg/OR
Paint booth filters	0,040	± 0,011	kg/OR
Waste paints	0,047	± 0,052	kg/OR
Paint chips from sanding	0,074	± 0,021	kg/OR
Sepiolite	0,015	± 0,029	kg/OR
Common waste			
Cardboard and paper	0,21	± 0,27	kg/OR
Wooden packaging materials	0,48	± 0,23	kg/OR
Plastic packaging materials	0,087	± 0,017	kg/OR
Metallic packaging materials	0,51	± 0,22	kg/OR

Besides, in the field study was analysed how many waste managers or producers responsibility organizations were used by each of the repair shops visited. The results show that, in average, each repair shop deals with 6 different waste managers.

4 Organizational models proposal

In this research work, we have proposed three alternative multilevel organizational models for setting out the reverse logistics of the waste generated in repair shops throughout vehicles' use-phase. In this reverse logistics systems could take part up to four types of agents: repair shops; specialized waste managers (GRE); multi-purpose waste managers (GGR); and control entity (EC).

Repair shop (taller): is one of the official repair shops certified by one particular OEM.

Specialized waste managers (GRE): this agent corresponds to the current waste managers or producers responsibility organizations (PRO), which are in charge of recovering just one particular type of waste. For instance, currently one specialized PRO has been set up for tyres recovery (SIGNUS) and another one is in charge of industrial oils recovery (SIGAUS). Those two PRO are the result of recent introduction of new legislation in Spain regarding the extended producer responsibility of those two products [13; 14]. Besides those PROs, there are other specialized waste managers for batteries, hazardous materials, etc. that support repair shops and other industries in their environmental management.

Multi-purpose waste managers (GGR): this agent would act as the single contact a repair shop would handle for managing all the different waste types generated by the repair shop activity. The role of this figure is to act as a manager of waste managers. If the GGR role was introduced in the system, that would enable that a single entity takes care of all the waste generated in the repair shops within the geographic scope under its responsibility, either directly or through GRE.

Control entity (EC): it is the organization that collects and centralizes all the information coming from GRE or GGR (if created), in order to evaluate the performance of the system and to control the effective application of environmentally-sound practices.

In Figure 2 the three proposed organizational models for the management of waste generated throughout vehicles use-phase are depicted schematically.

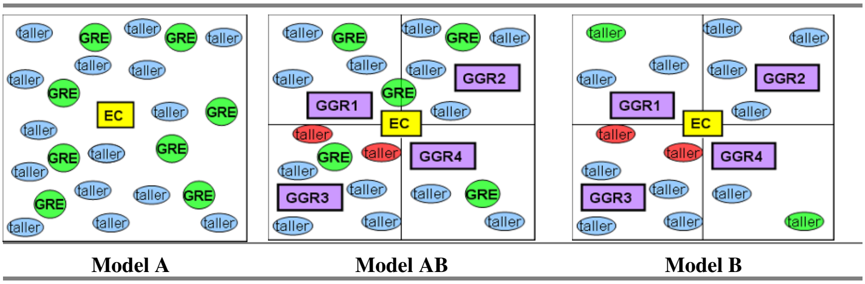


Fig. 2. Organizational models for waste generated throughout vehicles life-cycle

Model A corresponds to the current situation (waste managers are product-specific, PRO model), except for the introduction of a Control Organization (EC) that supervises the system. Each GRE is in charge of collecting all the quantities generated of their specific waste product (tyres, oils, batteries, waste paints,..) in all the repair shops of the geographical area considered.

Model B corresponds to a situation in which there are no specialized waste mangers (GRE) but multi-purpose waste managers (GGR) that are in charge of collecting all the waste products generated in the repair shops in a given geographic area.

Finally, model AB is a hybrid between the above-mentioned models. The GGR acts as the single contact point for the repair shops allocated under its scope. For the collection of the most common and massively generated waste products, the GGR relies on specific waste managers (GRE) that provide support to all the GGR created in the geographical area considered.

The information and materials flows are different within each organizational model. The models proposed are depicted in Figure 3, ranged by the organizational complexity involved within each alternative (model A involves the highest organizational complexity, model B the lowest). The materials flows are represented by the blue arrows whereas the red arrows correspond to information flows.

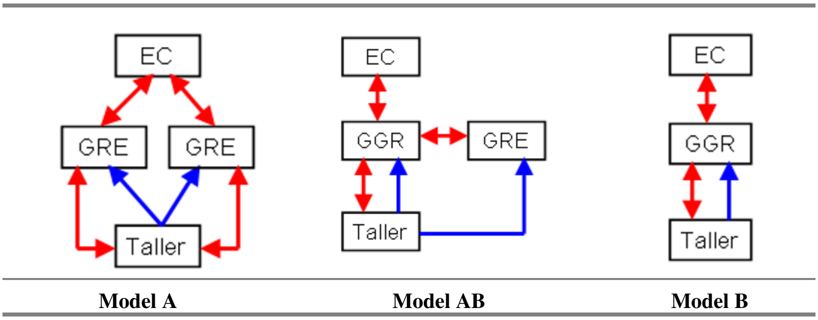


Fig. 3. Organizational complexity of the three alternatives.

5 Organizational models evaluation

Each alternative has been assessed from two perspectives: organizational complexity and operative efficiency. On the one hand, organizational complexity is a qualitative indicator that depends on the number of agents involved in the model and the corresponding amount of information flows among them. On the other hand, operative efficiency is a quantitative indicator that measures the workload required for the collection of all the waste generated along the 1073 official repair shops in the Region of Madrid. Operative efficiency is measured by the hours of truck per month required within each of the three models. This metric is determined by the time spent in transit by waste collection trucks and by the residence time of those trucks at the repair shops for waste collection operations. The first factor (transit time) depends on distances to be covered within each model. The second factor (residence time) depends on the number of repair shops visited by each waste collection truck. During the field visits, residence time was measured and its value ranged between 20 and 30 minutes, so for the purpose of this study, we used an average residence time of 25 minutes per visit.

Model A (current situation) resulted to perform worse than the two other alternatives (models AB and B) either from the organizational complexity perspective and from the operative efficiency perspective. Model B is simpler than model AB from the organizational point of view, but its operative efficiency is smaller: 222.000 against 185.000 hours-truck/month.

6 Conclusions

In the last decade, the automotive sector has concentrated their environmental efforts in providing solutions to the end-of-life vehicles problem. However, vehicles also generate a relevant amount of waste during their use-phase. Reverse logistics systems dealing with waste generated throughout vehicles use-phase manage a higher amount of materials and are more complex than reverse logistics systems for ELV. The number of points where waste is generated is much higher (capillarity of the repair shop system) and the characteristics of the different types of waste generated in those repair shops show a wide heterogeneity.

To the best of our knowledge, this is the first time that the problem of designing reverse logistics systems for waste generated throughout vehicles use-phase has been addressed in the operations management literature. In this study, the different types of waste that repair shops generate have been characterized, and the waste volumes generated per repair order in the repair shops of the region of Madrid have been estimated. In addition, we have made a first effort to design and quantitatively evaluate several alternatives for organizing the corresponding logistics system.

An integrated waste management system that considers waste generated throughout vehicles use phase with a holistic perspective has revealed to be the best choice (either from the organizational point of view and from operative efficiency point of view), as shown for the region of Madrid. Within this geographical scope, the integrated (holistic) model has led to better results than those obtained by the models that consider waste from just a product-specific perspective.

The expected benefits of such a holistic proposal in terms of environmentally sound practices are twofold. On the one hand, more efficiency within waste management activities leads to reduce repair shops' reluctance to get involved in those activities. On the other hand, the integrated model provides better control and enables to detect and penalise those repair shops that carry out no waste management activities. In addition, the system-wide perspective of the control entity facilitates the identification of the main challenges and barriers that the system has to deal with. Hence, special efforts can be proposed to address to those key issues, resulting in a continuous improvement of the system for proper treatment of the waste generated during vehicles service life.

Under this approach, the main further extensions of this research work will be directed towards the operational level of that waste management system. We will focus on aspects related to materials and the information flows. Within the materials flows, we intend to: (a) analyze the effects of introducing multiproduct transport equipment, and (b) to deepen our understanding on the collection frequencies required for different types of residues. Regarding the information flows, we will further research on (c) the monitoring, and (d) deviation analysis, to be carried out by the Control Entity.

Acknowledgments This research work stems from the participation of the authors in a research project funded by Plan Nacional de I+D+i, reference DPI2007-65524, title DOLI "Análisis y desarrollo de técnicas para el Diseño y la Operación de sistemas de Logística Inversa". We would like to thank Manuel Kindelán and Juan José Coronado from SIGRAUTO for their collaboration and support during the data collection process. In addition, we would like to thank specially Jacobo Ozores Eizmendi for the statistical processing of data collected during the field visits.

References

[1] Carter, C.R.; Ellram, L.M. (1998). "Reverse logistics: A review of the literature and framework for future investigation". Journal of Business Logistics, 19 (1), pp.85-102.
[2] Cruz-Rivera, R.; Ertel, J. (2009). "Reverse logistics network design for the collection of end-of-life vehicles in Mexico". European Journal of Operational Research, 196 (3), pp. 930-939.
[3] Delgado Hipólito, J. (2002). "La logística inversa en el sector de automoción español" ENEGEP 2002: XXII Encontro Nacional de Engenharia de Produçao, VIII International Conference on Industrial Engineering and Operations Management. Curitiba (Brasil)
[4] Directive 2000/53/EC of the European Parliament and of the Council of 18 September 2000 on end-of life vehicles. Official Journal of the European Communities, L 269, 21.1.2000, pp. 34-43.
[5] Forza, C (2002) "Survey research in operations management: a process-based perspective", International Journal of Operations & Production Management, 22 (2), pp.152 – 194.
[6] Guide,D., Harrison, T.P.y van Wassenhove, L.N. (2003). "The challenge of closed-loop supply chains". Interfaces, 33 (6), pp. 3-6.
[7] Krikke, H.R., Kooki E.J, y Schurr, P.C (1999). "Network design in reverse logistics: A quantitative model". New Trends in Distribution Logistics. Lectures in Economics and Mathematical Systems, 480, pp. 45-61. Springer-Verlag.
[8] Ozores Eizmendi, J. (2009). "Análisis para el diseño de un sistema de Logística Inversa de componentes y residuos generados durante la vida del automóvil". Unpublished master thesis. ETS Ingenieros Industriales. Universidad Politécnica de Madrid. Supervisor: Joaquín Delgado-Hipólito.
[9] Krikke, H, leBlanc, I, van Krieken, M, Fleuren, H. (2008). Low-frequency collection of materials disassembled from end-of-life vehicles. On the value of on-line monitoring in optimizing route planning. International Journal of Production Economics, 111, pp. 209-228.
[10] Schultmann, F., Zumkeller, M. y Rentz, O. (2006). "Modeling reverse logistic tasks within closed-loop supply chains: An example from the automotive industry". European Journal of Operational Research, 171 (3), pp.1033-1050.
[11] Real Decreto 1383/2002, de 20 de diciembre, sobre gestión de vehículos al final de su vida útil. Boletín Oficial del Estado, 3 enero 2003, núm.3, p.185.
[12] Real Decreto 1619/2005, de 30 de diciembre, sobre la gestión de neumáticos fuera de uso. Boletín Oficial del Estado, 3 enero 2006, núm. 2, pp.352.
[13] Real Decreto 679/2006, de 2 de junio, por el que se regula la gestión de los aceites industriales usados. Boletín Oficial del Estado, 3 junio 2006, núm. 132, pp. 21061.

Recovery Network arrangements – the WEEE case

Paulina Golinska[1]Arkadiusz Kawa[2],

[1] Poznan University of Technology,[2]Poznan University of Economics,

arkadiusz.kawa@ue.poznan.pl, paulina.golinska@put.poznan.pl

Abstract. The life cycles for electric and electronic equipment get shorter every year. It results in a growing amount of waste which needs to be reused or disposed. Legislative regulations in number of countries oblige the producers to organize the recovery network. Configuration of the recovery network is a complex task due to the big number of relations between reverse supply chain participants. In practice the dynamic changes in recovery network appear very often. The recovery operations follow push logic. The reverse flows are supply driven. Companies have problems to stimulate the time and quantity of returns. It is difficult to make planning many weeks in advance because in dynamically changing conditions forecasts quickly become outdated. Authors proposed a model based on graph theory and agent technology that helps to solve this problem by dynamic configuration of reverse supply chains. The simulation results based on proposed model are discussed.

Keywords: recovery network, WEEE, recycling, reverse logistics, software agents

1 Introduction

Electric and electronic equipment's waste (WEEE) is a big problem in number of well developed countries. The customers exchange computers, printers or servers more and more often. Since 2005, member states of the European Union have begun implementing the WEEE Directive, which requires manufacturers to provide the drop-off points for unwanted electronic devices. The manufacturers might reprocess the WEEE in number of ways. The most typical are: remanufacturing, recycling and redistribution.

The challenge is to reach by reprocessing the "win-win" situation, where both environmental and economic goals are met. The useful life cycle might be prolonged by reselling refurbished equipment, remanufacturing components as spare parts or reclaimed raw materials. The environmental goal is met by efficient reverse flow management. When there is a reduction of the waste amount being disposed. Moreover by computer equipment most of the environmental footprint is cumulated in production phase. Reclaiming of such burns by traditional bulk recycling is impossible [11]. The major of energy is used for production of semiconductors which cannot be reclaimed by recycling. Other recovery options seem to be more appropriate. The other more customized recovery options reprocessing options (e.g.

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_45,

refurbishing, remanufacturing, repairs) require better organization of goods collection and their rendering.

Manufacturers meet the need to organize a recovery networks for their products. Recovery networks involve collection of used products from the customers, reprocessing and future redistribution to the market. The customers become re-suppliers. Moreover they drive all the reverse flows of materials. It is difficult to match demand and re-supply in the reverse part of the supply chain.

In this chapter the emphasis is placed on dynamic arrangements within recovery network in order to provide reverse flow of materials that the best match to the demand. The aim is to minimize costs and optimize IT returns' reprocessing.

The chapter's structure is as follows, the brief theoretical background is provided in Section 2. Proposed model is presented in Section 3. The simulation experiment and its results are discussed in Section 4. Final conclusions are stated in Section 5.

2 Reverse logistics in computer industry

2.1 Reverse logistics and network configuration

Reverse processes start with all activities rendering used products available and physically moving them to the place of further treatment (collection). The inspection/separation denotes all operations determining whether a given product is in fact re-usable and in which way. It results in splitting the flow of used products according to distinct re-use and disposal options [4]. Reprocessing may take different forms including recycling, repair and remanufacturing. In addition, activities such as cleaning, replacement and re-assembly may be involved. Re-distribution includes all activities needed to direct delivery of re-usable products to a potential market. In this chapter issues related to the redistribution to alternative markets will be ignored. Environmental friendly supply chain management requires a continuous course of actions in order to decrease the environmental impact of products and technology used by a manufacturer and its pre-chain (suppliers) and post-chain (collection, inspection and reprocessing activities).

Reverse processes in supply chain differ from the forward one. It is mainly because reverse materials flow is supply-driven not demand driven. It is difficult to control the timing and amount of returns which are pumped into recovery network by products' users. Computer companies try to stimulate the reverse material flow by lease programs where return dates are defined. The lease programs are mainly addressed to institutions, individual returns are less coordinated. The return products are refurbished or remanufactured as appropriate, repackaged and resold. Company offers remarketed products for most product types, and follows strict processes to protect user data and to meet environmental requirements.

The following types of return might appear in the recovery network [6]:

- end-of-life returns,
- commercial returns,
- warranty returns,
- production scrap and by products,

- reusable packing material.

The flows can differ with quality and, consequently, value, with end-of-life returns and warranty returns being the most valuable. The reasons why companies try to close their supply chain are:

- legislative -strict provisions concerning waste disposal and using non-renewable resources),
- marketing (creating ecological image of a company),
- economic (cheaper resources that can be used without influencing quality of a final product, subventions, preferential tax rates)

Products returned to manufacturer that are not suitable for reuse enter the recycling programs. Consumer recycling services vary by country, depending also on local regulations. Producers make arrangements with commercial customers depending on the equipment involved and the specific circumstances.

In order to meet this goal the efficient arrangement of materials flow in recovery network is a must.

2.2Computer Industry Insights

The number of installed PCs worldwide has growth over 1 billion units, according to Gartner, Inc. The analysts estimate the worldwide installed base of PCs is growing just under 12 percent annually. At that pace, it will reach 2 billion units by early 2014.

Computer industry is especially interesting application domain for reverse logistics because of the following characteristics:

- mass production(big materials flow),
- short life cycles,
- potential for reprocessing.

Many ‘end-of-life’ products are still in good working condition and may therefore find useful application. On the other hand, quick depreciation puts this option under significant time pressure [2].

The environmental friendly practices in computer industry include mainly:

- extension of the products useful life when possible through a refurbishing process,
- proper disposal of units that cannot be recovered.
- utilization of useful components and materials from recyclable products.

Electronic equipment often contains heavy metals and other hazardous substances, and must be refurbished or recycled properly. E-waste contains harmful elements, including lead, cadmium, mercury, chromium. Governments worldwide are stepping up environmental regulations. On the other side used IT equipment can be a source of valuable resources.

In Europe manufacturers create the European Recycling Platform (ERP) in 2002. Most of the top producers began pursuing environmentally friendly disposal policies long before they were mandated by government regulations. Nowadays the leader in reprocessing practices is HP. The company offers for its customers recycling and reuse programs. HP has aimed to recycle900,000 tones of electronic products and supplies by the end of 2010 (since 1987). In reality 884,000 tones of electronic products and supplies has been recycled. In total, more than 1.07 million tones of electronic products and supplies have been recovered and reused by HP since 1987.A total of 186,000 tones have been reused since 2003.

HP also uses a network of vendors (service providers) to process, resell and recycle return products. The company issues Global Reuse and Recycling Standards which define conditions and requirements for storing, handling and processing returned equipment in ways that prevent from the leak of harmful substances. Nowadays company has in the pool in recovery network about 500 recycling providers' locations around the world. Institutions providing reuse services for HP products must ensure that those operations occur in on time and secure. The time issue is highlighted by the network configuration. The company tries to limit the storage of goods for recycling ore reuse must not be stored for more than 90 days.

Another example of recovery network configuration is IBM. IBM's asset recovery assumes priority on reselling equipment as a whole. The products are sold through IBM's sales network as certified remanufactured equipment. The business partners and brokers are also involved in these operations. For the PC sector, IBM uses a different channel. The products are tested by Global Assets Recovery Services (GARS) and then are auctioned off in large batches to brokers. Overall, IBM is able to resell some 80% of the PCs returned from the business market [8]. The valuable components are delivered as spare parts to IBM's own service division. In addition, GARS also sells recovered components to external brokers. The remaining equipment is divided into about 50 different material fractions and it sells them to specialized recyclers [8].

A professional asset recovery program provides a good opportunity to find value in older equipment and to enhance the organization's reputation for environmental friendly institution. Professional recovery companies have specialized skills: logistics (inventory control, transport, storage, etc.), data wiping, equipment refurbishment, resale and environmentally responsible recycling. The example of materials flow (arrows) in holistic (forward and reverse) supply chain is presented in figure 1.

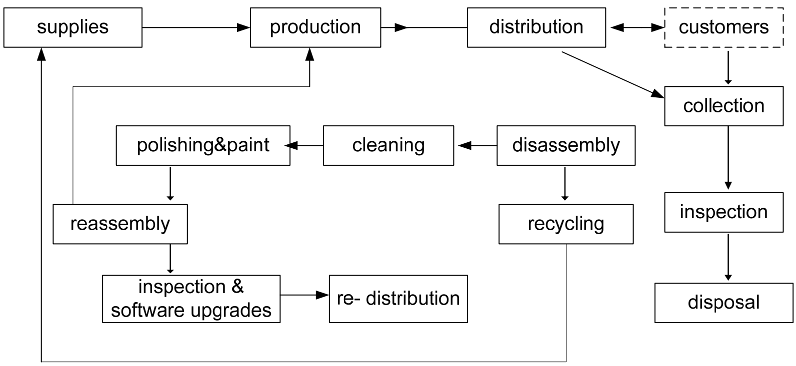


Fig. 1. The recovery network in the computer industry

The structure of the network presented below (in fig. 2) is typical for the recovery network in the computer industry. The organization of computer production is conducted by Original Equipment Manufacturers (OEM). Flagship Companies (FC) which own such makes as Dell, HP, Apple, Toshiba, Acer control the purchase of key elements for computers for OEM which, in turn, are responsible for buying from third tier suppliers and so on.

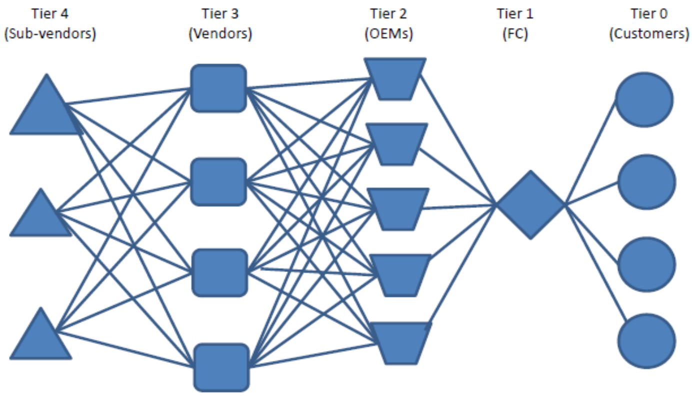


Fig. 2. The recovery network in the computer industry

2.3 Previous work

The configuration process is an arrangement of parts or elements that gives the whole its inherent form. The previous work on recovery network configuration has taken in consideration costs of investments or operational costs in order to find the fixed geographical location of new facilities/points for recovery and product collection [e.g. 1, 7]. In the dynamic changing economic environment it is more important to focus on the changes in a system (supply chain) than on its total redesign. On account of a huge number of entities which can take part in a supply chain and the complexity of the relationships between them, the configuration process is multipronged and requires particular attention.

A re-configurable network should be a self-adjusting and resilient system reacting to the changes taking place in its individual parts. In practice, planning product renewal many weeks in advance is hardly effective as in dynamically changing conditions forecasts quickly become outdated. That is why the information about the current network situation must be constantly updated and stored in a place accessible to all the interested parties. Parties involved in the cooperation have their own resources, capabilities, tasks, and objectives so there are difficulties in coordination of the constant flows of information, materials, and funds across multiple functional areas both within and between chain members [9].

Thanks to agent technology and graph theory used in logistics it is possible to depart from fixed supply chains, in which enterprises are dependent on one another, and replace them with dynamic configurable supply chains, including constituents, which offer the best conditions of cooperation at a given moment. The proposed RNA model enables to find the cheapest path with appropriate capacities in the whole recovery network. Therefore, a company being a leader of a recovery network, can satisfy its demand more quickly and propose a competitive price to customers.

3 RNA Model

3.1 Graph Theory in Recovery Network

The RNA (Recovery Network Arrangement) is based on DyConSC model [10] and extended here with the recovery concept. It is mainly aimed at building dynamic and flexible temporary supply chains. Nowadays it is especially important because customer demand, production lines and distribution network frequently change. This model enables each entity of the supply chain to independently adjust their plans in such a way that they become optimal both within one enterprise and the whole supply chain. Such a supply chain may be successfully realized by agent oriented systems.

In the RNA model four tiers of enterprises and one tier (represented by customers) have been distinguished. The first tier is represented by FC followed by OEMs, Vendors and Sub-vendors. For example, OEMs designs and manufactures product for recovery. Vendor provides disposition services of electronic hardware products and materials to or on behalf of FC. It also includes logistics service providers that either provide the processing services directly or through third-party recycling, reuse, or disposal providers. Sub-vendor (any subcontractor or downstream third party) provides disposition services of electronic hardware products and materials to or on behalf of FC's Vendors. FC provides requirements for recovery. Such an enterprise network comes in the form of a stratified, directed graph consisting of *n*sources (Sub-vendors) and one sink (FC).

In RNA model goods and information flows take place between consecutive tiers. All goods deliveries are carried out sequentially from the supplier of the last tier to the supplier of the first tier. The information flow is possible thanks to software agents. Autonomous agents representing different enterprises cooperate, co-ordinate and negotiate conditions in order to achieve their common goal.

All supplies are conducted sequentially so no tier can be omitted. As can be seen in the figure 3, a flow (edges) of goods in certain quantities takes place between the entities (nodes) in the recovery network. In such network the cheapest flow with an appropriate capacity is finding [10].

Although it describes the task of linear programming, solving it by general liner programming methods is ineffective due to its network structure. In this case the Busacker-Gowen (BG) algorithm, which is presented in [4] is suitable. This method consists in increasing the flow along consecutive paths augmenting as much as their capacity allows. The order of appointing paths depends on their length which, in this case, is determined by unit costs. If the flow has achieved the defined value, computing finishes. Otherwise, the network is modified and next stages are repeated until the flow of the predefined value is accomplished.

To find the cheapest chain from the source to the sink the algorithm of finding the shortest paths must be applied. The RNA model has used the BMEP algorithm (see more in [5, 10]).

3.2 RNA Model Assumptions

A given recovery network of enterprises is managed by FC. It controls the whole reprocessing of a product in real time, from the receipt of the returned product through gaining resources necessary for the refurbishment to the delivery of ready (renewed) products to the customer. FC arranges reverse supply chains (materials flow paths) within a given network of cooperation enterprises (potential recovery network). Such chains are created for the needs of a specific transaction evoked by the customer's demand (e.g. via product return in order to carry out the recovery process). FC is also engaged in the optimization of the already existing "reverse supply chains" and the control of their efficient accomplishment so that the customers' expectations related to service quality are met and the costs are reduced at the same time. However, the remaining enterprises from the network are directly responsible for the organization and co-ordination of the streams (of goods and information) generated by the suppliers and recipients of the next tier.

The fundamental assumption of the proposed RNA model is form of a stratified, directed graph with individual nodes and edges represented by software agents. A number of additional presumptions essential for correct comprehension and operation of the model have also been distinguished. It is assumed that:

- FC administers a tool which enables to visualize the network composed of all the suppliers and recipients, the relations between them as well as the review of the whole production process.
- All suppliers of the individual tiers have the same or very similar production process.
- FC has access to information about product prices, quality, etc. and supply (production capacity) offered by all members of the enterprise recovery network.
- Customers' individual return notices are collected and consolidated at specified time intervals (e.g. once a day) and passed on by FC to the right members of the configured supply chain.
- Separate graphs, in which the current connections between enterprises are represented, are built for each collective order.
- A homogeneous Bill of Materials, which provides information necessary to calculate the size of the production and supply order, is used in the whole network. Thanks to that, suppliers of subsequent tiers know what products, semi-products, subsets, individual elements, raw materials and in what quantities to deliver in order to produce a given good[12].
- The realization of the flows between suppliers and recipients may be carried out by the enterprise itself or by an external provider (e.g. a logistics service provider, a courier).

- The costs of sending a flow unit along an edge in a graph are treated as the result of synthetic evaluation of the cooperation between the recipient and the supplier. The software agent of each recipient carries out an evaluation of its direct suppliers, taking into consideration a set of criteria, and then places it on the register server. The information is constantly updated.
- The total of the flows outgoing from a given supplier to their recipients equals the supply value (production capacity) of the supplier in question.

4 Simulation results

The RNA model was implemented in the NetLogo. It is a programmable modeling platform for simulating which allows to give instructions to a lot of independent agents interacting with one another and performing multiple tasks. The turtles (agents) can be connected to one another by "links" which are also programmable. Collectively, the turtles and links are called agents [13].

In the simulating model four kinds of "breeds" were distinguished: FC, OEMs, Vendors and Sub-vendors, which allowed to define different behaviors and "agent sets" of those breeds.

The quantity of the potential entities in each tier (except for the 1st tier) is assumed to range from 5 to 200. This number can be increased or decreased with the slider (*nodes-num*). There is only one FC in each network (see fig. 3). Different FCs from other recovery networks may compete with others [10].

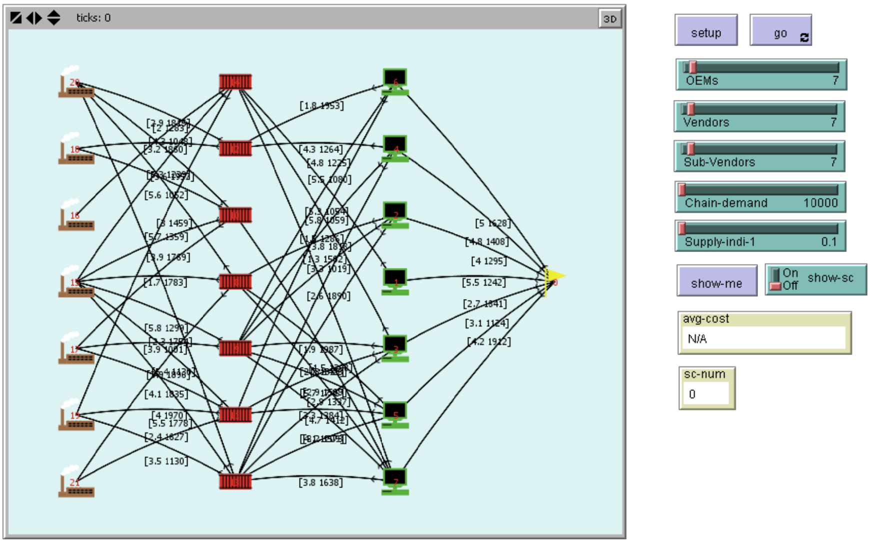


Fig. 3. Screenshot of exemplary recovery network in the NetLogo platform

Two other parameters of this network were distinguished: *chain-demand* and *supply-indicator*. The first one is a demand of the FC which equals the whole supply chain demand by day. The second one is a factor of the supply changeability of particular entities of the network.

The properties of link agents between constituents were chosen randomly as a pair of *cost* and *capacity*. This *cost* is very widely understood in this paper. It is worth to notice that, generally, sellers give different prices, some of which include other additional costs, but others do not. A lower price is offset by significantly higher acquisition costs such as those of delivery, monitoring, coordination and other administrative tasks[2]. Thus, it is very difficult to compare them with one another. Moreover, the criteria for the choice of the preceding entity may comprise the price, product or service quality, production and delivery time, reliability, customer service, location, etc. In the RNA *cost* comprised all these components. All of them are quantified and, as a result, can be comparable. We set the cost as a variable between 1.0 and 6.0. In turn, *capacity* is a variable which depends on the aforementioned *supply-indicator*.[1]

Due to the fact that time, or carrying out the recovery on time, to be more precise, is an important parameter, it has been assumed that in a given network there are only such connections between the suppliers of consecutive tiers which can guarantee that the whole operation from the moment of receiving the returned good, through gaining resources, the refurbishment to the product delivery will be completed in 90 days.

In the recovery network we look for such supply chains which meet the requirements and are most effective. In order to find such chains (so the shortest path in the graph), the BG and BMEP algorithms are used. Because the FC demand can be completely or partially satisfied, there can be one or more such chains. Their number depends on the supply and demand changeability.

In order to check the capabilities of recovery supply chain configuration and the effectiveness of the RNA model a lot the simulation experiments were carried out. Their aim was to study how the changes of the node numbers (*nodes-num*) and *supply-indicator* influence the average supply chain numbers (*sc-num*) and the average cost of sending a flow unit along the supply chain (*avg-cost*) in the recovery network. For multiple runs of the model the BehaviorSpace tool was used which allows collecting data in an external file [10].

For the first group of the simulation experiments it was assumed that *supply-indicator* = 0.1 and *chain-demand* = 10000[2]. The number of entities (*nodes-num*) in a particular tier was changing and consecutively amounted to: 5, 10, 20, 50, 100 and 200 (simultaneously, this number in other tiers was stable and equaled 20). The simulations were run 1000 times for each case. The findings of the experiment show that as *nodes-num* augments (from 5 to 200), *avg-cost*decreases by 30% on average, but for OEMs the fall is greatest and reaches 44%(see fig. 3).It can be explained by the following dependency: the more suppliers there are in a given tier, the higher the competitiveness among them is and the lower the prices, the better the conditions of

---

[1]It is established according to the following procedure: c*hain-demand* * *supply-indicator* + *random (chain-demand* * *supply-indicator*). For example, if *chain-demand* = 10000 and *supply-indicator* = 0.1, then *supply* amounts to not less than 1000 and not more than 1999.

[2] The total annual reuse of equipment in the HP company amounts to approximately 2,5 million of units per year. We divided this number by 250 working days.

cooperation, etc., become for the final customers. The greatest decline of *avg-cost*is observed when *nodes-num* is increased from 5 to 50 (by 25% on average).Figure 4 also shows that the greater the nodes-num in the vicinity of the FC (so OEMs, Vendors and Sub-vendors successively), the lower the *avg-cost*.

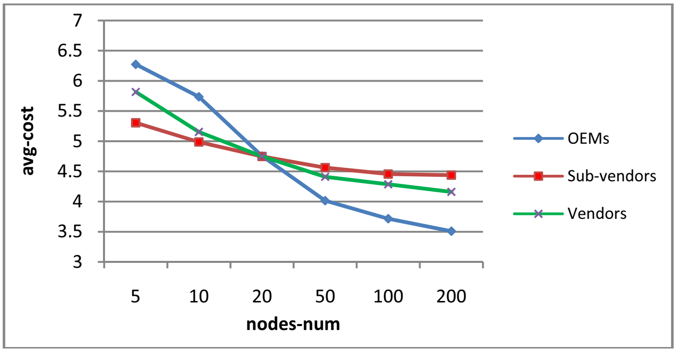


Fig. 4. Influence of enterprises number change in particular tiers on the average cost of sending a flow unit along a supply chain in the network

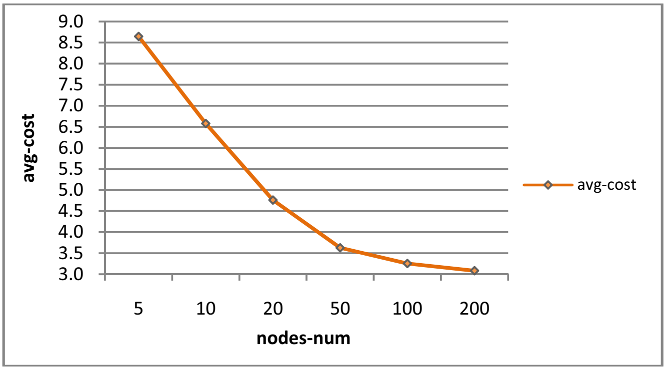


Fig. 5. Influence of enterprises number change simultaneous in all tiers on the average cost of sending a unit along a supply chain in the recovery network.

In the next stage, we changed all *nodes-nums* at the same time and noticed the greatest decrease of *avg-cost* when *nodes-num*rose from 5 to 50 (by 58%), too (see fig. 5). A further modification of this parameter is also beneficial but not to such a large extent. It must be remembered that a big number of suppliers ensures lower product prices for the recipient, guarantees more safety and reduces the risk of production stoppage, but, on the other hand, causes an increase of the servicing costs of such co-operation (maintenance costs of information systems, control, search of supply sources, negotiation, establishing the co-operation conditions, audit, etc.). One must not forget about the hidden costs related to a limited number of suppliers, either, such as the cost of lost sales caused by a lack of products or about the fact that liberation from a monopolist supplier is time-consuming. In the case of our recovery network a number of suppliers in individual tiers equal to 50 may be recommended.

In the last part of the simulations, the *supply-indicator* variable was shifted from 0.1 to 1.0 (consecutively 0.01, 0.05, 0.1, 0.2, 0.5, 1.0), on the assumption that *nodes-num* is stable and amounts to 20 and *chain-demand* = 10000.[3] The simulations were carried out 1000 times for each case..

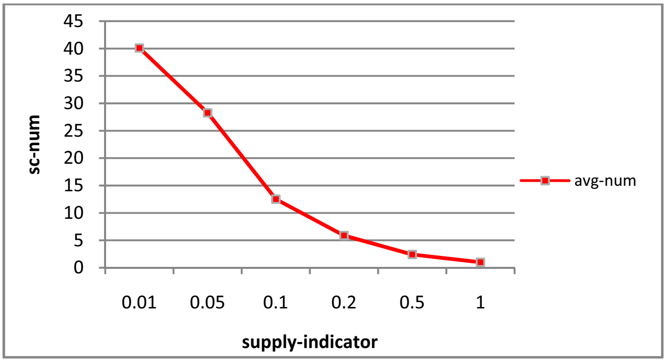


Fig 6. Influence of the factor of supply changeability on the supply chains number in the recovery network.

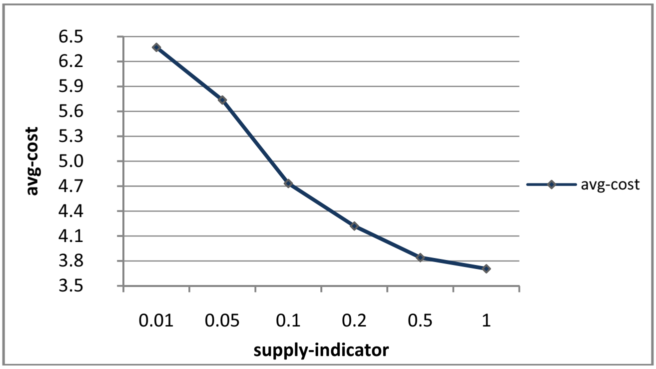


Fig. 7. Influence of the factor of supply changeability on the average cost of sending a flow unit along a supply chain in the recovery network

The results from the experiment show that *sc-num* falls from 40 to 1 (see fig. 7). It is worth to notice that augmenting *supply-indicator* ten times (i.e. from 0.01 to 0.1) leads the average supply chain numbers which can satisfy the demand of the FC more quickly

[3]Here *supply* fluctuates between (100 + random 100) and (10000 + random 10000)

to plunge from 40 to 13, i.e. by 68%. As a result of the rise of *supply-indicator* from 0.01 to 1.0, *avg-cost* comes down from 6.4 to 3.7, i.e. by 42% (see fig. 6). The main conclusion from this part of the simulation experiments is that it is more profitable to cooperate with a trading partner with greater capacities and an ability to offer greater supply. It reduces the number of supply chains

5 Conclusions

Application of the agent technology and graph theory in logistics allows departing from fixed supply chains, in which enterprises are dependent on one another, and replace them with dynamic configurable supply chains, including constituents, which offer the best conditions of cooperation at a given moment. The presented RNA model enables to find the cheapest supply chains with appropriate capacities in the whole enterprise network. Therefore, a company being a supply chain leader can satisfy its demand more quickly and can propose a competitive price to customers.

It is noteworthy that the proposed RNA model offers many benefits for the network of enterprises, its participants and the final customer. Some of the most important ones have been distinguished below: goods flow visualization; fast and easy building of closed-loop supply chains; delivery time, stock and cost minimization. The proposed model allows also: quick identification and elimination of bottlenecks, as well as very quick reception of the returned product, in accordance with the customer's expectations, at competitive prices. It gives a possibility to build scenarios and carry out simulations independently.

References

[1] Beamon, B., Fernandes,C.(2004): Supply –chain network configuration for product recovery. Production Planning and Control, vol.15 no.3, pp. 270-281.

[2] Blackburn, J.D., Guide, Jr., V.D.R., Souza, G.C., Van Wassenhove, L.N. (2004): Reverse Supply Chains for Commercial Returns, California Management Review 46(2): 6-22

[3] Cannon, J.P., Homburg C. (2001): Buyer-supplier relationships and customer firm costs. Journal of Marketing 65 (1).

[4] Dekker, R., Fleischmann, M., Inderfurth, K., Van Wassenhove, L.N. (Ed.)(2003): Reverse Logistics: Quantitative Models for Closed-Loop Supply Chains. Springer Verlag, Berlin

[5] Deo, N., Kowalik, J.S., Sysło, M.M. (1983): Discrete Optimization Algorithms with Pascal Programs. Prentice-Hall Inc., Englewood Cliffs.

[6] Fleishmann M. (2001): Quantitative Models for Reverse Logistics, Springer Verlag, Berlin.

[7] Fleischmann, M.(2003): Reverse logistics network structures and design,[in]: GuideJr V.D.R., Van Wassenhove L.N.(eds.)Business Aspects of Closed Loop Supply Chain, Springer Berlin

[8] Fleischmann M., van Nunen J., Gräve B., Gapp R. (2004):Reverse Logistics – Capturing Value in the Extended Supply Chain, ERIM Reports Series, ERS-2004-091-LIS (download from www.erim.eur.nl on 21 march 2010).

[9] Golinska, P. (2009):The concept of an agent-based system for planning of closed loop supplies in manufacturing system. In: Omatu S. et al (eds.)IWANN 2009 part II. LCNS vol.5518 pp. 346-349, Springer-Verlag, Berlin Heidelberg (2009)

[10] Kawa, A.:Simulation of Dynamic Supply Chain Configuration based on Software Agents and Graph Theory. In: Omatu S. et al (eds.)IWANN 2009 part II. LCNS vol.5518 pp. 382-389, Springer-Verlag, Berlin Heidelberg (2009)

[11] QuariguasiFrotaNeto J., Walther G.,.Bloemhof J, van Nunen J.A.E.E , SpenglerT., (2010) “From Closed-Loop to Sustainable Supply Chains: The WEEE case”, International Journal ofProduction Research, vol. 48/15, pp. 63-81.

[12] Reid, R., Sanders, D., Nada, R.:Operations Management. John Wiley & Sons (2002)

[13] Wilensky U.:NetLogo itself. NetLogo. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, http://ccl.northwestern.edu/netlogo/

Reverse logistics for used portable batteries in Spain - an analytical proposal for collecting batteries

Eva Ponce-Cueto, José Ángel González Manteca, Ruth Carrasco-Gallego

Industrial Engineering, Management and Statistics Department.

Universidad Politécnica de Madrid (UPM)

eva.ponce@upm.es, jagonzalez@etsii.upm.es, ruth.carrasco@upm.es

Abstract. The disposal of batteries is a problem that has grown in the last few years, due to the increase in the use of portable devices. The main goal of this paper is to propose an analytic model for helping logistics managers to choose the appropriate location points in order to situate the collection points for used portable batteries in the Spanish context. The objective of the model is to collect, in an efficient way, the maximum number of portable batteries. The proposed model has two parts: a static part and a dynamic part. In the first part of the model (static part) we will compare the potential candidates for each alternative. It is based on the multicriteria method called Analytic Hierarchy Process (AHP). In the second part of the model, the input parameters will be: the global mark for each alternative we have calculated before and the distance between potential candidates. As a result of this part, the model will select the recommended collection points according to the criteria defined before. We can conclude that this model helps managers in the decision of locating/modifying collection points in two ways: to add new collection points to a reverse logistics network that needs more points or to delete collection points from a network that has more points than those recommended.

Keywords: reverse logistics, disposal, collection points, used batteries

1 Introduction and justification

Generation of electronic waste is currently an important problem in modern society. In Europe, Waste of Electrical and Electronic Equipment (WEEE) annual quantities are estimated in the order of 8.3 Mt [22]. Each EU citizen produces 17-20 kilograms of technological waste per year [20]. Batteries supply energy to many kinds of portable electric and electronic devices such as: telephones, radios, computers, mobile phones and even electric and hybrid cars. More than 40 billions of batteries are sold worldwide. According to this situation, countries have to decide what to do with billions of spent batteries containing millions of tons of toxic and hazardous compounds [16].

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_46,

According to the European and other countries´ legislation (USA, Japan) used batteries and accumulators are considered as hazardous waste. Batteries may contain toxic metals such as cadmium, mercury and lead, so their disposal must be controlled [1]. As a legal response to this problem, the European Union has issued regulations for electrical and electronic equipment WEEE [9; 10] and for spent batteries [11]. All EU Member States producers have been required to organise collection and environmentally sound management of all electronic equipment put on the market since 2005 (Directive 2002) and for batteries since 2008 [11]. A selective collection system is needed according to the European Batteries Directive 2006/66/EC. The collected waste batteries should be treated properly. The Directive, which entered into force on 26 September 2006, quantifies recycling targets for collected zinc carbon and alkaline waste batteries. It sets out a recycling rate of 50% for consumer waste batteries.

In the literature review made, we have found some studies dealing with different waste battery treatment options [2; 4] and other studies that have developed several recycling processes for different types of waste batteries: waste nickel–cadmium batteries [12; Zhu et al. 2003); alkaline batteries [13]; lithium-ion batteries [14].

Regarding the collection and design of the closed-loop supply chain for spent batteries, the case of Germany is presented in the work of Schultamnn et al. [21], the Iran case can be found in Zand and Abduli (2008), the Poland case in Rogulski and Czerwinski [18]. The Brazilian situation is presented in the work of Bernardes et al. (2004; 2003) and a report on hazardous household waste generation in Japan can be consulted in Yasuda´s work [23]. No scientific literature was found regarding the Spanish case.

According to Schultmann et al. [21] the spent batteries can be divided into: (1) batteries and large accumulators for industrial purpose, (2) nonrechargeable (primary) portable batteries, and (3) rechargeable (secondary) portable batteries.

The present study is focused in the design of the reverse logistics network of portable batteries in the Spanish context. More specifically, we propose an analytical model for locating collection points in the reverse logistics network for used batteries. An analytical description of various types of collection schemes together with alternative modes of transportation are analytically presented in the work of Salhofer et al. [19]. Morrissey and Browne [15] presented a comprehensive literature review of models used for tackling waste management problems. However, the existing scientific work is relatively restricted to municipal solid waste.

In the Spanish context, the Royal Decree 106/2008 fixes that producers are to fulfill by the 31st of December, 2011 a collection rate of 25% and by the 31st of December, 2015 a collection rate of 45%. An appropriate system of selective collection is required for used batteries and accumulators. A network of selective collection points will be created according to population density, enough number of bins, accessibility and a suitable distance so that citizens can reach them easily. This study provides an easy-to-use decision support tool for helping managers to solve this problem. On the one hand, the model proposed in this paper takes into account the legal requirement and, on the other hand, tries to improve the efficiency of the current collection system.

2 Objectives and methodology

The main goal of this paper is to propose an analytic model for helping logistics managers to choose the appropriate location points in order to situate the collection points for used portable batteries. The objective of the model is to collect, in an efficient way, the maximum number of portable batteries. So, this model will try to achieve a more efficient use of resources and also to achieve the collection targets included in the Directive 2006/66/EC, of the European Parliament and of the Council of 6th September 2006 on waste batteries and accumulators and also in the Spanish Royal Decree 106/2008, 1st February 2008.
More precisely, the general aim of this paper can be broken down into the following objectives:

- To explore the reverse logistics practices for used portable batteries in Spain
- To characterize the reverse logistics network for used portable batteries in Spain
- To identify the criteria to be taken into account in the location decision model
- To identify the alternatives to analyze
- To choose the appropriate analytic technique for solving the decision problem of deciding where to locate the container bins for collecting portable used batteries.

The methodology used to achieve these objectives includes two main blocks. The first one is mainly based on the inductive approach principles of case study research [6; 7]. To build the case, we have first reviewed the scientific literature about reverse logistics management for e-waste, specific literature of the sector (portable batteries) and current legislation related to the topic. Secondly, we have visited Spanish treatment plants (one of the main batteries recycler in Spain located in Catalonia) and also enterprises engaged in the collection of portable batteries (more specifically, we have contacted with the main take-back system operating in Spain). Additionally, interviews have been held with the logistics managers of these companies. The experience acquired in the field study has enabled us to characterize the reverse logistics practices of used portable batteries in the Spanish sector. For the second block, the analytic model, the methodology we have followed is based on the AHP multicriteria method for comparing the criteria we have identified in this study (we have used the Expert Choice program). We have also developed a quantitative tool for calculating the distance between collection points (developed in Visual Basic).

3 Reverse logistics practices for used batteries in Spain

The main steps in this reverse supply chain are:

- Selective collection from the consumer
- Transportation to the waste consolidation centre

- Transportation to the recycling facilities
- Sorting the collected batteries
- Recovering valuable components from the sorted fractions and transform them into secondary material

Selective collection is the point of contact between citizens (generators) and disposal operations. In the Spanish system, this collection point could be located in supermarkets, large distributors, malls, public institutions (schools, universities, town halls, etc.) or at recycling centres.

Spain is divided into 17 regions and each Integrated Management System in charge of collecting batteries and transporting them to appropriate storage facilities has to be authorized by each region. There are four Integrated Management System (IMS) authorized in Spain for collecting batteries: Ecopilas with 70% share of market; ERP with 25% of the market; ECOLEC 3% and ECORAEE 2%. Ecopilas is operating in Spain since year 2000 and this foundation includes the main batteries producers (Energizer, Cegasa, Philips, Sony, Kodak, etc.). This IMS collected in 2009, 1.170 ton of spent batteries (corresponding to more than 40 million batteries). There are more than 8.500 bins in the Spanish network, and the cities with more than 1000 bins are Madrid and Barcelona [5].

The collection systems are responsible for transporting the spent batteries to intermediary facilities for storage and load consolidation: Waste Load Consolidation Centres (WLCC). There is usually at least one or various per region (for instance, there is one in Andalusia, another one in Madrid, etc.). The objective of this storage centres is to lower the cost of transport to the treatment plant.

Once the batteries are collected and store, they are sent to the treatment plant. Currently 100% of what is collected is transported to recycling plants, primarily because it is a delivery charges (•/Ton) for transporters, which makes sure that reaches 100%. In Spain are mainly three recycling plants, one in Catalonia, another one in Vizcaya and the third one in Valencia. There are some specific facilities for lead treatment and others only for sorting and pre-treatment (Ni-Cd and rechargeable batteries) that sends batteries to European facilities (located in France and Belgium).

4 An analytical proposal for collecting batteries

The need for locating battery collection containers in an efficient way, amply justify the development of analytical models to improve the currently system used in Spain.

The model presented in this article deals with selecting the most appropriate points to set up a network of centres for efficient collection, enabling more cost-effective management of resources.

The starting point is a comprehensive set of possible points where you install the centres of collecting. These items include supermarkets, schools, municipalities, companies, universities, recycling centres, etc. The postal address of each point is a necessary input for the developed tool. The proposed model serves both to configure network point candidates and to select the most suitable ones on the basis of an already established network.

An important aspect is the amount of points selected for each specific location. The initial hypothesis is to consider 1 collection point for every 1.000 inhabitants, based on studies of EPBA (European Portable Battery Association).

Another initial aspect to consider is that some points should be included in the network of collection centres by legal imperative. This is the case of the recycling centres: all cities of over 50.000 inhabitants should have at least one.

Potential candidates to join the network of collection centres are grouped into eight groups: shopping centres, supermarkets, small shops, universities, public centres, schools, businesses and individuals. The latter could correspond to large communities of neighbouring or different types of partnerships.

Our model includes two important considerations for selecting the most appropriate points set. On the one hand, the characteristics of each specific point, which assesses the following criteria: accessibility; public fluency (frequented often); public awareness. On the other hand, the distances among the selected points are maximizing covered geographic areas in order to obtain efficient solutions.

The proposed model consists of two parts: a static part and a dynamic part. In the first part of the model (static part) we compare the potential of the eight groups considered. The second part (dynamic part) of the model deal with the influence of the distance between the candidates. Figure 1 summarizes the structure of the developed model.

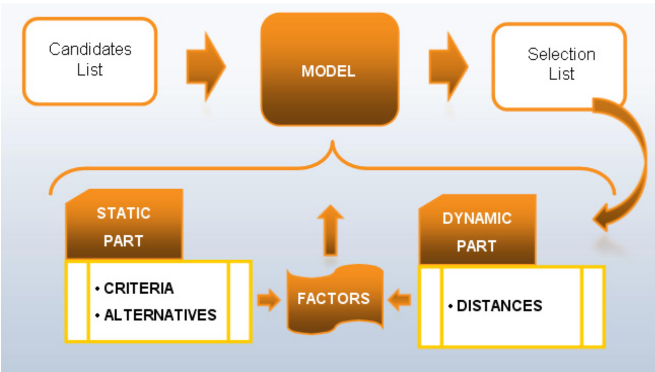


Fig. 1. Structure of the developed model

4.1 Static part

The essence of the static part is to compare the candidates on the basis of the established group points. It will therefore analyze the most advantageous group for the location of collection centres. At the conclusion of this analysis, a numeric value between 0 and 1 will be allocated to each group, which quantifies the adequacy of the points that make up the group to be selected as collection points. The sum of the numeric values of all the groups considered in this research is the unit.

The comparison between the eight defined groups (shopping centres, supermarkets, small shops, University, public centres, schools, companies and individuals) is done considering three criteria: accessibility, public fluency (frequented often); public awareness. For tackling this problem the AHP multicriteria method was used and the Expert Choice program was selected to perform binary comparisons

Using the multicriteria decision tool AHP, we have compared and analyzed groups pairwise according to the criteria, as well as the weight of each criterion in the location of collection points. For these comparisons have been used the opinions of experts in the field of used battery collection. Figure 2 includes the final result of this comparison.

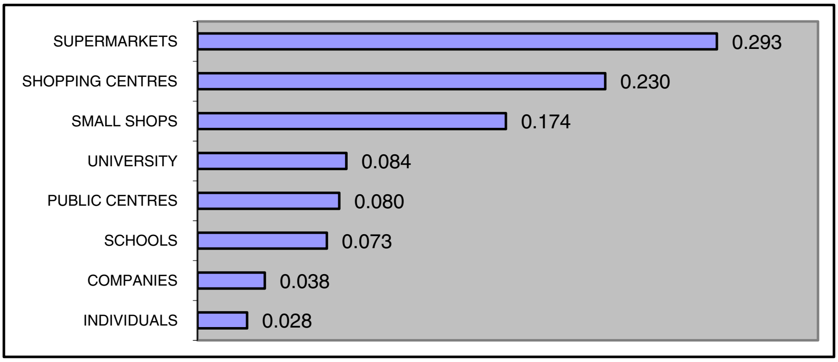


Fig. 2. Final result in static part

4.2 Dynamic part

In the dynamic part the model provides a tool to quantify the value of each candidate point depending on the proximity of previously selected points. In particular, the considered distance is the smaller of the distances to the set of points that have already been selected.

Again a numerical value between 0 and the highest value obtained in the static part, which in our case has been 0,293 will be allocated to each candidate. Than bigger lesser distances of the candidate to the previously selected items, point more attractive is that point to be selected and, consequently, greater numeric value assigned in the dynamic part of this tool.

The objective of the dynamic part is the geographical dispersion of the points selected, thus avoiding the excessive concentration of points in the same area.

Calculation of distances between points has been through the coordinates of each point. We have used the Routing Maps Geocoding tool for the conversion of address of the candidate points in geographical coordinates. The algorithm for the calculation of the distances between points, selection of the lesser of the distances of each candidate point in relation to the selected points and allocation of the corresponding numerical value has been programmed with Visual Basic in Excel 2007.

For the use of the tool, the user has to enter the number of collection points that will join the network, as well as the valuation assigned in the static part and the dynamic part. This allocation will depend on the characteristics of the town to study (density of population, geographic dispersion, etc.). In the study presented here, we have assigned a factor of 0,6 to the static part and 0,4 to the dynamic part.

The developed tool will provide a list of the most appropriate points to form the network of collection centres. The amount of points selected matches the number previously assigned.

5 Case study

The model we have developed is applicable to any area or city which knows the applicant points to select the most appropriate. You can also apply to the case of having to reduce the existing collection points.

The case study selected for the application of the tool has been the Spanish city of Valladolid. This medium-sized city has a population of 288.900 inhabitants. Using the ratio of 1 container per 1.000 inhabitants, 289 collection points need to be located.

According to data provided by Valladolid town council, the City currently has 654 collection points. This data tells us that it would be necessary to remove 365 containers for the design of a network of centres for efficient collection according to the studies of the European Association EPBA.

The proposed model selected the 289 most appropriate points in a total 671 minutes time. For the top ten points, the tool used only 16 minutes. However, the time required for successive points has increased due to the increased number of matrices used in the programmed algorithm as it increased the number of selected points.

The first 10 selected points allow observing the logic used by the developed algorithm. Figure 3 shows the results in the plane of the city of Valladolid. As expected from this tool, the selected points are divided by various neighbourhoods that make up the city.

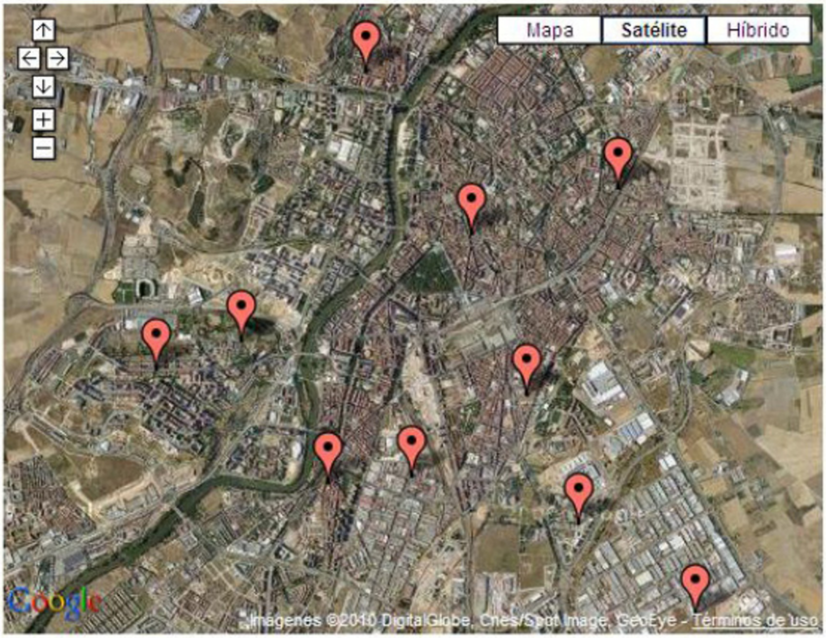


Fig. 3. Results of the first 10 points selected by the tool

Figure 4 shows the final distribution of 289 items selected according to their geographical coordinates of latitude and longitude. This figure shows greater density of points in the central part of the city opposite lower density in the peripheral part of the same.

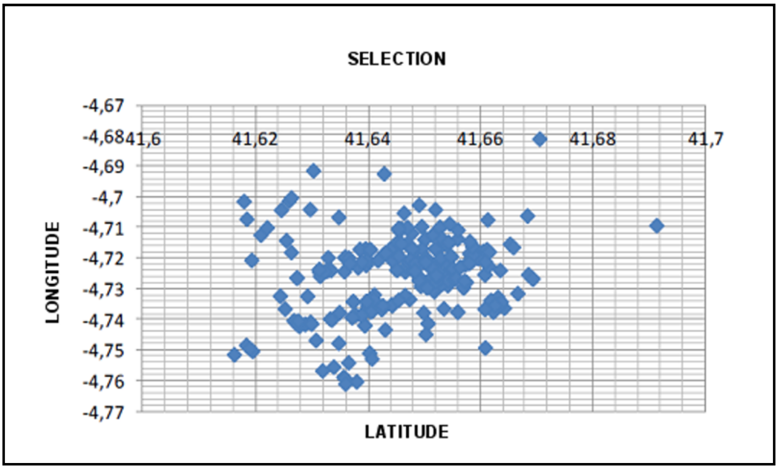


Fig .4. Result of the distribution of the 289 selected points

Attempt to reduce the response time of the tool, has reduced the number of candidate points. The elimination of candidates may have originated in the proximity of other candidates or previous experience. In particular he returned to experiment the model with 522 and 406 points candidates. Obtained response times are reflected in figure 5.

		CANDIDATES LIST		
		406	522	654
SELECTION LIST	10	6	9	16
	20	12	20	32
	30	18	31	49
	40	24	41	67
	50	32	52	85
	60	38	62	103
	70	46	73	121
	80	52	83	139
	90	59	92	159
	100	66	102	171
	289	193	312	671

Fig 5. Response times in minutes for experimentation

6 Analysis of results

The developed model facilitates the selection of points according to previously defined criteria. In either case the objective of the model is collecting, efficiently, of more battery out of use. We can, therefore completing the model helps in the process of decision of the selection or alteration of points that will integrate collection network.

Verification and validation of the model processes can observe the quality of responses and their contribution to the addressed problem. One of the difficulties presented by the model is the high response time in case of using a high number of candidate points. The proposed tool needed 671 minutes to solve the case previously submitted when 654 candidate points were introduced. The processor used in the testing phase has been a 2.6 GHz Intel Core 2 Duo processor. Obviously, the use of more powerful equipment can significantly reduce the response time.

In either case, this limitation can become very important to apply the model to a big city such as Madrid or Barcelona. One solution to this situation to continue to implement the tool with shorter response times is the elimination of some of the candidates for different reasons. Figure 5 shows the sensitivity model response time before candidates point reduction. Another possible alternative is the fragmentation of the big city in smaller areas to use the application in each one. This latter solution has the disadvantage of not analyzing the relationship of the distances between selected points of different areas.

The tool develops sample broad possibilities for addressing the location of points of spent batteries in an analytical way.

7 Conclusions

As a result of the dynamic part, the model will select the recommended collection points according to the criteria defined before. The objective of the model is to collect, in an efficient way, the maximum number of portable batteries, in compliance with current regulations. We can conclude that this model helps managers in the decision of locating/modifying collection points in two ways: to add new collection points to a reverse logistics network that needs more points or to delete collection points from a network that has more points than those recommended. This paper contributes to the Reverse Logistics area, by proposing, for the first time, an analytic model with two parts: a static part and a dynamic part, for locating collection points in a reverse logistic network for spent batteries in the Spanish Case.

The developed tool has some limitations that should be taken into account when addressing the problem. These limitations are mostly imposed by the simplifying assumptions that have had to assume: 1) it has been considered an area of uniform density; 2) the tool works better when the number of candidate is less, so it works appropriate for cities but it is not enough for regions. As further developments of this research work we propose some improvements in the tool for achieving lower response times and also put modifications up for adapting the tool to tackle a wider geographic area. Another extension is to develop a vehicle routing and scheduling model for collecting portable batteries. Currently, the model used by managers of this system is a collection model based on demand. The development of a model for planning these collections could improve the efficiency of the current logistics system.

Acknowledgments This work stems from the participation of the authors in a research project funded by Plan Na-cional de I+D+i, reference DPI2007-65524, entitled DOLI "Análisis y desarrollo de técnicas para el Diseño y la Operación de sistemas de Logística Inversa".
We would like to thank Rafael Herreros, Manager of ECOPILAS, the Integrated Management System for collecting batteries in Spain, and to Gabriel García, Operations Manager, ASIMELEC (environmental association for EEE), for their valuable contribution to this paper. We would also like to express our gratitude to Maria del Campo Acebal.

References

[1] Bernardes AM, Espinosa DCR, Tenorio JAS (2004) Brazilian policy on battery disposal and its practical effects on battery recycling. J. Power Sources 137: 134–139

[2] Bernardes AM, Espinosa DCR, Tenorio JAS (2004) Recycling of batteries: a review of current processes and technologies. J. Power Sources 130: 291–298

[3] Bernardes AM, Espinosa DCR, Tenorio JAS (2003) Collection and recycling of portable batteries: a worldwide overview compared to the Brazilian situation. J. Power Sources 124: 586–592

[4] Briffaerts K, Spirinckx C, Van der Linden A, Vrancken K (2009). Waste battery treatment options: comparing their environmental performance. Waste Manage. 29: 2321–2331

[5] Ecopilas (2009) Memoria annual 2009. D. Legal: AS-5481-2010

[6] Eisenhardt L (1989) Building Theories from Case Study research. Academy Management Review, 14 (4): 532-550

[7] Ellram LM (1996) The use of the Case Study Method in Logistics Research. Journal of Business Logistics, 17 (2): 93-138

[8] EPBA (2010) European Portable Battery Association. Official Webpage URL: http://www.epbaeurope.net/ (accessed 16.12.2010)

[9] European Union (2002a). Directive 2002/96/EC European Parliament and Council of 27 January 2003 on waste electrical and electronic equipment (WEEE). Official J. European Union L37: 24-38

[10] European Union (2002b). Directive 2002/95/EC European Parliament and Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS). Official J. European Union L37: 19-23

[11] European Union (2006). Directive 2006/66/EC of the European Parliament and of the Council of 6 September 2006 on batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC. L 266 26/09/2006, p. 1-14

[12] Huang K, Li J, Xu Z (2010). Characterization and recycling of cadmium from waste nickel–cadmium batteries. Waste Management 30: 2292:2298

[13] Kuo YM, Chang JE, Jin CH, Lin JY, Chang-Chien GP (2009) Vitrification for reclaiming spent alkaline batteries. Waste Manage. 29: 2132–2139

[14] Li J, Shi P, Wang Z, Chen Y, Chang CC (2009). A combined recovery process of metals in spent lithium-ion batteries. Chemosphere 77: 1132–1136

[15] Morrissey AJ, Browne J (2004) Waste management models and their application to sustainable waste management. Waste Management 24 (3). 297-308

[16] Pistoia G, Wiaux JP, Wolsky SP (2001) Used battery collection and recycling. Industrial Chemistry Library, (Editors), 10 Elsevier.

[17] Royal Decree 106/2008, de 1 de Febrero, sobre pilas y acumuladores y la gestión ambiental de sus residuos. Boletín Oficial del Estado, de 12 de febrero de 2008, 37: 7399

[18] Rogulski Z, Czerwinski A (2006) Used batteries collection and recycling in Poland. Journal or Power Sources 159: 454-458

[19] Salhofer S, Schneider F, Obersteiner G (2007) The ecological relevance of transport in waste disposal systems in Western Europe. Waste Management 27 (8): S47-S57

[20] Savage M, Ogilvie S, Slezak K (2006) Implementation of waste electric and electronic equipment directive in EU 25. IPTS, European Commission Joint Research Centre, Technical Report Series EUR 22231 EN, ISBN 92-79-01926-0.

[21] Schultmann F, Engels B, Rentz O (2003) Closed-Loop Supply Chains for spent batteries. Interfaces, 33 (6): 57-71

[22] WEEE Forum (2010) Official Webpage, URL: Http://www.weee-forum.org (accessed 12.10.2010)

[23] Yasuda K (2006) Report on hazardous household waste generation in Japan. Waste Management & Research, 24 (4): 397-401 doi: 10.1177/0734242X06064821
[24] Zand AD, Abduli MA (2008) Current situation of used household batteries in Iran and appropriate management policies .Waste Management 28: 2085-2090
[25] Zhu N, Zhang L, Li C, Cai C (2003) Recycling of spent nickel–cadmium batteries based on bioleaching process. Waste Manage. 23: 703–708.

Using environmental demands to improve Supply Chain Performance

Paul Eric Dossou[1], Philip Mitchell[1]

[1]ICAM Group, ICAM Vendée,

paul-eric.dossou@icam.fr, philip.mitchell@icam.fr

Abstract. How will Small and Medium Enterprises (SMEs) fare after the present economic crisis? At the moment when economic experts are forecasting domestic growth in France of only 0.6% for this year, and less than 2% for 2011, one of the fundamental aspects to address for the optimisation of the performance of a SME would appear to be its structure. The Supply Chain remains the backbone of Small and Medium Enterprises and its optimisation implies good overall control of the system concerning transport and distribution as well as internal logistics. GRAI Methodology is one of the three main methodologies (with PERA and CIMOSA) used for modelling enterprises. To support this methodology different tools have been developed. A module called GRAIQUAL for implementing, managing and improving quality in SMEs is being developed. It goes without saying that this article will also include the environmental dimension present through the need to reduce the carbon footprint in the Supply Chain. After a short presentation of the concepts of GRAIQUAL and the new performance criterion (the carbon footprint), a detailed case study will be presented to show the concepts of optimisation of Supply Chain performance using GRAI Methodology.

Keywords: Carbon reducing, Quality, Supply Chain Management, Quality Management, Knowledge Management, Production System, expert system.

1 Introduction

The recent economic difficulties of European countries are undisputable. Indeed Greece and Ireland need to be helped by the European Union and IMF, but they could be followed by Portugal, Spain for example. The precise economic situation of European countries is not clearly visible on big counts.

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_47,

In any case, in the crisis Small and Medium Enterprises have suffered from the consequences of globalization and the difficulty to export. They have to prepare for the outcome of the crisis by improving themselves and being ready to adapt their supply chain to the future economic context of the world. Three main methodologies (PERA, CIMOSA and GRAI) of enterprise modeling could be used for improving SMEs global performance and particularly their supply chain. The main criteria of performance improvement are cost, lead time and quality. It appears to us that carbon management could be added to them in order to insure a real evolution of the enterprise supply chain and to conform to the demands of the supply chain of the future.

In this paper, a short description of GRAI Methodology is presented and the concepts of GRAIMOD a tool being developed for supporting this methodology (especially how to use carbon management in all of the supply chain) are explained. An example of an enterprise will be presented.

2 GRAIMOD

GRAI Methodology is used for analyzing and designing enterprises [3]. The GRAI approach is composed of four phases: An initialization phase to start the study, a modeling phase where the existing system is described, an analysis phase to detect the inconsistencies of the system and a design phase during which the inconsistencies detected are corrected and a new system proposed. GRAIMOD is a tool being developed for supporting GRAI methodology (fig1). This tool is elaborated around a kernel (GRAIKERN) and contains four modules.

GRAIKERN is a graphic editor used for representing the different models associated to GRAI methodology. It is an interface between the different modules. GRAIXPERT is a hybrid expert system for managing the analysis of the existing system and proposing a new system. It is composed of two sub-modules in interaction with GRAIKERN: the Knowledge Capitalization (KCM) and the Knowledge Based System (XPERTKBM) [4], [5], [6]. GRAIMANAGER is a management module used for organising the different interactions between the modules of GRAIMOD. The concept of the working database of EXCATS (Expert Computer Aided Tool Selection) is used for elaborating GRAIWORKER [2]. GRAIWORKER is the work base elaborated for managing, modifying and capitalising knowledge about the studied case. GRAITRANS is a **Transfer Interface** used for putting the new case in GRAIXPERT in order to improve its Cases Base [1]. The reference model elaborated for each enterprise domain will be improved by the acquisition of this new model in GRAIXPERT [7], [8], [9]. This new tool is being developed by using Java technology particularly Jade (Java Agent Development Framework) platform in order to combine Case based Reasoning with Multi-agent systems. GRAIMOD is used for improving the supply chain of an enterprise. Indeed, the triptych (cost, lead time and quality) is optimized but the originality of this tool is the use of carbon management as a new important performance criterion. The decomposition used above allows to improve quality.

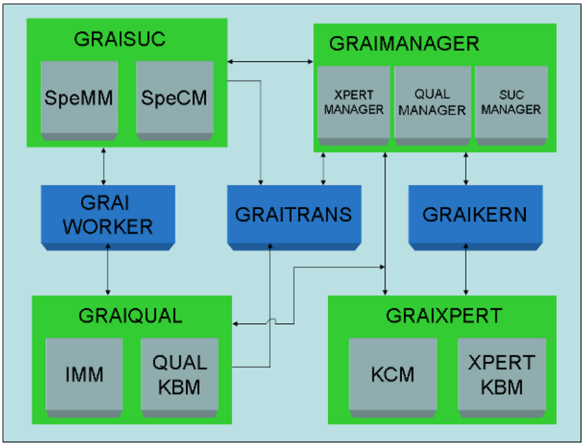


Fig. 1. Architecture of GRAIMOD

Cost and lead times are also optimized in the same way by choosing a SCM tool for the enterprise in order to manage the whole supply chain from the suppliers to customers. Indeed, for each sub-part of the supply chain, we can define a type of quality and measure the level of quality.

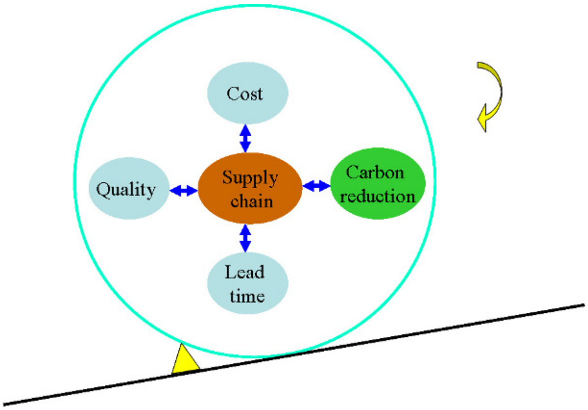


Fig. 2. Carbon management

The improvement of quality facilitates the respect of lead time and reduces the cost of the product. We can also notice that this improvement of quality implies the respect of environmental demands. For each part of the supply chain everything is done for making the enterprise sustainable. So the three main performance criteria are highly related to carbon management. The objective is to use different techniques and methods for reducing carbon in each part of the supply chain (fig 2). In reality enterprises need to:

– Assess dependence on fossil fuels,
– Anticipate fluctuations in energy prices,
– Limit the impact of the activity on the environment.

Even if researchers do not agree on the degree of damage to the planet caused by human beings, it is now clear that each enterprise has to reduce carbon levels. GRAIQUAL, one of GRAIMOD modules, allows to improve each part of the supply chain by using well-known quality tools. This improvement could globally be represented by the following figure.

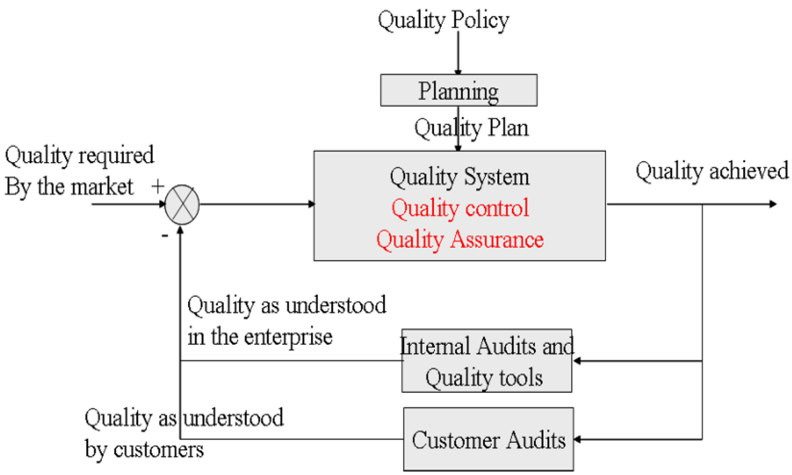


Fig. 3. Quality System Management

The quality system has to be improved by adapting a quality policy and plans. Then it means that each part of the production system will be improved for respecting quality. The quality system of an enterprise will be improved every day. So we can measure all the time the level of quality.

u(t) is the representation of the input (it means the quality required by the customer), v(t) the representation of the output, g(t) the function associated to the served system (the quality system) and k(t) the function of the feedback (customer and internal audits). Laplace transforming could be used for formalizing this system. If e(t) is the difference between the quality required and the quality comprehended by customers and people in the enterprise, then the objective is to reduce this difference to zero. We can calculate the transfer function as follows:.

$$V(p) = G(p) * E(p)$$

$$E(p) = U(p) - V(p) * F(p)$$

$$then \;\; V(p) = G(p) * [U(p) - V(p) * F(p)]$$

$$V(p) * [1 + G(p) * F(p)] = G(p) * U(p)$$

$$so \;\; \frac{V(p)}{U(p)} = \frac{G(p)}{1 + G(p) * F(p)}$$

Then the temporal relation between v(t) and u(t) could be deduced. This loop will be applied to each part of the supply chain. A zoom on the procurement part and the relation with suppliers allows to define a vector q_p associated to the product, and then to able to quantify the local optimum for this supply chain part and simultaneously take into account the impact on the environment. The best quality of raw material could be chosen according to lead time. An economic study allows the choice of the best raw material not only in terms of cost performance of the supply chain but also in respect of the environment. The optimization of the global supply chain is done by using a set of software adapted to the enterprise helping it to react more quickly and to meet customer's demands. The goal is to be able to guarantee to the customers the delivery date and quality of the product and furthermore to reduce costs. It means the management and optimization of each part of the supply chain from suppliers of suppliers to customers of customers, but also the integration of all the chain. It is essentially the synchronization of the industrial, logistic and commercial processes, the reduction of information-handling and decision-taking cycles, and the reduction in enterprise process complexity. We can deduce that the choice of these tools is crucial for the enterprise. The addition of the environmental dimension also complicates the situation. The use of GRAISUC allows to facilitate the improvements of the supply chain and to choose and implement the appropriate SCM tool for the enterprise.

3 Example

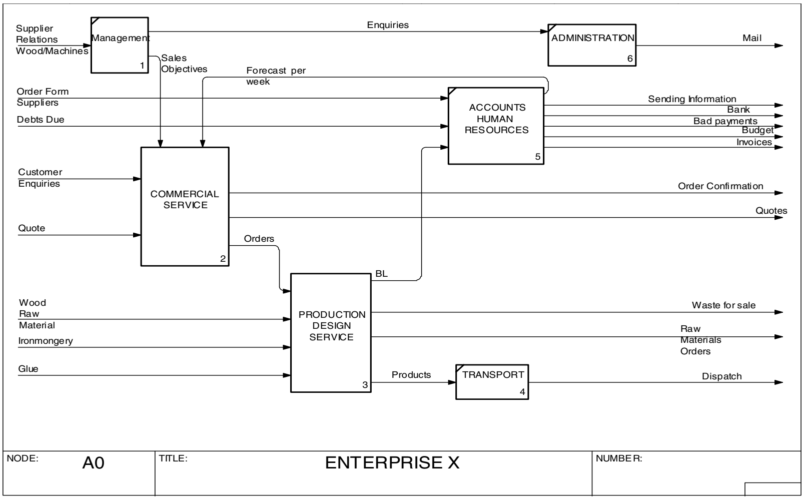
This example is presented for illustrating the different concepts presented above. The enterprise is specialized in wood with a workforce of 46 employees. This enterprise, located in Rennes in the west of France, has a turnover of 10 million . The activity of this company is the elaboration of doors and windows for houses (fig 4). The customers of the enterprise are the building trade (craftsman, fitters, joiners and merchants). The enterprise covers three regions: Normandy, Paris and Brittany offering a range of windows, French windows and doors in Moabi, Oak, Pine and Movingui. Some specific reference models are defined but from each of these models, the customer could modify any feature: dimension, glazing, ironmongery. Then, the joineries are custom-built according to customer orders.

Fig. 4. Example of Doors and Windows of the enterprise

In five years, the enterprise has changed its production system. But the enterprise has now some difficulties, due to the different changes and the increase in customer demand. The economic environment and the actual context of the enterprise impose the elaboration of a new organization and the optimization of the whole supply chain. The main problems were about respect of customer lead time, quality of products and processes, and carbon management.

For improving this enterprise, a modeling was made. First of all, interviews were done, in order to acquire the context of the study. Then, a modeling phase allowed to obtain models according to GRAI methodology. Some observations of the enterprise process were done for improving the production cycle. The information obtained enabled to elaborate actigramme models, GRAIgrid and GRAInets of the existing system, which, in turn, allows to detail links between services of an enterprise and in the production system to define the organization of machines (fig 5).

The next phase is the analysis phase during which the previous models were explored in order to find inconsistencies of the system. As expected, the detection of inconsistencies of the system allows to observe a lack of quality (products, process, SQA (Supplier Quality Assurance) and respect of norms), the enterprise did not respect lead time, the environmental demands were not respected, the whole supply chain was not optimized.



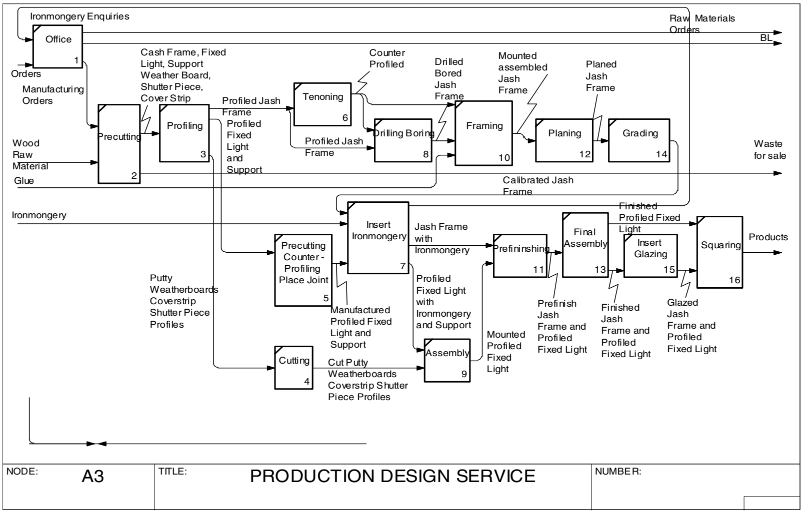


Fig. 5. Enterprise Decision and Production Design Service Processes

From the analysis of this enterprise some requirements associated to points to improve were defined. :

Table 1. Requirements and Points to improve

Points to improve	Requirements
To create quality functions and implement a quality system	Obligation to implement a procedure for obtaining CE label Lack of quality function
To organise maintenance functions	Transform curative maintenance into preventive maintenance
To reorganise the following functions: sales, design service, purchasing, procurement, planning and dispatch.	To manage and optimise communication between services To reduce decisional levels and to structure the different decisions To anticipate customer orders
To optimise the supply chain, choose and implement a SCM tool	Reduce the time lost time for the acquisition of orders Cut time for treating customer orders Establish coherence between tools of the enterprise

For the elaboration of the quality system GRAIQUAL, a sub-module of GRAIMOD, was used. This module contains norms and rules of quality. The obligation of implementing the CE label and the lack of quality approach in the enterprise show the necessity to develop an efficient quality system. A quality system has to manage product and process quality and provide assurance of quality. CE label implementation implies the elaboration of a product checking approach everywhere on the supply chain and the definition of the treatment of non-conformity on the whole process. In order to achieve that, we need to put into place control on all aspects - equipment, raw material and components, the product during the process, and before dispatch. For each function of the enterprise local optimization was elaborated. For instance, we proposed to elaborate a storage area for wood offcuts. The objective was to reuse this wood for producing small pieces and thereby optimize the use of wood. We also proposed to use wood shavings for heating.

Then we associated to each function a green touch. The optimization obtained had an impact on cost and lead time, but we also tried to respect environmental demands and reduce carbon levels in order to obtain a sustainable chain. For example, we organized the sourcing and selection of suppliers for choosing partners who have ISO 14001 certification. This constraint allows not only to respect the environment and reduce the carbon footprint but also to improve the quality of raw materials. For wood, we insisted on the origin by choosing shorter distances of procurement, by paying attention to the traceability of the wood, and the different wood quality norms. For marketing, we proposed to use this environmental engagement for promotion and obtaining of new customers. The enterprise will propose to customers an environmental contribution for each product. This means that some cost reduction has to be made in order to be competitive and to incorporate the ecological dimension.

GRAISUC was used for choosing and implementing a SCM tool in this enterprise in order to manage the whole system in the short, medium and long term. For instance, the improvements were also about the organization of the enterprise and the software. The enterprise had three software tools: Prodevis for studying product price, Sage for accounting and commercial management, WinX for production management. These software tools had no link between them. So there was a lot of time spent entering data in each tool. The enterprise took 6 weeks to give a quotation to a customer enquiry instead of one week. It means that the lack of relation between the tools implies 5 weeks delay for the production and the lead time. Two solutions were presented to solve this disastrous situation: to invest in integrated software for creating the link between the three tools or on a unique supply chain management tool for replacing the previous tools. The drawbacks and advantages of the solutions are outlined below.

Table 2. Proposed Solutions Drawbacks and Advantages

Solution 1 (keeping the three tools)		Solution 2 (replacing the three tools)	
Advantages	Drawbacks	Advantages	Drawbacks
Less expensive Very quick implementation	Not a long-term solution Many tools Difficulties of information management Would not respect all the needs of the enterprise No maintenance tool	Optimization of management processes Unique software tool Global improvement for choosing the right tool Long-term solution Maintenance tool	More expensive Adaptation of the chosen tool to the enterprise Time needed for implementation

Both solutions were proposed to the Director of the enterprise and he chose solution 2 in order to obtain a new structure of the enterprise. This strategic choice means that the habits of the enterprise and the information exchange modes will be changed in order to improve the global performance of the enterprise. For the choice of the new tool a handbook was developed by using GRAISUC which took into account the specificity of the enterprise. The new models (GRAI models obtained after enterprise modeling) of the enterprise were translated into functionalities. These functionalities were sent to SCM editors. The process for the choice of the most suitable solution is detailed in the following figure.

The enterprise obtained CE label, ISO 9001 and ISO 14001 certifications. The industrial activities conform to existing legislation regarding the protection of the environment. The impact on the environment is minimized by using and researching ways to have a reasoned use of resources and protection of the environment in the framework of sustainable growth. The implementation of OHSAS 18001 will be the next step of improvement.

4 Conclusion

All the European enterprises have to resist economically and financially to the present crisis. However, they have to be ready for the future economic growth in Europe. The evolution of their structure will allow to achieve this objective. GRAI Methodology could be used for helping them. The concepts elaborated for GRAISUC and GRAIQUAL, two modules of GRAIMOD the software being developed for supporting the methodology, have been illustrated in this paper. The three main performance criteria (cost, quality, lead time) are completed with a fourth one: Carbon management, in order to anticipate the constraints of the future supply chain (horizon 2015). A new optimum integrating this criterion is defined. A real example of the use of these concepts for improving the global supply chain of an enterprise is presented. The efficiency of the enterprise supply chain is very important for the global strategy of an enterprise. The introduction of environmental dimensions everywhere in this enterprise is an advantage. For instance it could allow to choose the suppliers and establish durable collaboration with them. It allows to respect environmental demands and norms, to participate in the saving of our planet, but also to be able to use this opportunity for promoting the enterprise and its values. This last point has an immediate positive impact on customers' reactions. The cost of carbon management could be reduced in this way and the global new philosophy of supply chain optimization will be beneficial to the enterprises and particularly SMES.

References

[1] Aamodt, A.: Case-Based Reasoning: foundational issues, methodological variations, and system approaches. Artificial Intelligence Communications, 7, (1), 39-59, 1994

[2] Arezoo, B. and al.: Selection of cutting tools and conditions of machining operations using an expert system. Computer in Industry, vol 42, Number 1, pp43-58, 2000

[3] Burke, E.K., and al.: Structured cases in case-based reasoning – reusing and adapting cases for time-tabling problems. Journal of KBS, vol 13, Issues 2-3, pp159-165, 2000

[4] Brown, D.C., Chandrasekaran B.: Expert system for a class of mechanical design activities. Knowledge Engineering in CAD, Elsevier, Amsterdam, 1985

[5] Chen D., Doumeingts G., Vernadat F.B., 2008, Architectures for enterprise integration and interoperability. Past, present and future. Computers in Industry 59 p.647-659

[6] Dossou, P.E., Mitchell P.: Implication of Reasoning in GRAIXPERT for modeling Enterprises. DCAI 2009, Salamanca, Spain, 2009

[7] Dossou, P.E., Mitchell P.: How Quality Management could improve the Supply Chain performance of SMES. FAIM 2009, Middlesbrough, United Kingdom, 2009
[8] Dossou, P.E., Pawlewski P.: Using Multi-agent system for improving and implementing a new enterprise modeling tool, PAAMS2010, Salamanca, Spain, 2010
[9] RUSSELL S. J., NORVIG P., Artificial Intelligence. A Modern Approach. Prentice-Hall, Englewood Cliffs, 1995
[10] Xia, Q., and al.: Knowledge architecture and system design for intelligent operation support systems. In the journal Expert Systems with applications, vol 17, Issue 2, P115-127, 1999

ERP integration as a support for logistics controlling in supply chain

Adam Koli ski[1], Paweł Fajfer[1]

[1]Poznan School of Logistics,

Adam.Kolinski@wsl.com.pl, Paweł.Fajfer@wsl.com.pl

Abstract. Effective management of the flow of goods includes both the physical transport of goods and the flow of information concerning a given transport. As the goods go through various stages of the supply chain, the information undergoes numerous changes. For this reason, the IT systems used by all business partners to control the flow of goods and information within the supply chain must guarantee the integrity of information at every stage. Providing speed and accuracy of information in supply chains, is one of the main tasks of logistics controlling. In this manuscript the authors try to present the problem of integrating ERP in the supply chain and its impact on logistics controlling.

Keywords: logistics controlling, ERP Integration, SCM

1 Introduction

Integration of supply chain is a complex idea. The comprehension of business processes interactions along supply chain is an important factor to succeed in the fast changing and competitive business arena. The main role of controlling is to support connection supply with demand in an integrated, coordinated and efficient manner. The crucial condition of the integrated controlling analysis in supply chain is decision optimization concerning choosing: process and work flow, resources used to activities execution, the level of engaged resources, resources allocation in supply chain and activity performance. Controlling analysis provides companies with integrated insight into their supply chain costs and incomes behaviour. Logistics controlling is used by a company to objectively examine costs attributed to products moving along supply chain and incomes attributed to product sale at the target market [19]. However, in the contemporary economy there are not only classical supply chains which assure customers with access to specific standard products on standard conditions. There are also supply chains which, apart from playing their key role, put stress on some aspects of their activity, thus, improving their competitive advantage by offering a product which is unique in

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_48,

terms of supply terms but still remains a standard product. Other supply chains specialize in providing their customers with unique products [5].

From logistics controlling point of view integration of business partners is based on two ideas. The first one is joint creation of the value of a product or service which is aimed at a target market and implementing new solutions due to comparison with the best players in the market. The other one is efficient flow of current management information which has an enormous influence on the level of competitiveness of the whole supply chain.

But we must remember that any decision taken by the management company should be consistent with the idea of eco-efficiency. It is based on the concept of creating more goods and services while using fewer resources and creating less waste and pollution. According to the World Business Council for Sustainable Development (WBCSD), critical aspects of eco-efficiency are [15]:

- a reduction in the material intensity of goods or services;
- a reduction in the energy intensity of goods or services;
- reduced dispersion of toxic materials;
- improved recyclability;
- maximum use of renewable resources;
- greater durability of products;
- increased service intensity of goods and services.

2 The role of logistics controlling in supply chain

The idea of controlling in a company has not been unequivocally stated in neither scientific nor technical literature. A number of definitions concerning aims and application of controlling in a company can be found in literature. The most general one defines controlling as a process of guidance which is aimed at a company's product and realised through planning, control and reporting.

It needs to be pointed out that the idea of controlling is very often mistakenly associated with already known concepts of management. The idea of controlling is to compare the real state of things with the plans and aims of a company and to implement necessary corrections whenever any abnormalities occur in those plans [18]. For this reason, controlling is very often wrongly associated with control only, whereas controlling processes deal not only with control but also with disposal, governing, planning and navigation. As there is lack of a clear-cut definition of controlling in the literature, controlling processes have not been treated seriously by the management board of a company. Nowadays we can observe an increasing interest in controlling tools but mainly in the aspect of financial controlling [12]. Controlling is a management support system which by means of coordinating the processes of planning, organizing and control, as well as information gathering and processing, ensures effective business management to achieve the planned objectives [20]. The basic difference between logistics and controlling in the aspect of coordination is that logistics plays sectional part in the service system and controlling plays the same part in the management system [16].

Due to the complexity of the process of logistics management in a company logistics controlling applies to a very expanded area of activities. Figure 1 shows the place of logistics controlling in a controlling system of a company allowing for the basic area of logistics controlling activities.

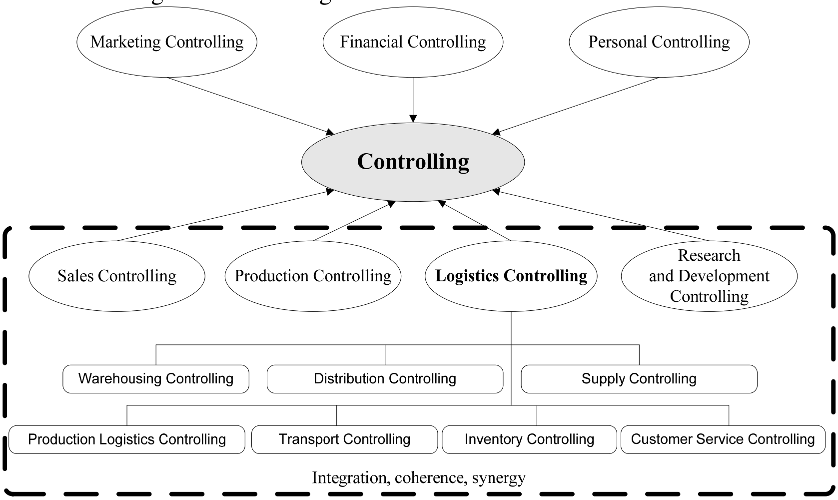


Fig. 1. The place of logistics controlling in a company's structures
Source: Own Study [13]

Supply Chain Management means design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand, and measuring performance globally [1]. Logistics controlling, which is an important tool in supply chain, is becoming a real determinant in managing these multi-subjective structures. In this respect, the range of controlling is reaching far beyond the area of one particular company. As supply chain is complex, logistics controlling integrates functions which are orientated on a product and technical processes and aspects of social integration. It is revealed in coordination and managing more and more participants in the process of creating value [21]. Implementing controlling in a supply chain helps to share the risk minimize the level of engaged funds and application of sustainable development doctrine. It is done through perfecting one's qualifications with the help of business partners' qualifications. Strong cooperation and information exchange during each phase of the process of creating a value allows for generating long-term profits which are competitive not only for the whole supply chain but also for the environment. Figure 2 shows the ecological benefits of logistics controlling.

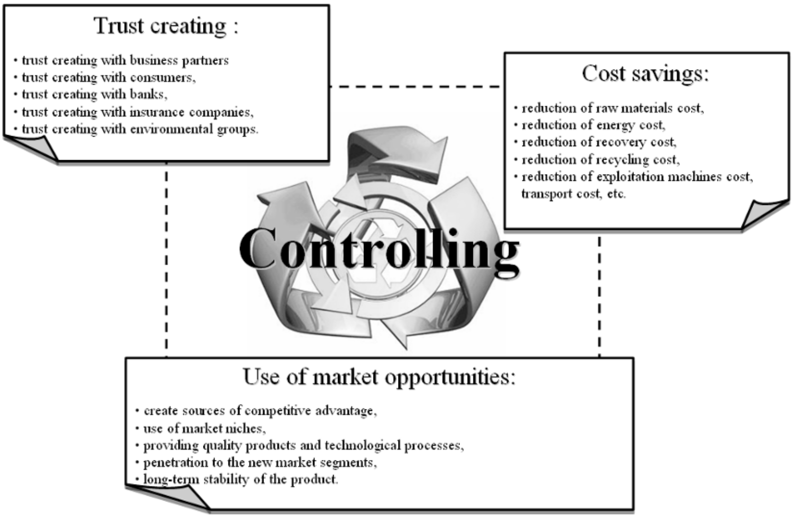


Fig. 2. Ecological benefits of logistics controlling
Source: Own Study

Logistic supply chain is generally based on efficient distribution which guarantees physical flow of goods as well as information connected with transfer. Physical flow of goods is a basic function from the point of view of managing a green supply chain. However, the flow of information between different links of a supply chains causes many problems. Effective use of available information Technologies May result in supply chain „disintermediation", which May lead to improved supply chain operations. The effectiveness of information management is central and critical to the successful execution of logistics and supply chain responsibilities and processes [3]. The premises of expanding an efficient information infrastructure on the level of a supply chain and which is designed to exchange current information about the flow of goods are based on three areas [17]:

- unification of the data which is exchanged in a supply chain,
- improvement of technical-organisational possibilities of information exchange between individual partners in a supply chain,
- guarantee that the exchange data will be lawfully binding.

3 Integration IT systems in companies of supply chain

An integration of firms among supply chain is difficult, because a integration process makes firms to bring in a lot of organizational and structural changes, information and documentations flow principles, and even changes in information systems. Authors will present in this manuscript a problem of IT systems integration in a supply chain.

ERP systems have been focus of attention among managers for years. These systems aid with business management in range of manufacturing planning, distribution planning, enable to get quick response for demand changing on the market[4].

Due to module structure of ERP system, process of integration of all area of activity of enterprise is simplest than in case of (accidentally of) oldest IT systems (work on different computerized information systems in different sections of company). Among many tasks of ERP systems is generating of comprehensive financial analysis to leading management needs. Thanks to clear modeling structure of company's costs controlling module is very useful during making important decisions for enterprise. There is a lot of tools which can be used to making analysis and reports. It enables comparing of planned value real and postulated, forecasting activity and following of cash flow, installation of cost of internal activity [2].

There are many advantages of using ERP systems and the most important are [4]: integrate particular department of company; enable adaptation of company to faster information rotation and control of courses of economic processes in external and internal rates - modeling of enterprise orientated on processes; enable using information many times and share information by different departments of company without negative consequences (loss of accuracy or cohesion; enable work in real time; during implementation, influence on improvement operation processes of whole enterprise; combine Manufacturing Resource Planning methodology and many solutions which influence on increase of company's efficiency (e.g. Just In Time, Total Quality Management, benchmarking, Lean manufacturing etc.). Thanks to the integrity of departments information is passed between them, as the read data warehouse and displayed in the table caused by the user. Such a solution could virtually eliminate internal paper documentation. The exact introduced into the system translates to better communication within the company, not only minimize costs associated with the manufacturing process, but also human error and the purchase of a traditional paper documentation required for circulation. This improves the environment and contribute to being more environmentally friendly.

No doubt, ERP systems increase on improvement information flow supervision in the company. It is related with more effective management. In cooperation among supply chain companies, is very important to exchange of products, money and information. Although, according to conducted research concerning integration chain supply almost 70 percent responders answered ERP system as a tool to integrate information [9], they concentrate on integration of internal process, like sale, production or warehouse management [10]. It is necessary to use such IT tools (IT systems), which are helpful in integration of supply chain area. By gaining access to the suppliers' production and delivery schedules, buyers can improve their own production plans and delivery schedules. Correspondingly, suppliers can use the buyer's real time store level data to plan their inventory levels, and production schedules [22]. Sharing order status information among the supply chain partners improves customer service quality, speeds up the payment cycle and provides cost savings [10].

Well implemented ERP system helps company In management. Regulates processes within enterprise and keeps them in order. The company become stronger and more organized. But it is not enough, because there are many companies in the market and the market competition increases among them. It causes that customers become less loyalty and change their suppliers. They can faster and easier make choices concern purchases, therefore they demand from their purchases major variety, quicker reaction on their needs, more convenient deliveries conditions, etc. [4]. Achievement company's success (consist on keeping customers) depend on cooperation this company with their suppliers and receivers.

Among supply chain partners take place products, money and information flow. Information become treat like a common resource (not only a strategic resource of one company). Cooperation of enterprises depend on common planning and realization of undertakings. Therefore to everyone of supply chain's link land information about needs and demands of customer, level of stock in warehouse, manufacturing planning, demand, etc.

A global supply chain management is a number of business processes mutual related:

- Customer Relationship Management (CRM). Currently, if company's management correctly identify customer needs and ensure efficient realization, then the company could hold its customers [8]. CRM grows directly from idea of creation of value by close contact with customer. It is based on rule of continuous develop of marketing strategy which is connected with strengthen customer's loyalty (Harrison and Van Hoek 2008). A basic assumption of CRM is maximization income from company's customers and maximization their satisfaction [8].
- Service management. It gives a possibility constant monitoring of products availability, delivery dates and delivery availability. It replenishes, generated by CRM, planning procedures defining way of delivery and supervision of customer's products.
- Demand management. It is based on advanced demand forecasting techniques. It customizes manufacturing availabilities to customer's expecting.
- Orders realization. It integrates manufacturing, logistics and marketing plans of producer. It aims at keeping positive relations with suppliers in supply chain. It provides to customer's value added and reduce costs connected with supply products to the market.
- Manufacturing flow management. This process is directly related with flexible manufacturing of products, quality management, analysis of deviation reasons and continuous stock level control.
- Supplier Relationship Management (SRM). It identifies and builds close relationship with crucial suppliers.
- Development and product sale. The basic importance attributes to quickly delivery a new or improved product to the market.
- Complaint management. It is important aspect in SCM. It may contribute to achieve competitive advantage of company.

Integration of supply chain links is possible thanks to the Internet. It facilitates integration IT systems different companies collaborate within supply chain. It makes a platform to sales and purchase transactions. Internet makes a new model of supplier-customer model: electronic market [8].

This market is like a communication and information platform on which a demand is shaped. There is also supply and price is shaped. Conditions of transactions are established on this platform. Internet enable to dynamic establish of a way for products, money, information flow in potential supply chain (Januszewski 2008) moreover ERP systems enable the supply chain partners to share information such as order status, product schedules, and sales records, to integrate major supply chain processes and to plan production, logistics and marketing promotions [6]. Restriction also affects the formation of paper documentation, which contributes to environmental protection.

E-business is the establishment of a computer network to search and retrieve information In support of business decision making and inter-organizational cooperation. The Internet helps to manage supply chain activities by offering information about what kind of product is demanded, what is available in the warehouse, what is in the manufacturing process, and what is entering and exiting the physical facilities and customer sites [6].

Figure 3 shows model of IT solution, which connects ERP system, concentrates on customers and suppliers and uses advantages of Internet to build integrated tool, that could be used to collaborative with supply chain partners. A center of this tool is ERP system, which is a foundation of efficient acting organization. It focuses on companies within a supply chain and therefore collects and transform data about suppliers and receivers. Use of Internet and e-commerce tools help the company to become stronger than competition on the market.

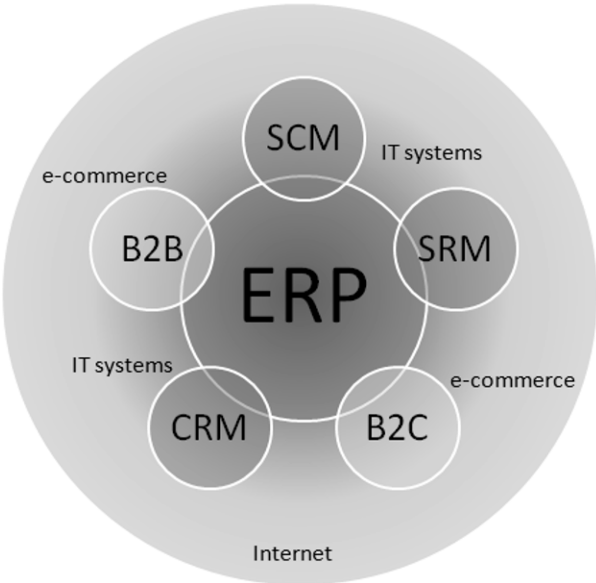


Fig. 3. IT tool which integrates supply chain partners

4 Summary

In order to ensure efficient communication between partners there needs to be a universal form of record which would be recognised by different computer systems. Due to numerous operations the system which deals with data exchange must be reliable and have solid construction. After receiving information about sale, the supplier puts it into the system of production planning to order necessary materials and fill in the itinerary with a new task. Therefore, no one should be surprised that integrating all these processes on the level of the whole supply chain is extremely difficult (Harrison and Van Hoek 2008). Using computer systems in a company ensures fast information exchange between individual links in a logistic supply chain. Ecological opportunities in supply chain integration is presented in figure 4.

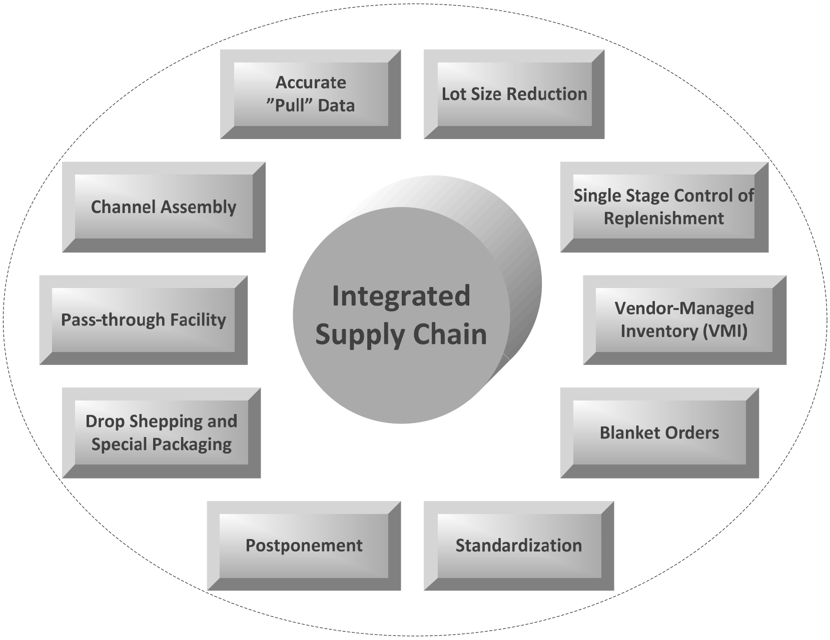


Fig. 4. Ecological opportunities in supply chain integration

Opportunities for effective management in the green supply chain include the following 10 items. Accurate "Pull" Data are generated by sharing point-of-sales information so that each member of the chain can schedule effectively and computer-assisted ordering. Lot Sizes Reductions are reduced through aggressive management. This may include developing economical shipments of less than truckload lots; providing discounts based on total annual volume rather than size of individual shipments; and reducing the cost of ordering through techniques such as standing orders and various forms of electronic purchasing. Single Stage Control of Replenishment means designating a member in the chain as responsible for monitoring and managing inventory in the supply chain based on the „pull" from the end user. This approach removes distorted information and multiple forecasts that create the bullwhip effect. Vendor-Managed Inventory (VMI) means the use of a local supplier (usually a distributor) to maintrain inventory for the manufacturer or retailer. Blanket Orders are unfilled orders with a vendor. A blanket order is a contract to purchase certain items from a vendor. It is not an authorization to ship anything. Shipment is made only on receipt of an agreed-on document, perhaps a shipping requisition or shipment release. The purchasing department should make special efforts to increase levels of standardization [7]. All standards which are created in a company should be balanced, namely they should be both stiff and flexible [11]. As for the stiffness, it refers to the procedures which must be obeyed by the worker on his workplace while flexibility allows for workers' creativity so that they would not be limited by the imposed standards [14]. Postponement withholds any modification or customization to the product (keeping it generic) as long as possibile. The concept is to minimize internal variety while maximizing external variety. This understanding of the entire supply chain reduced both risk and investment in inventory. Drop Shipping and Special Packaging means the supplier will ship directly to the end customer, Rather than to seller, saving both time and reshipping costs. Pass-through Facility is a distribution center where merchandise is held, but it functions less as a holding area and more as a shipping hub. Channel Assembly is an extension of the pass-through facility. Channel assembly sends individual components and modules, rather than finished products, to the distributor. Channel assembly treats distributors more as manufacturing partners than as distributors [7].

The faster the reaction to market's needs the more competitive the whole supply chain. Faster reaction to market needs entails also benefit in terms of sustainable development. Optimizing transportation and inventory affects not only the level of the company's costs but also the eco-efficiency. It needs to be pointed out that using the information system of ERP class as the only tool which controls all processes in a company is very often not enough. The reason for such a situation is usually the complexity of the processes and peculiarity of a company which makes the management of a company implement systems which function in the specific area in a more detailed way. Information systems which support ERP system's practicality aim at delivering reliable information from particular areas of a company. This information makes it possible to make the right decisions on the operational as well as strategic level.

References

[1] APICS Dictionary (2004) 11th Edition American Production and Inventory Control Society, Inc. Falls Church

[2] Ciesielski M (2009) Instrumenty zarządzania łańcuchami dostaw. PWE, Warszawa
[3] Coyle J, Bardi E, Langley C (2003) The management of business logistics: a supply chain perspective. South-Western
[4] Długosz J (2009) Nowoczesne technologie w logistyce. PWE, Warszawa
[5] Fertsch M (2008) Supply Chain Assessment - selected methodological issues. LogForum 4.3.1:1-6
[6] Gunasekaran A, Ngai EWT (2004) Information systems in supply chain integration and management. European Journal of Operational Research 159:269-295
[7] Heizer J, Render B (2008) Operations Management. Pearson Prentice Hall, New Jersey
[8] Januszewski A (2008) Funkcjonalność informatycznych systemów zarządzania - Tom I. PWN, Warszawa
[9] Kauf S (2010) Integracja łańcucha dostaw a konsekwencje dla sfery zarządzania ogniwami łańcucha. Gospodarka Materiałowa i Logistyka 9:2-7
[10] Kelle P, Akbulut A (2005) The role of ERP tools in supply chain information sharing, cooperation, and cost optimization. International Journal Production Economics 93-94:41-52
[11] Kolińska K, Cyplik P (2010) Work standardization - tool for increasing effectivness of activities. In: Fertsch M (ed) Innovative and inteligent manufacturing systems. Publishing House of Poznan University of Technology, Poznan: 195-210
[12] Koliński A (2010) Diversification of Production – innovative tool for Controlling. In: Fertsch M (ed) Innovative and inteligent manufacturing systems. Publishing House of Poznan University of Technology, Poznan: 241-250
[13] Koliński A, Trojanowska J, Pająk E (2010) Theory of Constraints as supporting element of logistics controlling. In: Badzińska E (ed) Sources of Competitive Advantage for Enterprises. Publishing House of Poznan University of Technology, Poznan: 71-84
[14] Liker J (2004) The Toyota Way: Fourteen Management Principles from the World's Greatest Manufacturer. McGraw-Hill, New York.
[15] Lovins, L. (2008) Rethinking production, In: State of the World 2008. Innovations for a Sustainable Economy, The WorldWatch Institute: 34-44
[16] Pfohl H-Ch (2004) Logistikmanagement: Konzeption und Funktionen. Springer Verlag, Berlin
[17] Pfohl H-Ch (2010) Logistiksysteme: Betriebswirtschaftliche Grundlagen. Springer Verlag, Berlin
[18] Powell JD, Kelley CA (1981) Management. McGraw-Hill, New York
[19] Śliwczyński B (2008) Controlling in supply chain - tool for process integration. LogForum 4.2.4:1-8
[20] Śliwczyński B (2010) The Reference Model of Supply Chain Operational Controlling in Value Management. LogForum 6.1.3:21-36
[21] Weber J (2002) Logistikkostenrechnung. Springer Verlag, Berlin
[22] Zhou H, Benton WC (2007) Supply chain practice and information sharing. Journal of Operations Management, 25:1348-1365

Potential benefits of applying e-markets to waste management

Żaneta Pruska[1], Martyna Malak[1], Joanna Oleśków-Szłapka[1], Agnieszka Stachowiak[1], Paulina Golińska[1]

[1] Poznan University of Technology,

zaneta_pruska@wp.pl, martyna_malak@interia.pl, joanna.oleskow-szlapka@put.poznan.pl agnieszka.stachowiak@put.poznan.pl, paulina.golinska@put.poznan.pl

Abstract. Contemporary enterprises should take the fact that their activity influences environment into consideration. Except from monitoring their competitors they should be involved in environment protection and remember that final products and wastes as well are results of processes they perform. The following paper is to prove that numerous companies in Poland take advantage of waste management, including waste selling, re-using and benefiting from cheaper material sources. To provide some theoretical background, authors introduce the idea of sustainable development, wastes definition and present possible solutions that can be applied in wastes management area. The solutions presented include electronic wastes market operating in Poland. Short description of some of the wastes markets is to be presented, as well as benefits emerging from enterprises' cooperation with wastes markets.

Keywords: e-markets, waste management, secondary materials

1 Introduction

Development of technologies and science, except from facilitating many areas of economic and everyday life, has brought some negative results. Increase in production (thanks to using new technologies) resulted in increased pollution of environment around us with excessive wastes. In the XIX and the second half of the XX century enterprises were striving to increase their profit [1]. The pace of industry development and increased production of wastes, together with common belief that landfills are the only way to dispose wastes has led to growing degradation of natural environment. One of the most important challenges of our times is the problem of wastes management and disposal [10].

A steady increase in the amount of waste generated has been noted in Poland in the last 30 years. Of the approximately 145 million tones of waste produced currently every year, industrial waste account for 133 million tones and the amount of industrial waste has decreased over the last 10 years. The decrease and subsequent stabilization in waste generation is caused mainly by the changes in the structure of national

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_49,

industrial production, including the reduction in coal reduction level (mining wastes) and improvement in its calorific value (power station wastes) [6].

Contemporary enterprises should take the fact that their activity influences environment into consideration. Except from monitoring their competitors they should be involved in environment protection and remember that final products and wastes as well are results of processes they perform. In the following paper the authors introduce the idea of sustainable development, wastes definition and present possible solutions that can be applied in wastes management area, including wastes market operating in the Polish market. Short description of some of the wastes markets is to be presented, as well as benefits emerging from enterprises' cooperation with wastes markets.

2 Wastes as a profit opportunity

"Wastes are used physical goods, as well as liquid, solid and gas substances generated by humans in their everyday activities and business activities, unnecessary in time and place they were generated in and harmful for environment" [9].

As it was mentioned above, fast civilization development in contemporary times is characterized, among others with large quantity and variety of consumption and investment goods, which results in increased amount of wastes. Wastes are generated in workplaces (industrial wastes), and in everyday life (municipal wastes) [9]. In the following chapter the authors focus on industrial wastes as they make over 90% of total amount of wastes generated in Poland. Mining industry, as well as energetic and steel industry together generate over 80% of industrial wastes [20].

Enterprises, at different stages of supply chain, cope with wastes management problems such as:

- Own wastes, connected with enterprise's performance, including hazardous wastes (toners etc),
- Post-production and post-use wastes,
- Reusable wastes,
- Packaging wastes, which were generated with raw materials and components in production and distribution process
- Products which were not sold [15].

Process of wastes reduction is one of the most important areas of scientific research in industrial countries as enterprises searching for new solutions enabling reusing products and regaining their value. Because of that, solutions in production and logistics area are implemented to bring back the value of used products lost in exploitation process and to re-introduce these products to the market. The crucial element of strategy of enterprises functioning in the market is creating "the green image", respondent to the idea of sustainable development. Because resources are limited, re-using products is economically attractive [12], and area connected with waste can be unlimited area of creating added value for enterprises. Just like in a well managed farm, each of things has value that should be appreciated [4], and wastes, when they are managed become goods, whereas defining given material as a waste or as a raw material is determined by production technologies applicable in the area analyzed [20]. Waste re-use in not only the matter of individual enterprises, but also of the more general approaches and global strategies, with the well known sustainable development idea.

One of the firsts, and the most popular explanation and definition of the term "sustainable development" is the statement from the WECD report from 1987 (also called Brundtland Report) – "at the present stage of civilization development sustainable development, which is development thanks to which needs of today's generations can be met without decreasing chance of future generations for meeting their needs, is possible". The report proves, that contemporary civilization has reached the level of welfare which can be maintained only when properly managed. The model of such economy assumes, that relation between economic growth, care for environment and human health should be created [18]. With other words, to reach sustainable development, a process of changes in necessary so that exploitation of natural resources, investments, technology development and institutional changes were realized in full harmony with the present of future potential to be used to meet human needs and aspirations [10].

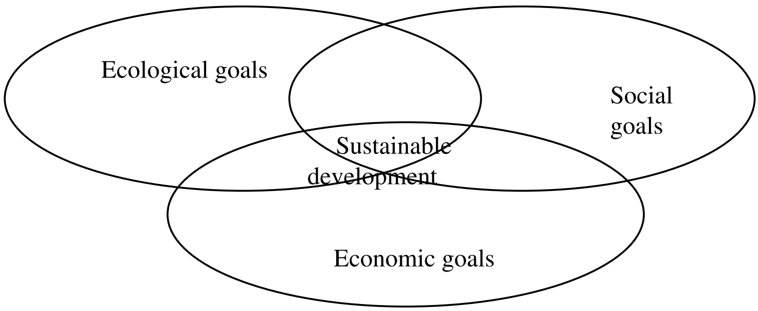


Fig. 1. The three crucial factors creating sustainable development, *Source:* [19]

The idea of sustainable development should not be treated as a demand to stop economic development but as a demand to improve life quality instead of increased expansion of industrial production [19]. Modern approach to the idea of sustainable development starts exactly where three ideas: natural environment, society and economic results meet. The idea refers to J. Elkington's theory, in which he suggest simultaneous analysis and balancing of three crucial dimensions (the Triple Bottom Line): economical, ecological and social (fig.1).

With such approach, sustainable development is "not only the matter of good corporative citizenship, which is collecting points for reduction of harmful emissions from the factory or providing health protection program, but a fundamental principle of intelligent management" [18]. Managers start to see ecological issues as an integral part of business strategies, despite solving global problems connected with environment pollution is not a core activity of an enterprise. The strategies enable enterprises creating positive image, and gaining competitive advantage as well [6].
The approach to be accepted is the one formed by H. Rodham Clinton, according to which "economic development and clean environment are not contradictive goals –

actually these goals are harmonized as life quality and economic activity depend on care for environment"[9]. The natural consequence of the idea of sustainable development is striving for benefiting from reverse logistics and closed-loop supply chain, as these approaches allow to benefit from secondary materials and improve efficiency of company's performance [13,14].

3 Wastes markets and waste management

Wastes markets are generally electronic (internet) markets, a group more and more popular and often applied in many areas of economy. Using internet market brings numerous benefits, including reduction of costs of searching for new business partners. Openness of internet is the feature influencing fast development of electronic markets, as well as relatively low costs of access to the internet. Practically, access to the internet is not limited for large corporations but it can be used by medium and small enterprise as well. Electronic markets' architecture is analogical to other e-business services. Markets which are web-pages are the most common solutions, as offers are exchanged just like other information with www pages. Their main advantage is the fact that all that is needed to use them is an internet browser. It means that an internet user who is used to searching for information in www services can easily and quickly master using such internet markets [5].

Wastes management is defined as collecting, transporting, recycling and disposing wastes, as well as supervising the above mentioned activities and the places where wastes disposing is processed [7]. The basic activities connected with wastes management are the following:

1. Minimization of amount of wastes generated.
2. Maximization of wastes management.
3. Limiting wastes storage in natural environment as much as possible.

To meet the requirement concerning minimization of waste generation and protection of environment it is necessary to know biological, chemical and physical features of waste; possibility of transformation wastes to wastes less harmful for the environment; eco-toxic hazard caused by wastes, technical and economical opportunities of wastes utilization as well as natural and technical conditions of wastes storing [3]. As not every entrepreneur has the knowledge presented above, they generally get rid of wastes storing them, and giving an advertisement in a wastes market seems to be a rational solution for their re-use and changing them into useful goods so that they could be used in other production cycles.

An obvious activity striving for minimization of wastes generated is modification of devices and technologies, and in consequences developing clear (waste-less or low-wastes generating) technologies. Thanks to clear technologies resources are fully used. It is a chain of technological processes which are connected with excavating and processing raw materials without generating wastes or providing their management without disturbing natural environment. However, developing and implementing such technologies is very difficult. It is a result of simultaneous application of physical, chemical and biological processes which are from different fields and branches. To develop such system, commitment of numerous scientific departments, construction offices and technological offices is required and these are often from many areas and not from one enterprise [17]. Using internet markets is not that cost-generating and wastes generated in technological processes do not threaten the environment thanks to finding business partners who can use wastes in their production cycles.

Maximization of wastes generation and limiting the amount of wastes stored in the environment are activities which go together. If a company searches for possibilities to manage wastes it could not avoid in a given production cycle, it is beneficial for environment. Such alternative does not have to be costly and does not have to require new technologies or numerous specialists from a given area of knowledge. It is just enough to put an advertisement on and to search for business partners who can use a waste in their production cycle. As it was mentioned before, wastes are items and substances which cannot be used in time and place they were generated in. However, for other enterprises, in another time and place they can be a useful raw material, component or even a product [19].

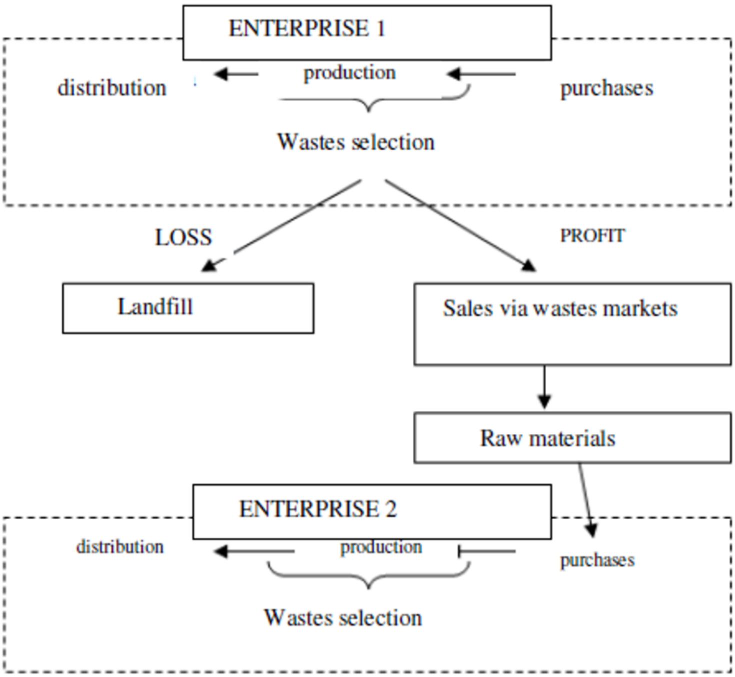


Fig. 2. Wastes management with wastes markets

Generating waste has always been treated as something wrong but unavoidable. However generating large amount of wastes is a sign of poor wastes management and should be corrected by minimization of wastes in order to avoid environment degradation. Each waste, when its re-managed becomes a useful good again [20], and wastes markets give such opportunity to enterprises and are a much better alternative for wastes disposal than landfills, (fig. 2).

4 Wastes e-markets – examples

Internet wastes markets can be used with internet browsers. After “internet wastes market” is typed, web pages in which adverts with wastes offered by enterprises are presented and possibilities to give new adverts are given as well. In the following chapter the idea of wastes markets and the way they operate are presented, as well as short description of some of the polish wastes markets are introduced.

The first of the wastes markets presented is accessible at the following e-addresses: www.gieldaodpadow.pl and www.recyclingtrade.com.

The advertisements in the page are about selling and buying waste, and to facilitate navigation waste are divided into the following categories: plastics, metals, wood, paper, alternative fuels, electronics, gum and used machines. Full content of adverts is accessible for registered and logged in users. It is a condition necessary to be met to get the opportunity to make a transaction of waste sales or purchase. Each user is allowed to own one customer panel only. All the advertisements can be read and written in: Slovakian, Ukrainian, English, Russian, German [22].

The next wastes market operating in the Polish market is the “Polish Internet Wastes Market” available at the following web address: www.gielda-odpadow.pl

The market is designed for enterprises generating and collecting wastes, as well as for wastes owners as they are defined in the Wastes Statement dated on 27.04.2001. Putting an advertisement is payable, however the full content of an advert can be read by every party interested. Additionally, information on example of given waste management method is required in the advertisement. Except from advertisement, with the web-page of the wastes market it is possible to find links on the wastes issues i.e. State Waste Management Plan [23].

“Free market b2b” is accessible at the e-address www.gartija.pl/gielda.php and it is a free platform for information concerning environment engineering exchange. There are categories of advertisements connected with wastes, divided into subgroups including: wood, metals, construction wastes, packaging, plastics etc to make navigation easier. To put an advertisement registration is required [24].

„European wastes market” available at the following e-address: www.euwaex.com is ran by an enterprise registered in Poland Euwaex Sp. z o.o. the market enables exchange of trade offers connected with wastes, but also with machines and transport. An enterprise interested in an advertisement put in the market, to get the full access, as in previous cases, needs to be registered and give the following information: full address, NIP, REGON. The page is operated with three languages: Polish, English and German [25].

In the Polish market there are other wastes markets which are available in the services connected with environment protection issues and in other portals. For example, in the web page http://www.plastech.pl at the address: http://www.plastech.pl/oferty-b2b/kategoria_3_1pf/Odpady interested parties can finds advertisements concerning sales or purchases of wastes. Giving advertisements in this case, like in the previous mentioned, is possible only after registration on the portal is completed.

The biggest markets, focused on matching business partners interested in selling or buying wastes were presented above. The authors hope that the issues will be more and more popular and in consequence more and more wastes markets will be created which will make them more competitive and user friendly so that finding the best offers and cooperation was possible. Enterprises interested in taking part in such projects should have no problems with registration and navigation. Architecture of waste markets operating nowadays is similar. In most of them wastes are divided into groups (presented in the descriptions above). Codes of wastes can be used in most cases as well as identification of origin of partners. Transportation costs are extremely important for companies, it is quite common that enterprises operate in some regions of Poland only. The markets discussed are compared in terms of navigation opportunities (table1):

Table 1. Comparison of electronic wastes markets

Wastes market (WWW page)	Is there opportunity of grouping wastes?	Is there possibility to use codes to find wastes?	Is there possibility to find partners in given (chosen) voivodships?
www.gieldaodpadow.pl	yes	yes	yes
www.gielda-odpadow.pl.	no	no	yes
www.gartija.pl/gielda.php	yes	no	yes
www.euwaex.com/	no	yes	no

In the wastes markets numerous wastes suitable for recycle can be found, as for example waste foamed polystyrene that can be used in production of construction materials by mixing it with plaster [23], waste of foamed polyurethane and multi-material plastic wastes (including glue fillers) which can be used in production of heat-insulating plates [25] and many others. Reusing wastes as raw materials and components seems to be a key issue for success of many enterprises. Pro-ecological organizations managed to implement strict law regulations which are supposed to help to protect natural environment. Numerous tax privileges and low-percentage loans for entrepreneurs are introduced as financial motivation tools to result in production profile changing and secondary materials use [1]. Additionally, more and more entrepreneurs come to the conclusion that wastes use can reduce production costs by buying cheaper raw materials. Legal regulation are not the only reason for using secondary materials, as in industrial countries percentage of re-used materials is 40-50% on average and for some materials it is almost 75% [30], financial motivation is important as well. As a result, demand on primary materials (raw materials, natural resources) is still increasing, but more slowly than production level. Enterprises provide goods to satisfy customers and, in the same time provide such opportunity for future generations. The situation can also be observed in Poland, and both, economic and ecological factors are to be blamed, as natural environment protection importance and energy consumption in manufacturing processes are considered. Secondary materials are the source of cheap and pro-ecological materials for production [30]. The table below provides data on aluminum from primary and secondary sources use in manufacturing facilities in 2009.

Table 2. Turnover of aluminum in productions units in 2009

Supply				Use					Stock as of the end of the year
total	from own activity	procu-rement	import	total	self-consum-ption	domes-tic sales	export	natural wastes and losses	
in thousand tones									
343,3	112,6	176,7	54,0	343,6	198,7	139,7	5,1	0,2	18,5

Source: [31]

Plastics are the group of waste particularly important as they are the largest group of wastes stored in landfills. Use, and consequently production of plastics has been increasing during the last years because of their perfect mechanical features and comparatively low price [22]. Plastics can also be used as secondary materials: average price on LDPE suggested by producers in 2010 was 4,93 PLN for kg (the lowest price was in January 2010 – 4,19PLN per 1kg, and the highest in October, 5,44PLN per 1kg) [31], while waste LDPE is available on average for 3,30PLN/kg. naturally, the price on waste LDPE depends on its condition, sorting mode and the branch of origin. However, the conclusion is quite clear – the price on secondary material is much lower. The table below presents the turnover of plastics, including LDPE.

Table 3. Turnover of plastics in productions units in 2009

Supply				Use					Stock as of the end of the year
Total	from own activity	procure ment	import	total	self-consumptio n	domes-tic sales	export	natural wastes and losses	
in thousand tones									
359,7	256,7	102,2	0,9	365,1	131,6	221,5	8,8	3,8	31,6

Source: [30]

Polyurethane foam, which is a material used in furniture industry, though not only, can be purchased from its producers or as a secondary material. Producers provide foam pieces of the following size 120cmx200cmx2cm and weight type T22 for

11,37PLN per piece[2], but the price is negotiable, depending on the order size or continuing cooperation between the trading parties. Waste foam which is generated when cutting large blocks can be purchased at much lower prices – even 5PLN for the piece of the standard size presented above, though the weigh type may differ. Such difference between prices on the primary and secondary market is a huge chance for enterprises, especially from SME sector, as they generally produce smaller quantities and their demand is lower than the one of large companies.

5 Summary

Waste management is not only an opportunity to protect environment but also a chance for small and medium enterprises which can use wastes in their production processes as valuable raw materials at lower costs. Small enterprises use simpler, less complex technologies and perform lots of activities manually which may be an advantage when using wastes as raw materials and influence final product price decreasing it. It makes small enterprises more competitive than big enterprises using high technologies and complex processes. Large corporations sign contracts with suppliers and it makes their cooperation with suppliers less flexible, while other enterprises are more flexible and have more business contacts with suppliers of wastes, which gives them competitive advantage. For them, waste is not loss but opportunity to increase income and/ or decrease operating costs connected with raw materials purchases. Small enterprises are not doomed to lose the fight for customers with large corporations, but they should search for solutions and opportunities similar to those offered by wastes markets. The hidden opportunities are a kind of “cure” for environment we should fight for so that natural environment was not completely destroyed. Managers should also consider future generations and their requirements and opportunities to satisfy their needs. Possible lack of resources and raw materials to be used in production would lead to global crisis and slow or even stop world economy which means that making decisions today we are fighting for future for the next generations. Wastes markets enable creating symbiosis between enterprises generating waste and enterprises which are able, having knowledge and skills, how to allocate these waste in a way that could be beneficial for all the parties of wastes trading transactions. Increased interest and involvement into wastes markets leads to wastes amount on landfills limitation and, what seems to be even more important, limits the wastes to be stored in landfills to those that cannot be reused or recycled, which is fully coherent with the idea of sustainable development presented in one of the firsts sections and all the legal regulations concerning wastes issues in Poland and European Union.

The examples presented above are only some of numerous opportunities of using cheaper secondary resources. These hidden opportunities, decreasing operating costs are a better motivation for enterprises to strive towards sustainable development than strict low regulations. The further research to be conducted is on the analysis of economic benefits from reverse logistics and on contemporary dynamic nets (supply

[2] Average price defined after interview with furniture industry representatives

chains) of enterprises created to maximize competitive advantage of SMEs thanks to cooperation with customers, reverse logistics and closing the loop.

References

[1] Bieda B., „Zarz dzanie gospodark odpadami na wiecie" [in:] Zrównowa one wykorzystanie zasobów w Europie – surowce z odpadów, red J.Kudełko, J.Kulczycka, H.Wirth, Wydawnictwo IGSMiE PAN, Kraków 2007

[2] Berny J.S., 2008, „Ekologistyczne problemy przedsi biorstwa", Dworecki S.E. (red.), Usprawnianie zarz dzania logistyk przedi biorstwa, Wydawnictwo Akademii Podlaskiej, Siedlce, ss. 157 – 181.

[3] Bendkowski J., Wengierek M., 2002, Logistyka Odpadów, Tom 1. Procesy logistyczne w gospodarce odpadami, Wydawnictwo Politechniki 1 skiej, Gliwice.

[4] Brdulak H., Michniewska K., 2009, „Logistyka odzysku", [w:] Logistyka, 5, pp. 16 - 21.

[5] Ciesielski M., 2009, Instrumenty zarz dzania ła cuchami dostaw", Polskie Wydawnictwo Ekonomiczne, Warszawa.

[6] Edwarczyk N., Stachowiak A., 2009, „Koncepcja zamkni tej p tli ła cucha dostaw", [in:] Logistyka, 1, pp. 74 – 76.

[7] Górski M., 2005, Gospodarowanie odpadami w wietle wymaga prawa wspólnotowego i polskiego prawa wewn trznego, Wydawca Futura, Grzegorz Łuczak na zlecenie Polskiego Zrzeszenia In ynierów i Techników Sanitarnych, Oddział Wielkopolski, Pozna .

[8] Grodzi ska-Jurczak M., Management of industrial and municipal solid waste in Poland, Resources, Conservation and Recycling 32 (2001) 85-103

[9] Karma ska A., 2007, Zarz dzanie kosztami jako ci, logistyki, innowacji, ochrony rodowiska a rachunkowo finansowa, Wydawnictwo Difin, Warszawa.

[10] Korze Z., 2001, Ekologistyka, Biblioteka Logistyka, Pozna .

[11] Kowalski Z., 2005, „Zagro enia rodowiska naturalnego. Modele zrównowa onego rozwoju", Tabora A. (red.), Gospodarowanie odpadami i substancjami niebiezpiecznymi. Tom 1. Ustawodawstwo, składowanie odpadów, transport towarów niebezpiecznych, dokumentacja, Centrum Szkolenia i Organizacji Systemów Jako ci Politechniki Krakowskiej im. Tadeusza Ko ciuszki, Kraków, ss. 277 – 308.

[12] Kozłowska B., Manczarski P., Zabawa S., 2005, Gospodarka odpadami, w tym odpadami niebezpiecznymi. Informator, Futura Grzegorz Łuczak: na zlec. Polskiego Zrzeszenia In ynierów i Techników Sanitarnych. Oddział Wielkopolski, Pozna .

[13] Krikke, H., Pappis, C.P., Tsoulfas, G.T., Bloemhof-Ruwaard, J.B. Design principles for closed loop supply chains: optimizing economic, logistic and environmental performance, Erasmus Research Institute of Management, Report series research in management, October 2001

[14] Krikke, H., le Blanc, I. and S. van de Velde (2004) Product modularity and the design of closed-loop supply chains, California Management Review 46(2):23-39

[15] Kruczek M., ebrucki Z., 2009, „Operator logistyczny w modelowaniu sieci logistyki zwrotnej", [in:] Logistyka, 5, ss. 22 – 23.

[16] Michniewska K., 2006, „Znaczenie edukowania w zakresie logistyki odzysku i ekologistyki", [in:] Logistyka, 4, ss. 87-88.

[17] Pruska ., Malak M., Stachowiak A. Rogers D.S., Tibben-Lembkers., Going Backwards: Reverse Logistics Trends and Practices, Pittsburgh, Reverse Logistics Executive Council, 1999, 1-137

[18] Rosik-Dulewska Cz., 2000, Podstawy gospodarki odpadami, Wydawnictwo Naukowe PWN, Warszawa.
[19] Rutkowski K., 2008, Najlepsze praktyki w zarz dzaniu ła cuchem dostaw. Wyj naprzeciw wyzwaniom społecznej odpowiedzialno ci biznesu, Szkoła Główna Handlowa w Warszawie, Warszawa.
[20] Szołtysek J., 2009, „Ewolucja logistyki zwrotnej. Odpady i sposoby ich zagospodarowywania na przestrzeni wieków oraz co z tej lekcji wynika współcze nie", [in:] Logistyka, 5, ss. 8 - 11.
[21] Szołtysek J., 2009, Logistyka zwrotna, Wydawnictwo Biblioteka Logistyka, Pozna .
[22] Twardowska-Schmidt, Wykorzystanie polimeru odpadowego PP/HDPE do wytwarzania włókien [in:] Zrównowa óne wykorzystanie zasobów w Europie – surowce z odpadów, red Kudełko, J.Kulczycka, H.Wirth, Wydawnictwo IGSMiE PAN Kraków 2007
[23] www.gieldaodpadow.pl, retrieved on 12.07.2010 r.
[24] www.gielda-odpadow.pl, retrieved on 12.07.2010 r.
[25] www.gartija.pl/gielda.php, retrieved on 12.07.2010. r.
[26] *www.euwaex.com,* retrieved on *12.07.2010 r.*
[27] http://www.euwaex.com/rejestracja.php, retrieved on 14.07.2010 r.
[28] http://www.plastech.pl/oferty-b2b/kategoria_3_1pf/Odpady, retrieved on 15.07.2010
[29] http://www.plastech.pl/wiadomosci/artykul_2854_1/Zagospodarowanie-odpadow-styropianowych, retrieved on 16.07.2010 r.
[30] http://styl-zycia.ekologia.pl/ekologiczny-dom/Odpady-opakowaniowe-mozna-wykorzystac-w-budownictwie,12181.html, retrieved on 16.07.2010 r.
[31] GUS, Departament Produkcji, Gospodarka materiałowa 2009, Warszawa 2010
[32] GUS, Departament Bada regionalnych i rodowiska, Ochrona rodowiska 2010,Warszawa 2010

Application of eco-balance in area of logistics - a case study

Mateusz Piaskowski[1], Anna Stasiuk[2]

[1]Mandersloot Polska Sp. z o.o.
[2]Poznan University of Technology

mateusz.piaskowski@op.pl, anna.stasiuk@poczta.onet.pl

Abstract. Purpose of this article is presents analyzed impacts of ecology in logistics of exploitation stock car. Authors used the ecological balance and the analysis of the causes and effects of defects (FMEA) to identify whole complex of a company impacts on the environment and formation group of remedial measures and permanent reduction or total elimination of these impacts.
Factor influencing the choice of theme is the rise in recent years environmental awareness translates to not only the increasingly strict emission standards of the traditional engines. Also to a wider idea of alternative energy sources and methods of propelling vehicles. Great shortcoming of today's commercial vehicles and their destructive influence on environment are phenomena known to all who are not only professionally engaged in automotive problems, but also to lots of groups and individuals, who monitor the progress of constructional technological car's build and production only as an amateurs.

Keywords: eco-balances, FMEA process, FMEA product

1 Ecological perspective on logistics

One of the major challenges before the man in the twenty-first century is protection of the environment. Earth's natural resources through the issuance of many harmful chemicals into the atmosphere, soil and water were severely limited. Exploitation of non-renewable energy sources and raw material causes worked out them systematically. Nowadays used mining technology doesn't protect the environment from local degradation - chemical or radiological contamination, mining damage, landscape degradation, devastation of the biosphere of plants and animals. In the case of excessive and too frequent number of adverse impacts often comes to loss of balance in the ecosystem. In many developed countries there is a view that the ecosystem in relation to the primary logistics functions to be associated with a rather broad concept recirculation.
This process is based on the recovery of secondary raw materials and energy from used goods, and eliminating all types of waste that are generated not only in the processes of supply and distribution, but also in after sales service and operation of these goods.

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_50,

The term neutralize waste is understood as elimination, or at least significantly reduce the risk to hygiene - health, which is achieved not only through the combined processes of recovery of secondary raw materials or energy, but also through the orderly processes of storage places for doing so in the designated areas, meet legal and regulatory requirements for environmental protection .
Self-term ecologistics is defined as an integrated system which is based on the concept of management of recirculating flow streams of waste material flows in the economy and streams related information with them. This system have the task of ensure the readiness and ability for the efficient collection, segregation, processing and reuse of waste by the technical rules and process, fulfill the standard and legal requirements imposed by the environmental protection.
The integrated system for what is considered Ecologistics, can also take technical and organizational decisions in directions to minimize negative effects on the environment and the accompanying processes in the logistics supply chain. Ecologistics in a systemic perspective includes not only technical-processing and organizational-informational elements, but also economic factors.

2 Eco-balance as a tool for measuring

For this purpose a series of tools, referred general to as "eco-balancing". Eco-balance is an activity designed to identify a comprehensive impact analysis of object on the environment, as particularly important to take into account weaknesses, together with their full assessment and fixing measures.

Emergence of the ecological balance of the text on a breakthrough in the 1960s and '70s of the 20th century. They were the methods used to draw up an energy analysis. However, they take into account the nature and form of raw materials and the environmental burdens associated with emissions (mainly water and air). In the USA were include. study on assessment of the costs of environmental implications of the use of renewable energy sources. Parallel started work on defining the burden of the environment by waste from the packaging. These analyses are performed on behalf of most individual companies, and their purpose was to search for packages which are likely to constitute a minimal burden on the environment

The methods of eco-balancing don't develop marketable in so impressive pace without computer programs greatly facilitating the collection and processing of the data. Modern ecological balances make it easier to quantitatively determine the existing threats to the environment caused by the products, processes and operations.

In addition, the analysis enable the team of remedial measures with a view to a lasting reduction in or total elimination of the effects of the company on the environment. Ecological balances include logistic systems in the enterprise, i.e.: supply system, production, distribution and recycling of waste. This analysis focuses not only on the components of these systems, but also defines the relationships between these elements and their interaction and relationships with the environment in time and space.

In the case of focus on one subsystem of eco-balance, the heaviness point tend in the direction of logistics points of contact with the other subsystems.
In the ecological balance we highlight the four subsystems:

- company balance (Input-Output),
- processing balance,
- the balance of the line product (Life Cycle Assessment),
- the balance of the location and environment of the company.

The company balance (Input-Output) fulfills a similar role as the characteristics of the organic technology (Environmental Technology Profiles-ETP). Its purpose is to inventory all the entering and outgoing materials, energy, material emissions and non-material emissions (vibration, noise, radiation) and of the basic products and the associated.

For the essence of the company balance shall be deemed to be material and energy flows, but technological processes of machinery and equipment make up the black box ("black box"), outside its range. This happens because the meaning of logistics are not materials flow. Impact on the environment at the level of the share company balance dominates the two main categories of effects i.e.. consumption of resources and energy, and indeed in the manufacture of gaseous and particulate matter, solid waste and sewage and the generation of non-material emissions. Relationship between balance of Input-Output and the environment is divided generally into three basic categories, each of which contains information and ecological parameters.

All material-energy flows in environmental balance are studying in two stages. The first includes the Input-Output in the whole company, and as far as process flow of raw materials and energy are on different parts of a split of a technological process and be presented in relation to a specific time interval.

Way of impact the company on the environment concerns not only technology processes, but it is linked with the supply and distribution logistics. The concept of the logistics supply chain management and distribution is quite wide and represents the area, and lists:

- suppliers,
- distribution
- consumption (exploitation),
- the waste liquidation including the recovery of secondary raw materials,
- the vertical movements of materials through the manufacturing process,
- purchase policy and collection of raw materials,
- storage of final products,
- recycling of external and internal,
- transport and warehousing,
- source of raw materials.

2.1 Analysis of the causes and effects of defects – FMEA

2.1.1 The Idea and application

FMEA method (Failure Mode and Effects Analysis) is used mainly in order to identify potential defects and calling them for reasons that may cause a reduction in the use of the product, reducing its efficiency and effectiveness of implementation processes disrupt, or harm users or customers on the loss of tangible propertyloss of health and even life. The role of this tool is an indication of the process elements or components of the product in respect of which action should be taken to prevent or at least limiting the risk of potential errors.[5]

Distinguished the FMEA product (construction) and FMEA process. FMEA product and process FMEA differs area uses and also criteria and subject to analysis. The difference is visible also in the nature of the posed questions (problems), how the description of the defects, the causes and effects. [2]

The purpose of FMEA product (construction) is a description of the weak points of the designed product in such a way that even before the implementation of the relevant construction work, and then in production, there was the possibility of introducing changes. Analysis of FMEA can be carried out during the preliminary design work. Stated weak points may refer to:

- features that the product is make real,
- the reliability of the product during exploitation
- ease of use by user,
- ease of repair in the event of a failure,
- the technologically of construction.

Analysis of FMEA product (construction) is carried out in situations when it is placed on a new or retrofit old product, introduced new materials and technologies, new opportunities for the use of the product, there is a large threat for man or environment in the event of failure of product (it is not acceptable for instance defects), exploitation of the product takes place in particularly difficult conditions, and when they are undertaken significant investments in the enterprise.

In the case of analysis FMEA process are considered broad processes, in which the products are produced and their parts or assemblies, and also processes use or servicing (including the provision of services). Its purpose is to specify the factors which impede compliance with stated in the specifications of the product or service requirements, or may impede the course of the same process.

Analyzed are factors associated with:

- methods and parameters of processes,
- measures and analysis – control,
- machinery and equipment,
- the terms of usage,
- environment influences [2].

2.1.2 Stages of design FMEA

When selecting a range of FMEA, and how to conduct it can be approached in two ways:

- offending - is when this approach analyzed are those areas which have been found to have problems. The scope of the analysis shall be chosen on the basis of the current problems with the product or process, customer complaints, analysis of the deficiencies, etc. The disadvantage to this approach is limited by the ability to detect potential risks in the operation of the product or process. Analyzes these already exist, it is not noted by a threat that occurs rarely, but its effects can be very serious. This approach is most often used because of the simplicity of the conduct and content (sheets are simple and clear, and their analysis does not require special preparation of the investigator)

- systemically – namely the product, construction or the processes shall be considered as a whole, as a system composed of smaller subsystems, which in turn have their own lower-tier subsystems. Each element of the system carries out a specific function. Can this be internals (otherwise the essential for the item), exit (i.e. uploading to other elements), and the features of entry (understood as a collection of items appearing higher in the hierarchy of the system). In this case, the determination of the boundaries of the system and extract it subsystems is one of the first and most important tasks of the working group. [2]

3 Ecologistics in enterprise

3.1 General information about the research object

Company specializes in logistics and transport of all kinds of products requiring controlled-temperature carriage of goods in Europe. The company has two terminals handling the storage facilities – office. One of them, with an area of 5 500m^2 is located in the Netherlands. While the complex machine – Office in the village near Poznan occupies approximately 5 000m^2. Both warehouses are equipped with the highest quality storage facilities and systems, warehouse management WMS class. Both Headquarters, in Poland and the Netherlands, are also the terminal of transshipment. Company largely deals with:

- the removal of goods from the loading place,
- storage and additional services,
- the supply of goods to the customer.

Company operates on the basis of the strategy, which sets out its development. The main elements include: Speed, Safety, Comfort. These are benefits that are most commonly sought among companies operating in the transport industry.
Types of transport services offered by the Company:

- transport cold trailers various fresh and frozen meat,
- transport of half-carcases,
- transport fresh flowers,
- transport of dangerous goods (drivers possess the appropriate certificates, and the vehicles are equipped with ADR packets),
- transport of cargo of neutral
- forwarding services within the transport of goods which do not require specific temperature of carriage.

In response to the needs of the client store fully different functions:

- external warehouse,

- distribution warehouse from which the shipment of the goods takes place throughout the country,
- warehouse logistics-handling for goods which are rewrapped and delivered to customers throughout Poland (fast moving consumer goods, e.g., flowers).

3.1 Ecological balance company

Execution balance ecological company helps identify these sensitive areas of the entire manufacturing process, or only the individual stages of the process, in which the quantity of necessary resources, energy and the quantity of collected all kinds of emitted substances can be reduced.

Company balance Input – Output provides a quantitative indication of the impact of company on the environment (entering and outgoing materials, energy, basic products and associated materials emissions and beyond material including vibration, noise and radiation).All factors together with the relevant breakdown are shown in the following table.

Table 1. Company balance enterprise in terms of tabular

No.	Location	Environmental aspect	Conditions	Impact on the environment	Aspect	Amount [year]	Cost [zł /year]
AIR EMISSIONS							
1.	Boiler rooms works	Emission of gas boiler	Normal	Air pollution	Indirect	-	-
2.	Streets, transport, car wash on the square	Emissions from the combustion of fuels in machines, cars, vehicles	Normal	Air pollution	Direct	**1)**	
3.	Transport database (square)	The emission of fumes from paints and solvents	Normal	Air pollution	Direct/in direct	-	-
4.	Area of the company	Emissions of the gases in the event of fire	Emergency	Air pollution	Direct	-	-
5.	Offices and social	Freon	Emergency	Air pollution	Indirect	-	-
ELECTRICITY CONSUMPTION							
6.	Transport company database	Consumption of electricity to illuminate the square and storage	Normal	Intermediate consumption of natural resources	Direct	**2**	
7.	Buildings, of transport database, housing administrative, boiler rooms,	Electricity consumption in non-productive	Normal	Intermediate consumption of natural resources	Direct		

	protection, car wash, lighting						
GENERATION AND DISCHARGE OF WATER WASTE							
8.	Transport database (square)	Waste water wet	Normal	Pollution of surface water	Direct	**3**	
9.	Social rooms	Domestic waste water	Normal	Pollution of surface water	Direct		
10.	Objects from company, administrators of objects	Effluent after fire	Emergency	Pollution of surface water	Direct	-	-
CONSUMPTION OF NATURAL RESOURCES							
11.	Boiler Rooms	Natural gas, fuel oil	Normal	Consumption of natural resources and their depletion	Indirect	**4**	
12.	Vehicles, machinery and equipment	leaded petrol and diesel	Normal	Consumption of natural resources and their depletion	Direct	**1**	
13.	Social rooms, boiler rooms, transport database, car wash	Water	Normal	Depletion of underground water deposits.	Direct/in direct	**5**	
14.	Rooms warehouse, car wash, protection	Paper	Normal	Consumption of natural resources and their depletion	Direct	-	-
15.	Transport database (square)	Road salt	Normal	Consumption of natural resources and their depletion	Indirect	-	-
NOISE, VIBRATION AND RADIATION							
16.	Streets, transport database area	Noise and traffic noise	Normal	Improvement of sound climate	Indirect	-	-
17.	Transport database	Noise caused by the use of pneumatic, electric and combustion	Normal	Harmfulness to health	Direct/in direct	-	-
18.	Offices, warehouse, protection	The electromagnet ic radiation generated by the computer equipment and mobile phones	Normal	Harmfulness to health	Direct	-	-
19.	Offices	Radioactivity of the fire watch	Emergency	Harmfulness to health	Indirect	-	-
GENERATION OF WASTE							
20.	Service	Cleaning oily	Normal	Pollution of	Direct	-	-

	workshop (outsourcing)			the Earth's surface, groundwater			
21.	Service workshop (outsourcing)	Oil filters	Normal	Pollution of the Earth's surface, groundwater	Direct	-	-
22.	Service workshop (outsourcing)	Scrap steel	Normal	Pollution of the Earth's surface	Direct	-	-
23.	Rooms (administrative, social, storage, protection, car wash, square)	CFL-I and mercury-containing devices	Normal	Pollution of the Earth's surface, groundwater	Direct	-	-
24.	Rooms (Office and social), car wash, workshop service (outsourcing)	Waste plastics and rubber	Normal	Pollution of the Earth's surface	Direct	-	-
25.	Workshop service (outsourcing), square company	Hydraulic oils, motor, gear and lubrication	Normal	Pollution of the Earth's surface, groundwater	Direct	-	-
26.	Offices, social, warehouse	Non-segregated municipal waste	Normal	Pollution of the Earth's surface, groundwater	Direct		**6**
27.	Warehouse company	Goods damaged during transport to the MSPL	Emergency	Pollution of the Earth's surface, groundwater	Direct	-	-
27.	Offices, warehouse, protection	Computer equipment, mobile phones, emergency power supply device	Normal	Pollution of the Earth's surface	Direct	-	-
28.	Offices, warehouse, protection	Batteries	Normal	Pollution of the Earth's surface	Direct	-	-
29.	Offices, warehouse	Toners	Normal	Pollution of the Earth's surface	Direct	-	-
30.	Office, security, storage, car wash	Scrap	Normal	Pollution of the Earth's surface	Direct	-	-
31.	Warehouse	Wood	Normal	Pollution of the Earth's surface	Direct	-	-
32.	Workshop service (outsourcing), square	Accumulators	Normal	Pollution of the Earth's surface	Indirect	-	-
33.	Transport	dangerous	Normal	Pollution of	Indirect	-	-

	database (car wash)	waste		the Earth's surface, groundwater			
34.	Transport database	Other waste than dangerous	Normal	Pollution of the Earth's surface, groundwater	Indirect	-	-
LAND POLLUTION							
35.	Transport database (square), the streets, drivers and employees using official vehicles	Leakage oil of motor vehicles and machinery to the ground	Emergency	Land pollution	Direct	-	-
36.	Transport database (square)	Salt to the land of mud after snow	Normal	Land pollution	Direct	-	-

1. By entering into the air gases from combustion of the fuel company is required to incur any charges for the use of the environment. As regards the payment of fees for the use of the environment shall apply the provisions of the law of 27 April 2001 r. Environmental Protection Law (Dz.u. z 2008 No 25, poz. 150 ze zm.). The levy due shall be determined. The amount of the fee in respect of the implementation of the gases or particulates into the air depends on, as the case may be, the quantity and type of gases or particulates into the air. The fee is set according to the rates in force during the period in which the use of the environment took place. To this end, the model is used, whereby charged is the fee:

The amount of the fee [zł]	=	the quantity of fuel combusted [Mg]	×	unit rate charges for gases into the air from a unit of the burned fuel [zł/Mg]

Fares are expressed in zloty per Mg that is złoty per tonne. The fuel consumptions expressed in a unit of volume is converted into a unit of weight taking into account that its density is 0,84 kg/litre for diesel.

Fuel consumption in 2009 [l]: 1 796 990
The quantity of fuel combusted [Mg]: 1 509,472 = 1 509,472 [Mg]

The fee for the operation of rolling stock car environment in 2009 is:
1 509,472 [Mg] x 4,25[1] [zł/Mg] = 6 415,26 [zł]

[1] Coll. U. 2008 nr 196 poz. 1217 - Council of Ministers Ordinance of 14 October 2008 on charges for the use of the environment

2. Company hasn't distribution of electricity consumption for each unit (warehouse, car wash, protection, an administrative building). Therefore, the figures quoted refer to the energy consumption of the entire enterprise.

Lifetime by a year [h]: 3 828
Total consumption of electricity [Wh]: 264 094
The average price of electricity [zł/Wh]: 0,4773

The fee for the consumption of electricity in 2009:
264 094 [Wh] x 0,4773 [zł/Wh] = 126 052,07 [zł]

3. Fee collection and treatment of waste water from companies:

The quantity of water consumed in 2009 [m3]: 1 992
The price for the discharge of waste water in area of the municipality [zł/m3]: 3,96
The ending for the discharge of waste water treatment fee: 1992 [m3] x 3,96 [zł/m3] = 7 888,32 [zł]

4. The fee for the consumption of gas in the enterprise:

The quantity of consumed gas in 2009 [m3]: 72 280
The price for gas [zł/m3]: 0,4187
The final fee for consumption of gas in the enterprise:
72280 [m3] x 0,4187 [zł/m3] = 30 263,64 [zł]

5. The fee for water consumption in the enterprise:

The quantity of water consumed in 2009 [m3]: 1 992
The price for water [zł/m3]: 3,31[2]
The final fee for water consumption in the enterprise:
1992 [m3] x 3,31 [zł/m3] = 6 593,52 [zł]

6. The fee for the export of municipal waste in the enterprise:

The quantity of waste in 2009 [m3]: 540
The price for the export of waste [zł/m3]: 30

The final fee for exports of municipal waste in the enterprise:
540 [m3] x 30 [zł/m3] = 16 200 [zł]

3.2 The balance of the areas location

The balance of the location and areas of company is particularly extensive. Its development is very labour-intensive because of the need to conduct multiple

2 The rate in 2010 is 3,48 [zł/m^3]. [7]

interviews and checklists. For further considerations in State of the existing work assumes that you can specify on the basis of information obtained from the company and its own observations. The balance of the areas location has been carried out for individual objects contained in the company.

Building governance – office supplies (together with boiler):

Input	Output
- Consumption of raw materials and materials: natural gas, water, paper, toners, batteries, fluorescent and mercury-containing devices, electricity (for non-productive); - Computer equipment, mobile phones, emergency power supply device;	- Emission of gas boiler; - Emission freons; - Domestic waste water; - The electromagnetic radiation generated by the computer equipment and mobile phones; - Radioactivity of the fire watch.; - Waste plastics and rubber; - Non- segregated municipal waste; - Scrap;

Warehouse:

Input	Output
- Consumption of raw materials and materials: water, wood, paper, toners, batteries, fluorescent and mercury-containing devices, electricity; - Computer equipment, mobile phones, emergency power supply device;	- The electromagnetic radiation generated by the computer equipment and mobile phones; - Waste plastics and rubber; - Non- segregated municipal waste; - Scrap; - Goods damaged during transport to the MSPL;

Building protection:

Input	Output
- Consumption of raw materials and materials: paper, batteries, fluorescent and mercury-containing devices, electricity (for non-productive); - Computer equipment, mobile phones, emergency power supply device;	- The electromagnetic radiation generated by the computer equipment and mobile phones; - Non- segregated municipal waste; - Scrap;

Car Wash:

Input	Output
- Consumption of raw materials and materials: paper, water, batteries, fluorescent and mercury-containing devices, diesel, electricity (for non-productive);	- Emissions from the combustion of fuels in engines, cars, vehicles; - Danferous waste; - Waste plastics and rubber; - Non- segregated municipal waste; - Otger Non-dangerous waste; - Scrap; - Waste water wet and directly resulting from the cleaning; - Noise caused by the use of pneumatic,

	electric and combustion;

Enterprise Area:

Input	Output
- Consumption of raw materials and materials: paper, water, road salt, fluorescent and devices containing mercury, diesel, electricity; - Diesel;	- Emissions from the combustion of fuels in cars, vehicles; - The emission of fumes from paints and solvents; - Waste water wet; - Leakage oil of motor vehicles and machinery to the ground; - Noise caused by the use of pneumatic, electric and combustion; - Salt to the land of mud after snow;

Depot Container:

Input	Output
- Consumption of raw materials and materials: paper, oil filters, accumulators, hydraulic oils, motor, gear and lubrication, fluorescent and devices containing mercury, diesel;	- Emissions from the combustion of fuels; - Noise and traffic noise; - Scrap steel

In addition, in the deliberations, it should be noted that the location of the company in a continuous change land-use, cover the surface of the terrain and its sculpture. Due to the fact that, on the premises there is a increased automobile traffic, specialized vehicles, transport of materials, loading and unloading.

4 Conclusion and further research

To the general activities of the company aiming reducing the harmfulness of the transport generated by own services, you must analyze the main areas, which significantly contaminate the environment. The largest emissions of harmful substances are characterized by these areas, which contribute to the implementation of the services make use of vehicles and machinery. Therefore the analysis should take account of the action, which may be taken in the different areas together with the solutions (tab. 3).

Table 2. Areas of the company subject to analysis together with the proposed actions.

Area	Action
The fleet of	- purchase cars more ecological (cars meeting the requirements of EURO 5, hybrid cars, special lines ecological popular models, for example Skoda

trucks and cars	Greenline) - Training safe and economical driving among workers (the so-called training eco-driving) - monitoring fuel consumption + bonuses for the most energy efficient drivers, - the use of biofuels, - application of energy efficient tyres;
Missions staff	- verification of the travel needs of business and the replacement of the traditional travel tele-, video-and web conferencing, - consolidation of travel expenses (one trip to several clients, instead of several separate journeys in the same direction), - preferences for more ecological means of transport (in order from the most preferred means of transport: rail, car, plane) - carbon offsetting emissions (to invest in a pro-ecological initiatives such as the planting of trees as compensation for emission of carbon dioxide during travelling expenses);
Workers commute from/to work	- location of the place of work that allows the efficient use of more ecological modes of transport (public transport, bicycle) and/or collaborate with local public transport operators (extension or modification of the line, additional stops, more frequent courses), - incentive schemes for employees (refunding cost of the tickets, bicycles under the premium), - education staff in the principles of eco-driving, - promoting the idea of carsharing, i.e. the mutual lift of workers of one car, - free buses/mini buses for employees on specific directions, - tele-work, working from home – many posts already allows for such solutions;
Commute for workers of a company to customers	- creating the infrastructure necessary to use greener forms of transport, - campaigns informing and awareness.
Purchase of transport services/logi stics	- "green" supply chain - to reduce the use of road and air to rail and sea transport; - taking into account ecological aspects in the design of the supply chain. the degree of fulfillment of vehicles, delivery deadlines; - requirements for suppliers of transport services (e.g. relating age of vehicles, training for drivers, etc.) - building awareness among business partners: presentations, training, action plans, - promotion leaders through larger orders, long-term cooperation, etc.

Application of the above proposed solutions would not only reduce impact on environmental by reducing the impact of transport to be used in the company to its activities, but would be the way to create a more environmentally-friendly workplaces (e.g. help for workers who organize travel to work)developing the offer of services for existing customers and opening the possibility of obtaining new. They are also a way of obtaining reliable and permanent business partners.

The introduction of gases or particulates into the air from the combustion process fuels in internal combustion engines involves transfers of charges for the use of the environment. Reduction of fuel consumption is also lower those fees and less burden on the budget of the company from their title. As can be seen from the company balance Input-Output carried out in the earlier part of the costs of these present at 7 000 $/year, while among the lower because the company has a fleet of trucks, which already meet the EURO 5 emissions standard

Company X should eventually make many actions to protect and the reduction of the pollutants emitted. These activities should be carried out in terms of constraints and protection:

a. water and land:

- to safeguard against the introduction of pollutants into water and land,
- organizing places of storage of the waste according to their nature,
- the application of the company sorbents in order to avoid the possible introduction of petroleum substances into drains (mainly on the car wash),
- all that this waste should be stored in containers in a way appropriate to the nature of the waste and preventing its penetration into the environment (air-tight containers, roofing)

b. atmospheric air:

- limiting the emission of pollutants into the air.
- in the area of the company X is not removed to the atmosphere freon and other refrigerants with aggregates. Not Burns also to any of the elements of ITS (cables for the recovery of copper, burning tires, etc.)
- in the installation of heating boilers are used for gas high-metaning GZ50 (use of fuel with low sulphur content).

c. against noise:

- reduction working time of equipment emitting noise,
- making periodic servicing of machinery and equipment,
- the use of enclosures, screens, devices with a high acoustic nuisances.

d. limitation of nuisance waste management:

- waste separation,
- proper storage of waste.

e. restrictions on consumption of water and electricity:

- efficient use of electricity consumption,
- use a power efficient lighting,
- install the self-counters current monitoring electricity consumption individual installations,
- maintaining the installation in a good state of repair, the reduction in water consumption,
- monitoring water consumption.

d. protection of the landscape:

- transport database and stores that do not disfigures the landscape view unordered trucks transport DCC and ECC and pallets 1200 x 800 mm in at the back of the store. The buildings front company with the warehouse effectively override our square with self-trailers. The establishment is surrounded by high trees and shrubs deciduous leafy and coniferous wood forming an effective protection landscape.

e. preventing the occurrence of adverse events (accidents):

- to prevent accidents and minimize their effects,

- sewer rainy fitted with devices self-cleaning,
- washing of vehicles equipped with the position of the separator for petroleum substances,
- the use of systems security warehouse before the fire and explosion,
- mounted hose before fire,
- manual fire-fighting equipment,
- ventilation of the store,
- use sorbents (sand, sawdust, rags),
- periodic training of employees.

On the basis of past deliberations and analyses to note once again as of great importance to care about the environment in the enterprise. It is true that the basic aim of each undertaking is primarily to generate profit, and only later when the company it has, has the ability to specify the purposes of other non-economic related, inter alia, the development of the company or its staff. Therefore, the proposed solution is to deploy and maintain and improve continuously by company X of the environmental management system (abbrev. EMS-Environmental Management System) compatible with the requirements of the standard ISO 14001: 2004. Same fact the implementation, application and improvement of the management system can be adequately represent and provide Customers, contractors and the surroundings in which the company operates through an environmental certificate. This is a proof of the company on its give weight to the improvement of the environmental effects, which causes its activities.

Functioning in company environmental management can help you organize and consolidate the actions for the protection of the environment. Its application to improvement of environmental management, which is very important in a situation exacerbating is legislation from the scope of the protection of the environment, increasing the cost of pollutants disposal and waste disposal facilities and increased legal liability. It is also a way to increase the competitiveness of enterprises and reduce energy consumption and use of resources. Bad practice in this respect, give rise to an increase in the cost of both internal and external.

If you want to implement an environmental management system company X should first determine its current position in terms of the environment when carrying out its review. The purpose of this review should be to consider all environmental aspects of the company as the basis for the establishment of an environmental management system. Its implementation should cover four key areas:

- identify environmental areas, including those resulting from normal operating conditions, as well as the terms unnormal (including starting, stopping, and hazardous situations and accidents),
- identification of applicable legal requirements and other requirements to which the company committed,
- an assessment of the functioning of your company's environmental management practices and procedures (including activities related with purchase and conclusion of agreements),
- assessment of existing already in dangerous situations and accidents.

Tools and methods of the review, depending on the nature of the activities may include checklists, interviews, direct checks and measurements, the results of previous audits or other reviews. You may want to carry out such a review in the company taking into account the results of interviews with people who are working in the past, and now in the company (or on its behalf) in order to determine the extent of past and present activities of the company and carried out by its services. This review should also include the evaluation of internal and external communications with the parties concerned (including incidents or accidents and complaints related to the lack of compliance with legal requirements or other, to which the fulfillment of the previously committed). In addition, should be collected information associated with the current management practices, such as:

- monitoring of the process of purchase of harmful and dangerous to human health and the environment,
- storage and handling of chemicals (e.g., organizing, storing various chemicals primarily for car wash located at the square company),
- monitoring of emissions of non-organized sites,
- methods of disposal,
- equipment associated with readiness and response to industrial accidents,
- consumption of resources (e.g. lighting offices after business hours)
- protection design of plants and habitats during construction, temporal change in processes,
- environmental training programs,
- the completeness of the records from the monitoring and recovery of the past entries easily.

Company X should define environmental objectives and targets at the appropriate levels of management and for the relevant services. Establishing objectives should take account of the significant environmental aspects, technological options, financial and operational requirements and also the interests of the company and the point of view of interested parties. Objectives and tasks of the transmitted should be in the form of programs, defining the steps, the responsibility for their implementation and the means and time limits within which they are to be achieved. They should be measurable (if possible) and consistent with the policy environment, as well as in accordance with the applicable legal requirements and declaring the idea of continuous improvement

Using the method eco-balancing has been identified, in which company shall be established for the operation (materials and raw materials) and those whose business is disposes (emissions, waste water, solid waste). However, to take full advantage of this method, there was no quantitative data, which could not be present. The reason for this was lack of company records and documentation containing the volume consumed and emerging factors.

References

[1] Gołembska Elżbieta [red.], Kompendium wiedzy o logistyce, Wyd. Naukowe PWN, wyd. III, Warszawa 2006;

[2] Hamrol A., Zarządzanie jakością z przykładami, Wydawnictwo Naukowe PWN, Wyd. II zmienione, Warszawa 2008;

[3] Kłos Z., Kasprzak J., Rola ekobilansowania w kształtowaniu maszyn, urządzeń i systemów, Zeszyty Naukowe Politechniki Poznańskiej – Budowa Maszyn i Zarządzanie Produkcją – Nr 6/ 2007;
[4] Korzeń Z., Ekologistyka, Biblioteka Logistyka, Poznań 2001;
[5] Łuczak J., Matuszak – Flejszman A., Metody i techniki zarządzania jakością. Kompendium wiedzy, Quality Progress, Poznań 2007;
[6] Dz. U. 2008 nr 196 poz. 1217 – Rozporządzenie Rady Ministrów z dnia 14 października 2008 r. w sprawie opłat za korzystanie ze środowiska;
[7] www.zukkomorniki.com.pl/uchw289.doc

Part VII
Information Management for Sustainable Production

Comparison of Enterprise Integration Concepts (PLM and EA) from the point of view Green Manufacturing

Pawel Pawlewski[1], Paul Eric Dossou[2]

[1]Poznan University of Technology
[2] ICAM School of Engineering

pawel.pawlewski@put.poznan.pl, paul-eric.dossou@icam.fr

Abstract The chapter presents opportunities to change manufacturing to green. Manufacturing organization is described from high level point of view – enterprise integration. The concepts of Enterprise Integration are presented. The first one is PLM - Product Lifecycle Management concept specification. The other is Enterprise Architecture description. As example of Enterprise Architecture – CIMOSA and GRAI was selected and presented. The chapter compares these concepts and evaluates them from the point of view of green manufacturing. As conclusion the three lifecycle approaches are defined as the postulate to supplement and to extend actual enterprise integration concepts.

Keywords Manufacturing system, Integration, Enterprise Architecture, Environmental Engineering

1 Introduction

Several manufacturing companies include going green in their mission statement. There are many ways to implement technologies and workplace practices to improve the environmental outcomes of production processes. Green manufacturing can lead to lower raw material costs, production efficiency gains, reduced environmental and occupational safety expenses and an improved corporate image [16]. Green manufacturing provides many opportunities to come into these effects [22]:

- Reduce your consumption of natural resources. Try using solar energy and power to fuel your business.
- Unplug machines that are not in use. Leaving the machines plugged in actually does suck power despite what you may think. This is why its also a good idea to turn off your computers at night and to unplug the surge protectors so extra energy is not being wasted.
- Reduce your emission of toxic chemicals and materials.
- Reduce the amount of waste your company produces

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_51,

- Change your lights to energy-saving lights.
- Introduce a recycling program within the company and encourage employees to dump recyclable materials into the correct bins.
- Start purchasing green products and encourage your employees to do the same.
- Purchase a water fountain and avoid using bottled water. Encourage employees to use their own bottles to hold the water.
- Set up a system where lights are motion sensitive and will shut off after 10 minutes of inactivity. This way you will be able to save power by shutting off lights in rooms that are not in use.
- Purchase green materials like recycled paper and plastics.

Most frequently cited hazardous waste minimizations actions are presented in table 1 [3].

Table 1. Most frequently cited hazardous waste minimizations actions [3]

Waste minimization actions
Improved maintenance schedule, recordkeeping, or procedures
Other changes in operating practices (not involving equipment changes)
Substituted raw materials
Unspecified source reduction activity
Stopped combining hazardous and nonhazardous wastes
Modified equipment, layout, or piping
Instituted better controls and operating conditions
Ensured that materials not in inventory past shelf life
Changed to aqueous cleaners

In many publications [2], we can find lists of activities which are necessary to perform to attain green effects. Interesting is how these propositions influence in existing enterprise integration concepts. The chapter is organized as follow: in section2 the concept of enterprise integration is described and two main approaches are presented – Product Lifecycle Management (PLM) and Enterprise Architecture (EA). The first – PLM is introduced in section3. GRAI and CIMOSA architecture are presented in section 4 as leading enterprise architecture. Finally comparison between these enterprise integration concepts from the point of green manufacturing and environmental engineering is including in section 5.

2 Integration of an Enterprise

Figure 1 shows three elements of an enterprise, which are tightly bound and related: product development, manufacturing (production), practice, experience in business.

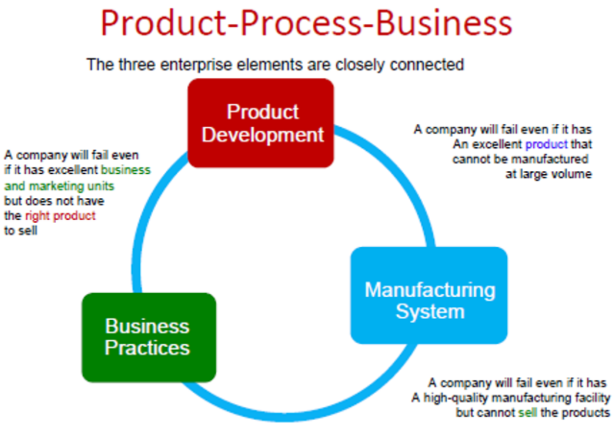


Fig. 1. The three closed connected enterprise elements, *Source: [15]*

An enterprise which cannot offer a superb, perfect product cannot start a mass production – in a large scale. On the other hand, if an enterprise does not administer a high quality manufacturing system, it will not be able to sell the product. Next, as a result the lack of business and marketing skills, an enterprise may not offer an appropriate product. Therefore, in order to succeed, a company must integrate three basic activities:

- creativity in inventing, creating and developing a product (Invent)
- making (Make)
- delivering, i.e. distributing, marketing and servicing (Deliver)

At present, there two main concepts that attempt to integrate an enterprise. Integration is imposed by contemporary market conditions. Their characteristic feature is the fact that there are no certain things: neither market expansion, nor the demand, neither the length of the production cycle, nor the pace of technological changes or the nature of competitiveness [12]. Such a situation creates a number of problems for a company, which need to be currently solved. Apart from integrating the basic activities of a company, there are many more: integration of markets, integration of development and manufacturing, integration of suppliers and manufacturers, integration of the designing and manufacturing phases, integration of equipment delivered by various suppliers, integration of software components and so on. Such a case is described as the necessity for enterprise integration. Thus, it is not only the question of connecting various physical and software applications, but also the requirement for total business integration, aimed at making use of the already-existing and new resources of an enterprise, so as to achieve business goals defined and coordinated by the company management. Enterprise integration consists in redefining a number of traditional notions, i.e. considering an enterprise as a complex set of business processes and a net of relations, that together form a system designed to suit the needs of a particular set of goals. At the moment, two comprehensive concepts of enterprise integration can be distinguished:

- PLM Product Lifecycle Management
- EA Enterprise Architecture

3 PLM – Product Lifecycle Management

In order to maintain competitive advantage in the changeable world economy, enterprises must be able to quickly develop new products and adjust their production potential and functionality to current market needs. Enterprises that manufacture goods of high complexity level (e.g. machine-building industry, automotive industry, aircraft industry) take advantage of Product Lifecycle Management concepts, so as to manufacture products competitively. Throughout the whole lifecycle of a product, i.e. from its initiation (idea of the product) till it is finished, the PLM approach offers methods of management and product development, information related to the product, including products management, manufacturing, marketing, order and supply processes – Figure 2 [17].

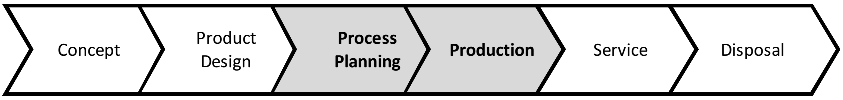


Fig. 2. Product Lifecycle Management concept

The term Product Lifecycle Management was introduced in the 1990s [14]. It is the effect of over 20-year-old evolution of technology and market. Engineering design was given a new shape due to the development of Computer Aided Design, which made it possible to create 3D geometric models of products. Recording a construction as an electronic digital database, led to a rapid increase in the number of data about the product. In order to fulfill the need for quick easy and safe access to these data, PDM Product Management Systems were developed. Initially, the systems focused on managing CAD files, and they were limited to the engineering aspect of a product. However, owing to increasing requirements and needs of the users, the systems began to expand. Applications concerning the product structure, changes control, configuration management, process management with use of duty diagrams, visual access to data and group work were created. Other systems began to cover growing areas of an enterprise activity. In the mid-1990s, new acronyms started to appear in order to name the concept: CPC – Collaborative Product Commerce, 3D-PLM – 3D Product Lifecycle Management, PKM – Product Knowledge Management. Finally, the term PLM – Product Lifecycle Management was established.

PLM is defined as a concept that integrates managing the information about the product throughout the whole lifecycle of a product [17]. Such an idea is possible owing to the latest achievements of Information and Communication Technology, and it is perceived as vital support to current needs in the process of introducing innovations at the lowest possible costs.

Figure 3 shows the vision of Product Lifecycle Management with an emphasized role of Information Technology [19].

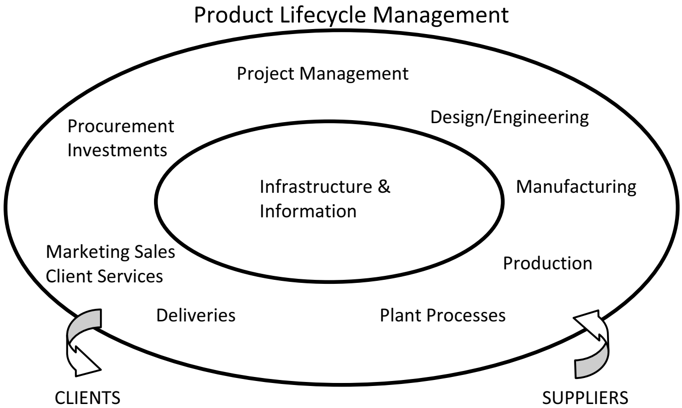


Fig. 3. Product Lifecycle Management vision

Figure 4 presents Product Lifecycle Management which takes into account the non-physical material flow [13]. The three main phases of the general model of a product lifecycle are taken into consideration:

- the initial phase including design and manufacturing (beginning of life)
- the middle phase including logistics (distribution), servicing and maintenance (middle of life)
- the final phase including reverse logistics, disassembly, renovation, re-use, recycling, removal (end of life)

The figure takes into detailed account the continuity of the processes of the product lifecycles.

A characteristic feature of PLM concept is the fact that it is focused on the product, contrary to other solutions used in an enterprise, i.e. SCM Supply Chain Management focusing on the chain, CRP Customer Relationship Management focusing on customers and consignees, and ERP Enterprise Resource Planning focusing on the best use of resources [14]. PLM emphasizes the management aspect while traditional CAx systems (CAD/CAPP/CAM/CAE) concentrated on the engineering aspect. The research [17] clearly defines the differences between CAD and PLM: the information which is generated by CAD systems is controlled by PLM systems. The PLM system does not include any features related to engineering works. PLM attempts to create the substance of the product, where the traditional CAx systems fail.

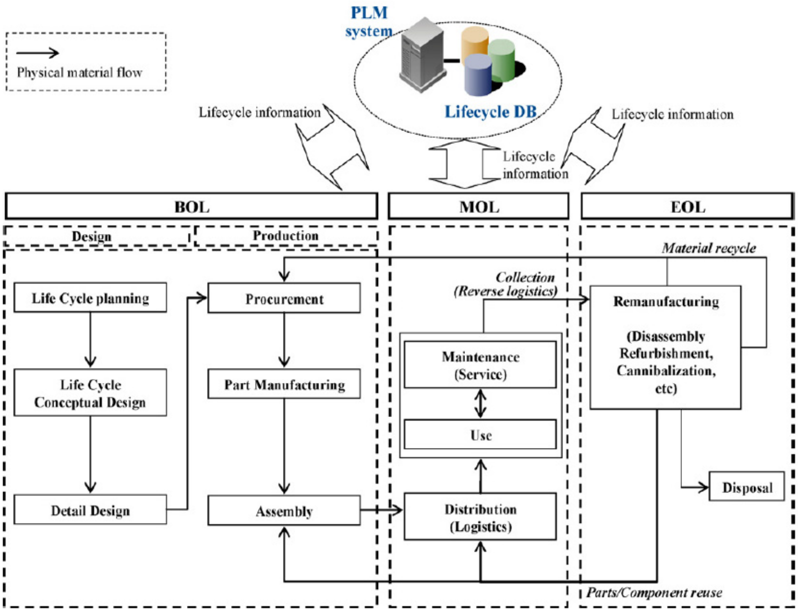


Fig. 4. Whole product lifecycle

A characteristic feature of PLM concept is the fact that it is focused on the product, contrary to other solutions used in an enterprise, i.e. SCM Supply Chain Management focusing on the chain, CRP Customer Relationship Management focusing on customers and consignees, and ERP Enterprise Resource Planning focusing on the best use of resources [14]. PLM emphasizes the management aspect while traditional CAx systems (CAD/CAPP/CAM/CAE) concentrated on the engineering aspect. The research [17] clearly defines the differences between CAD and PLM: the information which is generated by CAD systems is controlled by PLM systems. The PLM system does not include any features related to engineering works. PLM attempts to create the substance of the product, where the traditional CAx systems fail.

At the moment, in the market there are tools that support managing data, information and knowledge in the lifecycle of a product. The existing CAD programs are expanded by PLM functions concerning managing documentation, e.g. products made by Autodesk [23] or Geometric [24]. Also other tools support the modeling of a product, e.g. ENOVIA SmarTeam made by Dassault Systemes [25]. One of the most important companies in the market is Siemens, which offers an advanced PLM system [26]. In the company website, Siemens states the following: "Product Lifecycle Management facilitates such convergence, as in the past was foreshadowed by Enterprise Resource Planning ERP and Customer Relationship Management CRM. At the beginning of the 1990s, ERP solution made it possible to standardize financial, human resources, production and warehouse systems. Ten years later, CRM solution united the automation of a call center and running the sales, which made it possible to improve the servicing and contact with a customer (consignee). At the moment, Computer-Aided Design (CAD), Computer-Aided Manufacturing (CAM), Computer-Aided Engineering (CAE), Product Data Management (PDM) and Manufacturing Process Management (MPM) converge through PLM. PLM is unique from other enterprise software solutions because it drives top-line revenue from repeatable processes. By providing the application depth and breadth needed to digitally author, validate and manage the detailed product and process data, PLM supports continuous innovation." [27]

4 EA Enterprise Architecture

Integration of an enterprise consists in redefining a number of traditional notions, starting from defining an enterprise as a complex set of business processes and a net of relations between them, so that they create a system designed to suit the needs of a specific set of goals. The planning representation of the structure of such a set of processes, often shown as a block diagram, can be presented as a framework defined as enterprise integration reference architecture. Therefore, it is the framework that puts in order and organizes as a model all the concepts referring to the process approach in the realm of economic activity of an enterprise. Such a model, apart from identifying process in an enterprise, must include information concerning equipment, data, transfer of data, people involved and functions to be performed. Moreover, it must address the design activities and manufacturing processes, and represent the flow from the material to the product. Thus, it is necessary to provide an enterprise modeling language that is easy to understand for employees who are not information technologists; yet, the language must be sufficient to comprehensively model the industrial environment.

Table 2 includes the register of the most important architectures, their full names, websites of their authors and people working on particular architectures, and websites that provide the most complete information (information dated from July 2010).

Table 2. List of the most important architectures

Name	Full Name	WWW
ARIS	Architecture of Integrated Information Systems, Architektur Integrierter Informationssysteme	http://www.ids-scheer.pl
C4ISR	The C4ISR concept of Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance – obecnie Dodaf	http://www.lm-isgs.co.uk/defence/c4istar_overview.htm
CEAF	The Commission Enterprise IT Architecture Framework	http://ec.europa.eu/dgs/informatics/ecomm/doc/ceaf_guide_v1_1.pdf
CIMOSA	Open System Architecture for CIM	http://www.cimosa.de/
Dodaf	The Department Of Defence Architecture Framework	http://www.architectureframework.com/dodaf
DoD TRM	The Department Of Defence Technical Reference Model	http://www.defenselink.mil/cionii/docs/DOD_TRM_V0.4_10Aug.pdf
E2AF	Extended Enterprise Architecture Framework	http://ce.sharif.edu/~moshref/papers/e2af/e2af.pd

		f
EUP	Enterprise Unified Processing	http://www.enterpriseunifiedprocess.com/
FEA	Federal Enterprise Architecture	http://www.whitehouse.gov/omb/egov
GERAM	Generalized Reference Enterprise Architecture and Methodology	http://www.opengroup.org/architecture/ wp/saha/TOGAF_GERAM_Mapping.htm
GRAI	Graphs with Interrelied Results	http://www.gfi.fr/fr/8WW8/index.php
IAF	Integrated Architecture Framework	http://www.capgemini.com/services/soa/ ent_architecture/iaf/
IFEAD	Institute For Enterprise Architecture Developments	http://e2pm.info/ifead%20about.htm
ISO15704	Industrial automation systems – Requirements for enterprise-reference architectures and methodologies	http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=28777
ISO/IEC 14252	Information technology – Guide to the POSIX Open System Environment (OSE)	http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=23985
JTA	Joint Technical Architecture	http://aerodefense.ihs.com/products/ standards/military-specifications/ jta-standards.htm
OASIS	Organization for the Advancement of Structured Information Standards	http://www.oasis-open.org
PERA	Purdue Enterprise Reference Architecture	http://www.pera.net
PROSA	holonic reference architecture for manufacturing systems	http://www.mech.kuleuven.be/goa/prosa. htm
SAGA	Standards and Architectures for e-Goverment Applications	http://www.kbst.bund.de/saga
SCOR	Supply Chain Operations Reference	www.supply-chain.org
SOA	Service Oriented Architecture	www.serviceoriented.ws
TAFIM	Technical Architectural Framework for Information Management	http://www.sei.cmu.edu/str/descriptions/ tafim.html
TEAF	Treasury Enterprise Architecture	http://www.eaframeworks.com
TISAF	Treasury Information System Architecture Framework	http://www.eaframeworks.com
TOGAF	The Open Group Architecture Framework	http://www.opengroup.org/togaf/
XAF	extensible Architecture Framework	http://www.xaf.nl/
Zachman	Zachman Framework	www.zifa.com

The analysis of the architectures shown in the table leads to the conclusion that at the moment there are two predominant approaches. The first one is dominated by computer science, whose aim is to integrate an enterprise around information systems; here the staring point is IT service of business processes. The other approach aims at integrating an enterprise around business processes, i.e. manufacturing processes, production processes. The first approach is represented by such reference architectures as CEAF, Dodaf, FEA, TEAF, TOGAF. The best known architectures representing the other approach are Computer Integrated Manufacturing Open System Architecture – CIMOSA, within this architecture the name ‘Enterprise Architecture’ was used for the first time [1], PERA – Purdue Enterprise Reference Architecture [20], GRAI-GIM Integrated Methodology [6], Zachmann Framework [21] i ARIS [18].

There are numerous similarities between CIMOSA and ARIS architectures; they both represent process-oriented approach, pointed at modeling and monitoring the flow of activities. GRAI-GRIM architecture is based on GRAI decision-making model, in which integration is achieved by the coherence of global and local decisions. PERA and Zachman architectures do not introduce new formalisms as for modeling, but only provide complex definitions of patterns and templates, the framework of an architecture.

In the literature, CIMOSA, GRAI and PERA are considered the leading architectures that represent the three main approaches [9; 7]. However, in the present work, PERA architecture will no longer be considered since it does not introduce any new formalisms related to modeling.

4.1 CIMOSA

The acronym CIMOSA (Computer Integrated Manufacturing Open System Architecture) is the name of an open system architecture aimed at an enterprise integration. Originally, in the late 1980s, the architecture was created for CIM Computer Integrated Manufacturing, within a series of European projects ESPRIT: EP688, 5288 and 7110, supported by the European Commission. Over 30 European organizations, including industrial enterprises (British Aerospace, Daimler Benz, Fiat, Renault, Philips, Siemens), IT companies (IBM, DELL, Hewlett-Packard) and universities participated in designing and validating this architecture within independent accompanying projects VOICE, CIMPRES, CIMOSA-PES. Their main purpose was to develop methodology including:

- the language of enterprise modeling – EMF Enterprise Modeling Framework, which would precisely represent business operations, supporting their analysis and modeling, and facilitating the creating of executive models,
- integrated infrastructure for managing the model – IIS Integrating InfraStructue,
- methodology that would support the users in developing their CIM program throughout the whole lifecycle of a system – SLC System Life Cycle.

These purposes were achieved and compiled in the form of CIMOSA Formal Reference Base [8]. These concepts and ideas became the basis of standards for modeling and integrating an enterprise, i.e. CENTC 310 i ISO TC 184/SC5WG1 [4].

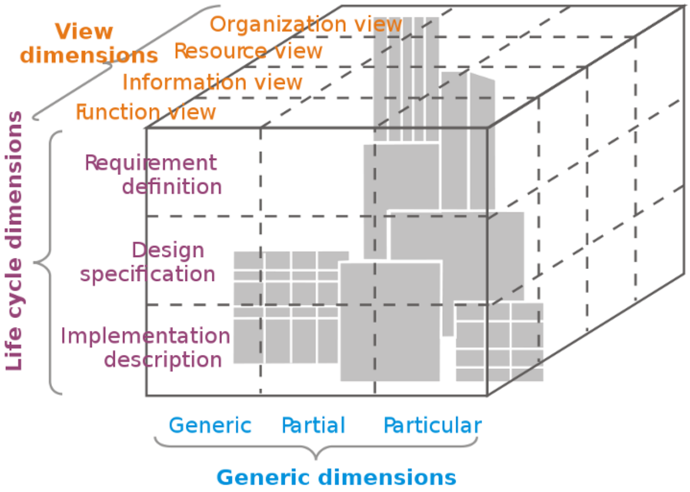


Fig. 4. CIMOSA Cube, *Source:[30]*

The basic structure used for modeling an enterprise is a molecular structure called CIMOSA cube (Figure 4). The cube has three dimensions:

- CIMOSA architecture levels (used to gradually specify the models) including general level, enabling the collection and compilation of general models, intermediate level used in industrial models, detailed level, used in detailed models of enterprises;
- CIMOSA modeling levels (used to gradually introduce the model) including: defining the requirements, model specification, implementation of the system description;
- CIMOSA intersections (used to gradually generate the models) including: functional, representing operations of an enterprise as a set of hierarchically structured processes; the process is defined by the events that bring it about, and by the results that arise from it, information, gathering all the information defined and incorporated in an enterprise; information is structured by hierarchically defined set of information classes; resources, including set of all information about resources of an enterprise, organizational, recording all information about formal organization of an enterprise.

A comprehensive overview of CIMOSA concept is shown in Figure 5.

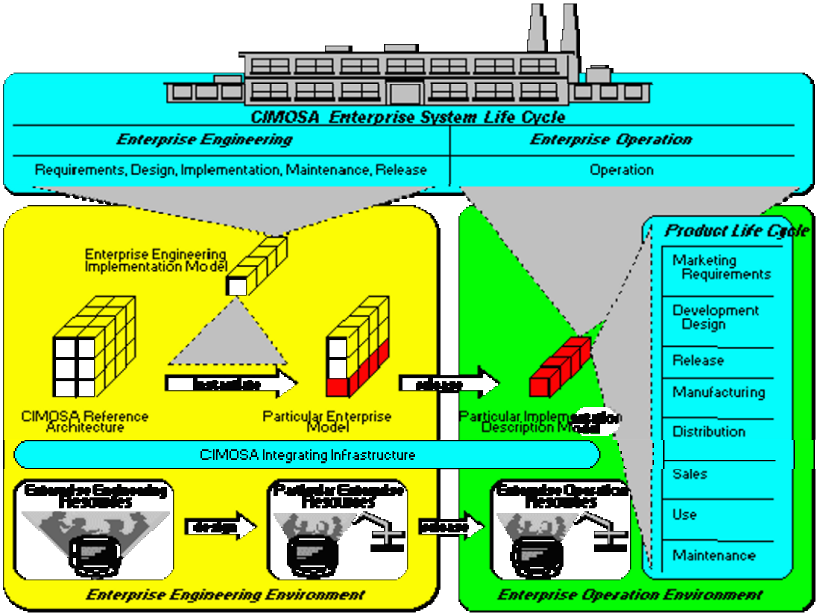


Fig. 5. The CIMOSA Enterprise System Life Cycle, *Source:[29]*

4.2 GRAI

Investigations conducted in LAP/GRAI laboratory at Bordeaux University led to defining the reference model GRAI, which generally describes the structure of manufacturing system and its control. The research works were carried out under the guidance of professor G. Doumeingts [5; 10; 11]. In the course of these investigations, graphical elements that represent the concept of the model were formally defined and a general, structural approach towards the implementation of the model was proposed. The effects of the research were implemented through European projects (ESPRIT and EUREKA) in such enterprises as FIAT, AEROSPATIALE, Lyonnaise des Eaux, SNACMA, DEC, Alcatel, Pirelli, Iberia, Elval and so on. The methodology has been constantly developing and at present it is called GIM Grai Integrated Methodology. It is based on the concept of GRAI model, its formal description and approach, and it consists of five basic domains (Figure 6):

- reorganization of an enterprise,
- IT solutions – selection, implementation, technology,
- productivity management,
- industrial strategies,
- knowledge management.

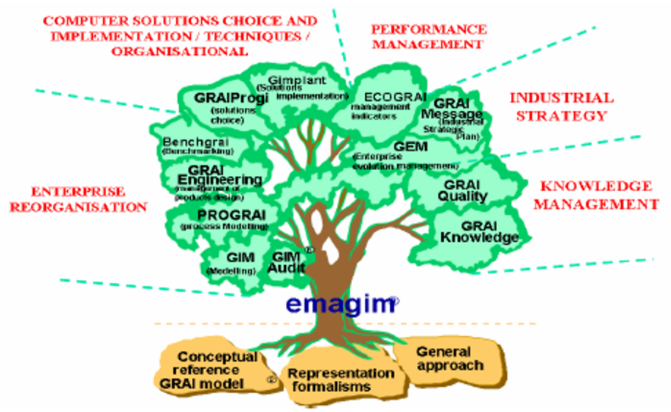


Fig. 6. The GRAI methodology tree, *Source: [9]*

GRAI model makes it possible to generally describe an enterprise. The comparison of GRAI modeling with BPM Business Process Modeling shows that BPM is a one-dimension modeling, while GRAI is multi-dimension modeling. Figure 7 shows a general GRAI model for the whole enterprise.

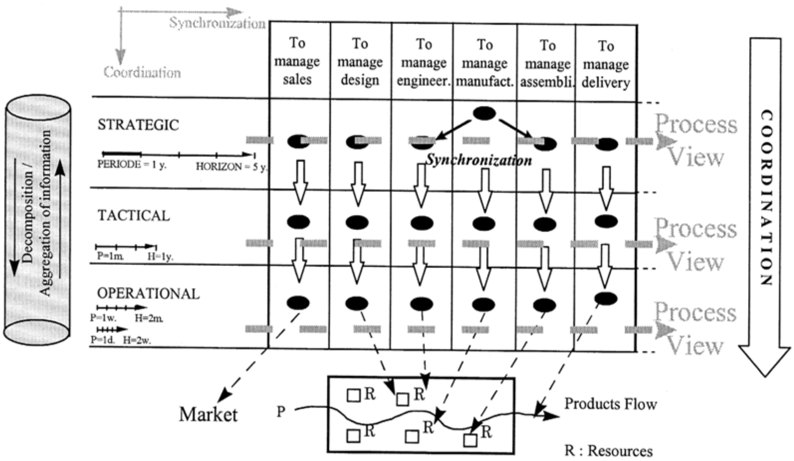


Fig. 7. The GRAI methodology tree

Since the decision-making system in an enterprise is very complex, GRAI model proposes decomposing it in order to make the modeling easier.

Two axes are defined in the model (Figure 7): vertical and horizontal.

Vertical axis related with the classic decomposition of a decision into three basic horizons:

- strategic – definition of goals in a long period of time

- tactical – decisions taking into account products and resources in a medium-term time horizon
- operational – decisions facilitating product transformation with use of resources in a short period of time.

For each level, time characteristics are determined as for the time horizon and its division into time intervals.

Horizontal axis is related with functional decomposition of a decision. GRAI takes into account six functions of an enterprise:

- sales management,
- design management,
- engineering management,
- manufacturing management,
- assembly management,
- supplies management.

The model can be expanded by other functions, depending on the type and character of an enterprise. GRAI model was developed in order to facilitate integration between decision-making levels and functions. The matrix structure makes it possible to coordinate functions (vertical direction) and processes (horizontal direction) through decision-making levels. Moreover, there is a strong relation between the decomposition of the physical system and the decision-making levels; each level controls a more or less aggregated part of the physical system. The conceptual decision-making center is defined as a point of intersection for the function and decision-making level. Such a model can be decomposed in more detail, taking into consideration GRAI recommendations as for synchronization. At each decision-making level, it is necessary to synchronize availability of the product and resources in order to improve the effectiveness of activities.

5 Conclusions

The research was done based on the literature reviews. The main conclusion is that presented concepts don't focus enough in green manufacturing and environmental engineering.

PLM - Product Lifecycle Management focus on product development but the core of interesting is the integration of management the information about the product throughout the whole lifecycle of a product using the latest achievements of Information and Communication Technology.

CIMOSA is a enterprise modeling framework, which aims to support the enterprise integration of machines, computers and people. The framework is based on the system life cycle concept, and offers a modelling language, methodology and supporting technology to support these goals. The original aim has been to elaborate an open system architecture for CIM and to define a set of concepts and rules to facilitate the building of future CIM systems.

GRAI is multi-dimension modeling and focus on decision process in classical six function (sales, design, engineering, manufacturing, assembly, supplies) of an enterprise in three main horizons – strategic, tactical and operational.

Based on literature review performed during our researches the three lifecycle approaches are selected and defined as the postulate to supplement and to extend presented enterprise integration concepts. [22]

The first one approach focus on product design – to design product for reuse. Designing product can be used in later generations of products. It means that a product is made with recycling capabilities in mind. Newer models can be created not by the creation of an entirely new product but by adding to the existing product, thus eliminating waste and unnecessary product costs.

The second approach involves a method for developing products so that they can easily be taken apart. When a product part is no longer functional, that one part can be removed and repaired, rather than needlessly replaced. Also, when the product has ceased to be useful, different parts of the product can be removed and either reused or recycled in the manner that is best fitting for that part of the product.

The third approach is to develop a method for developing products so that the parts can be used in different products. This can be accomplished in several ways. It is possible to save on efficiency when parts can cooperate with various products. For example, if one machine can create a part used in more than one product, then the plant is saving the expense and energy of having to have product specific machinery. This principle also applies to the time following the product's term of good use. The product can be returned and parts recreated from the original materials.

References

[1] AMICE [1993]: CIMOSA – Open System Architecture for CIM, 2nd edition, Springer-Verlag, Berlin

[2] AME [2007]: Green manufacturing: case studies in lean and sustainability, Productivity Press, 2007

[3] Atlas M., Florida R. [2001]: Green manufacturing, [in:] Dorf R.C. Technology, humans and society – Toward a sustainable world. Academic Press, USA

[4] Berio G., Vernadat F. [2001]: Enterprise modelling with CIMOSA: functional and organizational aspects, Productio Planning & Control, Vol. 12, No. 2, s. 128-136

[5] Bitton M., Doumeingts G., Marcotte F. [1993]: ECOGRAI: Method for design and implementation of performance measurement systems for industrial organization, working paper. GRAI Laboratory. Universite de Bordeaux.

[6] Chen D., Doumeingts G. [1996]: The GRAI-GIM reference model, architecture and methodology, in: P.Bernus, et al. (Eds.), Architectures for Enterprise Integration, Chapman & Hall, London

[7] Chen D., Doumeingts G., Vernadat F.B. [2008]: Architectures for enterprise integration and interoperability. Past, present and future. Computers in Industry 59 s.647-659

[8] CIMOSA Association [1996]: CIMOSA Formal Reference Base, Version 3.2. CIMOSA Association e.V., Germany.

[9] Dossou P.E., Mitchell P. [2008]: Supply Chain Management and Optimization – the impact of Enterprise Modelling. Proceedings FAIM. University of Skovde.
[10] Doumeingts G: [1984]: Methode GRAI: Methode de conception des systemes en productique, These d'etat, Automatique, Universite Bordeaux
[11] Durcos S., Doumeingts G., Akif J.C. [1993]: Standarization of the GRAI method. The TIME Project, Doc_id: GRA/WP2.T1/0/D/C/014. Bordeaux.
[12] Hammer M., Champy J. [1996]: Reengineering w przedsi biorstwie. Neumann Management Institute. Warszawa.
[13] Jun H.B., Kiritsis D., Xirouchakis P. [2007]: Research issues on closed-loop PLM Computers in Industry 58, s. 855–868
[14] Liu W., Zeng Y., Matlez M., and Brisson D. (2009), Product lifecycle management: a review,The 2009 ASME International Design Engineering Technical Conferences (IDETC) and Computers and Information in Engineering Conference, San Diego, August 30- September 2, 2009, DETC2009-86983.
[15] Pasek Z.J. [2010]: Reconfigurable Manufacturing, Lectures materials, Poznan
[16] Porter M.E., van der Linde C. [1995]:"Toward a New Conception of the Environment-Competitiveness Relationship", The Journal of Economic Perspectives 9, no. 4, Fall 1995.
[17] Saaksvuori A, Immonen A [2008] Product Lifecycle Management, 3rd ed.,Springer, Berlin Heidelberg New York
[18] Scheer A.W. [1994]: Business Process Engineering. Reference Models for Industrial Enterprises, 2nd edition, Springer-Verlag, Berlin.
[19] Siller H.R., Estruch A., Vila C., Abellan J.V., Romero F.[2008]: Modeling workflow activities for collaborative process planning with product lifecycle management tools Journal of Intelligent Manufacturing 19 s.689–700
[20] Williams T.J. [1994]: The Purdue Enterprise Reference Architecture, Computers in Industry, vol. 24 (no 2-3), s.141-158
[21] Zachman J. [2009]: The Zachman Framework: The Official Concise Definition. www.zachmaninternational.com (data dost pu: 14.02.2009)
[22] http://businessknowledgesource.com/manufacturing/saving_the_planet_with_green_manufacturing_030856.html#more
[23] www.autodesk.pl, 2010
[24] http://plm.geometricglobal.com/, 2010
[25] http://www.3ds.com/products/enovia, 2010
[26] http://www.plm.automation.siemens.com, 2010
[27] http://www.plm.automation.siemens.com/pl_pl/plm/definition/, 2010
[28] http://www.businessknowledgesource.com/manufacturing/taking_your_manufacturing_green_some_simple_steps_024179.html
[29] http://cimosa.cnt.pl/Docs/Primer/primer5.htm, 2010
[30] http://en.wikipedia.org/wiki/CIMOSA, 2010

“Green” possibilities of simulation software for production and logistics – a survey

Pawel Pawlewski[1], Jakub Borucki[1]

[1]Poznan University of Technology

pawel.pawlewski@put.poznan.pl, jakub.borucki@gmail.com

Abstract. The chapter presents the results of the author’s studies which consisted in software technologies for simulation in production and logistics. Green requirements for these technologies are defined. In first phase simulation techniques like spreadsheet, programming languages, programming libraries, specialist simulation software agent technologies are evaluated and compared. For next phase five specialist simulation packages were chosen and evaluated in details. From this list, one package was selected with built-in “green” functions. Example of using selected software package to investigate carbon dioxide emissions in factory which produce bottled milk and cheese was described.

Keywords: Manufacturing system, simulation techniques, logistics

1 Introduction

Today more companies are starting the initiative to go green and reduce their impact on the environment. Going green has become the newest item in the mission statement of several manufacturers and third party logistics companies. The main subject which dominate conversations between manufacturers and environmentalist is the controversy concerning global warming and manufacturing. In order to reduce waste, several manufacturers and third part logistics companies have begun going green. Organizations are under huge pressure to reduce their carbon emissions and save money by eliminating waste from their processes. The two sets of initiatives go hand-in- hand:

- the less energy you use and waste,
- the less energy you pay for.

The challenge lies in the ability to model processes to understand what energy is being used where, and for what, not in recognition of the need to reduce energy use for the sake of the planet and the balance sheet. The questions are: how can we cut energy costs without having an impact on customer service, profitability and competitiveness? Those questions are difficult to find full answers. But manufacturers and third party logistics companies are increasingly recognizing

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_52,

that they can use simulation and optimization techniques to model their use of, and investment in, energy supplies.

The pressure to reduce energy use in business stems from three main sources [23]:

- one regulatory,
- one fiscal,
- one simply relating to doing the right thing for the environment.

In many ways, understanding energy use in industry is the same as in the home or office. Attitudes of the companies and consumers have changed over time. Now they recognize the need to reduce energy use in order to slow climate change and save money. But achieving these goals are very difficult because organizations haven't the tools that enable adding energy analysis on top of other process rules and calculations. Organizations must invest in technology to see easy the effects on energy use of manufacturing and supply chain changes. But these problems are traditionally classified as 'too difficult' or 'too expensive'. Simulation techniques especially Visual Interactive Simulation (VIS) [11] help to work with these highly complex scenarios and calculations. Simulation software supports choices and decisions between different options. Understanding the true cost of energy is not typically an intuitive process. The questions are: What happens to our energy costs if we make or deliver a particular product once a day or every half an hour? What impact will sourcing subproducts locally have on our fuel bill? Simulation technology can help to find answers using graphical representation of the impact of different choices on energy use. As green requirements for simulation can be defined the ability to model, track and even optimize the use of resources and materials consumed in the process modeled. This is in addition to the normal improving of efficiency, service and levels of production.

This chapter is organized as follow: in section 2 the simulation techniques like spreadsheets, programming languages, programming libraries, specialist simulation software, multi-agent technologies are described. Section 3 presents selected simulation software packages: Anylogic, ExtendSim, Arena, Witness, Quest; and their "green" features. Example of using one selected simulator in green implementation is including in section 4.

2 Simulation software techniques

Full overview of features of all types simulation contains paper of Ricky G. Ingalls [12]. Researchers work on expanding the use of simulation upon new problem categories [7]. The question is why it is so. As a matter of fact, simulation is based on modelling the reality. In his classic work, J. Forester [9] presented the classification of models used in the management and economical sciences. Forester noticed that most of the models used in the discussed area, were stable-steady state models. The models of stable-steady state category can be successfully used for describing certain management problems, i.e. mainly layout planning and modelling problems and, to a wider extent, problems of changes in an organization [5]. This section discusses the possible uses of process simulation software techniques. The main questions are:

- What types of software can be used for developing simulation models?
- What specific packages are available?
- How can an appropriate package be selected?
- Which “Green possibilities” are available?

For discusses following simulation software techniques were selected:

- Spreadsheet,
- Programming languages,
- Programming Libraries,
- Specialist Simulation Software,
- Multi-agent Technologies.

A spreadsheet is a computer application that displays multiple cells that together make up a grid consisting of rows and columns, each cell containing either alphanumeric text or numeric values. Spreadsheets are frequently used for financial information because of their ability to re-calculate the entire sheet automatically after a change to a single cell is made. The most prevalent spreadsheet today is Microsoft Excel, which is part of Microsoft Office. Most other spreadsheets operate similarly and have similar features as Excel [18]. “Spreadsheet simulation” refers to the use of a spreadsheet as a computer platform for representing simulation models and performing simulation experiments. Spreadsheet simulation simply involves the use of a spreadsheet to represent the model, do the sampling, perform the model computations and report the results.

Today many languages are offered on the market [10]. For discrete event simulation are: AutoMod, eM-Plant, Arena, GASP, GPSS, Plant Simulation, SimPLE++, SimPy - an open-source package based on Python, SIMSCRIPT II.5 - a well established commercial compiler, Simula, Poses++ - a discrete-event simulation system with Petri net based modeling [22]. Hybrid solutions, which combines continuous and discrete events capability are: AMESim - simulation platform to model and analyze multi-domain systems and predict their performances [21]; AnyLogic - multi-method simulation tool, which supports System dynamics, Discrete event simulation, Agent-based modeling; Modelica, open-standard object-oriented language for modeling of complex physical systems; EcosimPro Language (EL) - Continuous modeling with discrete events; Saber-Simulator - Continuous and discrete event capability. It simulates physical effects in different engineering domains (hydraulic, electronic, mechanical, thermal, etc.); Simulink - Continuous and discrete event capability; XMLlab - simulations with XML; Flexsim 4.0 powerful interactive software for discrete event and continuous flow simulation; Simio software for discrete event, continuous, and agent-based simulation. Standard programming languages like Visual Basic, C++ and Java are to used in simulation works.

Programming libraries in Java form new class of simulation software. Operating system independence, opening for network and internet cause that Java stands one of most popular and most important computer languages. Following three libraries are available for use (free access):

- DESMO-J - this simulation framework has been under active development at the University of Hamburg for many years [16, 17]. DESMO-J is based on Java. The acronym "DESMO-J" stands for "Discrete-Event Simulation and Modelling in Java". DESMO-J is public domain software and licensed under the APACHE public license. The internet platform for DESMO-J is www.desmoj.de.

- JiST, - The JiST is a high-performance discrete event simulation engine that runs over a standard Java virtual machine. This software is developped by Cornell Research Foundation – authors are: Rimon Barr, Prof. Zygmunt J. Haas, Dr. Robbert van Renesse [1]. This work has been supported in part by the DoD Multidisciplinary University Research Initiative (MURI) program administered by the Office of Naval Research and by the Air Force Office of Scientific Research. The acronym Jist stands for "Java In Simulation Time. The internet platform for JiST is http://jist.ece.cornell.edu.
- SIMKIT. The SimKit is a software package written too in the Java. SimKit is copyright under the GNU Public License. SimKit is Open Source Package, and may be downloaded from the internet at <http://diana.gl.nps.navy.mil/Simkit/>. Simkit is a programming toolkit that supports this kind of component-based modeling. In its current form, the simulation modeler interacts with Simkit at the Application Programmer Interface (API) level, in contrast to commercial Graphical User Interface (GUI) environments. A GUI for more intuitive model building in Simkit is currently under development. Simkit create simulation using a component framework. The component framework is based on a listener design pattern especially useful for simulation models. The objects created are called Listener Event Graph Objects, so the component framework is called LEGO [3].

On the market are available many specialist simulation software packages. Two broad types of specialist simulation package are identify [15].

- General purpose simulation package – are intended for use on a wide range of applications, albeit they might have special features for some applications,
- Application orientated simulation packages are focused on specific applications, for instance, medical, production scheduling or call centers. A more focused package tends to be easier to use, possibly only requiring the entry of relevant data, but it obviously has a much narrower range of application.

The majority of specialist packages enable a simulation to be built as well as run in a visual and interactive manner. The software provides a predefined set of objects and the user selects required objects from the menu. The logic of the model is built as process flow between simulation objects. For more complex logic the packages enable their own internal language, so the modeler requires little in the way of programming skills.

During the projects performed last years in the Department of Management Engineering Poznan University of Technology, the list of specialist simulation software was formed and now this list is preparing for web presentation. Characteristics of these packages including data about suppliers, documentation and demonstration version availability will be described. Table 1 presents list of specialist simulation software with suppliers and their actual (December 2010) www addresses.

Table 1. List of Specialist Simulation Software

Software	Supplier
ExtendSim AT	Imagine That Inc. (USA) www.extendsim.com
The Decision Tools Suite	Palisade Corporation (USA) www.palisade.com
Anylogic	XJ Technologies (Russia) www.xjtek.com
Witness	Lanner Group Limited (England) www.lanner.com
ShowFlow2	Incontrol Simulation Product Software BV (England) www.showflow.com
AutoMod	Applied Materials (USA) http://appliedmaterials.com/products/automod_2.html
Bluesss Simulation Software	Raczynski Consulting (Poland/Mexico) www.raczynski.com
Enterprise Dynamics	Incontrol Enterprise Dynamics Inc. (Holand) www.enterprisedynamics.com
Micro Saint Sharp	Alion MA&D Operation (USA) www.alionscience.com
Portfolio Simulator	ProModel Corporation (USA) www.promodel.com
eM-Plant	Tecnomatix (Germany) www.ugs.com
Vanguard System	Vanguard Software Corporation (USA) www.vanguardsw.com
AutoShed AP	Brooks Automation (USA) http://www.automod.de/autosched-ap.html
Flexsim Software	Canyon Technology Center Park (USA) www.flexsim.com
Simcad Pro	Createasoft (USA) www.createasoft.com
Crystal Ball Professional	Oracle Crystal Ball Global Business Unit (USA) www.decisioneering.com
ExpertFit	Averill M. Law & Associates (USA) www.averill-law.com
L-Sim	Lanner Group Limited (England) www.lanner.com
Lean Modeller	Manufacturing Resources Group of Companies (Canada) www.mrgc.org
SAIL	CMS Research Inc. (USA) www.cmsres.com
ProModel	ProModel Corporation (USA) www.promodel.com
Analytica	Lumina Decisions System (USA) www.lumina.com
MAST	CMSResearch (USA) www.cmsres.com
Arena	Rockwell Automation (USA) www.arenasimulation.com
Simul8	Simul8 Corporation (USA) www.simul8.com

Multi-agent technologies are represented by NetLogo na Jade.

The NetLogo was designed and authored by Uri Wilensky [20], director of Northwestern University's Center for Connected Learning and Computer-Based Modeling. Development has been funded by the National Science Foundation and other foundations. NetLogo was designed in the spirit of the Logo programming language to be "low threshold and no ceiling," that is to enable easy entry by novices and yet meet the needs of high powered users. The NetLogo environment enables exploration of emergent phenomena. It comes with an extensive models library including models in a variety of domains such as economics, biology, physics, chemistry, psychology and many other natural and social sciences. Beyond exploration, NetLogo enables the quick and easy authoring of models. It is particularly well suited for modeling complex systems developing over time

[13]. Modelers can give instructions to hundreds or thousands of independent "agents" all operating concurrently. This makes it possible to explore the connection between the micro-level behavior of individuals and the macro-level patterns that emerge from the interaction of many individuals. NetLogo has many thousands of active users. It is freely available from the NetLogo website - http://ccl.northwestern.edu/netlogo/. NetLogo is in use in a wide variety of educational contexts from elementary school to graduate school. Many teachers make use of NetLogo in their curricula. NetLogo comes bundled with a large library of sample models covering many domains in natural and social science [17].

JADE (Java Agent Development Framework) is a software Framework fully implemented in Java language [19]. JADE is free software and is distributed by Telecom Italia, the copyright holder, in open source software under the terms of the LGPL (Lesser General Public License Version 2). Since May 2003, a JADE Board has been created that supervisions the management of the JADE Project. Currently the JADE Board lists 5members: Telecom Italia, Motorola, Whitestein Technologies AG, Profactor GmbH, and France Telecom R&D. The internet platform for JADE is http://jade.tilab.com. JADE simplifies the implementation of multi-agent systems through a middle-ware that complies with the FIPA specifications and through a set of graphical tools that supports the debugging and deployment phases [2]. The acronym FIPA stands for “The Foundation for Intelligent Physical Agents”. The internet platform for FIPA is www.fipa.org. The FIPA mission is The promotion of technologies and interoperability specifications that facilitate the end-to-end interworking of intelligent agent systems in modern commercial and industrial settings. The main goal of JADE is to simplify development while ensuring standard compliance through a comprehensive set of system services and agents. JADE can then be considered an agent middle-ware that implements an Agent Platform and a development framework. It deals with all those aspects that are not peculiar of the agent internals and that are independent of the applications, such as message transport, encoding and parsing, or agent life-cycle. The latest version of JADE is JADE 4.0.1 released on 7 July 2010.

The final comparison presented in table 2, bases on extended features presented in [8]:

- A. Range of application,
- B. Modeling flexibility,
- C. Duration of model building,
- D. Ease of use,
- E. Ease of model validation,
- F. Run speed,
- G. Time to obtain software skills,
- H. Price,
- I. Support.
- J. Built-in “green” functions

As built-in "green functions" we understand these functions which can factor in the cost of electricity, oil gas or other energy sources into scenarios and adjust calculations for the optimum outcome.

Table 2. A comparison of spreadsheets, programming languages, programming libraries, specialist simulation software, multi-agents tecfhnologies for process simulation modeling [8].

Feature	Spreadsheet	Programming language	Programming Library	Specialist simulation software	Multi-agent technologies
A	Low	High	Medium	Medium	Low
B	Low	High	Medium	Medium	Medium
C	Medium	Long	Short	Short	Medium
D	Medium	Low	Medium	High	Medium
E	Medium	Low	Medium	High	Medium
F	Low	High	High	Medium	Medium
G	Short (medium for macro use)	Long	Medium	Medium	Medium
H	Low	Low	Low	High	Low
I	Low	Low	Medium	High	Medium
J	Low	Low	Low	Medium/High	Low

Now only some specialist simulation packages offer possibilities to use built-in "green" functions. If manufacturers and third party logistics companies want to use other software techniques, they must invest in programming works to prepare these functions according to their requirements.

3 Specialist simulation software

Based on the list of simulation software presented in table 1 and on authors impressions and experiences from the premier international forum for disseminating recent advances in the field of system simulation – Winter Simulation Conference 2010, five simulators was selected for "green" evaluation:

- Anylogic,
- ExtendSim,
- Arena,
- Witness,
- Quest.

AnyLogic is a simulator that has its roots in Agent Based Simulation. It is product from XJ Technologies (www.xjtek.com). In the past few years they have tried to widen the appeal by including in the same structure Discrete event and Continuous Simulation. A key point about AnyLogic is that the platform for the simulation is Java. This makes it possible to take any model and export it as a Java applet which will run on a web page. However the interlinking of the different model types, etc and some of the interface look a lot like programming – not easy for non coders. The model needs compiling before it will run which for large models can take a significant time. New 3D module shown at WinterSim – looks limited being in Java – loaded as a control on the simulation view with very simple graphics – but again is portable to the applet being in Java.

ExtendSim is a low cost, low level, very visual product from Imagine That Inc. based in the US [6]. The basic modelling approach is block diagram – i.e. like process modelling in Visio or suchlike. More logic is visible on screen than in other systems as you need a block to add logic, distributions, etc. This makes it friendly at first. The sheer quantity of blocks on the screen is a major weakness with larger models due to the cluttered displays. When areas of blocks are collapsed into modules then the user has to navigate several levels to see logic – again this is cumbersome. Models are fairly easy to construct with lots of mouse input. The 3D view has some nice touches – such as footprint trails but is essentially very cartoony. Still makes simple models look complicated as many blocks needed on screen.

Arena is a simulator from Rockwell Automation. It has a strong and well respected link to the 1970's simulation programming language Siman. It's continued link to that code makes it somewhat unwieldy as it still generates Siman code as an intermediate step before running a model although this is largely hidden from the user now. This does make the package less interactive than other simulators. Arena has only push – difficult to effect pull logic. Lack of name change cascading – change a name and you need to chance all references. Arena is now owned by Rockwell – this is visible in their recent developments which have entirely focused on factory planning and integration with the Rockwell database and the support of other planning tools in the Rockwell family [14]. The basic Block diagramming approach is a bit like process modelling (say in Visio). This is fine but then all layout has to be done in addition – time consuming. A great strength of Arena is university teaching and use – especially US – very widespread.

Witness is the product from Lanner Group. The range and capability of elements in Witness is unparalleled. Using the correct construct for the correct model leads to quick effective modelling. The richness of functionality within the basic element types gives the modeler professional flexibility through direct specification of complex constructs such as multi-cycle activities (machines), specialized power and free elements, supplied process modules, tracks and vehicles, fluids, arrival profiles, and much, much more. Witness rules offer the most powerful options in simulation systems today – in addition to Push, Pull , Least, Most, Percent, Sequence, etc. Witness has more powerful options such as nested If rules and Match options. Witness is one of the few simulation products to offer truly powerful hierarchical modelling. Through unlimited levels of module structure the modeler has the speed and power of being able to clone and reuse whole sections of previous models. Witness is very easy to use. The method of modelling is straightforward and easy to learn – select and place elements/modules from the wide range supplied. Witness offers the widest range of data linkage – Direct links to Excel and any OLE DB database (ORACLE, SQL Server, Access, etc.), CAD systems, Process Mapping systems, XML save formats and more. Also a wide range of picture and video display formats and is one of the few products to offer integrated recording of the model to video. Witness offers

2D and 3D modelling. Witness incorporates unique optimization technology. The Witness optimizer offers an easy to use interface to specify experiments and algorithms developed by world leaders in optimization technology.

Delmia/Quest is a product almost entirely focused on manufacturing from Dassault [4]. Users create 3D worlds directly from libraries of specific manufacturing components. The physical nature of their direct modelling in 3D lends their models greater accuracy and in some ways smoother and easier VR than is possible with other simulators. However the physical detail also makes the modelling take longer (much longer) and the code to introduce logic into a model is much more complicated than in for example Witness. Delmia offers a suite of other modelling tools that embrace areas such as Ergonomic modelling and Robotics – this offers manufacturers a unified marketing suite of modelling products. Quest is disappearing inside the whole Delmia suite with little emphasis or development momentum. Their main strength is the integration within the suite and will usually be sold as part of a much larger deal. DELMIA did not exhibit or present at WinterSim 2010.

In tables 3,4,5 and 6 comparisons based on selected criteria are presented

Now only Witness package offers possibilities to use built-in "green" functions. For other software packages , investing in programming works to prepare these functions according to requirements is necessary.

Table 3. A comparison of specialist simulation software – general criteria

	Software	AnyLogic	ExtendSim	Arena	Witness	Quest
1.	Costs calculations	*	*	*	*	*
2.	OS Windows	*	*	*	*	*
3.	OS Unix/Linux	*				*
4.	OS Apple	*	*			

Table 4. A comparison of specialist simulation software – analysis/simulation criteria

	Software	AnyLogic	ExtendSim	Arena	Witness	Quest
1.	Experiment planning	*	*	*	*	*
2.	Animation (2D/3D)	*	*	*	*	*
3.	All-purpose	*			*	
4.	Manufacturing	*	*	*	*	*
5.	Procurement	*	*	*	*	*
6.	Material management	*	*	*	*	*
7.	Warehousing	*	*	*	*	*
8.	Distribution	*	*	*	*	*

Table 5. A comparison of specialist simulation software – modeling criteria

	Software	AnyLogic	ExtendSim	Arena	Witness	Quest
1.	Graphics model building	*	*	*	*	*
2.	Programming model building	*		*		
3.	Nonlimited model size	*	*	*	*	*
4.	Programming possibilities	*	*	*	*	*
5.	CAD files import	*	*	*	*	*
6.	Optimizer	*	*	*	*	*
7.	Wizzards	*	*	*	*	*
8.	Interactive debugging	*	*	*	*	*

Table 6. A comparison of specialist simulation software – analysis/simulation criteria

	Software	AnyLogic	ExtendSim	Arena	Witness	Quest
1.	Programming	*	*	*	*	*
2.	Built-in				*	

4 "Green Simulation" example

A model created in Witness software shows working of a small factory which produce bottled milk and cheese. The milk is delivered by a tanker with a capacity of 24 tons from several farmers. In one cycle of delivery the lorry covers a distance about 100 km. A row milk is stored in cooled tank, then is pasteurized and stored in a refrigerator. From there it is charged by the production lines of cheese and bottled milk. Finished products are packaged and delivered to two magazines. At the end of the process is the recipient, who collects the finished products at regular intervals. Whole process is presented in Fig. 1.

In the model, energy resources are worn : fuel, electricity and natural gas. Their use generates carbon dioxide emissions (carbon footprint). Deliveries can be made often and in small batches. Then the truck burns more fuel, but requires less energy to store milk. On the other hand, the supplier can realize a large supply, burning less fuel, but the milk must spend more time in the refrigerator, and electricity consumption increases.

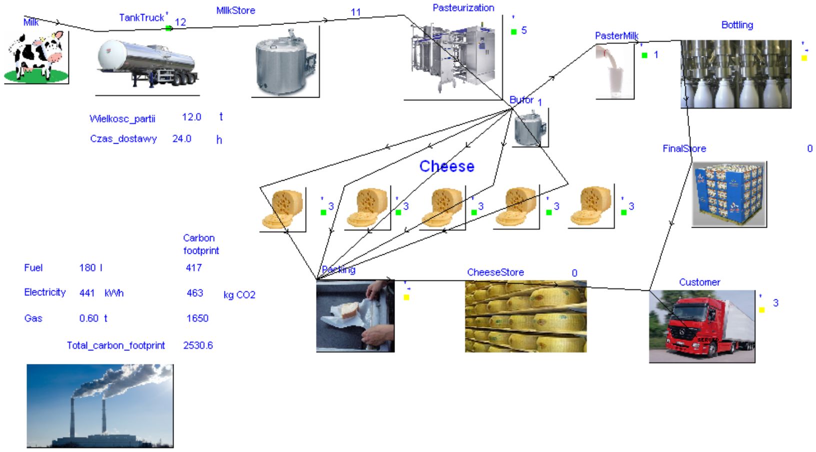


Fig.1. Full process of milk and cheese production

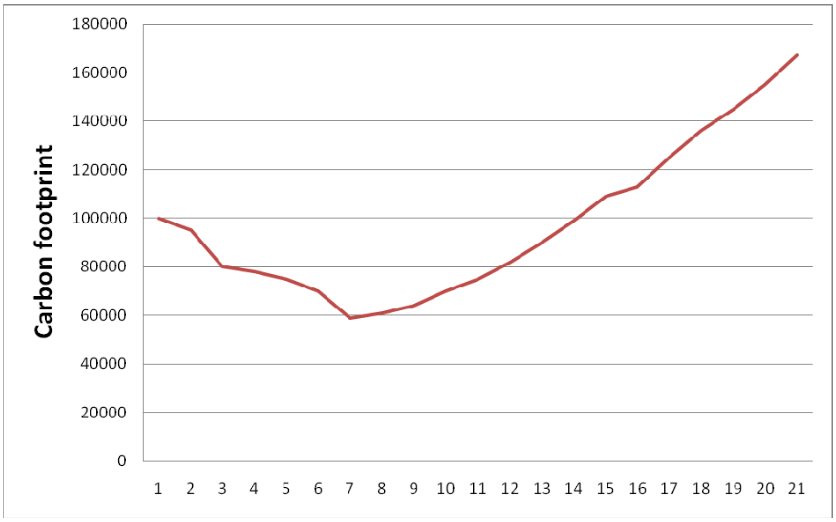


Fig.2 Carbon footprint (kg CO2) graph in dependence of delivery volume (t milk)

Optimization consists of choosing the size of such a supply to the carbon footprint as small as possible. On the basis of optimizing, we have matched the delivery volume at the level of 11 tones of milk. The carbon footprint is the smallest and then at 61 tones of CO2 over 1,000 hours during the simulation (about 3 months working creamery) – figure 2.

5 Conclusions

In the present chapter, the author presents the survey concerning software techniques for “green” simulation. Based on our researches software package Witness was selected for experiments. The main reason for this choice was fact that it was only one software package with some built-in “green” functions. The experiment was performed using data from milk and cheese factory. Building the process and using “green” possibilities were very easy to do. We can define which measures we will wish to focus on. From carbon to water, from electricity to oil, all measures that we can wish to model can be defined in the Costing and Sustainability definition tab located in the Model/Options menu dialog – Fig.3.

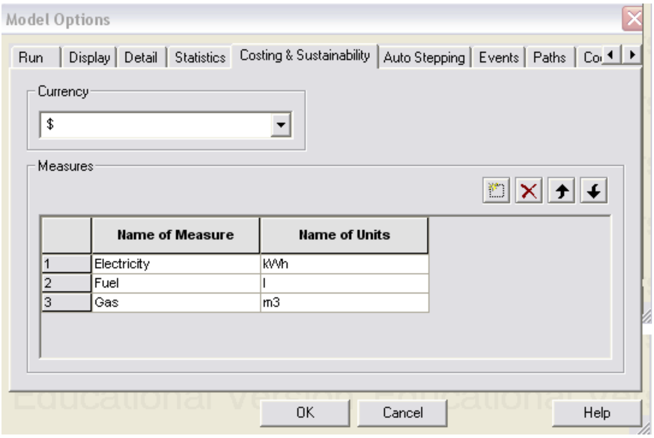


Fig.3. Model/Options menu dialog for selection measures in Witness

We select the units too for each measure. These can be the full words or typical abbreviations such as kWh for kilowatt hours. The unit definitions are the measuring units that should be used throughout the model and also form the display for the standard sustainability reports.

References

[1] Barr R., Haas Z.J., van Renesse R. (2005) JiST: An efficient approach to simulation using virtual machines. Software Practice & Experience, 35(6): 539-576, May 2005.

[2] Bellifemine F., Caire G., Greenwood D. (2007) Developing Multi-Agent Systems With Jade, John Wiley & Sons Ltd.,

[3] Buss A. (2002) Component based simulation based on SimKit. Proceedings of the 2002 Winter Simulation Conference E. Yücesan, C.-H. Chen, J. L. Snowdon, and J. M. Charnes, eds.

[4] Bzymek Z., Nunez M., Li M., Powers S. (2008) Simulation of a Machining Sequence Using Delmia/Quest SoftwareComputer-Aided Design & Applications, 5(1-4), 2008, 401-411

[5] Ciszak O. (2007) Komputerowo Wspomagane Modelowanie I Symulacja Procesów Produkcyjnych, Zeszyty Naulowe Politechniki Pozna skiej, nr 6, Budowa I Zarz dzanie Produkcj

[6] Diamond B., Krahl D., Nastasi A., Tag P. (2010) ExtendSim Advanced Technology: Integrated Simulation Database. Proceedings of the 2010 Winter Simulation Conference (B. Johansson, S. Jain, J. Montoya-Torres, J. Hugan, and E. Yücesan, eds.)

[7] Farr, R. Tannock, J. Holm, S. (2007) Parametric Factory Simulation for the Responsive Enterprise. In Proceedings of International Conference On Responsive Manufacturing ICRM,

[8] Fertsch M., Pawlewski P. (2009) Comparison of Process Simulation Software Technics, in: (eds.:Fertsch M.,Grzybowska K., Stachowiak A.) Modelling of modern enterprises logistics. Publishing House of Poznan University of Technology

[9] Forrester J.W. (1965) Industrial Dynamics, The MIT Press, Cambridge, Massahuttes.

[10] Gilbert N., Troitzsch K.G. (2005) Simulation for the social scientist, Open University Press, McGraw-Hill Educatiuon,

[11] Hurrion R.D. (1978) An Investigation of Visual Interactive Simulation methods Using the Job-shop Scheduling Problem. The Journal of the Operational Research Society © 1978 Operational Research Society vol.29 pp1085-1093

[12] Ingalls, R.G. (2008) Introduction to simulation. In Proceedings of the 2008 Winter Simulation Conference, ed. S. J. Mason, R. R. Hill, L. Monch, O. Rose, T. Jefferson and J. W. Fowler, Institute of Electrical and Electronics Engineers, Inc.

[13] Kawa A. (2008) Simulation of Dynamic Supply Chain Configuration Based on Software Agenss and Graph Theory, Distributed Computing, Artificial Intelligence, Bioinformatics, Soft Computing, and Ambient Assisted Living. Sigeru Omatu et al. (Eds) LNCS 5518 Springer

[14] Kuhl M.E., Zhou X. (2009) Sustainability Toolkit for Simulation-Based Logistics Decisions. Proceedings of the 2009 Winter Simulation Conference M. D. Rossetti, R. R. Hill, B. Johansson, A. Dunkin and R. G. Ingalls, eds.

[15] Law A.M., Kelton W.D. (2000) Simulation Modeling and Analysis. McGraw-Hill, New York,

[16] Page B., Kreutzer W. (2005) The Java Simulation Handbook. Simulating Discrete Event Systems with UML and Java. Shaker Publ., Aachen, Germany

[17] Page B., Neufeld E. (2003) Extending an object oriented Discrete Event Simulation Framework in Java for Habour Logistics. International Workshop on Habour, Maritime & Multimodal Logistics Modelling and Simulation – HMS 2003, Riga, Latvia, Sept. pp. 79-85.

[18] Pichitlamken J., Kajkamhaeng S., Uthayopas P. (2008) High Performance Spreadsheet Simulation On A Desktop Grid, Proceedings of the 2008 Winter Simulation Conference, S. J. Mason, R. R. Hill, L. Mönch, O. Rose, T. Jefferson, J. W. Fowler eds.

[19] Vrba P. (2003) JAVA-Based Agent Platform Evaluation, Holonic and Multi-Agent Systems for manufacturing, Marik V., McFarlane D., Valckenaers P. (Eds) Proceedings HoloMAS 2003 Prague, Czech Republic

[20] Wilensky, U. (1999) NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.

[21] http://www.amesim.com/ (2010)
[22] http://www.gpc.de (2010)
[23] www.lanner.com/en/pdf/sustainable_supply_chains.pdf (2010)

Balance index, balance analysis and IT tools supporting environmental decisions making

Marek Fertsch[1]

[1]Poznan University of Technology

marek.fertsch@put.poznan.pl

Abstract. The following chapter is to present the framework of environmental decisions making in micro and medium scale with IT system providing information necessary for efficient decisions making. The system is based on the idea of balance index and eco balance. Basic terms, assumptions and working scheme are presented in the chapters of the hereby paper.

Keywords: environmental decision making, environmental conscious management, operations management, production

1 Basic terms

The term crucial for the issues discussed in the following paper is the idea of balance. Balance is defined as a dynamic state. It is the relation between the system representing natural environment and the sub-system identified as it part for analytical purposes. Both systems interact and influence each other by products generated and exchanged partially intentionally and partially spontaneous as the systems are neighbors, and more exactly the one identified is a part of the larger one. The lemma taken in the following paper is the thesis that the perfect state, state which should be striven for, is when interactions between systems are balanced. It is based in the assumption that presently, closed and isolated systems in micro or medium scale, cannot be identified, as all the systems influence their neighbors. Interactions between environment and the system identified for the analytical purposes are continuous, but their intensity differs in time. If the time period is identified strictly, f.ex. a year, the interactions can be identified directly as well, summed up and compared. The result of such comparison can be used to assess what is the difference (variation) between the assumed perfect state (balance state) and actual status of the system and to identify some corrective actions. Comparing interactions between environment and the system identified within it is to be called balance analysis and its numerical value is to be referred to as balance index. Conclusion and actions taken after results of balance analysis is to be called environmental decision. The IT system facilitating the analysis and providing information required when ma king decision is to be called IT system for balance analysis.

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_53,

2 Balance analysis

To perform balance analysis, it is necessary to:
- Identify interactions between the system analyzed and its environment,
- Define period of time the analysis is to be performed for,
- Identify size of interactions flows within the period identified.

To perform analysis it is necessary to classify the identified interactions. The criteria to be used are character of interactions and classification leads to dividing the interactions into two basic groups, namely:
- Energetic interactions – electric power, heating power and other useful forms of energy,
- Material interactions – raw materials and processed products.

Material interactions can be classified with their use as a criteria, which leads to identification of the following categories:
- Energetic resources,
- Materials to be processed or improved (the category especially important for industrial objects analysis),
- Raw material and materials consumed by the system identified (f.ex. water used in industrial processes, consumption and for sanitary purposes, food etc.).

Material interactions can also be classified with their character, resulting in identification of the following groups:
- Consumer goods, useful or necessary for successful system functioning,
- Waste.

It also important to remember about possible change of character of goods which may occur at the time of their exchange between environment and the system identified. Material goods, which in one system are wastes, in the other can be consumer goods. In detailed analysis, not only amount of waste is important, but also their form (solid waste or liquid waste), raw material they are made of (paper, metal, ceramics) and their size.

3 Balance index

Balance index is numeric value, result of the balance analysis. It includes the following elements:
- General part, which is compiled summary of interactions between environment and the system identified for analytical purposes,
- Detailed part including results of balance referred to identified interactions.

General part can be identified with the formula defined below:

$$R = (O - O_n) / O \tag{1}$$

where:
R – balance index, R Є {-1,1},

O – general number of interactions between environment and the system, disregarding character of these interactions.
O_n – number of negative interactions between the systems and its environment (negative influence of the system on the environment).
The expected value of the index is 1 as it proves that there are no negative interactions between the system identified and its environment.
The detailed part of the index includes values ordered by their size and comparing interactions flow in the predefined period of time. Detailed part of the index includes the following parts:

- energetic interaction part,
- material interactions part.

Detailed part of the index can be identified with the following formula:

$$R_s = \{ O, E, M\} \tag{2}$$

where:
O - general number of interactions between environment and the system, disregarding character of these interactions,
E – set of values referred to energetic interactions, including their values calculated with use of size of interactions flows size and indicator enabling identification of theses interactions' form.

$$E = \{ ά_i e_i\} \tag{3}$$

where:
$ά_i$ – indicato of form of interactions used for energetic interactions,
e_i – calculated value of i- interaction
M – set of values referred to material interactions, includes their value calculated with use of interactions floks size and indicato enabling identification of form of these interactions.

$$M = \{ \mu_j m_j \} \tag{4}$$

where:
- μ_j – identificator of form of interaction used for material interactions,
- m_j – calculated value of j - interaction.

4 IT system for balance analysis providing information required for environmental decisions making

IT system providing information required for environmental decisions making should include the following modules:

- **calculation module**, which task is to calculate balance index according to principles presented above. The module should include memory function to enable remembering values of balance index when there are changes to its value or value of input data for detailed analysis introduced. Memory function should also include a kind of simulation to calculate potential value of the index, both general and detailed in case of changes of input data. Data for simulation can be introduced and put into the system by its user directly or be automatically copied from communication module. Simulation function should also enable visualization of simulation results comparison of current index value and value of its predefined components. The main goal of the simulation of calculation module would be supporting environmental decisions to be made by system's users. This function enables assessment of results of decisions to be made.

- **recording module**, which enables collecting data necessary to calculate balance index in general and detailed part. The module is a database which is used to record data on interactions identified, their dynamics (changes in time). Records should include quantities and values as well to provide full information on interactions. Author believes that is would be beneficial for the system to include automatic memory option, to collect and record data on environment condition (temperature, rainfalls, exposure to sun). forecasting function can also be included to calculate future values of interaction identified, their quantity and value as well.
- **communications module**: communication with system is performed via the Internet.

The following activities can be realized within the communication system:

- Exchange of information between users of the system. The exchange can be performed on many levels, and the simplest form is discussion forum designed to exchange opinions and experiences of users via e-mails exchanged by system's users. The form more advanced is providing access to branch information (for .ex. concerning new solutions in energy saving lights area). However, using this form may result in unauthorized use and access to these information, searching for them may be difficult and then used for sending adverts and other unwanted information, including spam. This problem is difficult to solve. To select and search for required information various techniques, including multi-agent systems can be used [1]. Their allocation on level of one balance analysis system may however appear difficult.
- access to regional bulletins on condition of environment and channel used to inform on potential hazards,
- access to information distributed by local authorities.

The idea of balance analysis system's structure introduced in the paper is presented in the scheme below (Fig. 1).

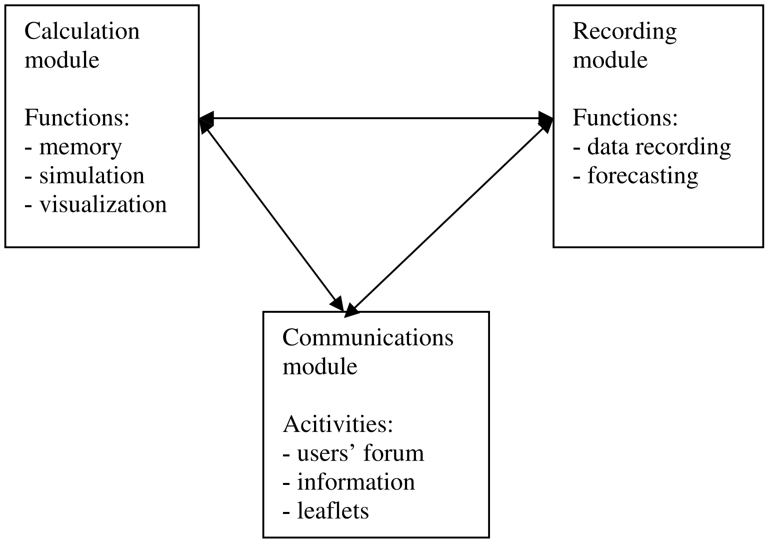


Fig. 1. Structure of balance analysis system

5 Conclusions

The framework of balance index and balance analysis presented in the following paper is not an alternative for eco-balancing and IT systems supporting eco-balancing presented in the literature [3]. Micro and medium scale used in the paper refers to a household or a workshop. Balance analysis presented by the author is not an alternative for professional IT system presented in the literature on environmental management and environment protection [2]. The advantage of the solution presented in the paper is its simplicity and popular character, which may draw attention of numerous computer users to environmental problems, not only in macro, but also in micro perspective – from household perspective. It can provide information for further analysis and in some cases making decisions beneficial from user's point of view and environment as well.

The inspiration for this article and problems it includes was author's personal experience with using personal computer to remind him of dues of collection of sorted wastes from his mansion.

References

[1] Golinska P., Fertsch M., Gomez J.M.., Oleskow J., The Concept of Closed-loop Supply Chain Integration Through Agent – based System, [in:] Information

Technologies in Environmental Engineering, ITEE – Third International ICSC Symposium, Springer, 2007. p. 189.
[2] Günther S., Gómez J.M., Rautenstrauch C., Griese S., Modelling of a Data Warehouse System for Environmental Information – A Case Study, [in:] Proceedings of Second International ICSC Symposium on Information Technologies in Environmental Engineering (ITEE'2005), Magdeburg 2005, p. 381.
[3] Grünwald C., Gomez J.M., Conception of System Supported Generation of Sustainability Reports in Large Scale Enterprise, , [in:] Information Technologies in Environmental Engineering, ITEE – Third International ICSC Symposium, Springer, 2007, p. 61.

Influence of selected methods of production flow control on environment

Justyna Trojanowska[1], Krzysztof ywicki[1], Edward Paj k[1]

[1]Poznan University of Technology

justyna.trojanowska@doctorate.put.poznan.pl, krzystof.zywicki@put.poznan.pl, edward.pajak@put.poznan.pl

Abstract. The chapter presents issue of influence of everyday activity of manufacturing enterprises on the environment. Authors draw attention to how great impact on the state of the environment have decision taken by production managers. Special attention is drawn to, inter alia, redundant transport during production processes and also generation of waste during production. In the chapter methods of production flow control are presented and compared them in terms of impact of the result of using it on the environment. In group of methods which are discussed are methods of family MRP - material requirements planning (MRP I), manufacturing resource planning (MRP II) and enterprise resource planning (MRP III / ERP). It is also analyzed optimized production timetable (OPT) and the Japanese methods of production flow control (JIT, KANBAN). At the end of article indicate of those methods of production flow control which are least harmful to the environment.

Keywords: production flow control, material requirements planning, just in time

1 Introduction

Production processes are inextricably linked to the necessity of transporting raw materials, semi-finished materials, tools, waste generation, both in the form of unused and no longer possible to reuse the raw materials, as well as shortcomings, which can not be recycled from exhaust emissions and other pollutants. Any production will not remain so without any impact on the environment. In the face of environmental problems facing the world today, the challenge for manufacturing companies has become such a production control to reduce the negative impact of operations on the environment. Awareness of people managing companies with environmental risks which are inherent to the manufacturing process is growing. Companies trying to harm the environment as little as possible not only in that they see a financial gain, which does not require payment of any penalty environment, but more often they feel responsible for future generations.

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_54,

The methods of production control is generally speaking we can divide the methods of classical and modern. The division is of course conventional methods. Classical methods for controlling the flow of production are contained in two areas:

- intercellular control of every cell in respect to all degrees of sophistication in the structure of manufactured products;
- intracellular control includes setting and monitoring of the conduct of the tasks of production only in the production of basic cells.

In turn, the modern methods of production control are:

- MRP I - Material Resource Planning, method which connects inventory control with planning of production;
- MRP II - Manufacturing Resource Planning, method for the hierarchical production planning, scheduling concerns at all levels - strategic, tactical, operational, until the scheduling of treatment;
- ERP - Enterprise Resource Planning, method relating to all significant corporate resources in terms of marketing, financial and logistics;
- OPT - Optimized Production Technology, method of optimizing the flows of materials, semi-finished products, finished goods by bottleneck;
- JIT - Just In Time (connect with technique of KANBAN), method that eliminates inventory and accelerating the flow of materials, intermediate products in the circuit logistics company.

It is worth noting that modern methods of production are based flow control is whether the principles drawn from elements of the classical methods. For this reason, the remainder of this article will discuss ways to control the production of only using the methods form modern group.

2 Methods – MRP system

2.1 Material Requirement Planning (MRP)

Material requirements planning is a systematic planning and control methodology for production and inventory. It is a procedure for planning and controlling the raw materials, purchased parts, and work-in-process inventories required in manufacturing a product. MRP is especially suitable for situations in which an end product is being assembled or manufactured from a variety of parts and components.

MRP is expressly designed for dealing with dependent, discontinuous, non-uniform demand, which is characteristic of manufacturing environments. Because of this, the benefits of MRP, when used properly, can be significant. They include the following [6]:

- inventory reduction – MRP determines how many of a component are needed and when in order to meet the master schedule. MRP enables a manager to procure that component as it is needed, thereby avoiding the costs of excessive inventory;

- reduction in production and delivery times – MRP identifies materials and component quantities, timings, availabilities, and procurement-and-production actions required to meet delivery deadlines. By coordinating inventories, procurement, and production decisions, MRP helps prevent delays in production;
- realistic commitments – realistic delivery promises can please customers. By using MRP, production can give the marketing department timely information about likely delivery times to prospective customers.

MRP, as a form of supply and production control based on an analysis of orders for finished goods, coordinate the material characteristics of the product in case to production scheduling.

2.2 Manufacturing resource planning (MRP II)

Manufacturing resource planning is a method for the effective planning of all resources of a manufacturing company. It is made up of a variety of processes, each linked together: business planning, production planning (sales and operations planning), master production scheduling, material requirements planning, capacity requirements planning, and the execution support systems for capacity and material. Output from these systems is integrated with financial reports such as the business plan, purchase commitment report, shipping budget, and inventory projections in dollars. Manufacturing resource planning is a direct outgrowth and extension of closed-loop MRP.

In MRP II the specific actions of the company has been allocated to appropriate levels of management. Strategic level includes the general objectives of the company, production planning, financial groups and other groups participating in it. These groups must ensure that adequate financial as well as material resources to produce at a specific time agreed quantity of product or service, and other groups in the area of marketing, distribution and sales. However, the tactical level of model which supervising the main production schedule, using the computer system, compares what is needed for the production with what he has. Given the time of receipt of materials and the acquisition of the remaining missing factors of production, the schedule is adjusted to the realities of realization. MRP II besides to control inventory levels also makes operational priorities of the constituent elements and controls the use of the capacity of individual episodes. The operative level notes the connection production activities and auxiliary operations with the business plan and financial results obtained at the strategic level of the company.

2.3 Enterprise resource planning (ERP)

The ERP systems allow making the assessment of material flows in production systems [2]. The Association for Operations Management APICS defines Enterprise Resources Planning (known also as MRP III) as framework for organizing, defining, and standardizing the business processes necessary to effectively plan and control an organization so the organization can use its internal knowledge to seek external advantage.

Structure of ERP system shows figure 1. Lead time, ideal supply and the intended performance are those parameters which serving the dynamic adjustment based on a broad-based governance rules parameters in the method of ERP. A key part of the whole model of ERP is the method of demand planning. This model is designed to quickly create more accurate analysis of their use during the implementation of long-term business plan, and of daily or weekly demand analysis, to determine the current data for the forecast.

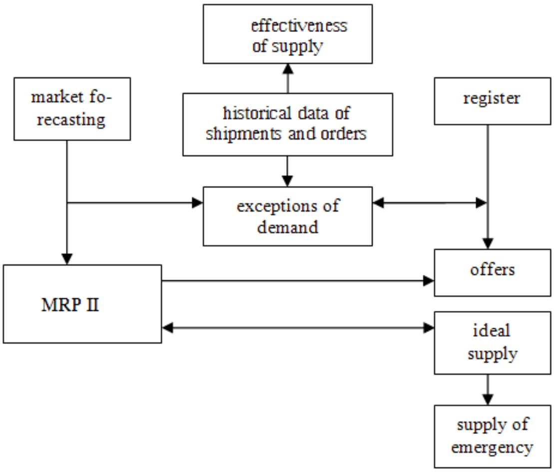


Fig 1. Structure of ERP system *Source: [1]*

Table 1. Advantages and disadvantages of using ERP system

ERP systems	
Advantages	**Disadvantages**
Provides integration of the supply chain, production and administrative process.	Very expensive to purchase and even more costly to customize.
Creates commonality of databases.	Implementation may require major changes in the company and its processes.
Increases communication and collaboration among business units and sites.	Is so complex that many companies cannot adjust to it.
Has a software database that is off-the-shelf coding.	Involves an ongoing process for implementation, which may never be completed.
May provide a strategic advantage over competitors.	Expertise in ERP is limited, with staffing an ongoing problem.

Source: [4]

3 Optimized production technology (OPT)

Optimized production technology is a proprietary scheduling system developed by dr E.Goldratt. The aim of OPT is to schedule bottleneck capacity in an efficient way. This schedule is the master for the demand placed on other capacities. OPT method needs special computer software. OPT method based on two fundamental manufacturing phenomena:

- dependent events, what means that all processes rely upon the completion of preceding operations;
- statistical fluctuations, process times fluctuate around an average.

The effect of these phenomena is that the capacity of a plant must be unbalanced and therefore bottlenecks are inevitable. The OPT method of scheduling dictates that material should only be launched on to the shopfloor at the rate at which it is consumed by the bottleneck.

The main features of OPT are described as follows [8]:

- balance flow not capacity;
- the level of utilization of any part of the system, which is not a bottleneck, is dependent on other constraints in the system, not the potential of the worker;
- tache utilization and activation of a resource are not synonymous;
- an hour lost at the bottleneck is an hour lost for the total system;
- an hour saved at a non-bottleneck is just a mirage;
- bottlenecks govern both throughput and inventories;
- the transfer batch may not, and many times should not be equal to the process batch;
- the process batch should be variable, not fixed;
- schedules should be established by looking at all the constraints simultaneously. Lead times are the results of the schedule and cannot be predetermined.

The steps used to develop OPT shown in figure 2.

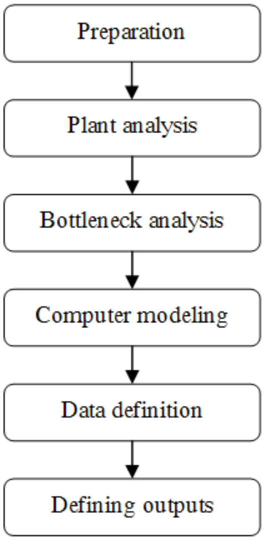


Fig. 2. The steps used to develop OPT

The benefits claimed for OPT are that it will schedule finite resources in order to achieve maximum factory effectiveness. Main benefits of using method:

- addresses the key problem of bottlenecks;
- improves profitability by simultaneously increasing throughput;
- reduces inventory and operating expenses.

4 Japanese methods

4.1 Just-in-Time (JIT)

The Association for Operations Management APICS defines just-in-time as a philosophy of manufacturing based on planned elimination of all waste and on continuous improvement of productivity. It encompasses the successful execution of all manufacturing activities required to produce a final product, from design engineering to delivery, and includes all stages of conversion from raw material onward. The primary elements of Just-in-Time are to have only the required inventory when needed; to improve quality to zero defects; to reduce lead times by reducing setup times, queue lengths, and lot sizes; to incrementally revise the operations themselves; and to accomplish these activities at minimum cost. In the broad sense, it applies to all forms of manufacturing job shop, process, and repetitive and to many service industries as well.

JIT typically require less floor space for equal levels of production. Reductions in square footage can reduce energy use for heating, air conditioning, and lighting.

Reduced square footage can also reduce the resource consumption and waste associated with maintaining the unneeded space (e.g., flourescent bulbs, cleaning supplies). Even more significantly, reducing the spatial footprint of production can reduce the need to construct additional production facilities, as well as the associated environmental impacts resulting from construction material use, land use, and construction wastes.

Just-In-Time can result in more frequent "milk runs" for parts and material inputs from sister facilities or suppliers, leading to an increased number of transport trips. This can contribute to traffic congestion, as well as environmental impacts associated with additional fuel use and vehicle emissions. Through efficient load planning, however, the environmental implications of increased milk runs can be significantly reduced or eliminated. What is also important, JIT when not implemented throughout the supply chain, can just push inventory carrying activities up the supply chain, along with the associated environmental impacts from overproduction, damaged goods, inventory storage space heating and lighting [7].

4.3 Kanban technique

Inseparable element of JIT systems is the method of kanban production management, which is based on the flow of documents in the form of cards attached to the trucks, which are delivered small amounts of components and other materials needed for production. It was introduced by Toyota Motor Company in Japan in the years 1950-1960 and defined as "a system of organization of parts supply, semi-finished materials for manufacturing at the time of the actual demand for these items" [5].

This system provides strict inventory control. In the traditional approach to overriding goal of industrial capacity utilization was not counted then the expenditure on the maintenance of magazines. Whiles the task of Kanban system is to start production ingredients only when it is really need it [1].

Benefits of kanban scheduling [3]:

- reduces inventory;
- improves flow;
- prevents overproduction;
- places control at the operations level;
- creates visual scheduling and management of the process;
- improves responsiveness to changes in demand;
- minimizes risk of inventory obsolescence;
- increases ability to manage the supply chain.

From a financial side, the inventory reduction not only saves the carrying cost of the inventory but also the physical space occupied by the existing inventory. The freed-up space can then be used for new business opportunities or may eliminate the need for planned expansions or leasing of offsite warehouses.

Steps to implementing kanban shows figures 3.

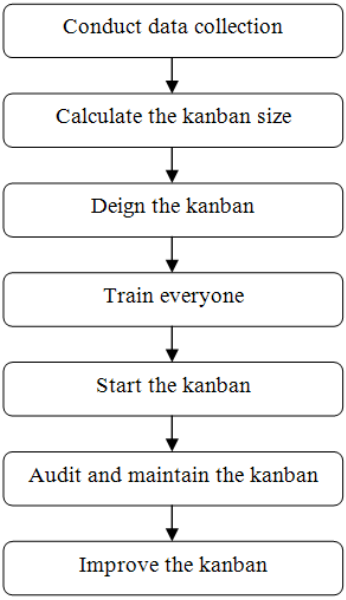


Fig. 3. Steps to implementing kanban

JIT connect with kanban systems reduce the amount of necessary in-process and post-process inventory, thereby reducing the potential for products to be damaged during handling and storage, or through deterioration or spoilage over time. Such damaged inventory typically ends up being disposed of as solid or hazardous waste. Frequent inventory turns can also eliminate the need for degreasing processes for metal parts, since the parts may not need to be coated with oils to prevent oxidization or rust while waiting for the next process step.

JIT connect with kanban systems help eliminate overproduction so potential benefits of using it for environmental performance is:

- decrease the number of products that must be scrapped or discarded as waste;
- decrease the amount of raw materials used in production;
- decrease the amount of energy, emissions, and wastes that are generated by the processing of the unneeded output.

It is important to note that JIT or kanban may not succeed at reducing or eliminating overproduction and associated waste if the products produced have large and/or unpredictable market fluctuations.

5 Summary

There are two systems in control of production - a pull and push. In the push system, production begins by anticipating future needs, i.e. make to stock. However, in a pull system initiates production as a reaction to the current needs of customers, in the case of typical make to order. These approaches can be combined and used simultaneously in a single production system. This is where we produce parts according to demand forecasts, and then assemble to order. So in the first part we deal with the production push, then pull production system.

Discussed methods of production control can also be attributed to these systems. MRP, MRP II and ERP systems can be likened to push, while JIT and KANBAN technique to pull system. While these methods are mainly the smooth implementation of material flow in so OPT method may serve to strengthen the results achieved by the chosen method. The efficiency of material flow is in fact subject to various constraints and bottlenecks in production. The efficient use of the possibility of bottlenecks, and so the more we use the opportunities arising from the application of the method of OPT, including the effectiveness of the method becomes greater, and consequently increases the efficiency of the whole enterprise. Making the most of opportunities bottleneck is having a positive impact on the environmental performance of the method, even in because of preventing the movement of defects. Setting the post of quality control before the bottleneck also affects the efficient use of machinery and reducing defects.

Comparison of MRP systems and Japanese methods of production control in terms of the impact of the method on the environment shown in table 2. Due to the fact that the goal of this article is to show the impact of flow control method of production on environment, the methods were compared in terms of only those aspects that were considered by the authors as the most important from the standpoint of environmental impact. They are:

- informatization - means amount and the way in which documents are archived;
- employees - shows how to approach and requirements put for workers influence on their ecological thinking;
- logistics – the way of reflect in production flow control of lenght of transport routes and the size of work in progress or inventory;
- defects - an approach to quality control of semi-finished products, and thus the impact on the prevention of deficiencies, and therefore unnecessary consumption of resources.

Table 2. Comparison modern method of production flow control in terms of the impact on environment

	MRP systems	Japanese systems
Informatization	MRP systems most commonly used for continuous production in accordance with specific schedules require extensive computerization.	Japanese systems using flexible production structure characterized by the simplified rules and minimum documentation archives.

Employees	In MRP systems, the emphasis is on targeting the specialized employees perform certain tasks. The current assessment of the labor productivity and a sense of the minimum impact on how the allocation of tasks is not conducive to ecological thinking.	Japanese systems pay attention on the training and ability to self-assessment. This approach makes employees have a greater impact on what is happening at the company exhibit a creative approach to the task and willing to report improvement proposals, also in terms of reducing the negative impact of production on the environment.
Logistics	Large inventory, long distances between the warehouse and production line, complex storage.	Minimum stocks of materials, supply of materials as close to the production stations.
Defects	The quality of semi-finished goods is controlled by a special cell, which often means the need to transport semi-finished products in the specified location.	The role of quality built into every thinking worker. Individual controlling and improving the quality makes it virtually deficiencies do not occur.

Analyzing data from table can be concluded that the Japanese methods of production control are more environmentally friendly, because of the better handling organization of transport or even a much smaller amount of waste. It is significant here that the approach to an employee in a subjective way, conducting training, also green, and use of knowledge, experience and ideas of employees in implementing improvements.

It is worth noting that a combination of methods is most appropriate. Evidence of this even when the fact that in the literature from time to time there are new methods of production control, which were created by combining various elements or objectives of the existing methods. Selection of appropriate control methods should be supported by thorough analysis of the situation, type of production, specific industry and market in which to exist. Not without significance is the introduction of cost-effectiveness analysis of a system of production control, because you should realize that if even the method of MRP and OPT, it is necessary to apply the appropriate software. Also, the introduction of any of the Japanese methods will require a reorganization of production, and thus incurred expenses.

References

1. Brzeziński M (2002) Organizacja i sterowanie produkcją (Organization and manufacturing control). Placet, Warszawa.
2. Golińska P (2010) Sustainable supply chain management – challenges for integration of distributed data sources. In: Grzybowska K. (ed.) New insights into Supply Chain. Publishing House of Poznan University of Technology, Poznan: 153.
3. Gross JM, McInnis K. R (2003) Kanban made simple. Demystifying and Applying Toyota's Legendary Manufacturing Process, Amacom, New York: 5.
4. Heizer J, Render B (2008) Operations Management. Pearson Prentice Hall, New Jersey.
5. Martyniak Z (1996) Nowoczesne metody zarządzania produkcją (Modern methods of production management). Wydział Zarządzania Akademii Górniczo-Hutniczej im. St. Staszica w Krakowie, Kraków.
6. Panneerselvam R (2005) Production and Operations Management. Prentice-Hall of India Private Limited, New Delhi.
7. Productivity Press Development Team (1998) Just-in-Time for Operator Learning Package. Productivity Development Team, Oregon.
8. Turner S (2010) The Little Black Book of Management: Essential Tools for Get-ting Results NOW. McGraw-Hill Companies.

Maintenance Management Initiatives towards Achieving Sustainable Development

Malgorzata Jasiulewicz-Kaczmarek[1], Przemyslaw Drozyner[2]

[1]Poznan University of Technology, Faculty of Management Engineering
[2]Warmia-Mazury University

malgorzata.jasiulewicz-kaczmarek@put.poznan.pl, przemyslaw.drozyner@uwm.edu.pl

Abstract. As sustainable development is a concept more and more popular, the need to provide its practical application has emerged. The way to help companies improve their economical, environmental and social performance is by minimizing waste. It means less waste generated and increase waste reusage or recycling; using resources such as materials, water and energy at the highest possible efficiency; avoiding or at least improving management of metalworking fluids, lubricating oils and hydraulics oils. Other goals are improved environmental, health and safety performance, adopting lean manufacturing and other sustainable engineering techniques, as well as improved working conditions. The achieve reduction of waste at production site best practice in manufacturing and maintenance processes are needed. The aim of this chapter is to present how well performed maintenance management can help to achieve sustainable development of a company.

Keywords: maintenance management, resources availability, environment

1 Introduction

Sustainable development is a very broad idea and it has numerous interpretations [6]. The term "sustainable development" was used for the first time in the Brundtland report developed by World Commission on Environment and Development, also called Brundtland Commission, in 1987. There, it was defined as a process aiming for aspirations of contemporary generation development and for providing the chance to meet these aspirations by future generations as well. Thus sustainable development is about reaching a balance between economic, social, and environmental goals, as well as people's participation in the planning process in order to gain their input and support [22] For company sustainable development means adoption of business strategy and actions which contribute to satisfying present needs of company and interested parties, as well as simultaneous protection, maintenance and strengthening of human and environmental potential which will be needed in the future [20]. Manufacturing businesses can contribute to this effort by designing products and production systems that have an insignificant or

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_55,

optimally low impact on the natural environment in terms of resource depletion, waste emissions, energy usage, and other impacts [16].
Environment protection, as well as including social interest in business activity is issues extremely important for entrepreneurs thinking seriously about long-term activity on the market.

In the past, environmental concerns about business have generally concentrated on large manufacturing organizations. It has been said that this is because "small businesses are written off as a group that is too expensive to reach, while attention is concentrated on the easier to reach large businesses" [17]. Nowadays, a significant number of SMEs (66.25%) saw environmental sustainability as important or vital to their future business activities [9].

2 Concept of "Green" Manufacturing

Green, or sustainable, manufacturing is defined by Allwood [1] as a method to "develop technologies to transform materials without emission of greenhouse gases, use of non-renewable or toxic materials or generation of waste". The term "green", often used interchangeably with "environmentally-safe". To achieve the "green" status, enterprises should, among others: improve manufacturing processes, use clear energy sources and use lower impact materials [8] (Fig. 1).

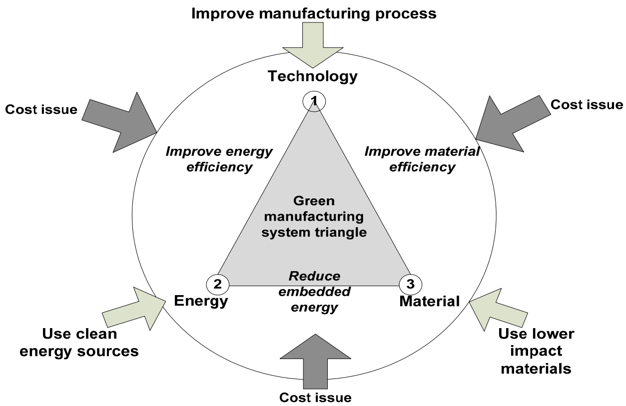


Fig. 1. Green manufacturing system triangle, *Source:[8]*

Manufacturing firms that have gone green are finding that it saves them thousands of dollars each year. Going green will cut down energy costs and can even save money on insurance rates. Experts predict that green manufacturing will be the most popular trend in the next years.
By implementing lean manufacturing companies can reduce wasted products and impact on the environment costs by 70% or more. And, however the goal of lean

manufacturing is limitation of waste by elimination of activities performed to create a product or a service but not adding them any value, analyzing results of lean manufacturing application one can say it is close to the idea of green manufacturing, which is a new approach to the way of doing business.

Sustainable (including green) manufacturing uses both technological and non-technological solutions, from selection of materials and production processes to organizational mission, structure, and performance reporting which is measuring, disclosing, and being accountable to internal and external stakeholders for organizational performance towards the goal of sustainable development.

So called Performance Indicators (proposed by Global Reporting Initiative – GRI) are divided to economical, environmental and social. Each category includes information concerning approach to management and dedicated set of basic and supplementary indicators.

The Aspects in the Environment Indicator set are structured to reflect the inputs, outputs, and modes of impact an organization has on the environment. Energy, water, and materials represent three standard types of inputs used by most organizations. These inputs result in outputs of environmental significance, which are captured under the Aspects of Emissions, Effluents, and Waste. Biodiversity is also related to the concepts of inputs to the extent that it can be viewed as a natural resource. Each aspect cover some indicators, for instance:

- Aspect: Materials: materials used by weight or volume. percentage of materials used that are recycled input materials,
- Aspect: Energy: direct and indirect energy consumption by primary energy source, energy saved due to conservation and efficiency improvements, Initiatives to provide energy-efficient or renewable energy-based products and services, and reductions in energy requirements as a result of these initiatives.
- Aspect: Water: total water withdrawal by source, water sources significantly affected by withdrawal of water, percentage and total volume of water recycled and reused.
- Aspect: Biodiversity: Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.
- Aspect: Emissions, Effluents, and Waste: total direct and indirect greenhouse gas emissions by weight, other relevant indirect greenhouse gas emissions by weight, Initiatives to reduce greenhouse gas emissions and reductions achieved.

Nowadays, there is over 2500 reports registered and revealed by the companies such as ABB, Bombardier, Coca Cola, 3M or Vodafone. Reports can be used for purposes like benchmarking and assessing sustainability performance, demonstrating how the organization influences and is influenced by expectations about sustainable development; and comparing performance within an organization and between different organizations over time.

Machine maintenance in a production company is a key issue; however, in a process approach it is usually classified as an auxiliary process for the production.

Meanwhile, the process can have a fundamental impact on the amount and cost of production, quality of the final product, safety of people and the environment. Additionally, it is a process results of which can be analyzed in countable values, and assets are comparatively easy to manage. All that makes maintenance in companies applying so called good engineering practices not only a cost-generator which should be avoided but also an active approach which can contribute to company's development and become an integral part of green manufacturing called "green maintenance".

3 "Green" Maintenance

Maintenance has been seen as a way to help to maintain production as efficient as possible. But, by this way, it is seen as a cost that, by consequence, diminishes the profits of companies. This implies that the maintenance has been managed as an activity less important and less valuated when compared with other activities in the companies, namely with production [11]. A better environment can be achieved through the reduced emission of pollutants, the optimization of green energy production and the optimization of maintenance interventions, which is an important contribution in getting equipment functioning as efficiently and effectively as possible and, of no less importance, to minimize the downtime caused by faults [12].

Maintenance departments do not have direct influence on energy and other medias use as they are emerging from technologies applied, however they can greatly influence it. Thus, they have influence on natural environment. What factors are among their responsibilities? Which elements of exploitation system can be positively influenced by maintenance departments?

It shows that there are plenty of opportunities, including simple service and fixing activities such as alignment or balancing or using advanced technical diagnostics methods, influencing lubricating or purchasing policy and maintenance strategy.

For example, unconcentricity of shafts may lead to energy use increased by 12%, and not well-matched or used clutch may lead to 4% losses. Exchanging traditional belts to high-efficiency belts of new generation in belt-transmissions provides energy savings by 2-4%. Making decisions concerning use of electric engines EFF1 leads to increasing efficiency by 26% compared to traditional electric engines.

Using energy-saving bearings in drives of machines and devices allows decreasing friction by 30%, and machines are capable to increase their maximum speed by 15%. Elimination of leaks in pneumatic installations, exchange of air preparing modes to the ones of high quality, use of connectors and wires characterized with low flow resistance, optimization of condensed air net system leads to energy savings by 10%. The next factor is choosing suitable condensers and their proper exploitation, especially in terms of condenser oil and its contaminations. They can be used for industrial, usable and heating water heating up. In hydraulic systems losses are generally consequence of hydraulic oil flow resistance. New generation filters should be applied as they are characterized with low flow resistance, i.e. filters with glass fiber or metal net insert.

Maintenance departments are also responsible for definition of maintenance strategy which is defined as an interrelationship description between maintenance echelons (on-site, in a repair shop, at the manufacturer, etc.) and indenture levels (subsystem, circuit board, component, etc.) including their maintenance actions [21]. The maintenance echelon is characterized by the personnel skill, the available means and the location. When the indenture level depends on the complexity of an item structure, the accessibility to its sub-items, personnel ability level, test and measure means safety considerations, etc. Miscellaneous strategies have been put forward for maintenance amongst which the most important ones are corrective, preventive, opportunistic, condition-based and predictive maintenance that considering each one's relevant industry each of them has advantages and disadvantages [7]; [15]; [2]; [14]; [18]; [19]

Strategies believed to be the most efficient include TPM (Total Productive Maintenance), RCM (Reliability Centered Maintenance), RBI (Risk Based Inspection) and RBM (Risk Based Maintenance) [3] . Proper maintenance strategy is directly connected with limiting negative influence on natural environment by:

- Providing regular monitoring of machines work parameters with technical diagnostics tools. High level of technical services planning can be achieved only when planning is based on reliable operational data. Consequently, production machines and devices condition monitoring is crucial for supporting sustainable management of manufacturing operations.
- Elimination of serious failures with formalized cause-effect analysis. Analysis of risk and decreasing uncertainty in reliability of machines and devices assessment Has become critical methods in strategic decisions making process, striving for technical safety providing (including its environmental aspects) and costs minimization. Risk analysis usually requires application of some tools including: FMECA, FMEA, RCA, FTA etc. [5]
- Preventing production cycle breakdowns by focusing on Overall Equipment Effectiveness (OEE).

Three elements consist on OEE. The first element of the OEE measure – availability, is concerned with the total stoppage time resulting from unscheduled downtime, process set-up and changeovers, and other unplanned stoppages. In simple terms, it is the ratio of actual operating time to the planned operating time, and takes into account the theoretical production time against which unplanned downtime is highlighted. The second element of the OEE calculation is ``performance rate". This measures the ratio of the actual speed of the equipment to the ideal speed. Performance efficiency is the product of the operating speed rate and net operating rate. The operating speed rate of equipment refers to the discrepancy between the ideal speed and its actual operating speed. The third element of the OEE calculation is the “quality rate", and is used to indicate the proportion of defective production to the total production volume. It should be noted, however, that the quality rate involves defects that occur only in that designated stage of production, usually on a specific machine or production line.

Research done by the authors in food industry enterprises proves that the following factors have the greatest impact on the OEE coefficient (because of influencing readiness coefficient): product development time, assortment changing time etc., hence, the factors not connected with maintenance processes. Thus, OEE is a general measure of efficiency of machines and devices utilization including aspects connected with efficiency of all interested parties, which are maintenance departments (losses caused by failures, lower efficiency and quality losses caused by poor technical condition etc), production department (setups, product development, work organization, workstation maintenance) and other departments, responsible for logistics, purchasing, training, organization, construction and technology development etc.. Thus, to increase OEE, cooperation between all departments is necessary, as well as including LCA approach in all the actions taken.

4 The case study

Poznan Brewery, along with Tychy and Bialystok Brewery are joint and create Kompania Browary S.A. in Poznan – a company which is a leader of Polish brewery industry and a part of SABMiller, the second in the world beer producer. As a consequence, the 10 priorities of sustainable development has been created to prove their responsible approach to business (fig. 2)

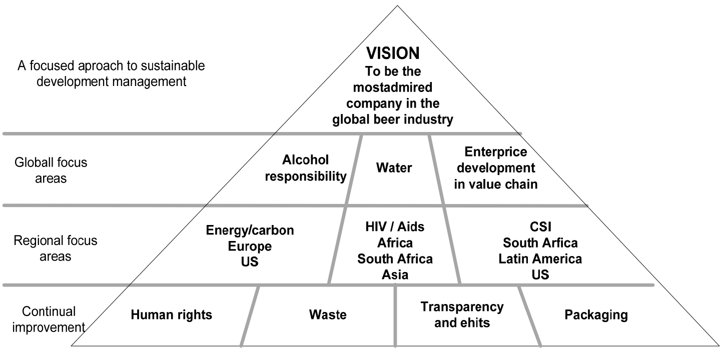


Fig 2. Ten sustainable development priorities
Source: http://www.sabmiller.com/files/reports/2010_SD_report.pdf

To monitor and measure progress, they have developed the Sustainability Assessment Matrix (SAM). This is a bespoke management system that enables to monitor the performance of operating businesses against the 10 sustainable development priorities. Each priority has a 'stairway' that plots a course through four levels of performance from minimum standard to best practice.

Each operation is required to complete an online assessment every six months. The results are collated to create a 'scorecard' for each business and region and, ultimately, for the group. The scorecards are assessed internally by regional and group CARACs (Corporate Accountability and Risk Assurance Committee is a sub-committee of the SABMiller plc board and is responsible for overseeing progress against our 10 sustainable development priorities) and is analyzed continuously to be an important element of the planning process. To facilitate sharing of best practice and consistency of assessment, teams from different countries review each other's scorecards through detailed in-country reviews and benchmarking exercises. Each business scorecard is also reported on website publicly.

In July 2009 SABMiller launched the 'Sustainable Development Way' which aims to ensure a consistent approach around the world and provides a credible point of reference for the business. In Kompania Piwowarska S.A. for each SD priority, goals and the way they should be evaluate have been defined (table 1).

Table 1. Goals and their evaluation modes: Water and Energy&Carbon

	Goals	Evaluation
Energy	Optimization of energy use Carbon Footprint – implementation of tools enabling assessment of influence of business decisions on CO2 emissions (f.ex. packages, distribution strategy) assessment of energy use in the supply chain	energy use ratio renewable energy use air pollution management (CO2 mainly), including emissions trade monitoring CO2 emission Energy management (ratios defined, measured and analyzed in core process of organization)
Water	Optimization of water use. Assessment of risk of lack of water for beer production caused by local conditions. Assessment of water use in the supply chain	water use ratio sewage quality brewery's demand on water vs local societies' demand on water and opportunities of water supplies in the next 10 years water use in the supply chain

According to the SAM model applied, priorities are assessed and reported every six months (fig.3).

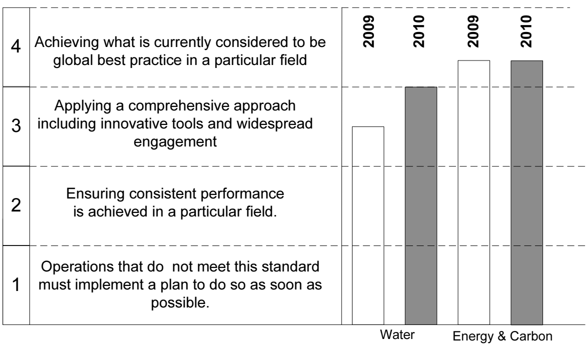


Fig. 3. Measuring achievements in Poznan Brewery for "Water" and "Energy&Carbon" priorities

Poznan Brewery benefit from implemented and continuously improving Integrated Risk Management System (IRMS), which meets requirements of Risk and Functioning Continuity Management programs of SABMiller and requirements of the following standards: ISO 9001:2008, ISO 22000:2005, ISO 14001:2004, OHSAS 18001:2007, PN-N 18001:2004.

WCM strategy realization (in SABMiller called "Manufacturing Way") in all the areas of the enterprise activity is strictly connected with realized and improved since 2000 TPM strategy. The model, the concept was based on, includes also pro-environmental activities and aspects.

The examples of pro-environmental activities realized according to "Manufacturing Way" strategy (IRMS is the element of this strategy), in which maintenance staff has been taken part in are listed and presented below.

Environmental Management System

Since 2001, beer producer from Poznan has been certified with Environmental Management System certificate ISO 14001. Its concern about natural environment is appreciated by f.ex. by the following rewards: "Panteon Polskiej Ekologii" (Polish Ecology Pantheon) by Minister Ochrony Środowiska (Minister of the Environment) and "Firma Przyjazna Środowisku" (Environment Friendly Enterprise) by President of Polish Republic. By realization of environmental policy of Poznan Brewery, goals and tasks for all the functional areas of the company are established. Departments of Techniques and Maintenance support realization of predefined goals. The examples of environmental goals and activities planned to provide these goals are presented in the table below.

Table 2. Environmental goals and their realization

Environmental goal	Improvement of chemicals in warehouses management.
Realization	Production Department and Techniques Department.
Planned activities:	1. Audit of chemicals storage conditions 2. Moving central warehouse of chemicals to the location meeting safety requirements (investment project) 3. Definition of optimal amount of chemical stored at hand 4. Development and implementation of instruction on safe storage of chemicals in production departments 5. Environmental failures risk assessment 6. Definition of procedures in case of failures 7. Training for all the operators and maintenance staff 8. Audits of CIP washing installations in terms of failure risk
activities taken by maintenance department to provide tasks 8 realization	1. Audits of installation dosing condensed chemicals and washing substances 2. Repairs necessary (identified thanks to audits) 3. Detailed analysis of reliability of all the elements of installation and identification of critical ones 4. Verification of preventive work plans based on analysis performed (frequency of audits and their range) 5. Verification of checklists for operators, mechanics and maintenance automatics (increased frequency of installation controls) 6. Additional covers and securities for pumps dosing condensed chemicals was planned as an investment and is being realized.

Example of activities in „water” and „energy” areas

One of the programs launched as a part of excellence strategy „Manufacturing way” in Poznan Brewery is the “Ideas campaign”, aimed to motivate employees by promotion of operational excellence, exceptional commitment and achievements. The program has been organized by the Production Development Department. Each employee can present an idea individually or as a part of a team, and the condition to be met to be the part of the Program is presentation and/or realization of an idea which brings added value:

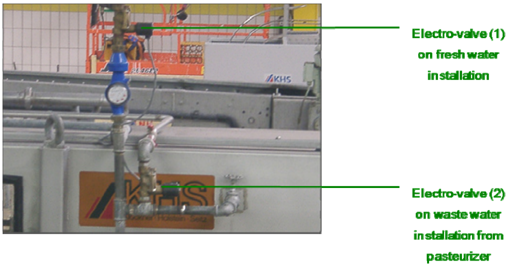
- According to the definition presented in the Program
- And is coherent to strategy and goals of the company,
- Is realistic and implementable.

Presentation of an idea requires filing in a project card which can be downloaded from a computer system. After the card is correctly filled in, it is passed to a manager responsible for the area in which the idea is meant to be realized. The manager is to check whether the idea meets the requirements and gives it the status. The manager is responsible for realization of the idea accepted, organizes resources, assigns jobs and coordinates work, or in any other way provides the idea realization. After the idea is implemented the manager changes its status in the computer system on „realized”, lists the results achieved and the members of implementation team with the jobs and roles they had. The decision on reward and its size is made by head of the department and managers team and experts, if necessary. Final acceptance of reward is done by the CEO responsible and the criteria for rewarding an idea are the following: cost reduction, efficiency improvement (of processes, time, work organization); opportunity of using the idea in other departments; products and services quality improvement, Safety and Hygiene of Work improvement, operational excellence and/or exceptional commitment and/or extraordinary achievements and other, bringing benefits to the enterprise.

Employees of the Techniques Department and Maintenance Department take part in the Program by presenting their own ideas or realizing ideas presented by other employees, f.ex. from Production Department. In the table 3 one of the ideas presented by L3 maintenance staff and results obtained are introduced.

Tab 3. Example of an activity realized in a program „Ideas campaign”

Water saving activities
Description of the problem and actions taken by the Maintenance Department for L3 (bottling)
Usage of fresh water on L3 crate washer and high sewage emission has made us search for a cheaper solution assuming that quality and efficiency of crate washing remain unchanged or even higher. Having observed the technical solutions on a packaging line which uses significant amounts of water during production process, one has noticed an analogy between the pasteurizer and the crate washer. Water used at the end of pasteurization process for cooling bottles is also used on regular basis for filling up pasteurizer zones, and water surplus is eliminated by the overflow pipe into the canal. We have come to the conclusion that is a wonderful opportunity to use the water surplus from the pasteurizer for crate washing. Close distance between these machines makes the modification quick and cheap. Savings of fresh water are huge. Crate washer during production time used fresh water from water installation. Water was constantly supplied to the final section of spraying section. Internal system of baths allowed to use this water in the section just before rinsing. Water surplus was directed to a canal. Crate washer used approx. 160-

180 m3 of water per day (24 hours of production). Crate water supply installation system has been equipped with 2 additional electro-valves to which a signal is sent from a water level sensor installed in water tank and synchronized with a water pump.

Results Water usage before modification**:** **160 - 180 m^3/24h** **Water usage after modification: 40 - 60 m^3/24h** **Water savings: 120 m^3/24h** Additional benefit which have been achieved is higher crate washing efficiency by using water from pasteurizer at approx. 50°C.

The project presented above supports water strategy implemented and used in SABMiller, which is based on the 5Rs (pRotect, Reduce, Reuse, Recycle and Redistribute) idea, a comprehensive, risk-based approach to managing water in business and in the value chain (fig.4).

Fig. 4. The '5R' model of water responsibility.
Source: http://www.sabmiller.com/files/reports/2010_SD_report.pdf

Examples of energy saving activities taken by the Techniques Department and the Maintenance Department are presented in the table 4.

Tab 4. Energy Saving Activities - examples

Activity	Description
Combined Energy Systems 1	– REVAP = double energy savings from CO_2 evaporation: – CO_2 evaporation ↔ intermediary circuit ↔ glycol cooling – Estimated electrical energy savings per year: 400 MWh – Estimated thermal energy savings per year: 1200 GJ
Frequency converters for big electrical motors	– Installed on both air and NH_3 compressors gives precise and optimal capacity adjustment for „last in queue" drive.
Close-loop condensate systems	– Monitored and maximized amount of returned condensate together with improved quality: – Quantity → % of returned volume – Quality → content of contaminants (corrosion, iron)

	– Energy → temperature
Dew point controlled condensation	– Ammonia condensing pressure optimization by using dew point based control to reshape Carnot-cycle curves.

Water and energy use is monitored systematically. For critical (in terms of water use) machines and devices, measures are taken every day by Chef of Production while energy use is checked once a week. Once a week, there is a meeting scheduled for Chef of Production and Maintenance Manager to analyze the measures taken. If the use measured is higher than predefined for each device standard, the team for planning corrective actions is appointed. Water and energy measuring systems help to identify areas for improvement (fig.5).

Fig. 5. Water measuring systems

Example of actions in "Lubricants management" area

For production lines of verified structure, reliability analysis is very important as the results obtained allow to identify the devices and elements which are the weakest elements often causing failures and breakdowns. Well-organized audits supported with proper diagnostics tools result in improved production lines operating.

The Techniques Department of Poznan Brewery employs experts in diagnostics who are responsible for implementation and realization of diagnostics program. Each of the experts is responsible for accepted diagnostic program with predefined diagnostics range and frequency. The following diagnostics techniques are applied in Poznan Brewery: vibro-accoustics, thermovision (f.ex. controlling parts of machines, controlling devices and others,)oil examination, faradic currents measuring, steam dehydrators examinations.

Oil examination is performed every six months for predefined transmissions. The goal of examination is one hand identification oil quality and on the other searching the oil for metallic elements to check whether elements of transmission are not used. Diagnostics program is predefined in SAP class software implemented in the company. The system generates orders for diagnostics automatically, however if the employees responsible for diagnostics decide that the condition of the machine requires intervention, they create a note in SAP and send it to the planner responsible for the area given, and he creates an order in the system planning the necessary activities. Before diagnostics was implemented, the good practice of maintenance was changing the oil according to transmission producer recommendations (once a year for mineral oils). Since 2004 diagnostics techniques have been commonly used, i.e. oil samples analysis. In the fig 6 oil use before and after diagnostics was implemented is compared.

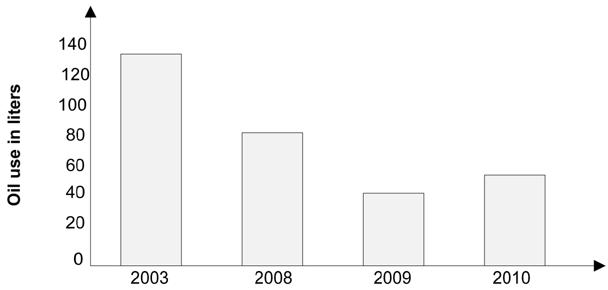


Fig. 6. Oil use compared

Better maintenance, supported by IT system (in 2000 MAXIMO was implemented, since 2007 performance has been monitored with SAP), results in increased efficiency of equipment and decreased emission of pollution, energy use and water use as well. These are only some reasons to say that maintenance in Poznan Brewery helps the environment.

5 Summary

Sustainable maintenance is a system organized in a way supporting pro-environmental approach to organization management. Environment-friendly maintenance system is combined of all the maintenance processes and includes service strategy selection (reactive, preventive, pro-active etc), purchasing materials and raw materials necessary to realize services, storing the materials mentioned before and performing services planned and unplanned, as well as utilization of used materials, exploitation fluid and lubricants.

Realization of “green” maintenance in an organization should be focused on three areas:

- assessment of influence of functional failures of machines and other devices on natural environment, selection of proper service operations and monitoring system using technical diagnostics tools and suitable software; such approach enables f.ex. identification of situations in which energy use is excessive and can be limited to decrease operational costs.
- Design for “green” maintenance. Decisions concerning new machines, devices, installations purchasing or modernization of infrastructure existing

should be based on environmental issues. Project assessment should be referred to total lifecycle cost, which enables identification of financial gains or losses emerging from predefined service and maintenance practices providing an excellent level of reliability, accessibility and maintainability.

– Sustainable lifecycle management – from concept design of new machines, devices and installations to sales. All units (departments) of an enterprise should be included and motivated to efficient management of their assets during whole period of exploitation. Lifecycle management in reference to environmental aspects requires knowledge of impact of all the components and materials installed in production system on natural environment, and of energy use as well as of amounts of waste and harmful side-products generated.

"Green" maintenance is unavoidable choice for sustainable development of enterprises and implementation of "green" maintenance is suppose to provide numerous economical, environmental and organizational benefits (table 5)

Tab 5. Potential benefits from using „Green maintenance" practices

Economical: • Decreased environmental fees (f.ex. thanks to waste segregation or lower use of energetic medias) • Decreased amount of exploitation materials used (f.ex. decreased use of oils or lubricants caused by applying technical diagnostics) • Decreased CPU of products manufactured (f.ex. thanks to decreased use of energy in production processes) • Decreased risk of potential failures • Decreased penalties for failures thanks to preventive and pro-active maintenance.
Organizational: • Improved communication between organizational units thanks to benefiting from interdisciplinary teams • Increased efficiency of services performed (f.ex. thanks to performing services on time and implementation of preventive and pro-active services) • Increased awareness of employees (f.ex. thanks to training programs organized for employees) • Better planning of services thanks to diagnostic tools use • Developing external communication procedures and efficient procedures of dealing with failures • Improved relations with business environment and administration involved
Environmental: • Decreased amount of waste generated • Decreased technological medias use (f.ex. thanks to modernization of facilities and machines) • Decreased use of lubricants • Elimination or decreasing penalties for illegal or inappropriate practices • Decreased disturbances and nuisance for local societies (f.ex. noise or other emissions) • Reduction of scarce or not-renewable natural resources use – gas, oil

Acknowsledgment. The authors wish to thank to Mr Dariusz Luczak, Maintenance Manager in Poznan Brewery for his help and cooperation.

References

[1] Allwood, J.: What is Sustainable Manufacturing?, Sustainable Manufacturing Seminar Series. http://www.ifm.eng.cam.ac.uk/sustainability/seminar/documents/050216lo.pdf. (2005). Accesed 20.12.2010

[2] Al-Najjar, B. Alsyouf, I.: Selecting the most efficient maintenance approach using fuzzy multiple criteria decision making. International Journal of Production Economics, 84, 85–100 (2003)

[3] Arunraj, N.S. Maiti, J.: Risk-based maintenance—Techniques and applications.

[4] Journal of Hazardous Materials, 42(3), 2007

[5] Carmignani, G.: An integrated structural framework to cost-based FMECA: The priority-cost FMECA. Reliability Engineering and System Safety 94, 861–871 (2009)

[6] Clifton, D.: Security and a Sustainable World. Journal of Sustainable Development. 2(3), 3-17 (2009)

[7] Coudert, T. Grabot, B. Archimède, B.: Production/maintenance cooperative scheduling using multi-agents and fuzzy logic. International Journal of Production Research, 40 (18), 4611- 4632 (2002)

[8] Dornfeld, D.: Challenges & Opportunities for Sustainable Manufacturing: Green as a Competitive Advantage http://lmas.berkeley.edu/public/wp-content/uploads/2009/06/challenges-opportunities-for-sustainable-manufacturing.pdf. Accesed 20.12.2010

[9] Draghici, A. Izvercianu, M. Vartolomei, M. Duran, Y.: Research on eco-business training requirements. Environmental Engineering and Management Journal, 8(4), 709-713 (

[10] Emmanouilidis, Ch. Pistofidis, P.: Machinery self- awareness with wireless sensor networks: a means to sustainable operation. Proceedings of the 2nd workshop ‘Maintenance for Sustainable Manufacturing’, 12 May 2010, Verona, Italy, pp. 43-50. (pre-print of the original published by Poliscript) http://www.ipet.gr/~chrisem/Files/CE_M4SM_2010a.pdf. Accesed 20.12.2010

[11] Farinha, J.T.: The Contribution of Terology for a Sustainable Future, Proceedings of the 3rd WSEAS Int. Conf. on Energy planning, Energy saving, Environmental education. 110-118, Accesed 15.12.2010 http://www.wseas.us/elibrary/conferences/2009/lalaguna/EPREWA/EPREWA14.pdf.

[12] Farinha, J.T. Fonseca, I. Simoes, A. Barbosam., Bastos, P. Carvas, A.: A Better Environment Through Better Terology, Recent Advances in Energy & Environment, pp 384-390 Accesed 15.12.2010, http://www.wseas.us/e-library/conferences/2010/Cambridge/EE/EE-64.pdf.

[13] Kopac, J.: Achievements of sustainable manufacturing by machining. Journal of Achievements in Materials and Manufacturing Engineering, 34(2), 180 – 187 (2009)

[14] Marquez, A.C.: Modeling critical failures maintenance: a case study for mining. Journal of Quality in Maintenance Engineering , 11 (4), 301–317 (2005)

[15] Mechefske, C.K. Wang ,Z.: Using fuzzy linguistics to select optimum maintenance and condition monitoring strategies. Mechanical Systems and Signal Processing, 17 (2), 305–316 (2003)

[16] Michaelis, L.: The role of business in sustainable consumption. Journal of Cleaner Production. 11, 915–921 (2003)

[17] Rutherfoord, R. Blackburn, R. A. & Spence, L. J.: Environmental management and the small firm: An international comparison. International Journal of Entrepreneurial Behaviour & Research. 6, 310–326 (2000)
[18] Saranga, H.: Opportunistic maintenance using genetic algorithms. Journal of Quality in Maintenance Engineering , 10 (1), 66-74 (2004)
[19] Sherwin, D.J.: Age-based opportunity maintenance. Journal of Quality in Maintenance Engineering, 5 (3), 221-235 (1999)
[20] Sidorczuk-Pietraszko, E.: The concept of sustainable development at organizational level, in Towards the Theory of Sustainable Development. Bialystok-Warsaw: Polish Academy of Science. Studies on Sustainable Development. 365 (2007)
[21] Simeu-Abazi, Z. Sassine, C.: Maintenance integration in manufacturing systems by using stochastic Petri nets. International Journal of Production Research, 37, 3927-3940 (1999)
[22] Sneddon, C. Howarth, R. B., & Norgaard, R. B.: Sustainable development in a post-Brundtland world. Ecological Economics, 57(2), 253-268 (2006)

Part VIII
Climate Change Modeling and Monitoring

Automated event sampling and real-time data access within hydrological measuring networks by means of Low-Earth-Orbiting Satellites

Hermann Stadler[1)], Albrecht Leis[1)], Markus Plieschnegger[1)], Paul Skritek[2)], Kurt Woletz[2)], Andreas Farnleitner[3)]

[1]Joanneum Research, Institute of Water, Energy and Sustainability, Graz
[2]University of Applied Sciences, Technikum-Wien
[3]Vienna University of Technology

Abstract. In the field of hydrogeological investigations event monitoring and event sampling are indispensable tools to get detailed information about parameters of the aquifer and the vulnerability. The use of event monitoring for microbiological investigations is a new field of activity, which was enabled by development of new communication structures and methods of analysing. The system, which is presented here, enables fully automated event sampling and real-time availability of data. By means of networking via Low Earth Orbiting Satellites data from the precipitation station (PS) in the catchment area are brought together with data of the spring sampling station (SSS) without the need of terrestrial infrastructure for communication and power supply. Therefore a completely automated event sampling procedure is made possible. Furthermore the whole course of input and output parameters, like precipitation (input system) and discharge (output system) and the status of the sampling system, is transmitted via LEO-Satellites to a Central Monitoring Station (CMS) which can be linked with a web-server to have unlimited real-time data access.

Keywords: measuring networks, Low Earth Orbiting Satellites, hydrological event sampling, isotope analyses, pollution microbiology

1 Background and aim of research

Water resources from alpine and other mountainous karst aquifers play an important role for water supply in many European countries. As regulated in the WFD (Water Framework Directive), karstic catchments require a sustainable protection. The increasing impact to such regions and the different utilization in the watersheds of karst springs are important reasons to establish early warning systems and quality assurance networks in water supplies. These systems rely heavily on in-situ measurements and near real-time availability of the data. With a satellite based networking of measuring and sampling stations it was possible to carry out precipitation triggered event monitoring campaigns at different karst

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_56,

springs [7] combining on-line measurements of hydrological parameters with field-laboratory based analyses of microbial faecal indicators [6].

2 System description

Based on extensive technical and cost comparisons and on validation measurements [4], the ORBCOMM LEO Satellite system was chosen. ORBCOMM is a "Little-LEO" system, with 30 servicing satellites in 6 orbit planes of 800 km altitude. It provides bi-directional "short message" data-transfer at 2.4/4.8 kbps, with data blocks preferably less than some 100 Bytes. ORBCOMM operates at frequencies about 140 MHz, providing large satellite footprints, and requires only low-cost/low-power equipment, allowing, e.g., simple whip-antennas as well as small solar-panels for power supply and transmission even from forests. ORBCOMM satellite modems are smart transceivers that include a user programmable microcontroller with several I/O-lines and AD/DA-converters (also with GPS-receiver) and can be used as "stand alone" data-acquisition systems.

The ORBCOMM modem transmits its data to the satellite, from where down-link transmission is performed either directly to one of the Gateway Earth Stations (GES) or as "globalgrams" (data stored in the satellite and forwarded to earth when the satellite passes the desired GES). The GES emails the data to the receiver via internet or re-transmits it to any "nomadic" ORBCOMM modem again via satellite.

Although the ORBCOMM system covers the entire globe, "visibility gaps" may occur between satellite passes. Best-case locations, however, showed about 70 % "satellite-in-view" and average transmission delays of only 3 minutes [4]. Further measurements and simulations of satellite gaps for environmental applications are reported e.g. in Stadler & Skritek [5].

3 Assembling, networked Stations and Data Streams

The precipitation station (PS) is located in the catchment area of the spring, where the event sampling will be carried out. It is equipped with a tipping bucket, a data logger and a LEO-Satellite modem. It can be supplemented with additional meteorological sensors and sampling devices. The monitoring and sampling site at the spring (spring sampling station, SSS) is equipped with an additional data logger, a pressure probe to register the changing of discharge, two automatic sampling units (one for the reference sample and one for the periodic samples) and a LEO-Satellite modem for real-time control and data transmission. It can be supplemented with additional hydrological or meteorological sensors.

Stream of data and information: As soon as the trigger-level is exceeded in the catchment area at the PS (predefined amount of precipitation in a definite period, both parameters are selectable) a trigger report is sent to the SMS via satellite. There the reference sample is taken automatically. In addition, the PS starts sending via LEO-Satellite continuously data about the rainfall to the CMS. The SMS is now ready to wait until the second trigger-level (increase of discharge, also programmable) is exceeded. If this happens, the periodic sampling within the event sampling starts automatically and the status information and measured values are continuously sent via satellite to the CMS and the local service team is informed.

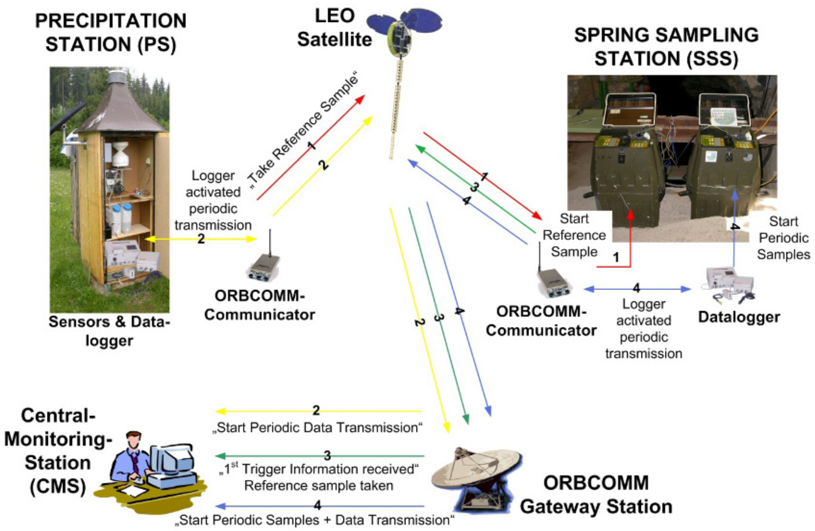


Fig. 1. Key layout of Assembling. Stream of data and information within a LEO Satellite based hydrological network for an event-triggered sampling and monitoring

Precipitation Station (PS): It records rainfall and other meteorological data. From the intensity and the recorded amount of precipitation a specific trigger criterion is derived. If this trigger-level is exceeded, the PS activates one or more SSS via satellite (Data Stream 1, Fig. *1*) to take the reference sample. This happens before the event affects the discharge of the spring. The CMS is also informed via satellite by receiving periodic data sets from the PS to observe the further trend of precipitation (Data Stream 2, Fig. *1*).

Spring Sampling Station (SSS): As soon as the activation data-set is received, the automatic sampling unit takes the reference sample. The status is sent to the CMS (Data Stream 3, Fig. *1*).This procedure can be repeated several times, depending on the number of sampling bottles in the automatic sampling device. This is necessary because due to the hydrological boundary conditions the upcoming event at the spring is worth sampling.

Now the SSS is waiting during a specified period of time for the increase of the discharge, which is the second trigger event. The trigger level is derived from the increase of the gauge height within a period of time and is chosen according to the characteristics of the spring. This trigger criterion is activated from the data logger. If the predefined trigger level is exceeded, periodic sampling is started automatically. The information is sent via satellite to the CMS. The SSS starts also periodic data transmission to the CMS to trace this event (Data Stream 4, Fig. ***1***).

Central Monitoring Station (CMS) and Web-Interface: There the information from all stations is collected. Additionally the local service team is informed from the CMS automatically of important facts like starting of rainfall (1st trigger) and starting of the sampling procedure at the SSS (2nd trigger) via GSM cell phones. Depending on the sampling time increment and the number of bottles in the automatic samplers, they can plan their next visit at the SSS to maintain the station.

The CMS provides an online Internet-Portal for access to these environmental data (Fig. ***2***). It is built around the server-based operating system Debian, which is a stable free software, providing perfect interaction and performance with the server. Among others, the server comprises a RAID-system for fault-tolerant operation.

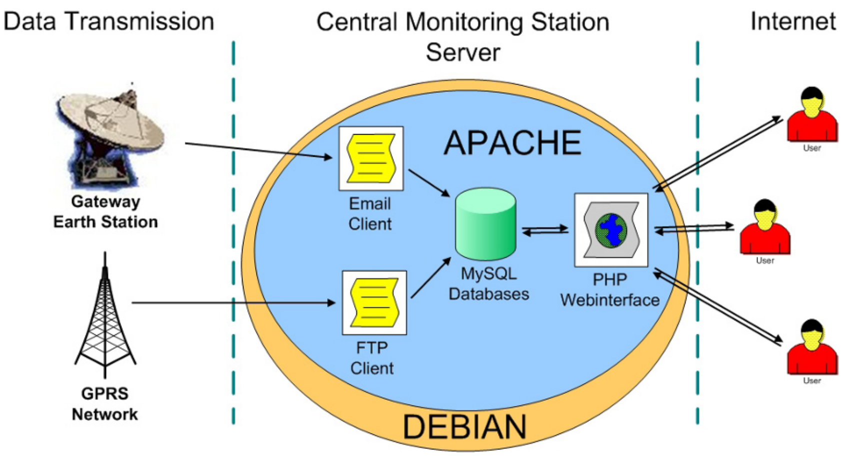


Fig. 2. Components and Activities at the Central Monitoring Station (CMS)

A dedicated email-client was developed to decode and extract the compressed measurement data sets and to store them into the integrated MySQL database. For this purpose Perl was used as the programming language, which allows very efficient coding.

The email-client is fully automated and dynamically coded, so no user defaults are needed for this stand-alone program. The client is also very easy to handle if additional measurement stations should be integrated into the system. It provides flexible and simple configuration e.g., for individual number of stations, types and coding of input data-sets. Additionally, the client automatically detects incorrect emails (syntax check) and stores them in a specific data-base table. In this case, it can also automatically send an information mail to the user on this error.

To provide on-line communication with access to the stored measurement data via the Internet, an Apache Web server was implemented on the Debian-Server. The dynamically generated online website can be viewed under http://wrms007.joanneum.at. The start-page is shown in Fig 3. The freeware PHP was used for programming these interactions between the Internet users and the CMS. Furthermore, PHP can also interpret other interface languages, e.g., XML or JavaScript, using standardized modules, which makes the chosen implementation very flexible for on-line environmental communication.

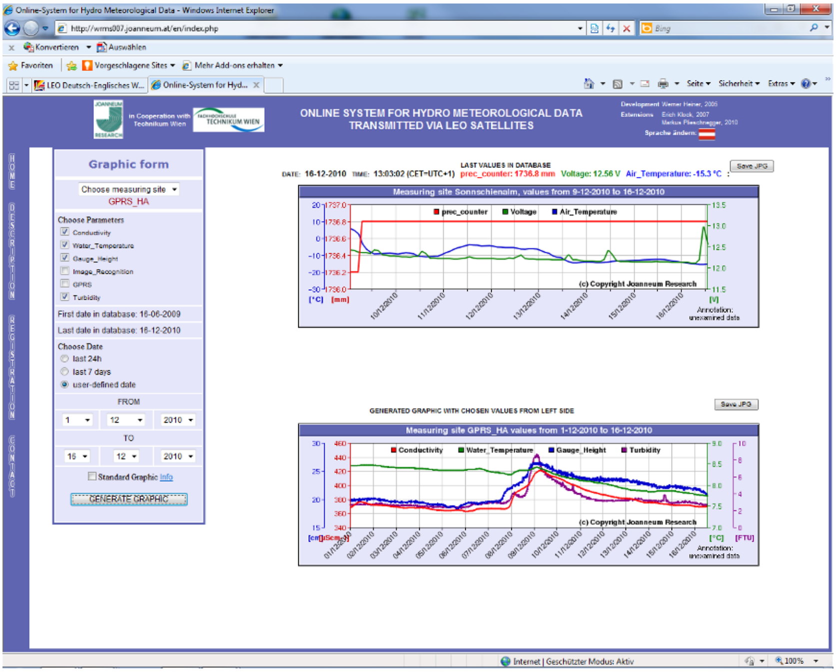


Fig 3. Dynamically generated Website for Online Data

Additional to the online graphical presentation, all co-workers and public access users may also download these graphics to their local machine. Using password-protection, several access levels to the data and visualization are feasible for different user groups, e.g., general public access to environmental information vs. individual access for specific in-depth data for research-project co-workers [2].

4 Study area and methods

The investigations were carried out in a karstic catchment area of the Northern Calcareous Alps. The event at the karst spring LKAS1 was caused by an aestival thunderstorm with 40.2 mm precipitation measured in the watershed at 1520 masl. The samples at the spring (n=157) were taken with automatic sample devices from August 21 to August 31, 2009.

E.coli was analysed by the Colilert system (IDEXX) directly at a field laboratory as previously described [6]. Hydrological in situ measured on-line parameters were collected with an increment of 15 minutes. To study microbial faecal pollution *E.coli* was chosen as indicator organism. In contrast to other standard faecal indicators, detailed previous investigations highlighted its excellent applicability as a general faecal pollution indicator in alpine karstic environment [1].

Long term Colilert analyses were also used for microbial system assessment of alpine karst aquifers. According to WHO, system assessment constitutes a crucial requirement for the establishment of water safety plans [8]. Furthermore microbial hazard analysis can be performed which subsequently can lead to microbial hazard characterisation. General microbial faecal hazards can be detected by traditional faecal indicators and are subsequently characterised by microbial faecal source tracking techniques. Knowledge about the quantitative and qualitative nature of microbial faecal pollution enables optimised environmental measures and hazard minimisation strategies. The system can also support quantitative microbial risk assessment under realistic bad case conditions by means of event sampling. The basic part of the described system can also be used for long term data acquisition. It includes remote control of the measuring station, quality surveillance of the measurements and web access to gathered data.

5 Applications and results

As alpine karst aquifers typically have short response times to rainfall events, especially to heavy thundershowers, it is important, to have a fast and reliable data link between the networked stations. From 2005 to 2009 seven Event-sampling campaigns at 4 different karst springs in the Northern Calcareous Alps in Austria were performed. All data were analysed concerning the suitability of the LEO-Satellite system for the described purpose. It could be shown, that the system is reliable and the streams of data in the network are despatched fast enough to serve the purpose also within an early warning system.

Both Rainfall and hydrological response (discharge) cause associated trigger signals. The precipitation trigger is exceeded, when more than 0.6 mm precipitation is measured within 5 minutes. This value was chosen after analysing typical alpine thundershowers of a precipitation station at a sea level of 1550 m. That means, the trigger marks not the beginning of the event, but an intensive phase of the rainfall event. A typical time lapse of the event, including the points of trigger time is presented in Fig. ***4***.

With a time lag of 6 minutes and 37 seconds between exceeding the rainfall-trigger in the watershed and executing the reference sampling it is clearly shown, that LEO-Satellite communication very suitable for this purpose.

The second triggering is the raise of the discharge of the spring. This reaction to the precipitation event has to be chosen individually for each investigated spring, according to its characteristics. As soon as the raise of discharge exceeds the predefined value, the first sample of the automated continuous sampling is taken. This sequence is shown in Fig. ***4***.

With this system it is possible to perform a completely automated event sampling, including also the very important reference sample. This reference sample characterizes the state of the investigated karst system before influenced by the causing thundershower.

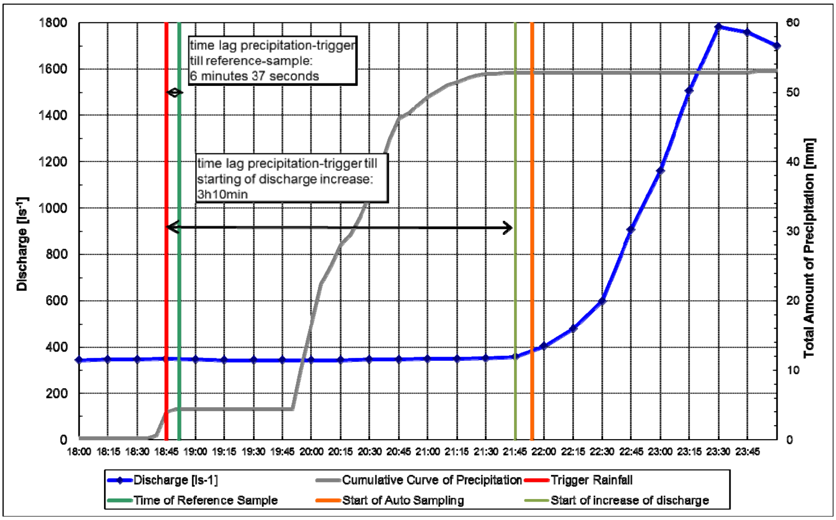


Fig. 4. Trigger times and hydrological response to precipitation

The integration of on-line measured data, laboratory and field laboratory analyses, all of them recovered with high time resolution, allows a deep insight to these sensitive aquatic systems. Especially the combination with environmental isotopes (Fig. ***6***) generates new knowledge of the dynamics, mass transport conditions with different transfer behaviour of the particular substances being of fundamental importance for the sensible use of early warning systems. As an example the correlation between SAC254 (Spectral Absorption Coefficient at 254nm) and *E.coli* during the course of the event is shown in Figure 5. *E.coli* is a significant parameter of faecal pollution in alpine karst aquifers [1]. Concerning the short reaction times of karst aquifers as shown above, *E.coli* analyses cannot performed in time. So it is necessary to look for parameter strongly related to *E.coli*. We found the SAC254 as a proxy. SAC254 can be measured in-situ. Via our communication system it is available near-real-time and can be used within an early warning system.

Very important for the use of SAC254 as an early warning proxy is the lead time of SAC254 to *E.coli*, which enables reactions times for water abstraction management. During this lead time the SAC254 is raising significantly, *E.coli* does not. As both parameters are surface related, we interpret this as an elution process of *E.coli* from soil. This behaviour enlarges the capability of SAC254 as an early warning proxy. A second important behaviour both parameters is the strong correlation of them during a discharge event (Figure 5). Our long term investigation has pointed out that there is no correlation of *E.coli* and SAC254 beyond events.

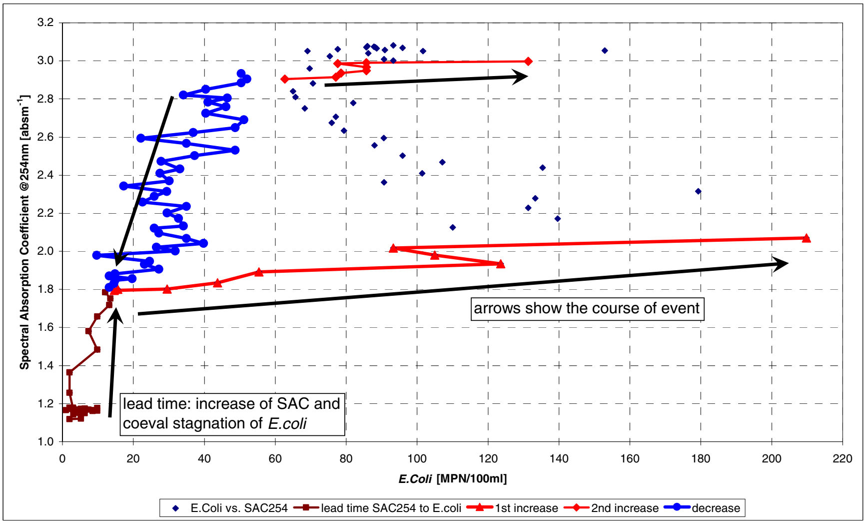


Figure 5: Correlation of SAC and E.coli during the observed event.

The comparison of the Oxygen-18 as a proxy of the aquifer-dynamic and SAC254 as indicator of surface related mass transport of substances show different behaviours during the event, but at the starting point of the event, there is no difference between these parameters. The hydraulic reaction, identified as the raise of discharge, is the first changing part of the system. SAC254 as a surface related parameter and Oxygen-18 as fingerprint of the water start changing nearly at the same time. We interpret this as the reaction of a well exchanged aquifer with immediate response to rainfall events as Oxygen-18 seems to be influenced by "heavy" summer rain.

Complementary to this the Calcium-Magnesium ratio gives insight to water matrix reaction in the aquifer system. This is shown in Fig. ***6***. The decreasing of Calcium and a simultaneous stable Magnesium concentration can interpreted as activation of water flows from a more dolomitic part of the catchment area. In combination with geological investigations this data can be used to allocate different districts in the catchment area.

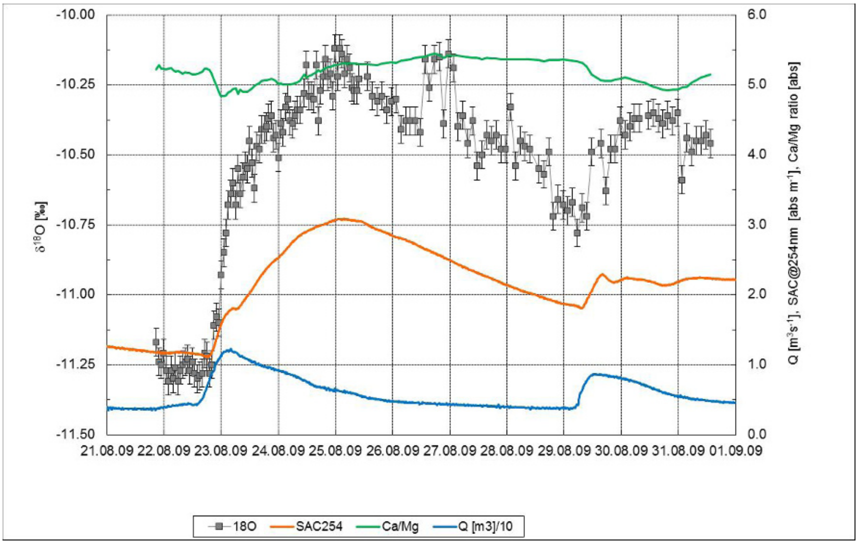


Fig. 6. Course of in-situ measured parameters and Oxygen-18 from laboratory analyses during observed event.

6 Conclusions

Conducting different hydrogeological investigations in alpine karst aquifers, both event based samplings and monitoring and continuous monitoring with near real-time data access, it could be shown networking of hydrological measuring points by means of LEO-Satellites is an appropriate tool. Using this backbone of communication it is possible to carry such research in areas without any terrestrial infrastructure of communication. This is very important in alpine regions, where GSM/GPRS communication is not available. In areas, where terrestrial infrastructure of communication is on hand, the described system can be combined with it. It is also to be mentioned, that the remote segment of the system is energy self-sufficient by using solar power.

It was also shown, that the LEO-Satellite communication is reliable and enables near real-time triggering as assumption for the use in early warning systems. By augmenting the combination of On-line measurements and laboratory analyses also to chemical parameters new insights to event related processes in a karst aquifer were enabled.

Acknowledgements. The work was carried out in close cooperation with the Vienna Waterworks (Dr. Wolfgang Zerobin) and supported by the area management of the Vienna Waterworks in Wildalpen (Ing. Christoph Rigler). Our thanks go also to Mr. Hermann Kain for the excellent technical assistance.

References

[1] Farnleitner A. H., G. Ryzinska-Paier, G. H. Reischer, M. M. Burtscher, S. Knetsch, A. K. T. Kirschner, T. Dirnböck, G. Kuschnig, R. L. Mach & R. Sommer (2010): Escherichia coli and enterococci are sensitive and reliable indicators for human, livestock and wildlife faecal pollution in alpine mountainous water resources. Journal of Applied Microbiology, Vol.109(5), 1599-1608

[2] Heiner, W. (2005): Online-system for hydro-meteorological data transmission via LEO-satellites (in German). Diploma thesis, p126, University of Applied Sciences Technikum-Wien, Vienna

[3] Skritek, P., Lukasch, F., Din, K., Hodi, T., Stadler, H. (2002). Environmental Data-Transmission using Low Earth Orbit Satellites. Proc. 16th Int. Conf. EnviroInfo2002, 727-734, Vienna.

[4] Skritek, P. & Pfliegl, R. (2002). "Near Online Vessel Tracking on European Waterways combining GPS and LEO-Satellite Transmission". In Proceedings of ENC-GNSS2002 Conf. (CD-ROM), Amsterdam.

[5] Stadler, H. & Skritek, P. (2004). Networking of Automated Event-Sampling Hydro-Meteorological Measuring Sites using LEO-Satellite Communication. Proc. 18th Int. Conf. EnviroInfo2004, Geneva.

[6] Stadler H., P. Skritek, R. Sommer, R. Mach, W. Zerobin, A. H. Farnleitner, (2008): Microbiological monitoring and automated event sampling at karst springs using LEO-satellites.- Wat. Sci. Tech. Vol.58(4), 899-909.

[7] Stadler H., E. Klock, P. Skritek, R. L. Mach, W. Zerobin, A. H. Farnleitner (2010): The spectral absorbance coefficient at 254nm as a near real time early warning proxy for detecting faecal pollution events at alpine karst water resources. Wat. Sci. Tech. Vol.62(8), 1898-1906.

[8] WHO (2005): Water Safty Plans. Managing drinking-water quality from catchment to consumer. 244p., WHO/SDE/WSH/05.06, Geneve.

Parallel and GPU based strategies for selected CFD and climate modeling models

Krzysztof Kurowski, Michał Kulczewski, Mikołaj Dobski

Poznan Supercomputing and Networking Center

krzysztof.kurowski@man.poznan.pl, michal.kulczewski@man.poznan.pl, mikolaj.dobski@gmail.com

Abstract. In recent years we have observed a huge increase in natural disasters, such as earthquakes, tornadoes and floods. Even Poland as a relatively stable region has experienced many big natural disasters, in particular three floods early this year with the estimated cost around 3 billion Euro. To address the dramatic changes in our climate, hydro-meteo scientists have to work together to share important data, tweak existing meteorological models, even couple them, ultimately achieving the goal of preventing such disasters in the future. The computing power and data capacity grow every day, and scientists are willing to run the hydro-meteo simulations at greater model size as well as use new archiving and back up services for historical analysis. However, to benefit from modern architectures, applications and data structures have to be adapted properly. In this chapter we discuss various ideas to improve the performance of Eulag - a numerical solver for all-scale geophysical flows using innovative computing technologies. We present preliminary results of applying the GPGPU and OpenMP shared memory model to Eulag, so that the application can be well scaled on cluster of GPUs or cluster of SMPs nodes respectively. Moreover, we present additional useful solutions to visualize the hydro-meteorological data at speed, as well as to share data in a secure way among end-users

Keywords: climate modelling, visualization, optimization, modern architectures

1 Introduction

In recent years we have observed a huge increase in natural disasters, such as floods, tornadoes and earthquakes. In 2010 Poland experienced three floods, with the estimated cost around 3 billion Euros. To address the dramatic changes in our

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_57,

climate, hydro-meteorological scientists and climate researchers from different regions have to work together to share important data, tweak existing meteorological models and couple them, ultimately achieving the goal of preventing such disasters.

On the other hand, the computing power and data capacity grow every day. Scientists are willing to run the hydro-meteorological simulations at greater model size as well as use new archiving and back up services for historical analysis available in remote data centers in the cloud fashion. Moreover, major hardware vendors promote highly parallel, many-core and power-efficient computing devices, focusing on low power computing cores rather than increasing their complexity and clock frequency as well as new computing approaches such as General Purpose Graphics Processing Unit (GPGPU) based computing, Cell B.E. or Field Programmable Gate Array (FPGA). However, to benefit from modern computing architectures, applications and data structures have to be adapted properly. In other words, legacy applications simply cannot take full advantage of the new computing hardware as they have to be often rewritten or implemented from scratch in a multi-threaded or multi-process manner to take full advantage of the hardware.
In this chapter we discuss various ideas to improve the performance of Eulag [1] - a numerical solver for all scale geophysical flows using innovative computer technologies. We present preliminary performance results of applying the GPGPU computing to the Eulag model. Additionally, we discuss how various procedures and data structures can be redesigned in order to benefit from the GPU-based computing. Moreover, we present additional useful solutions to visualize the hydro-meteorological data at speed, as well as to share data in a secure way among end-users.

The chapter is organized as follows. Section 2 describes the motivation behind applying the GPGPU paradigm to the Eulag model. As its general concept is related to the area of computational fluid dynamics (CFD), we discuss how various CFD modules can be executed efficiently on GPGPUs. Section 3 presents more details about our software development and optimization efforts performed in Eulag. Section 4 focuses on the visualization tools that can be used with Eulag and other scientific applications. Section 5 concludes our work performed at Poznan Supercomputing and Networking Center, and describes further steps as well.

2 Motivation

2.1 Computational Fluid Dynamics

Our experience with new computing architectures, such as GPGPU or Cell B.E., started with image and video processing applications [2]. However, with the advent of a new programming environment called CUDA (Compute Unified Device Architecture) we started testing other applications, including CFD software components [2]. In general, the CFD codes use various numerical methods to solve and analyze fluid flows. CFD methods are commonly used in various domains, such as aerodynamic body shapes optimization, numerical weather prediction, or oil and gas reservoir uncertainty analysis. In principle, CFD is a complex problem that needs a lot of computational power to obtain the results in a reasonable amount of time. That is why many of available CFD software components are optimized for running on clusters or supercomputers. However, since the behavior of particles in fluid dynamics depends only on behavior of surrounding particles, CFD should benefit greatly from GPU architecture consisting of hundreds of small cores as well.

2.2 Lattice Boltzmann

Lattice Boltzmann method (LBM)[3], [4] is a class of computational fluid dynamics methods for fluid simulation, which is an alternative for traditional methods, e.g. based on Navier-Stokes equations [5]. LBM models a fluid flow consisting of particles, which performs propagation and collision processes over a discrete lattice mesh. This approach to fluid dynamics has several advantages over conventional CFD methods, especially in terms of dealing with complex boundaries and high parallelization capabilities.

2.3 Running CFD simulation on different architectures

There are several open-source implementations of the LBM methods [6] available on the market. We focused on Palabos [7], a C++ implementation for workstations and clusters, and Sailfish [8], a Python version of LBM for GPU architectures. Our main application use case for LBM aimed to solve the rock permeability in porous media. However, for testing purposes, we focused on a lid-driven cavity 3D problem, which is known from its high memory utilization. That is why we had to restrict the mesh size to 300 points in each dimension during our tests. Simulation experiments were executed on both, cluster and GPU architectures, with the double precision being imposed. However, the domain size was optimized to fit the capabilities of GPU memory, as mentioned before. The results of performance tests were measured in Mega lattice sites updates per second. The following machines were used for testing:

- Cluster of 64 cores (Intel Xeon E5530 processors),
- Workstation with Tesla S1070 GPU,
- Workstation with Fermi GTX480 GPU;

The tests on workstation machines were performed with one GPU only, since Sailfish component does not support multiple GPU usage yet.

Obtained results are presented in Fig. 1. What we can see is that the bigger mesh size is, the more sites updates per second are performed, which is quite obvious. As one can note, the Tesla GPU achieved maximum rate of sites updates per second from the very beginning, while the cluster and Fermi GPU had to 'warm up' to achieve its best rate, i.e. the mesh size should be big enough to observe an increase in performance. We have to bear in mind that GPU tests were performed only on one GPU, and that when the price to performance ratio is considered, the GPU computing still is the winner. The only drawback with GPGPU computing is the memory limit. Computing cluster systems can be used more efficiently for LBM as they can handle large domain size simulations. Unless there are GPU cards with a much bigger memory size on the market, users have to focus on smaller size problems, or switch to other scientific methods that consume less memory, Since numerical weather prediction (NWP) problems, including climate modeling, belong to such class, we started working on enabling NWP methods to be executed efficiently on GPUs and other modern architectures.

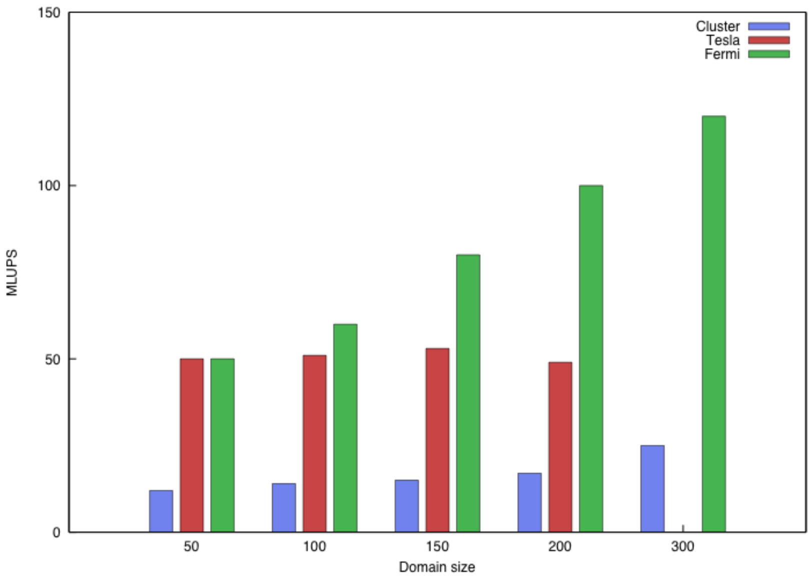


Fig. 1. LBM Lid Driven Cavity 3D MLUPS performance overview

3 Climate modeling

3.1 The Eulag model

Eulag [9] is high-resolution computational model for research of multi-scale geophysical fluid dynamics. Developed and supported by the Cloud System Group in the Mesoscale and Microscale Meteorology Division (NCAR) for more than twenty years, the Eulag solver offers many applications related to numerical weather prediction, including orographic and urban flows, solar convection and many more. The model consists of two numerical algorithms - nonoscilatory forward in-time (NFD) advective/convective transport, called MPDATA, and preconditioned non-symmetric Krylov-subspace elliptic solver GCR. These algorithms help to solve many different fluid equations, including anelastic, compressible and incompressible Boussinesq, incompressible Navier-Stokes or fully compressible for high-speed flows. The implementation of this model is known as a very stable and highly parallelized software, which scales well up to thousands of cores [10]. Therefore, our main motivation for our research was to select and adopt Eulag procedures and test their performance on GPUs to achieve even better performance.

3.2 GPU approach

Even though CUDA (Compute Unified Device Architecture) provides high level APIs for programmers, one still has to be familiar with the GPU architecture and various hardware constraints, including the memory size and its specific configuration. In fact, in the context of our tests, one of the key constraints is the host-to-device and device-to-host memory bandwidth. All the data computed on GPU has to be kept within its memory. Then, prior to computing, data must be copied into the device and once done copied back to the host. Moreover, the GPGPU computing is also very sensitive to branching instruction, e.g. *if* and *switch*. Therefore, if an application needs to be adapted to GPU, the code needs to be rewritten to get rid off the conditional statements. Taking this requirement into account, we performed some analysis of the Eulag source code to discover how often, and for how long, each procedure is invoked (Table 1). Then, we decided to concentrate the GPU acceleration on a certain procedure called *laplc*.

Table 1 Code profiling for test with varying grid (time[s] / calls [1])

a)

Domain size	**main**	**gcrk**	**precon_***	**laplc**	**update2**
128x64	33/1	24/289	14/4769	5/4480	9/28228
256x128	309/1	274/289	160/18830	41/18541	38/112594
512x512	1962/1	1798/289	851/19911	284/19622	227/119080
1024x512	14597/1	13840/289	7953/18847	2397/18558	2263/112696

b)

Domain size	**updatebt**	**updatelr**	**globsum**	**globmax**
128x64	2/27929	1/24611	3/34199	1/7788
256x128	11/98234	11/94916	35/145717	10/21849

512x512	32/103639	218/100321	398/143782	43/22906
1024x512	849/98319	661/95001	1287/140427	288/21855

Initially the *laplc* procedure appeared to be a long and complex method with multiple conditional statements. After some analysis, a particular single functionality of this method was extracted, providing a four-core parallel version of *laplc* routine with only one conditional statement present in the code.

3.3 PGI Accelerator

To enable GPGPU computations calculation blocks from legacy applications could be extracted, like Eulag procedures, then rewritten to CUDA or OpenCL (Open Computing Language), eventually compiled and linked with Eulag's code in Fortran. However, there is an alternative approach, namely the PGI Accelerator [11]. This technique automatically creates CUDA from the Fortran code based on OpenMP-like region directives. The PGI solution extends OpenMP-like preprocessor API with a *data region* sections to control the data manipulation between GPU and host memory. In this approach the programmer has only to write a few directives and the compiler does all the work behind: create GPU kernels, all required GPU API operations and prepare code responsible for data manipulation.
In 2009, PGI team performed work of enabling GPU technology to other NWP model - WRF (Weather Research and Forecasting model). The work considered rewriting parts of the WSM5 procedure - one of the most computationally intensive module of WRF - to make it GPU-ready, using the PGI Accelerator solution. Presented results [12] encouraged us to perform similar work with the Eulag legacy code.

3.4 Initial results

As mentioned before, the *laplc* routine was prepared to be run on 4 CPU (Intel Xeon 5405 2.0GHz) + 4 GPU (T10) environment. The results are presented in Fig. 2 and give the performance overview emphasizing the differences between pure CPU code (prepared with PGI compiler) and 1 to 4 GPU units.

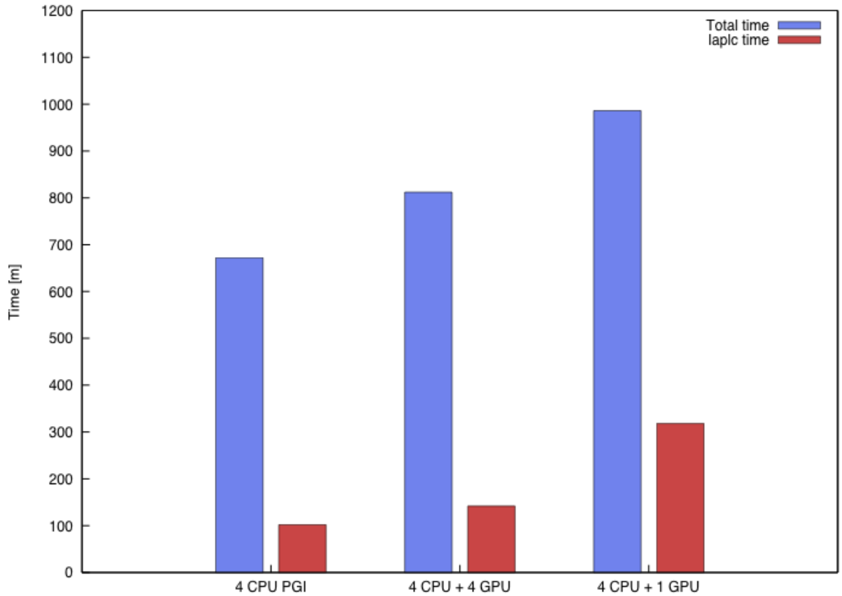


Fig. 2. *Laplc* performance time on different architectures

Unfortunately, our performance tests showed that none satisfactory speedup was gained. According to the results, the investigated procedure took even longer on GPUs. The main problem was the memory bandwidth bottleneck. The computational complexity was far too low comparing to the amount of data that need to be copied onto and off the GPU. Therefore, we decided to extract Message Passing Interface (MPI) messages from the *laplc* procedure onto a higher level to avoid constant data copying from and to GPUs .

3.5 An alternative approach for the GPGPU computing

As none acceptable rate of speedup was observed due to many MPI messages and memory bandwidth bottleneck, another part of the Eulag code was selected as a good candidate to better up the application efficiency. In fact we selected less MPI-proned procedure of Eulag - the Multidimensional Positive Definite Transport Algorithm (MPDATA) [13], one of the numerical algorithms present in Eulag. Years ago, MPDATA was treated as an inexpensive alternative to flux-limited schemes for evaluation of the advection of nonnegative thermodynamics variables in atmospheric cloud models. Later, it evolved into a class of transport algorithms, with a variety of extensions available. In Eulag, MPDATA is used for simulating rotating, stratified flows on micro to global scales.

The MPDATA part was separated from the source code and the conditional statements were removed, since they are not very suitable for the GPGPU computing.

After some analysis, we successfully managed to prepare a major part of the algorithm to run fully on the GPU. At the beginning only necessary input data is uploaded from the host memory to GPU. To achieve this stage, the GPGPU processing required various modification and creation of special data region to wrap all the accelerated loops within acceleration regions. Each called method within the GPU accelerated region needed to be manually inlined instead of its call. An interesting issue has been found during this step. When single precision mode has been applied, the code run properly either on CPU and GPU. However, when double precision was preferred, we observed an error level of 10^{-6}. Only the code compliant with *Compute Capability 2.0* produced verifiable results. This is however already solved problem as CC2.0 Fermi GPU is fully compliant with the IEEE754 standard.

Presented results were obtained from the test workstation machine equipped with an Intel Core2 Quad Q0550, 2.83GHz, 6MB cache, 1.5GB main memory and GeForce GTX 480 graphic card. The code depended on a given data set of dimensions. As one can observe, the code scales well with the multiple vertical matrices where each thread group was given a full separate layer of data as it is presented in Fig. 3.

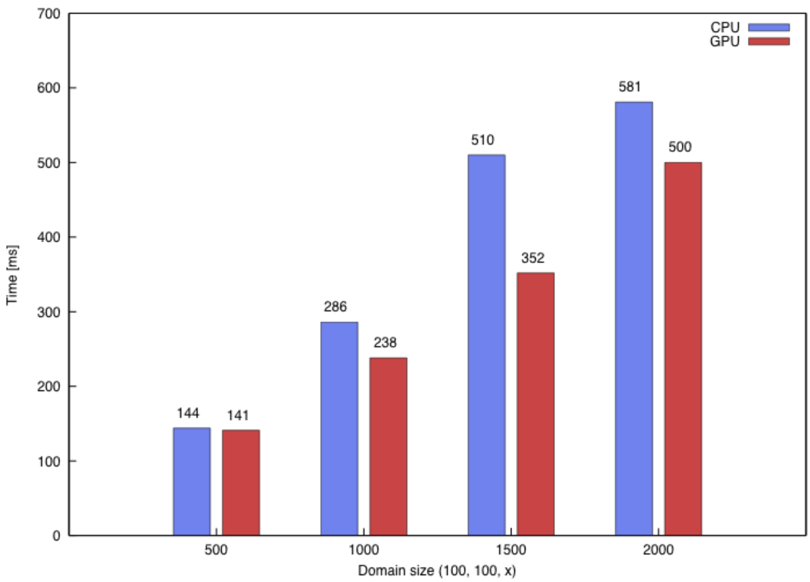


Fig. 3. GPU and CPU time comparison of MPDATA for domain size 100,100,X

Providing the GPU with a considerably flat but wide dataset resulted in many computations done sequentially what causes the performance decrease on GPUs as it is shown in Fig. 4.

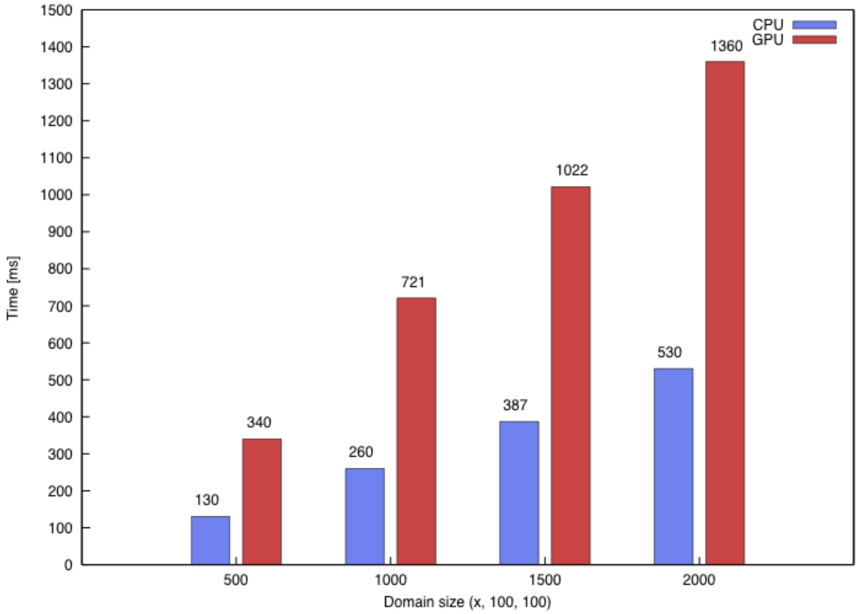


Fig. 4. GPU and CPU time comparison of MPDATA for domain size X,100,100

Fig. 5 and Fig .6 present GPGPU computation decomposition for domain size 100,100,X and X,100,100 respectively. The execution time was divided into the time spent on calculation, and time of sending data to GPU and back. What is interesting is that the time needed for data to be uploaded and downloaded to and from GPU does not vary with the type of dataset (flat and wide or high and narrow). What differs is the time spent on calculations, which proves that many of those are still done sequentially for specific type of dataset (flat and wide). To improve the efficiency for such dataset, a new algorithm dedicated to GPU architecture should be provided.

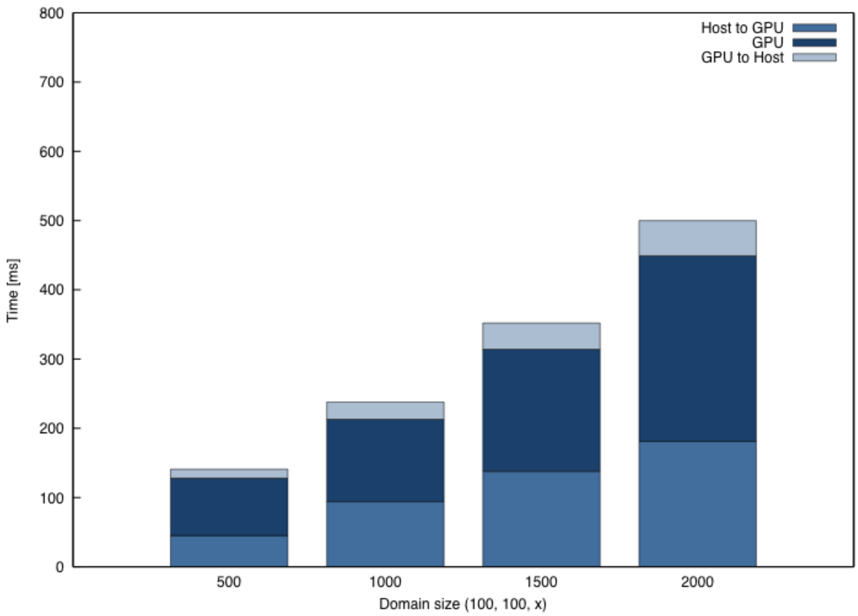


Fig. 5 GPGPU computation decomposition for domain size 100,100,X

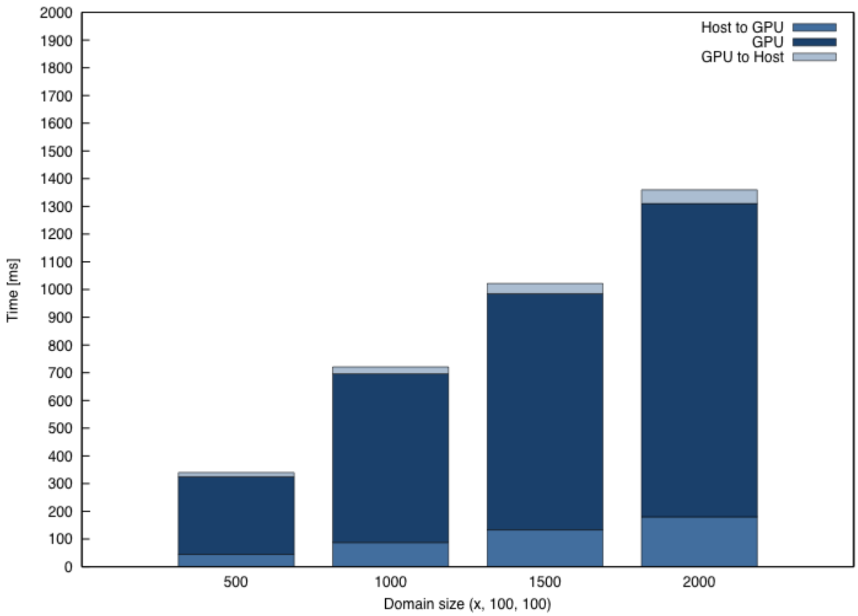


Fig. 6. GPGPU computation decomposition for domain size X,100,100

Working with Eulag as a good example of an application fully optimized for cluster environment we realized how difficult it is to introduce efficient CUDA parallel procedures. Technically speaking, the 3-level loops do not always provide stride-1 access to Fortran arrays and need to be reorganized. Some innermost loops still contained conditional statements, which dramatically reduced the GPU performance. Furthermore, most loops we discovered were created with cross-cell matrix dependency that prevents independent access for each working thread.

Based on presented results one can ask if porting a legacy application on new accelerated architecture makes sense. In our opinion, using an accelerated approach (e.g. the PGI compiler) or rewriting the legacy code will result in at least the same or similar quality code from the performance perspective. Naturally, depending on the application one can discover many regions or procedures that can be improved significantly. In our opinion any accelerating tool can help a developer to focus on the code while improving its performance on GPU and CPU. Using this approach, data management and data transfers can be easily wrapped within easily understandable and manageable data regions. The compiler has almost a full knowledge of the development architecture and thus automatically divides and deploys appropriate pieces (kernels) of the original code on GPUs to achieve a better. When a significant speedup is expected in case of moving to GPU architecture, a manual approach to code examination, including developing of the new, GPU-friendly algorithm may be needed.

4 Visualization and data management

Additionally, in order to ease hydro-meteorological community collaboration we provided a web-based Science Gateway solution. In fact, it is a kind of virtual connection between scientists and their computational tools within a web portal. Our solution offers a virtual space for communities, collaboration and data sharing and visualization capabilities in a comprehensive and efficient manner. Such solution allows users to access computational resources, process and analyze their data, obtain and visualize results in a user friendly, and secure, way. The core mechanism behind the Science Gateway is a Vine Toolkit [14]. It is a modular, extensible and highly easy-to-use tool, offering Application Programming Interface (API) for various applications, visualization components, with support for many different HPC and grid technologies. Vine Toolkit has been successfully used as a core web platform for various gateways. With the existing Science gateway tools we can easily envision a scenario in which a scientist may want to perform a simulation whether heavy rainfall will result in a danger of a flood. The proper Science Gateway offers scientist an ultimate and transparent solution to perform such scenario according to the following example procedures He enters a dedicated website where he select some meteorological data of the area of his interests. He is able easily to transfer input data to remote servers and begin an appropriate meteorological simulation, e.g. using accelerated computing resources. Once the simulation is completed the scientist is notified immediately that results are available. He can either download them to a local machine or visualize them using local application, or perform sophisticated visualization procedures remotely. There is an increasing interest in the field of real time and interactive high resolution visualization. We investigated two approaches: WebGL and OpenGL, which use client-side rendering, and one purely server-side rendering respectively and are available in Vine Toolkit.

We also started to investigate an approach to visualize scientific data on cluster machines, rather than on client machine or using web-based solutions. For testing purposes, we prepared a cluster instance of ParaView [15] running on hundreds of cores, where data is analyzed and rendered completely on the server side. Figure 1 presents some example CFD visualizations in ParaView. Initial obtained results encouraged us to deploy ParaView on even more traditional cores for postprocessing and visualization for larger amounts of data, but we are aiming in equipping cluster with GPU cards to speedup the rendering processes.

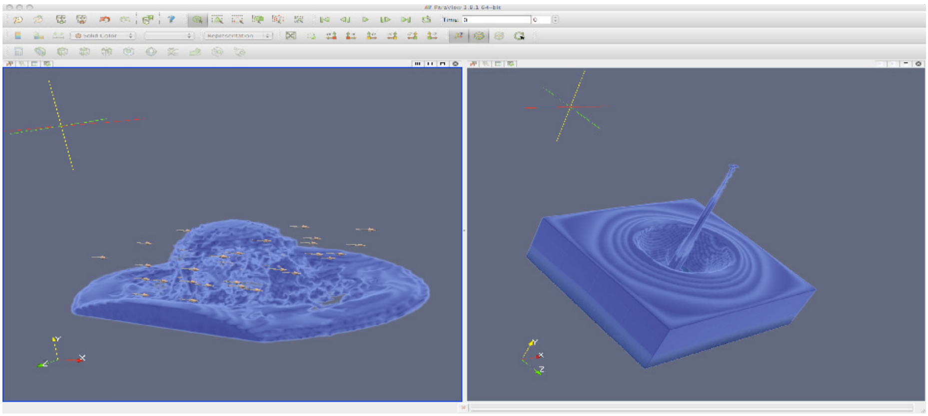


Fig. 7. Example CFD visualization in ParaView

5 Summary and further steps

In this chapter, we briefly presented our approach to apply example climate modeling procedures to modern architectures, in particular the GPGPU computing. Obtained results of applying GPGPU are promising, but still a lot of work needs to be done in order to achieve the desired, and payable, speedup. A selected climate modeling application - Eulag needs to be further investigated to find fragments of code numerically intensive and then adapted appropriately to the GPU architectures, what will require various development activities, e.g. conditional statement removal, data exchange minimization. Another approach would be to rewrite or even redevelop most important Eulag algorithms to make them GPU-friendly, thus obtaining better efficiency. These would be easier with some new applications being of great interest of the Eulag community.

We also consider applying other solutions, e.g. additional thread parallelization like OpenMP, so that legacy procedures can benefit from their hybrid nature (MPI and OpenMP). Since Eulag solver scales well on Blue Gene machine, it may be worth considering applying the OpenMP paradigm to Eulag, so that the SMP mode of the Blue Gene machine could be used. We believe, that it is worth also to investigate a hybrid approach mixing multiple parallelization mechanisms: MPI, threads and GPU at one time.

References

[1] Eulag http://www.eulag.org
[2] Bla ewicz M, Kurowski K, Ludwiczak B, Napierala K (2010) High performance computing on new accelerated hardware architectures. Computational Methods in Science And Technology Special Issue SEMI-ANNUAL:71-79
[3] Succi S (2001) The Lattice Boltzmann Equation for Fluid Dynamics and Beyond. Oxford University Press, USA
[4] Sukop M.C, Thorne D.T. (2006) Lattice Boltzmann Modeling. Springer
[5] Coheh I.M, Kundu P.K. (2007) Fluid Mechanics. Academic Press
[6] Geller S, Krafczyk M, Tolke J, Turek S, Hron J (2006) Benchmark computations based on lattice-Boltzmann, finite element and finite volume methods for laminar flows, Computer & Fluids, Volume 35, Issues 8-9, 888-897
[7] Palabos http://www.lbmethod.org/palabos/
[8] Sailfish http://sailfish.us.edu.pl/
[9] Prusa J.M, Smolarkiewicz P.K, Wyszogrodzki A. (2008) Eulag, a computational model for multiscale flows, Computer & Fluids, Volume 37, 1193-1207
[10] Piotrowski, Z.P, Kurowski, M.J, Rosa, B, Ziemia ski, M.Z. (2010) EULAG Model for Multiscale Flows - Towards the Petascale Generation of Mesoscale Numerical Weather Prediction, Parallel Processing and Applied Mathematics, Lecture Notes in Computer Science, Volume 6068/2010, 380-387
[11] PGI Accelerator http://pgroup.com/resources/accel.htm
[12] Wolfe M, Toepfer C. (2009) The PGI Accelerator Programming Model on NVIDIA GPUs Part3: Porting WRF. http://www.pgroup.com/lit/articles/insider/v1n3a1.htm
[13] Smolarkiewicz P.K. (1984) A Fully Multidimensional Positive Definite Advection Transport Algorithm with Small Implicit Diffusion. Journal of Computational Physics 54:325-362
[14] Russel M, Dziubecki P, Grabowski P, Krysi ski P, Kuczy ski T, Szejnfeld D, Tarnawczyk D, Wolniewicz G, Nabrzyski J (2008) The vine toolkit: A java framework for developing grid applications. Parallel Processing and Applied Mathematics: 331-340
[15] ParaView http://www.paraview.org/

Design of the efficient archival warehouse for weather forecast system

Slawomir Walkowiak[1], Lukasz Ligowski[1], Konrad Wawruch[2], Witold R. Rudnicki[1]

[1] Interdisciplinary Centre for Mathematical and Computational Modelling
[2] 7bulls.com

S.Walkowiak@icm.edu.pl;L.Ligowski@icm.edu.pl; kwaw@7buls.com; W.Rudnicki@icm.edu.pl

Abstract. The goal of this study is design of a database holding archives of weather forecast systems. The detailed description of the project and analysis of the database performance is presented, along with the experimental performance tests of key algorithms. A standard mode of data access is optimal for a sequential access to individual 2D grids (time-local and spatially-global), whereas new applications require reading long time series of localised data (spatially-local and time-global). The design goal is to increase a performance of access to archival spatially-local-time-global data, without visible degradation of performance of the standard access mode. The database is designed as two separate layers. The Format Translation Layer (FTL) is an interface between the database and the file-based output of the simulation and analysis programs. The Distributed Data Storage Layer (DDSL) is responsible for a secure data storage and an efficient access. The FTL reads output forecasts and converts them to the spatially local format. It splits large 2D arrays of data into small patches and forms 3D arrays, using time as the third dimension. The theoretical analysis of the performance shows that four orders of magnitudes improvement in comparison with the standard serial access and two orders of magnitude in comparison with parallelised version of the spatially-global access can be achieved.

Keywords: weather forecast system, data warehouse, data mining

1 Introduction

The goal of the project is to create a database engine for meteorological data, in order to facilitate analyses of historical data. Data from historical simulations may be used as a proxy for the real measurements in places where observational data is not available. There are numerous applications which can utilise such data. For example historical wind patterns may be used for locating wind turbines or studying transport of pollution. Historical relationship between meteorological conditions and power generation in an urban co-generation power plant can be

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_58,

used to develop model predicting power generation that is based on results of numerical weather predictions.

Historical relationship between temperature predicted by model and actual measurements in a particular orchard can be used for a localised model for frost prediction. Traditional archives of meteorological data are not designed for performing such analysis. Simulations are performed on 3D grids and therefore results of simulation are stored as collections of files containing time series of 3D grids (one 3D grid for each physical variable). A minimal unit of organisation is a single 2D grid for a single layer of a single variable in one moment of time.

Data is organised in a time-local and spatially-global manner, whereas the applications mentioned earlier require spatially-local and time-global access. The problem of data storage and access in large scientific projects is not limited to meteorology, to the contrary much larger data sets are being currently generated for example by astronomy [12], particle physics [13; 16], biology [5; 4; 14] etc.

Recently an initiative for creation of the general framework for the scientific databases, called SciDB project, has been established by several research organisations involved in generation of very large data sets along with database scientists [2; 3; 6].

The consortium aims at providing a rich set of features for storing and working with scientific data. The goal of the current project, namely designing and implementing database for weather forecast data allowing for a much faster access to the data for all relevant use cases, is limited in scope in comparison. However, most of the advanced features of the SciDB are not required in our application.

The limited scope of this project allows for a solution which can be simple and inexpensive, yet still quite general and scalable. An additional requirement for the system is that it should be compatible with current file-oriented methods of data analysis. In the following sections we will describe the design of the database and give some theoretical estimates of performance.

2 Design

2.1 The Data

The grids generated in weather simulation codes may be stored in individual files or may be a part of larger file. To collect a time series of data for a given location one needs to open all files containing interesting data. A process of collecting information is very slow, due to the following technical problems.

Archival data is stored in files and the natural method for accessing the data is sequential - one opens file reads the data, closes the file and goes to another file. This is roughly equivalent to reading in the sequential manner about 1 MB of data from a disk per single grid. Therefore, in order to collect ten year's history of a temperature in a single grid point with one hour resolution, one needs to access sequentially at least 10x365x24 = 87600 grids and read about 40 GB of data. Time of the sequential access to 40 GB of data takes about 400s on a standard disk in ideal conditions.

These calculations were performed with assumption that only a single grid is available for each time point. In reality there are several simulations carried out daily and therefore there are several results for any point of time. For example, if simulations are restarted every 6 hours and carried out for 48 hours (typical for medium scale simulation models), there are 8 different estimates of each variable in each grid point, and it is not obvious which estimate is best. Thus in practice we need to read all simulations and the estimated time for generation of the 10 years history of temperature in a single grid involves and reading 300 GB of data – the task that takes about 1 hour, while the useful part of the data occupies just 3 MB and could be read in a fraction of second.

In some cases a grid for a variable under scrutiny can be a part of much larger file – for example all grids for a single variable, or even all grids for multiple variables, can be stored in a single file, that is stored in a compressed form. In such situation the amount of data that needs to be accesses in order to be able to read history of a single variable in a single site can grow even more than hundredfold.

2.2 Use Cases

The design is developed with three typical access patterns in mind. The first pattern is typical for visualisation of weather forecast. User is interested in few grids covering entire prognostic area for limited time span - few days or one week at most. This is a traditional access pattern for meteorological data. The performance of standard file-based repository is sufficient for this access pattern. The second access pattern is when one collects historical meteorological data for small area, for example prospective site for a wind farm or area surrounding the orchard. In this case one is interested in a large number of readouts for very small number of grid points, for example four points closest to the point of interest. Very bad performance for this access pattern is a primary motivation for new design.

The third access pattern may arise for example for studies of transport of pollutants. Say, one is interested where a pollution from a new chemical plant may land in various meteorological conditions. To this end one needs to read all parameters affecting transport of pollutants such as wind, temperature, cloud coverage etc. downstream from the proposed site of the new plant. In most cases downstream is not well defined because it depends on wind direction. Also a range that needs to be studied depends on exact meteorological conditions on given day. On a day with strong winds it may be several hundred kilometres, whereas on a calm day it may very well fit within the closest grid points. The third use case leads to the rather demanding scenario for data processing, where the data access is intertwined with the analysis and required data depends on the results of the previous step.

The three use cases described above cover the whole range of possible data access patterns - in the first case one needs large area over short time, in the second time on needs small area over very long time and in the third case one needs variable area over variable time. The third use case can be reduced to a series of accesses of the second type, but with more limited time scope - usually only few hours for each patch would be relevant. Nevertheless, the overhead from reading the entire grids is larger in most cases and therefore the reduction to the second type is appropriate. The goal of the design is to deliver a satisfactory performance of data access in all cases. The current method for data access limits the second use case. An individual grid typically contains several hundred thousand numbers, whereas only few numbers are relevant for a single location. Therefore, only very small fraction of data read is actually useful.

The data is organised in the time-local manner, whereas the second use case requires spatial locality. This can be achieved only by reorganising data in such a way that smaller access units are spatially local.

2.3 Hardware

The technical limitations of the disks set a practical limit for the minimal size of the storage unit. With current hardware this limit is between 100 kB and 1 MB of data - reading smaller amount is very inefficient because it is dominated by seek time. This limit is actually very close to the size occupied by a single grid of meteorological data. Therefore a simple solution, namely splitting grids into smaller patches would not improve performance at all. To increase amount of spatially-local data one can needs to increase dimensionality of an array stored as a basic unit. For example instead of writing the results organised into series of 2D grids one could organise the data into 4D hypercubes, with three spatial and one time dimensions.

A slightly different organisation of data is actually more efficient for the typical query (such as in second use case). In most cases one is interested in data from a single layer (surface) or a couple of lowest layers of the grid. For example for a hypothetical wind farm only wind data on the layers up to at most 300 m are required. Therefore the optimal layout of the data is 3D - a complete time series from simulation for a single level in a small area.

Once we decided that a change of the data layout is required we need to provide tools for translation between traditional time-local and new spatially-local data layouts. This translation should work in both directions - we need to reorganise data for efficient storage but also we need to deliver traditional time-local arrays. Actually a more restrictive design requirement is in place - given a set of files in the original format we have to be able to store them in the new format and then retrieve the data from the archive and recreate entire set of files identical to the last bit. Therefore we have two implement two separate functionalities in the system - the efficient storage of data and the translation of the data between two layouts.

It can be best executed when whole system is also split into two layers - the data storage layer and the format translation layer. Such system is both simpler to design and implement and more universal than a monolithic dedicated one. The system is designed around a data container metaphor. The format translation layer writes to and reads data from these containers, whereas data storage layer is responsible for storing them safely and accessing them in an efficient way. Each data container is accompanied by meta-data - a detailed description of the content of container in the same way as a shipping container is accompanied by a shipping list. The information in the meta-data is sufficient for unique identification of the container content and for reconstruction of the original data from appropriate containers.

2.4 Format Translation Layer (FTL)

This layer is responsible for optimal packaging of the data to data containers and for interaction with users. It consists of two applications Writer and Reader. The Writer application takes original data, splits original arrays into small spatial patches, arranges several time lapses of the same patch into 3D arrays and packs them into data container. Then it creates meta-data describing precisely the content of the container. Once a container is ready it is delivered (together with meta-data contained in the shipping list) to the storage manager. The Reader application retrieves information from the system. The user interface delivers query containing information about the type of data as well as spatial and time ranges. This information is translated into conditions corresponding to the contents of shipping lists accompanying data containers.

The query for the container contents is delivered to the storage manager. Then the data required by a user is extracted from the containers, assembled to the required format and returned to the user.

2.4.1 Format of weather prediction data

The optimal format of data stored in the data containers may vary between programs, and even between various fields stored by the same program. It also depends on the time-span of the forecast. In our centre we use two weather forecast programs in the semi-operational manner – the UM model from UK Met Office [7] and COAMPS from US Naval Research Laboratory [11]. UM stores variables in a compressed form, with a precision dependent on the precision of measurements of a given meteorological parameter. COAMPS stores all data uniformly as 32-bit floating points numbers. The UM forecasts are run for 48 hours period, whereas COAMPS runs are performed in three different spatial scales and three different time-spans varying between 48 and 120 hours.

One can see that amount of data, as measured in bytes, generated by various simulation programs in various conditions may vary considerably, nevertheless, a size of data containers should be close to optimum, approximately 1 MB. Therefore contents and size of the single data container will vary, depending on the time-span of the single simulation and the type of data. There are four parameters affecting the size of the data packet - the length of numbers representation, a number of steps of a single simulation, the number of grid points in a single patch and also number of simulations stored in the same data packet. Two first parameters are fixed externally, therefore we can vary two last parameters, but their product must remain constant.

One may notice that by increasing the number of grid points stored in the single data packet we increase the performance of the system in the first use case since a lower number of data-packets needs to be read for reconstruction of a single grid. On the other hand decrease of the number of grid points increases performance of the system in the second use case because each data packet accessed by user contains higher fraction of data relevant to the query. Therefore the number of grid points in the data packet should be selected in such a way that a good compromise between system speed for both cases is achieved. The number of forecasts stored in the single data package is then adjusted in such a way that the total size of the data packet is near to optimal.

2.4.2 Distributed Data Storage Layer (DDSL)

The storage manager is responsible for storing the data container in the appropriate place and retrieving containers based on the query contents. The storage manager stores and retrieves data containers using information stored in the accompanying shipping lists. We assume that the system consists of H hosts, with D disks at each host. The total number of disks is N = H • D. For simplicity we assume that the volume of the data in the single data container V is 1 MB and that single disk can hold 2 TB of data. We also assume that the disk volume occupied by meta-data is negligible in comparison with the size of data container. Allowing for two thousand tags per container, which is very generous number, and 2 bytes per tag, all tags for containers on the disk would occupy less then 7 GB of disk space. In the realistic situation two hundred tags per container should be more than enough for most than sufficient for most situations.

2.4.3 Data security and system availability

The system is designed to provide data security and fault-tolerance by data redundancy and distribution. Data integrity is assured by application of control sums for containers. The data containers obtained from the format translation layer are multiplied and stored on different hosts. The level of data security is data dependent, each data container can be stored in variable number of copies. The proposed system has no downtime due to disk failures and system failures, provided that no more than two hosts (or disks) are down. One may note, that increasing the number of hosts and disks, which is necessary to hold multiple copies of data may be actually less expensive than adding large scale archival system. Usually data security is provided by using RAID matrices and tape backup of data. These mechanism theoretically offer a perfect combination of efficiency and cost for data protection task. In practice there are two well known problems with this approach. RAID matrices are not as reliable as theory predicts - the data security model of RAID matrices depends heavily on the statistical independence of disk failures. In practice the well known problem of the RAID matrices is the relatively high probability of failure during data reconstruction phase after failure of a single disk. Disks in the RAID matrix have identical usage pattern, moreover, it is quite likely that inexpensive are not only formally identical, but also were produced in the same batch. Therefore probability of their failure is not independent variable -- to the contrary there is quite high probability of subsequent failures if one disk failed. The reconstruction process requires very intensive disk operations, at the time when the probability of failure is high. Additionally, a failure of a RAID controller makes matrix useless.

The problem with tape backups is less technical and more organisational. Well functioning of backups requires perfect procedures, order, discipline and long organisational memory. In reality staff fluctuations, cost cutting, changes of technology, management oversights and short-sighted decisions as well as multiple other reasons may result in lost tapes, holes in the archives, non-functional restore hardware and storage media deterioration. The precious archival data has been lost in the best funded and most prestigious organisations due to all these factors.

Taking these factors into account we propose a distributed and redundant system with all archival data stored in the functional system. The data security is obtained by the redundancy built-in to the system. All data exists in at least C copies distributed between independent host and independent disks. For C=3 system can stand failure of two hosts and complete data loss on two disks failing at the same moment. The reconstruction of the data from failed disks requires only very limited activity of the remaining disks and is therefore not likely to result in the data loss. The random distribution of data between disks adds additional level of data security. In an unlikely event of simultaneous unrecoverable failure of three disks some data is lost. But, in contrast with the RAID system that loses all data in such a case, in the present system the amount of data lost is minimal - only $1/N^3$ of data containers would have all copies on three failed disks.

In a system with 50 disks one would loose 0.0008% of all data, which is inconvenient but hardly catastrophic. Also, one can have more copies of most sensitive data, thus minimising the risk even further.

An alternative approach to the security is assumption that the physical storage layer is safe - for example due to rigorous backup procedures etc., using high quality storage media, applying RAID matrices etc. In such a case system may hold only a single copy of each data container. This approach allows to increase amount of data which can be stored on a given hardware.

2.5 Data retrieval

Each container is uniquely identifiable by its meta-data (index entry). The index entry consists of a series of tags for each data packet stored in the container. The minimal list of tags are the type of variable, the exact time and date of simulation run, the copy number of the simulation (required in the case of ensemble forecasts), the number of data patch, the number of layer. Optionally shipping list may contain more information, to facilitate efficient searches. For example it may include information on minimal, maximal and mean value within each simulation. Collection of the shipping lists for all containers constitutes an index to the database contents. This index is distributed among hosts -- each host keeps the index for entire database.

When user demands some data the FTL translates his requirements into series of tags that must be present in the shipping list. The query is then formulated as a series of tags which have to be present in the container to be retrieved. The appropriate containers are identified by application of the faceted search algorithm. This stage is executed in the distributed manner for all hosts. Then the data containers containing all required tags are retrieved. System retrieves only a single copy of each container (for example the one with lowest copy number). The collection of containers that satisfy the condition required by FTL is delivered.

2.5.1 Index

The index of data is organised using the faceted classification technique [1]. Each data container has its meta-data entry holding corresponding tags - facets. Index entries are sorted by lengths of their facets list. To match an object each tag contained in a query must be present in it's entries. Therefore parts of index containing objects with lower number of tags are omitted. Every index's subset may also have inner structure to speed up the execution time of specific queries. That is done by additional sorting by chosen important labels - by year or variable. Chosen way of indexing offers a very flexible and efficient structure for finding data containers. Index's multi-level sorting allows to decrease the search space rapidly. Important feature of such constructed index is its negligible creation time - it is created on the fly with data containers. We assume that a number of tags required for identification of data within each container will vary between 6 and 200, up to 700 MB per disk.

This amount of data fits in the main memory, therefore operations on index are performed with the speed proportional to main memory read. In order to perform more specific searches one may define additional tagging functions. These functions can describe data container either in exact or approximate manner. Such description can be utilised to perform more advanced search using meta-data only. For example one may be interested in identification of number of days with meteorological conditions, such as heat waves, strong winds, heavy rainfall etc. Such days can be identified without looking into data containers if appropriate tags (maximum value for variable) are present in the meta-data. Such additional tagging is done once during data container creation or in background during normal system activity. This technique has been used already for accelerating analysis in data-warehouse applications [15].

2.5.2 Performance

After receiving the data container DSL first creates replicas of the container (if required). Then all copies of container are distributed randomly between hosts and disks. Each copy is accompanied by a copy of shipping list. Randomisation is performed in such a way that each disk can hold only single copy of the data-container. Also, provided that number of hosts in the system is larger than required number of copies, each host can hold only a single copy of each data container. When system retrieves the data each host receives the tags which describe containers which should be retrieved. Each hosts performs faceted search on its own part of the database index. Then it creates the lists of containers that it can retrieve. In the simplest version of the algorithm the storage manager requests copies with the fixed copy-number. Therefore each host delivers only these containers, which are marked with required copy number. Due to the randomisation of the data container distribution between disks one can expect that the number of data containers retrieved from each disk should be a random variable drawn from the Poisson distribution with mean equal to $\mu = R/N$, where R is a number of containers to be retrieved and N is the number of disks in the system. The maximum number of containers residing on one disk can be estimated to be lower than $\mu + 3\bullet \bullet\mu$. In a more sophisticated scheme requests may be more specific to achieve better balance of data read from various disks.

3 Performance Simulations

We will discuss two distinct use cases: accessing data for constructing visualisation of weather prediction and retrieval of the time series of single meteorological variable for a long period of time in a single location. In the second use case one can be interested for example in the history of wind velocity in the planned site of wind farm over last ten years. This operation was painfully slow in the current model and one of the goals of the project is to facilitate such access. The first use case involves reading selected arrays and displaying them in the form of maps, movies or meteograms. The elementary operation here is reading a single grid for a single variable. The time required for this operation should be small enough to allow for interactive work. Therefore we need to test timings of three tasks - accessing of the single grid, accessing multiple grids (for example 48 from a single simulation) and accessing single point in all grids for single value that were created over 10 year period. We compare three modes of access to data for these tree tasks. The first mode is an idealised version of the current situation. In this mode a human operator writes script which serially reads all relevant files, extracts required data and writes result to some file. The second mode utilises a simple distributed database with each grid stored as a separate data unit. The third mode utilises the database described in this study.

To simplify the analysis we use single standardised weather forecast model. In this model simulations are performed on the square 512×512 grid, each value is stored using 2 bytes, single simulation is performed for 48 hours and data is recorded each hour, simulations are started every 6 hours, therefore for each time point there are eight stored results generated in eight consecutive forecast runs. A single grid occupies 0.5 MB and hence 48 grids from a single simulation occupy 24 MB. All grids corresponding to a single time point (eight simulations) occupy 4 MB. In ten years system generates $N = 24 \times 8 \times 365 \times 10 = 700\ 800$ grids, each occupying 0.5 MB – 350.4 GB in total. In the data base mode grids are divided into small patches. Entire simulation for a single patch is stored in the 3D matrix. Several such matrices are stored in the single data container, which is the minimal entity accessible from disk. We assume that the disk seek time is 12.5 ms and average read throughput is 100 MB/s, which as of 2011 can be achieved by good performance desktop disks. The time of read data from a single file is estimated by adding average seek time and time required to read the contents. The parallel data storage system is built using off-the shelf standard servers. As an example we will use the system consisting of six servers, each one equipped with eight disks - 48 disks in total. All disks work independently. One should note that the standard mode of data storage in the UM model is significantly less suitable for spatially-local access than assumed here. All data from single simulation is written to the small number (three or four) of files. These files are subsequently compressed. Consequently the entire file, that may have several hundreds megabytes, has to be read and uncompressed in order to retrieve few numbers.

3.1 Serial and simple parallel modes

The time T of reading single grid is T = 0.0125 + 0.5/100 = 0.0175s. The first task cannot be parallelised, since all data is stored in the single disk. Therefore the time for the first task is identical in the simple parallel mode and in the serial mode.

In the second task the time in the current mode of operations the serial mode requires single seek and then reading 24 MB of data, T = 0.0125 + 24/100 = 0.2575s. In the parallel mode the task takes the same time as reading the single grid. Both tasks are executed very quickly in the current data access mode, parallelisation improves speed of the second task but is irrelevant since the serial access is good enough.

The third task is much more demanding. Grids generated within ten years occupy 350.4 GB in total. The time required to access this amount of data is equal to $700800 \times 0.0125 + 350.4 / 0.1 = 12\ 264$s. The total time is dominated by opening single files. If a simple optimisation is performed and all grids from single forecast are stored in the single file (48-fold reduction of seek operations) the total access time can be reduced to $29200 \times 0.0125 + 350.4/0.1 = 3\ 686$s. The time required for the second task can be evaluated simply by dividing numbers obtained for the serial mode by the number of disks. Therefore the time required in the unoptimised case is 12264/48 = 255 s and for optimised one is 3686/48 = 77s. This 48-fold speedup may be difficult to achieve in practical applications due to overheads, nevertheless, it good starting approximation.

3.2 Database mode

We consider three sizes of a single patch: 16×16, 32×32 and 64×64. All patches from the single simulation occupy $S \times S \times 2 \times 48$ bytes, where S is the patch size. Therefore they occupy respectively 24576, 98304 and 393216 bytes, and single container with size 1.125 MB will hold respectively 48, 12 and 3 simulations of the single patch, for patches 16 ×16, 32 × 32 and 64 × 64, respectively. Time required to read single data container is $0.0125 + 1.125/100 = 0.024$s.

In the database mode reading single frame involves reading entire simulation, therefore it is sufficient to analyse timings of Task 2 and Task 3. For the Task 2 one needs to read these data containers that contain all patches at the appropriate time and for Task 3 these data containers that hold data on single patch for all relevant times. The computations are presented in Table 1.

Table 1. Time required to read data from disk for Tasks 1 &2 and Task 3. Columns heads: C1 - # of disks; C2 time of reading of single container (ms); C3 - # of patches in a grid; C4 - # of parallel reads of containers *Ceil(C1/C2)*; C5 - total time for task (seconds); C6 - # of containers storing ten years of simulation of single patch; C7 - # of parallel reads of containers *Ceil(C6/C7)*; C8 - total time for task (seconds); C9 - speedup vs current access mode; C10 - speedup vs simple parallel access

Patch size	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
			Tasks 1&2				Task 3			
16 x 16	48	24	1024	22	0,52	609	13	0,31	11930	249
32 x 32	48	24	256	6	0,14	2432	51	1,21	3040	64
64 x 64	48	24	64	2	0,05	9743	203	4,82	760	16

One can see that the time required for completing Tasks 1 and 2 remains below 1s for proposed patch sizes, however, time increases with decreasing patch size. The system with smaller patches (say 8 x 8) would take too long for reconstruction of the single grid. On the other hand reading long time series of data is more efficient for small patches. The reading of data for the Task 3 shall take about 0.31 s for patch size 16 × 16, slightly over one second for patch twice as large, and more than 4 seconds for largest patch. Therefore the size 16 × 16 is the good compromise between execution speeds for time-local and spatially-local queries. The predicted speedups for the spatially-local access in the database mode are 2 or even 4 orders of magnitude with respect to the idealised model of current situation.

One should note that it is very unlikely that point of interest would fall precisely on the grid point. Therefore one needs to read at least four closest points to perform interpolation. Some users may want to read data from the close vicinity of the point of interest - for example one or two additional layers of points surrounding the target. Therefore the 'point' queries may in fact require reading 2 × 2, 4 × 4 and even more user-defined grids. There is a non-negligible probability that these user-defined grids may contain points belonging to two or four different patches and consequently, that system would need to read two or four patches instead of one. This probability rises quickly with the increasing size of the user-grid and decreasing patch size, nevertheless small patches are always more efficient than large ones for the Task 3. Therefore the patch size should as small as possible, provided that the response time in the first task is satisfactory.

3.3 Faceted search and data extraction

Data containers holding data requested by the query are identified by a faceted search performed on the meta-data. In our example the size of data container is $16 \times 16 \times 2 \times 48 \times 48 = 1152$ KB. Therefore 2GB disk can hold at most 1.7 million data containers. At least four tags are required to describe uniquely contents of data container: variable, patch number, first forecasted time and last forecasted time (we assume that consecutive forecasts will be stored in the same container). In addition each container will be tagged with minimal and maximal value, nevertheless, some additional tags may added to facilitate advanced searches.

To examine the overheads from the search algorithm we performed test of the faceted search using 2 million objects described with 26 tags. The response time was lower than 0.1s. Substantial speedups (more than one order of magnitude) can be achieved if two-level meta-data search is performed. Therefore the search mechanism will add a negligible contribution to the overall data access time, which will be dominated by the time required to read the data from the disks.

4 Discussion

We presented the project of the database system for scientific applications. The functionality of the project locates it in the middle ground between the advanced file system such as the HDF5 [9; 10] or the NETCDF [8] and the advanced database system such as the SciDB. In the initial application the functionality will be closer to that of the HDF5, but the design of the system allows for adding more functionality similar to that present in the SciDB. One fundamental difference between the approach presented here and both HDF5 and SciDB is the method for handling multidimensional data. Both HDF5 and SciDB handle them explicitly - the multidimensional array is main data structure and their design concentrates on methods for handling these arrays in efficient and extendible way. In the system presented here handling of arrays is separated from efficient storage. The DDSL does not care for contents of data containers. The only information required to store data in an efficient manner is a simple function defining similarity of objects using information from meta-data. Once DDSL knows that given set of containers contains similar data (similarity means here that data is likely to be read simultaneously) it knows what to do with them. This enables easy handling of irregular data (for example data organised in mesh, data from irregular collection of points etc.).

One should note, that some features of SciDB are very easily implemented into the system proposed here. For example versioning and tracking of dependencies is naturally performed by adding tags - a native operation in our model. One additional advantage of the approach presented here is that it can be used with existing applications, without modification of their code. Scientific simulation codes save their outputs in files and analysis software reads these output files. The system proposed here reads these files stores them in an efficient manner and then returns the original files when requested to do so - not a single line of code needs to be changed in existing applications. Current trends in storage hardware development suggest that in a not very distant future SSD disks may become a viable alternative to standard magnetic disks. The seek time of SSD disks is two orders of magnitude smaller. Consequently much smaller data containers could be used on such disks significantly improving performance. SSD disks can also by applied to store index data. This would allow for creation of more detailed meta-data description of data container to facilitate performing many searches using exclusively meta-data, without actually reading data from disks.

The results of analysis shows that system is theoretically capable of delivering the results of of both spatially-local and time-local queries interactively. The theoretical estimate of speedup for the spatially-local access varies between two and four orders of magnitude with respect to the idealised version of the current access mode, and up to six orders of magnitude with respect to the current operational system. The development of this system is currently under way at ICM.

Acknowledgments. The project is part of the PROZA project financed by EU structural funds, grant number UDA-POIG.01.03.01-00-140/08-00. Part of the initial design was funded by 7bulls.com.

References

[1] Allen R. Retrieval from facet spaces,. Electronic Publishing, 8:247-257, 1996.

[2] Becla J, Lim K-T. Report from the 1st Workshop on Extremely Large Databases. Data Science Journal, 7:1-13, 2008.

[3] Becla J, Lim K-T. Report from the 2nd Workshop on Extremely Large Databases. Data Science Journal, 7:196-208, 2008.

[4] Benson DA, Boguski MS, Lipman DJ, Ostell J, Ouellette BFF. GenBank. Nucleic Acids Research, 26(1):1-7, 1998.

[5] Berman H, Westbrook J, Feng Z, Gilliland G, Bhat T, Weissig H, Shindyalov I, Bourne P. The Protein Data Bank. Nucleic Acids Research, 28:235,-242, 2000.

[6] Cudre-Mauroux P, Kimura H, Lim K-T, Rogers J, Simakov R, Soroush E, Velikhov P, Wang DL, Balazinska M, Becla J, DeWitt D, Heath B, Maier D, Madden S, Patel J, Stonebraker M, Zdonik S. A demonstration of SciDB:a science-oriented DBMS. Proceedings of the VLDB Endowment, 2(2), 2009.

[7] Davies T, Cullen MJP, Malcolm AJ, Mawson MH, Staniforth A, White AA, Wood N. A new dynamical core for the Met Office's global and regional modelling of the atmosphere. Quarterly Journal of the Royal Meteorological Society, 131(608):1759-1782, 2005.

[8] Davis G, Rew R, Hartnett E, Caron J, Emmerson S, Davies H. NETCDF Users Guide, 2011.

[9] Folk M, Cheng A, Yates K. HDF5: A _le format and I/O library for high performance computing. In Proceedings of Supercomputing'99. National Center for Supercomputing Applications (NCSA), 1999.

[10] Folk M, Pourmal E, Balancing Performance and Preservation Lessons learned with HDF5, 2010.
[11] Hodur RM. The Naval Research Laboratory's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). Monthly Weather Review, 125(7):1414, 1997.
[12] Kantor J, Axelrod T, Becla J, Cook K, Nikolaev S, Gray J, Plante R, Nieto-Santisteban M, Szalay A, Thakar A. Designing for Peta-Scale in the LSST Database. ASP Conference Series, Vol. XXX. In R. A. Shaw, F. Hill, and D. J. Bell, editors, Astronomical Data Analysis Software and Systems XVI, 2007.
[13] Loebel-Carpenter L, Lueking L, Moore C, Pordes R, Trumbo J, Veseli S, Terekhov I, Vranicar M, White S, White V. SAM and the particle physics data Grid. In: Computing in High-Energy and Nuclear Physics, pages 765-769, 2001.
[14] Pop M, Salzberg SL. Bioinformatics challenges of new sequencing technology. Trends in genetics : TIG, 24(3):142-9, Mar. 2008.
[15] Slezak D, Wróblewski J, Eastwood V, Synak P. Brighthouse: an analytic data warehouse for ad-hoc queries. Proc. VLDB Endow, 1(2):13371345, 2008.
[16] Terekhov I. Meta-computing at D0. Nuclear Instruments and Methods in Physics Research, Section A, 502:402-406, 2002.

Impact of improved land-surface model coupled to NWP system on convective boundary layer variables

Richard Hodur · **Bogumil Jakubiak**

Abstract Land surface parameterizations in numerical weather prediction models direct the exchange of energy between the land surface and the atmosphere. The main purpose of this paper is to gain insight into how surface heterogeneity can influence the modeled convective boundary layer, and whether the complexity of the modeled land-atmosphere interactions can improve forecasts of convective precipitation. To achieve this the NOAH land-surface model has been coupled to the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). Selected cases of fair weather convective conditions and convectivly produced rain episodes were used to evaluate the behavior of a land-surface model coupled to a high-resolution numerical weather prediction system. Our experiments are designed such that different surface conditions (wet soil during rain episodes and dry soil conditions during fair weather days) and different atmospheric situations could be used to further our understanding of the behavior of the model by comparing model solutions to surface observations.

Keywords numerical weather prediction · surface heat fluxes · land-surface model

1 Introduction

The initiation of convection over land involves many complex dynamical and physical processes that occur over a variety of time and space scales. Many of these processes occur in the near-surface layer, and can be attributed to

R. Hodur · B. Jakubiak
University of Warsaw, Interdisciplinary Centre for Mathematical and Computational Modeling, Pawinskiego 5A, 02-106 Warsaw, Poland
Tel.: +48-22-8749144
Fax: +48-22-8749115
E-mail: jakubiak@icm.edu.pl

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_59,

land-air interactions. Selected cases of fair weather convective conditions and convectivly produced rain episodes were used to evaluate the behavior of a land-surface model coupled to a high-resolution numerical weather prediction system. The main purpose of this paper is to gain insight into how surface heterogeneity can influence the modeled convective boundary layer and whether the complexity of the modeled land-atmosphere interactions can improve forecasts of convective precipitation and surface fluxes. The basic tool used in our experiments is the NOAH land-surface model coupled to the Coupled Ocean Atmosphere Mesoscale Prediction System (COAMPS).

2 Description of the numerical models used

2.1 COAMPS system

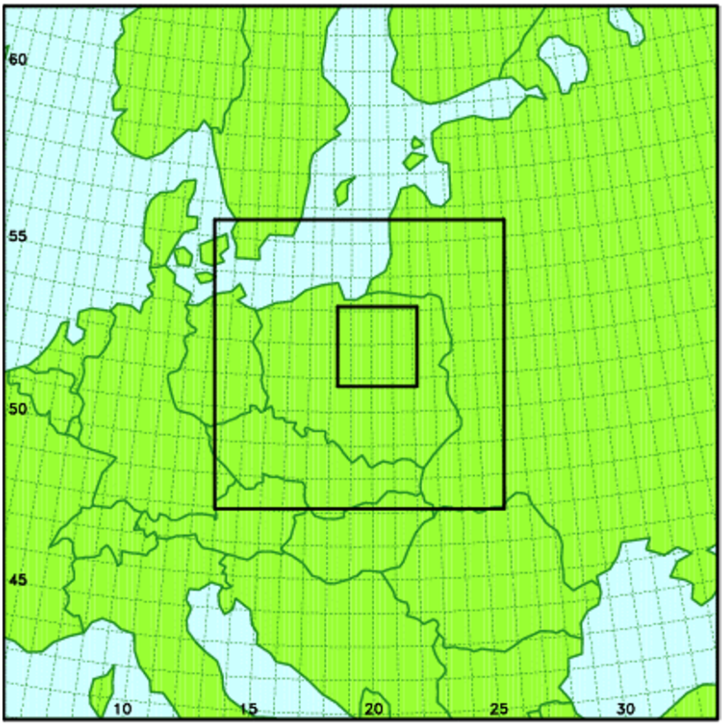


Fig. 1 Triply-nested COAMPS grid structure for the COAMPS/NOAH experiments, showing the extent of the coarse (9 km), medium (3 km), and fine-mesh (1 km) grids.

The U.S. NAVY COAMPS system (Hodur (1997)), now used operationaly at the University of Warsaw, has been configured using nested grids to achieve the high-resolution needed for our tests. In particular, we set up the domains to examine how well the model can simulate convective precipitation using a convective parameterization scheme on a 9 km grid, and explicit moist physics parameterization on grid resolutions of 3 km and 1 km. The coarse mesh (9 km) grid covered most of the Central European area, the medium mesh (3 km) covered all of Poland, and the fine grid (1 km) covered an area roughly corresponding to the area covered by one radar site inside north-central Poland. The model used 40 vertical levels. The extent of these grids is presented on Fig. 1. The verification data consists of point observations from selected meteorological stations and two-dimensional radar reflectivities available in 15 minutes intervals. In all of our experimental designs, COAMPS uses the level-2.5 turbulence scheme of Mellor and Yamada that solves both a prognostic equation for turbulent kinetic energy and a diagnostic equation for second-moment quantities such as the fluxes of heat, moisture, and momentum. The surface layer parameterization follows the Louis scheme, which uses polynomial functions for the bulk Richardson number to directly compute the surface sensible heat flux, surface latent heat flux, and the surface drag. Cumulus convection is parameterized using a modified Kain-Fritsch scheme, but only for grid spacings of 9 km and above. For higher-resolutions, the explicit moist physics approach is used to model convection.

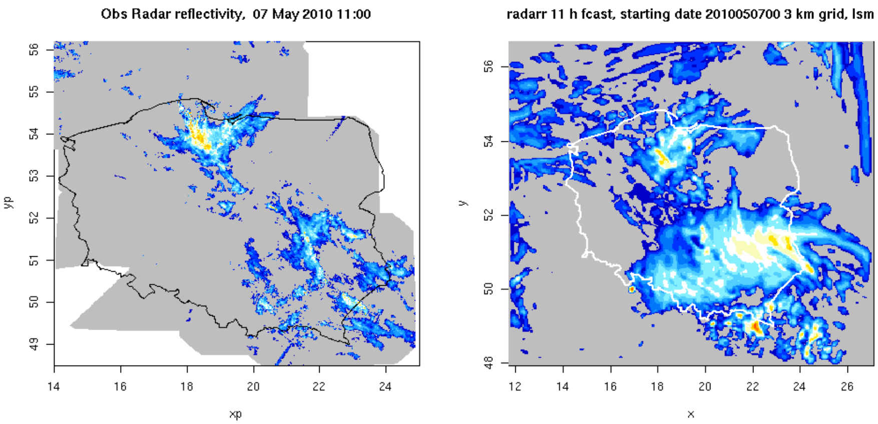


Fig. 2 7 May 2010, 11 UTC: Observed (left panel) and predicted (right panel) radar reflectivity

2.2 NOAH land surface model

The NOAH land-surface model (LSM) described by Ek et al (2003) has a multilayer soil hydrology configured with four soil layers: a thin 10-cm top layer, a second root zone layer of 20 cm, a deep zone layer of 60 cm and a subroot zone of 110 cm, having a uniform total soil depth of 2m. It solves explicitly vertical soil water transport using the diffusive form of Richards' equation as well as power relationships between soil hydraulic conductivity, water matric potential, and volumetric soil moisture in each layer. The infiltration rate is computed as a difference between the surface runoff and the through-fall rate, which is the sum of the rainfall not intercepred by the canopy, the dripping from the interception reservoir, and the snow melt. The surface runoff is calculated using a simple water balance (SWB) scheme. It is a storage-type water balance scheme that accounts for the spatial variability in precipitation and soil moisture. It depends on total soil moisture and on two constants that are specified based on fields experiments conducted in North-America. The NOAH can be run for 13 vegetation covers and nine different soil types. The LSM has 33 parameters: 10 related to the vegetation, and 23 that describe soil properties. In our experiments the NOAH is coupled to the COAMPS atmospheric model. The impact of the LSM on the quality of convective precipitation symulated by the COAMPS system has been tested using medium- and fine-resolution COAMPS grids.

3 Impact of lsm model on fluxes in boundary layer

Previous studies have shown that surface heterogeneities can modify the surface fluxes, and generate mesoscale circulations, that can lead to increased convection (Pielke (2001); Taylor and Ellis (2006); Jakubiak and Hodur (2010)). The influence of soil moisture on precipitation patterns seems to vary and may be dependent on multiple factors including the study region, the atmospheric model used, and the existing synoptic-scale pattern (Niyogi et al (2006)). The

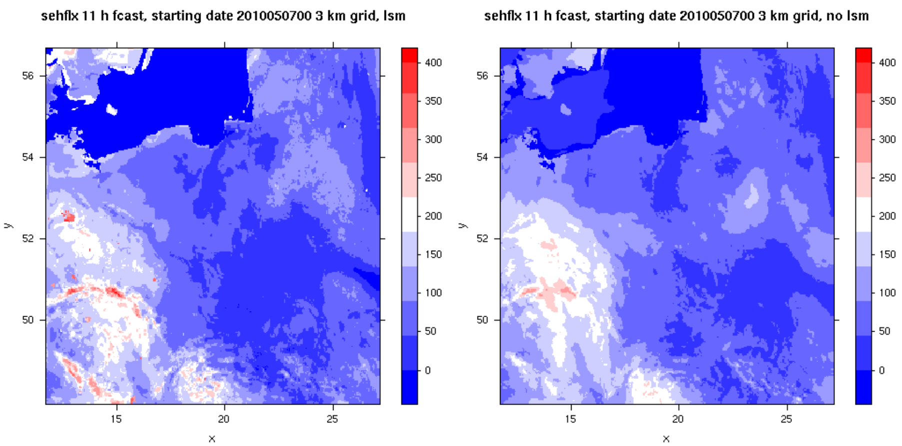


Fig. 3 7 May 2010, 11 UTC: Sensible heat fluxes from lsm (left panel) and no lsm (rigth panel) runs

usefulness of the NOAH land surface model coupled to COAMPS has been tested on cases of convective development during the four day period 7-10 May 2010. While strong convective development conected to intense precipitation episodes was evident on 7 and 10 May, both 8 and 9 May were dominated for fair weather conditions. A strong similarity between the observed and COAMPS-forecast reflectivity patterns for 7 May 2010, 11:00 UTC is seen in on Figure 2, although the forecast reflectivity field tends to be somewhat stronger and covers a larger area than observed. The patterns of forecast sensible heat fluxes shown in Figure 3 are related to the patterns of forecast reflectivity fields. In places where precipitation occured, the sensible heat fluxes are lower than fluxes in the precipitation free areas.

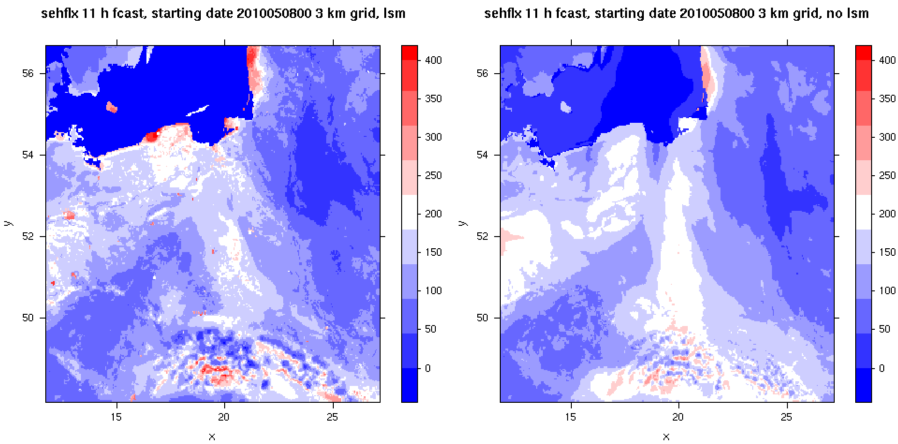


Fig. 4 8 May 2010, 11 UTC: Sensible heat fluxes from lsm (left panel) and no lsm (right panel) runs

A comparison of the results between the lsm and no lsm runs for the strong convection case (Figure 3) and the fair weather case (Figure 4) leads us to conclude that areas covered by rainfall are characterised by lower values of sensible heat fluxes compared to areas without precipitation. Also, the sensible heat fluxes are found to be reduced more in the lsm case than in the no lsm case. The fair weather sensible heat fluxes (Figure 4) reflect the complex structure of the surface heterogeneities, especially evident in mountainous regions. A much more complex structure is seen in the surface fluxes in the lsm case, mainly because of more advanced parameterization of land-atmosphere interactions.

The simulated radar reflectivity field at the ground level presented in Fig. 5 shows the well devloped convection in central part of Poland at 1400 UTC 10 May 2010, with a number of convective cells that produced heavy rainfall. The simulated radar reflectivity forecast at 14 UTC (right panel of Fig. 5), agrees qualitatively with the observed radar reflectivity (left panel), but some differences are noted. While the forecast precipitation zone appears to be too large, the bands of precipitation are forecast to be in the correct location, and

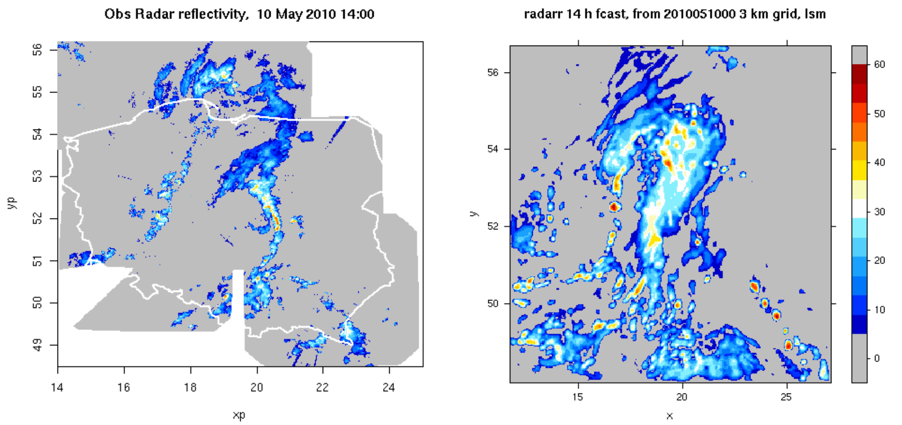


Fig. 5 10 May, 14 UTC: Observed (left panel) and simulated (right panel) radar reflectivity

the areal coverage of the precipitation/no precipitation appears to be qualitatively correct. The latent heat fluxes (Fig. 6 left panel) and the planetary boundary layer heights ((Fig. 6 right panel) are well correlated to the simulated radar reflectivity field. The latent heat fluxes are much lower in rainy areas comparing to rain-free regions. The small convective cells visible on the simulated reflectivity field are also present in latent heat fluxes patterns and in the complex pattern of the boundary layer heigths.

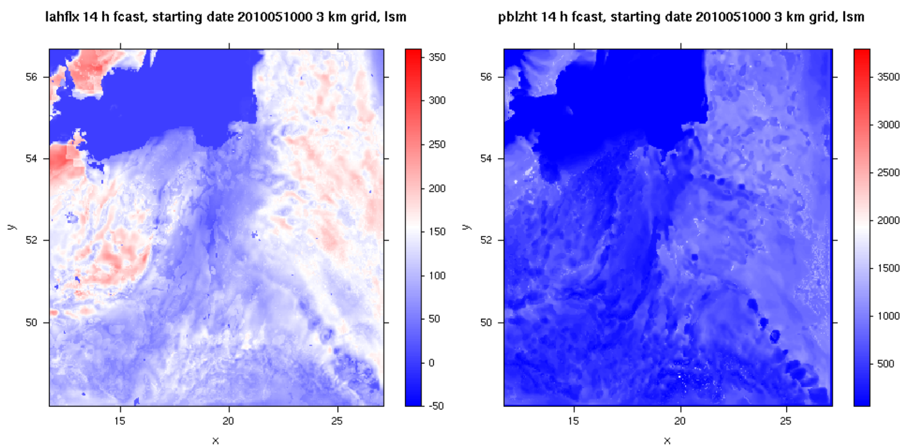


Fig. 6 10 May, 14 UTC: Latent heat fluxes (left panel) and PBL height (right panel)

The patterns of the solar radiation fluxes, presented in Fig. 7, are correlated to the distribution of cloud cover and the precipitation extent. The left panel shows the solar radiation simulated by the model on the fine mesh (1 km) grid.

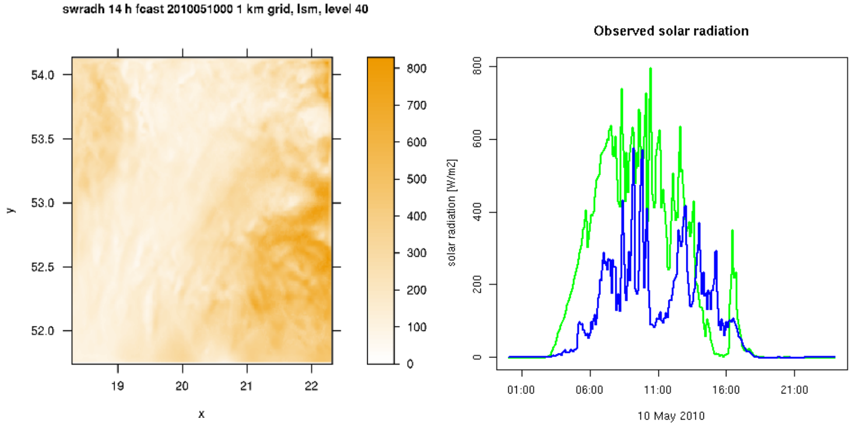


Fig. 7 10 May, 14UTC: Forecasted (left panel) and observed (right panel) solar radiation

In the right panel, the observed solar radiation fluxes from two meteorological stations are shown. The variability of the forecasted solar radiation fluxes is supported by the variability of the observed fluxes. The green line in the right panel of Fig. 7 represents the solar radiation in Warsaw, while the blue line represents the same values for Belsk. The distance between both points is only about 40 km, but the reported values of the solar radiation fluxes are significantly different, with these differences attributed to the differences in cloud cover. A comparison of the soil moisture and temperature patterns in

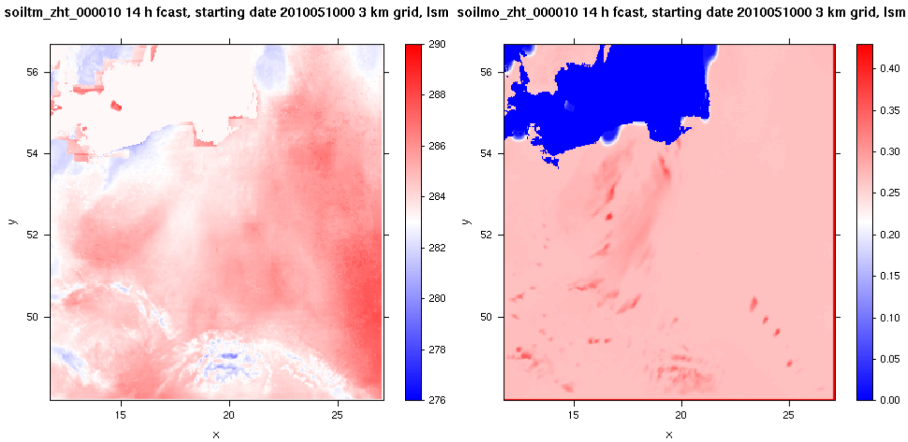


Fig. 8 10 May, 14UTC: Soil temperature (left panel) and moisture (right panel) at 10 cm depth

the near surface 10 cm layer presented in Fig. 8 to the 14 h forecast of latent heat fluxes (Fig. 6, left panel) and the planetary boundary layer height (Fig.

6, right panel) shows a strong correlation between the fluxes and the amount of soil moisture present.

4 Summary and conclusions

Proper partitioning of the surface energy fluxes that describe the evolution of the planetary boundary layer in numerical prediction models requires an accurate representation of the initial and forecast land-surface conditions. Our results indicate that a high-resolution numerical weather prediction model coupled to a land-surface model is able to simulate the evolution of the planetary boundary layer such that the forecast values agree, in a qualitative sense, with observed values. Further improvements will be directed to the assimilation of selected land-surface variables in a quasi-operational regime.

Acknowledgements This research was supported by the ONR NICOP grant N00014-09-1-1099, the COST Action ES0905, and the Innovative Economy grant POIG.01.03.01-00-140/08. Authors acknowledge helpful discussions with Dr Teddy Holt from NRL, Monterey, CA. We used computer resources of ICM, Warsaw University, radar observations from Baltex Radar Data Centre, Norrkoping, Sweden and observed radiation fluxes from Istitute of Geophysics, University of Warsaw and Central Geophysical Observatory of Polish Academy of Sciences.

References

Ek M, Mitchell K, Lin Y, Rogers E, Grunnmann P, Koren V, Gayno K, Tarpley J (2003) Implementation of NOAH land surface model advances in the National Centers for Environmental Prediction operational mesoscale ETA model. J Geophys Res 108:8851–8866

Hodur RM (1997) The Naval Research Laboratory Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS). Mon Wea Rev 125:1414–1430

Jakubiak B, Hodur R (2010) Experiments with a land-surface model coupled to a high-resolution NWP system. Proceedings of ESA ILEAPS conference "Earth Observation for Land-Atmosphere Interaction Science, Frascati, Italy 1:1–6

Niyogi D, Holt T, Zhong S, Pyle PC, Basara J (2006) Urban and land surface effects on the 30 july 2003 mesoscale convective system event observed in the southern great plains. J Geophys Res 111:D19,107

Pielke R (2001) Influence of the spatial distribution of vegetation and soils on the prediction of cumulus convective rainfall. Rev Geophys 39:151–177

Taylor C, Ellis R (2006) Satellite detection of soil moisture impacts on convection at the mesoscale. Geophys Res Lett 33:L03,404–407

Survey of rainwater quality modification as water supply in northern part of Iran

M. Tahghighi Haji Alizadeh[1] , M.T. Ghaneian[1],
M. Bahram Abady[2]

[1]Department of environmental health engineering, Faculty of Health, shahid sadoughi university of Medical Sciences, Yazd, Iran
[2]Q management environmental project co. Tehran, Iran

Abstract. Lack of water supply in recent years is one of the significant problems of both rural and urban societies, as water is one of sustainable development pillars. in societies with high rainfall seasons rainwater is one of the most accessible water resources, which could be utilized as sustainable and reproducible resource of water supply. As rain water contains very low amount of TDS (0-10) MgL^{-1} there is a need to modify rainwater TDS in order to make it potable. Besides biological effect of low TDS water on body, taste and odour problems always are reported by inhabitant of region. Mixing rainwater with water from other resources with higher TDS is one of the proposed solutions to solve this problem. In the study area samples from rainwater were grabbed and mixed with surface and groundwater after gathering information from inhabitant of region, results indicated that more than 85 percent of inhabitants were displeased of water quality. At first Samples were analyzed to obtain primitive amount of physicochemical parameters and mixed with water from surface and under ground resources in 3 ratio (1/10, 2/10and 3/10) to obtain the best ratio of mixing for providing water with optimum TDS and TH.

Keywords: efficiency, evaluation, rainwater, quality, modification, mixing, TDS (Total Dissolved Solids), TH.

1 Introduction

The increasing consumption of water and Lack of its resources in recent days lead water managers to detect for finding new resources of water. In this case Finding new resources for water warranty become the goal of managers. Meanwhile we should utilize renewable resources for water supplying to societies. Rainwater is one of the most available water resources in societies with high rainfall seasons. Rain water harvesting is one of the most familiar terms in these years [1]. Rainwater harvesting is

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_60,

an excellent tool which, with proper use, could dramatically reduce the continual strain on watersheds. Rainwater harvesting is not only useful is rural areas but also it can provide numerous benefits for urban ecosystems by managing storm water runoff [2]. Utilizing rainwater for indoor and outdoor uses is fast becoming more common.

Despite all vantages of rainwater harvesting, we should consider about some cramp factor such as physical, chemical and biological specification of rain water. TDS (total dissolved solids) is one of the physicochemical parameters which play an important role in water quality evaluation process. "Dissolved solids" refer to any minerals, salts, metals, cations or anions dissolved in water**.** TDS range in water supplies differ from 50 MgL^{-1} in some surface water to more than 1000 MgL^{-1} in ground water and mineral springs near volcanic mountain [3-4]. The EPA Secondary Regulations advise a maximum contamination level (MCL) of 500 MgL^{-1} (500 parts per million (PPM)) for TDS. Low TDS water is defined as that containing between 1 and 100 milligrams per liter (MgL^{-1}) of TDS. Rainwater is categorized as low TDS water which contains (0-20) MgL^{-1} TDS. Most of the consumer complaint is referred to water taste which caused by high TDS. Not only high TDS affect on water attributes like the taste but also low TDS content may have some medical side effect toward water consumers.

World health organization published report, which indicate that fluid and electrolytes of human body are better replaced with water containing a minimum of 100 mg/L of TDS [5]. But this may depend on situation and health level of human body. In 1992 SCIENCE ADVISORY COMMITTEE of WATER QUALITY ASSOCIATION publish report about consumption of low TDS water and possibility of some long terms potential harms which affect human health and life, but the exact effect would not be obvious until now. Although highly purified (distilled) water is believed by some to help for curing arthritis by washing out excess calcium and other minerals from deposits in joints, but they can leach minerals from body and thus cause disturbance in bodies [6-7]. Mixing rainwater with water from other resources in order to obtain water with optimum rate of TDS and achieving the optimum ratio of mixing are the mains scopes of this research.

2 Material & Methods

2.1 Study area

This study was conducted in Golestan province in north of Iran with the area around 21000 km^2. Lack of water supply in northern part of this region around Turkmenistan borderline is significant dilemma. Aqband, Narlidaq and Aytemer are three villages locate between 53°2´ north and 31°34´ east as shown in FIG.1. population of these villages is about 1000 people with annual raining about 240 mm/yr. inhabitants of villages utilize rainwater as a source of potable water and water for their animals. This paper is part of a comprehensive research which done by author on this region. Springs around villages and rainwater are the most common source of potable water for inhabitant of area.

Fig. 1: Map of study area in the north of Iran (Golestan province)

2.2 Data Collection

To fulfill this study at first stage information was collected by questionnaire from inhabitant of village about acceptability of rainwater. After it was clarified that more than 78 percent of inhabitants were dissatisfied with water quality, sampling is the next stage of this research, rainwater samples were grabbed from open area and house storage basin. These Samples were got in 4 periods of times (immediately; 6 hours; 12 hours; 1day after rain time) during 4 seasons of year. Totally 120 samples were collected from study area in each season, and analyzed to obtain TDS and TH levels.

Also samples of Surface water were grabbed from Atrak river and groundwater samples from nearest water well in the area. Samples of rainwater were mixed with surface and groundwater and being analyzed to determine final amount of parameters. ***Hanna Multiparameter GPS Enabled Water Quality Meter*** portable kit was utilized for TDS measurement, TH test were fulfilled by titration with EDTA [8].

3 Results

After collecting samples through study area from rainwater, surface water and groundwater, all samples were analyzed to obtain primitive amount of physicochemical like TDS and TH in same condition. Results of tests are presented in FIG.2 and 5 and discussed below. FIG.2 indicates TDS of rainwater, groundwater and surface water which were calculated during study period. Rainwater TDS was differed from (8-27) MgL^{-1} with the Mean of 13.6 MgL^{-1} during seasons over the year. The maximum amount is 30 MgL^{-1} in August 2010 and the least one is about 8 MgL^{-1} in April 2011. All amount of TDS in surface and groundwater in different seasons of the year also presented in below. TDS of surface water also fluctuated from (310-337) MgL^{-1} whereas this amount is about (568-637) MgL^{-1} for groundwater.

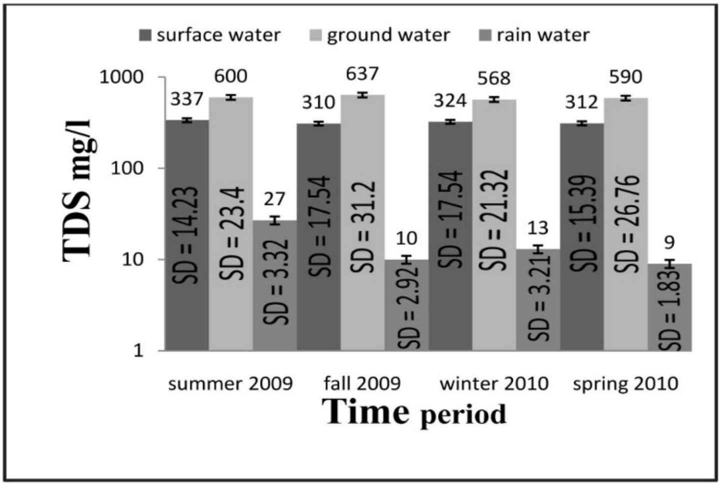
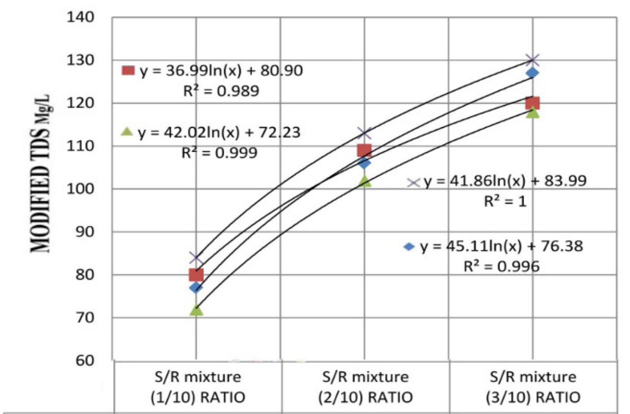


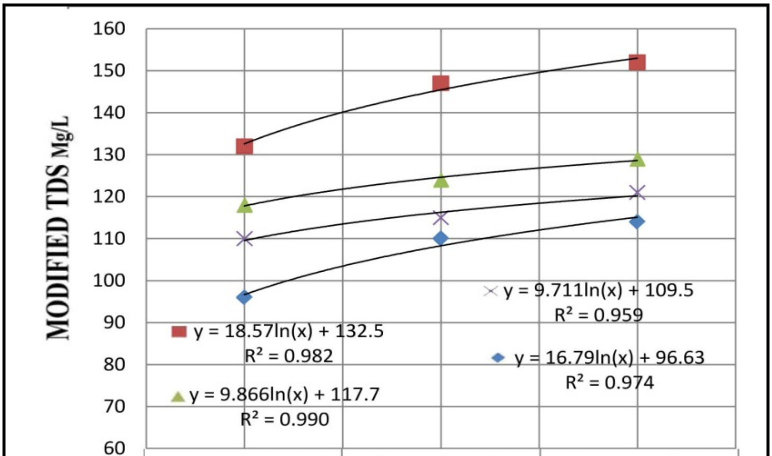
Fig. 2. TDS rate in surface water, groundwater and rainwater during different season of year 2009-2010

In the second part of research samples of rainwater were mixed with surface and groundwater with 3 ratio (1/10, 2/10 and 3/10) in 1/10 ratio 900 ml of rainwater were mixed with 100 ml of surface or groundwater. in each season 100 samples were analyzed. as mentioned in FIG 3 and 4, these results were gained: by utilizing 1/10 ratio of mixing with surface water TDS of rainwater modified up to 84 MgL^{-1} (4.37 as SD) for winter 2010 samples, this amount for 2/10 ratio is about 113 MgL^{-1} (4.67 as SD) again in winter 2010 and for 3/10 ratio is 130 MgL^{-1} (7.75 as SD) in winter 2010. Highest amount of TDS after mixing samples with surface water was reported in February 2010 about 138 MgL^{-1} and the least amount was about 70 MgL^{-1} in November 2009. For 1/10 mixing ratio of rainwater with groundwater, TDS of rainwater modified up to 132 MgL^{-1} (9.34 as SD) as a mean of 65 samples in summer 2009, this amount for 2/10 ratio is about 147 MgL^{-1} (13.36 as SD) in summer 2009 and for 3/10 ratio is 152 MgL^{-1} (9.31 as SD) again in summer 2009. Highest amount of TDS after mixing rainwater with groundwater samples was 163 MgL^{-1} in July 2009 and the least one is about 91 MgL^{-1} in May 2010. It is important to mention that all ground and surface water samples were grabbed from the nearest water resource near study area.



	S/R mixture (1/10) RATIO	S/R mixture (2/10) RATIO	S/R mixture (3/10) RATIO
spring	77	106	127
summer	80	109	120
fall	72	102	118
winter	84	113	130

Fig. 3. TDS of rainwater after mixing with surface water



	G/R mixture (1/10) RATIO	G/R mixture (2/10) RATIO	G/R mixture (3/10) RATIO
spring	96	110	114
summer	132	147	152
fall	118	124	129
winter	110	115	121

Fig. 4. TDS of rainwater after mixing with ground water

The second goal of this research was modifying rainwater TH. After primitive tests in study area The Mean value of rainwater TH is about 10 MgL^{-1} $caco_3$ (2.6 as SD) in summer 2009, 15 MgL^{-1} $caco_3$ (1.42 as SD) in fall 2009, 17 MgL^{-1} $caco_3$ (3.2 as SD) in winter 2010 and 25 MgL^{-1} $caco_3$ (2.09 as SD) in spring 2010. FIG.5 indicates the primitive amount of TH in water from different resources near study area.

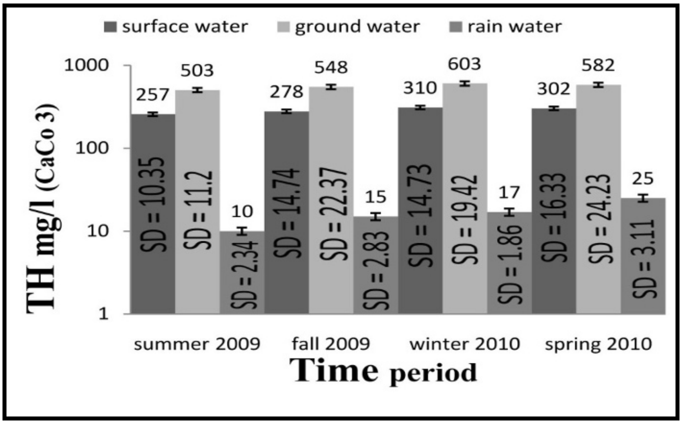


Fig. 5. TH rate in surface water, groundwater and rainwater during different season of year 2009-2010

Samples of rainwater were mixed with surface water and groundwater samples to obtain ultimate amount of modified TH of rain water after mixing process the same as TDS modification. At the first stage rainwater were mixed with surface water to modify its quality and obtain method efficiency. During this part of test TH of rain water samples were modified up to 83 MgL^{-1} $caco_3$ (4.42 as SD) in winter 2009 by utilizing 1/10 ratio of mixing, this amount for 2/10 ratio was changed to 107 MgL^{-1} $caco_3$ (4.73 as SD) in 2010 winter and 119 MgL^{-1} $caco_3$ (4.72 as SD) again in winter 2010 by utilizing 3/10 ratio of mixing. By the next step rainwater samples were mixed with groundwater samples. By utilizing 1/10 ratio of mixing TH of rainwater was modified up to 125 MgL^{-1} $caco_3$ (4.52 as SD) during summer 2010, whereas this amount for 2/10 ratio is about 140 MgL^{-1} $caco_3$ (8.62 as SD) again in summer 2010 and finally rainwater TH was modified to 144 MgL^{-1} $caco_3$ (4.85 as SD) in winter 2010. Groundwater was prepared from springs near the villages.

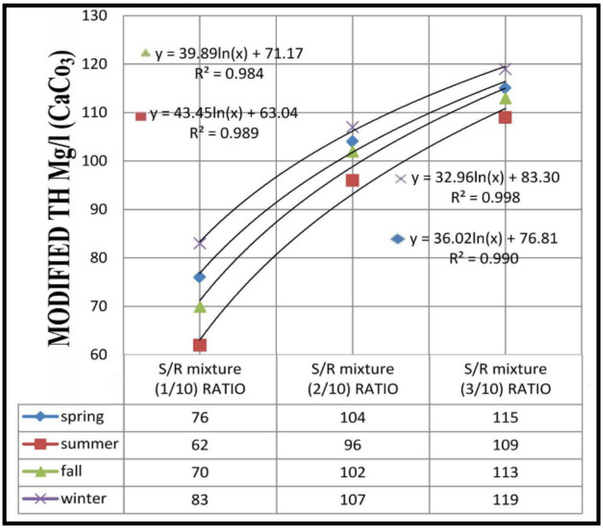


Fig. 6. TH of rainwater after mixing with surface water

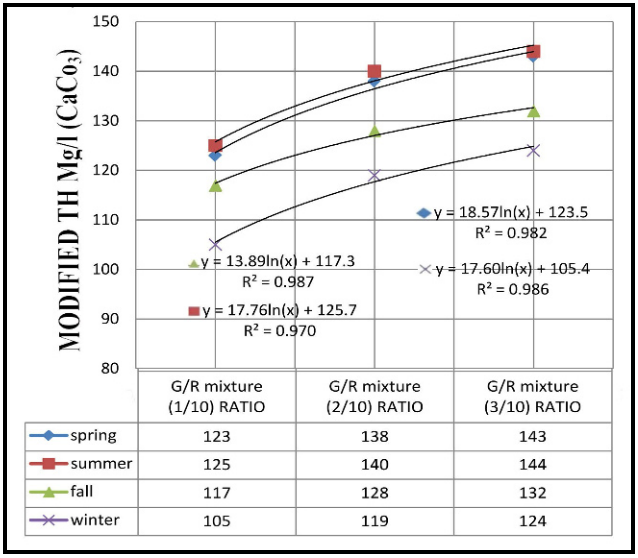


Fig. 7. TH of rainwater after mixing with ground water

4 Discussion

Prepare water supply in northern part of Golestan province is one of the most significant dilemma for water & wastewater managers. In this way they are encountered with two problems. First one is availability of water resources, Re to the lack of sustainable water resources around study area, finding Appropriate and acceptable resource of water supply is difficult. The second dilemma which affect on making Decision about mixing ratio is Efficiency of each method. In order to utilize rainwater as an appropriate water supply and make it more salubrious it is essential that be noticed about these factors. In fact these two factors which mentioned above should be considered to be able to make decisions about the final result. After testing and determination of final TDS and TH value, the diagrams of TDS and TH mean with their standard deviation (SD) against mixing ratio were plotted as it was indicated in above figures. After statistical and mathematical model analysis to determine the trend of TDS and TH modification during these tests, Lines equation were calculated in above charts with 95% confidence limit. Not only Preparing water with tolerable quality from surface or ground water resource is not so easy particularly in summer and also hot seasons and months over the year but also there is a need of treatment especially for surface water until the qualities of water reach the accepted standard by government and inhabitants of villages.

Although there is an augmentation in modified TDS amount By utilizing 2/10 mixing ratio and consider to the point that drinking and cooking water demand in hot seasons of the year especially in July and August is about 20Lday^{-1} from 150L of whole daily water demand in villages, therewith people can easily prepare 2/10 of 20L easily from water well around their villages. For higher mixing ratio although rainwater TDS could be modified up to higher proportion but this increase is , but provide water supply is the main problem. Hygiene and health of water resource should be consider strictly because access to clean water is a basic human right, In India, 1 person dies from water-related disease every minute and 4 people die across the globe (EPA 2008)[9]. In the end it should noted that instruction to inhabitant of village about how to mix water with rainwater in order to prevent sanitary problems is so important.

References

[1] Efe S. I., Quality of rainwater harvesting for rural communities of Delta State, Nigeria. *Environmentalist* , 26, pp. 175-181, 2006

[2] Salem, V.A. Adrienne, L.a. Branche, H.O. Wack, D. Crawford, N. Sojka, Cabell Brand Center. Virginia Rainwater Harvesting Manual [Brochure]. pp. 4-8, 2007

[3] UNEP. 2008, Water Quality for Ecosystem and Human Health. Second Edition.from:http://www.gemswater.org/publication/pdfs/water_quality_human_health.pdf

[4] C. Tang, Water Quality Study and Cost-Benefit Analysis of Rainwater Harvesting in Kuttanad, India. Submitted in partial fulfillment of the Bachelor of Science Degree with Honors in Environmental Science from the Center of Environmental Studies at Brown University, 2009

[5] WHO. 2006, Guidelines for Drinking-water Quality, First Addendum to ThirdEdition,Volume1Recommendations.From:http://www.who.int/water_sanitation_health/dwq/gdwq3rev/en/

[6] L.T. Rozelle, R.L. Wathen, consumption of low TDS water, A committee report by water quality association science advisory committee 1992-1993

[7] M. Tahghighi Haji Alizadeh, M.T Ghaneian, A. Motedayen, Efficiency evaluation of rainwater quality modification by utilizing mixing method with surface water and groundwater. 2011. 6th water resource management conference, riverside CA

[8] S. L. Clescerl, A. E. Greenberg, A. D. Eato, Standard Methods for Examination of Water & Wastewater (Standard Methods for the Examination of Water and Wastewater) American Public Health Association

[9] http://water.epa.gov/lawsregs/rulesregs/sdwa/lt2/upload/2006_03_17_disinfection_lt2_assessment_lt2_occurance_main.pdf

A new environmental image processing method for chemical weather forecasts in Europe

Victor Epitropou[1], Kostas D. Karatzas[1]*, Anastasios Bassoukos[1], Jaakko Kukkonen[2], Taru Balk[2]

[1] Informatics Applications and Systems Group, Aristotle University,
[2]Finnish Meteorological Institute

*kkara@eng.auth.gr

Abstract. It is common practice to present environmental information of spatial nature (like atmospheric quality patterns) in the form of pre-processed images. The current paper deals with the harmonization, comparison and reuse of Chemical Weather (CW) forecasts in the form of pre-processed images of varying quality and informational content, without having access to the original data. In order to compare, combine and reuse such environmental data, an innovative method for the inverse reconstruction of environmental data from images, was developed. The method is based on a new, neural adaptive data interpolation algorithm, and is tested on CW images coming from various European providers. Results indicate a very good performance that renders this method as appropriate to be used in various image-processing problems that require data reconstruction, retrieval and reuse.

Keywords: Image processing, data reconstruction, neural adaptive interpolation, computational intelligence, environmental image analysis

1 Introduction

There are numerous applications in environmental engineering that deal with images which represent environmental pressures or conditions, such as remote sensing imagery or the visual output of mathematical models. Common characteristics among these applications are the use of a spatial scale implied by the image's resolution and covered area of interest, a temporal scale, usually defined by the time variation of the studied environmental problem, and a colour or otherwise graphical intensity (information) scale, commonly representing numerical values of various parameters of interest.

When coming to the air quality management problem, model oriented images are usually the results of 3D models, that are called chemical weather (CW) models [8], and their colors represent concentration values of various air pollutants [9]. These images are geo-referenced (correspond to a specific geographic region), and they typically represent environmental pressures in terms of maximum or average air pollution concentration values for the time scale of reference (usually hours or

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_61,

days, [5]). A typical set of such CW models and the resulting images can be found in the European Chemical Weather Forecasting Portal [4; 1], that has been developed in the frame of COST Action ES0602 (www.chemicalweather.eu), where a number of CW modelling systems is made available [8].

CW images are like any other model result visualizations that do not follow a predefined norm, as they are produced by different modellers and providers. As a result, they are heterogeneous in presentation (geographic region, resolution, concentration/colour scale mapping etc.) thus hindering any meaningful unified presentation, merging or interpretation attempt. Also, some of the images are permanently altered with visible watermarks, compression artefacts, blurring, noise, symbols, text, lines etc. that would make a unified presentation even more visually unappealing.

Having access to the original simulation model data would be the only meaningful way to produce combined forecasts such as those used in ensemble modelling, but in the case of CW forecasting (as well as in many other engineering applications) the problem is that the actual (raw) data are usually not available for a variety of reasons. To overcome these limitations, a dedicated image parsing and data recovery system was developed. Its job is to convert the bitmap data from different data providers into an internally unified, index-based, hybrid point/raster-based representation of forecast data which can be made homogeneous when displayed, taking different scale, projections, value ranges etc. into account. This allows for the development of a new service in the ECheWeFoP, that will give users the opportunity to combine and to compare forecasting information coming from various providers, in a harmonized way.

2 Materials and methods

The image parsing method used in the ECheWeFoP implements a number of processing steps, including (a) screen scraping and (b) data reconstruction via image data interpolation. The procedure is followed by the necessary map transformations in order to produce uniform, indexed data using a unified format and geographical projection. Figure 1 presents the overall process.

Screen scraping is the step where the original image is automatically downloaded from the provider's website, cropped and parsed into a 2D data array, based on a chroma key constructed from the colour-based legend and the pixels of the original image. This chroma key is an RGB colour/value-index pairing map, under which the pixel colours of the original images are mapped to an integer index such as 0, 1, 2, 3 etc. based on their actual RGB value and the relative order of the legend's colours. Colours are also associated with minimum/maximum value ranges of the air pollutant concentration levels presented (e.g. Bright Red for concentration values ranging from 100 to 200 $\mu g/m^3$ would be index 15, Bright Orange from 50 to 100 $\mu g/m^3$ would be index 14 etc.). Special values are provided for cases such as invalid data (like data gaps due to the removed watermarks and geomarkers) and transparent regions that are easily recognizable, as they have no matching with the colour palette used for the graph. The final result of the above mentioned mapping procedure is called “recovered data”, which are better suited for further processing and comparison with other available data because now each pixel is mapped to a precise integer index with an associated range of real values.

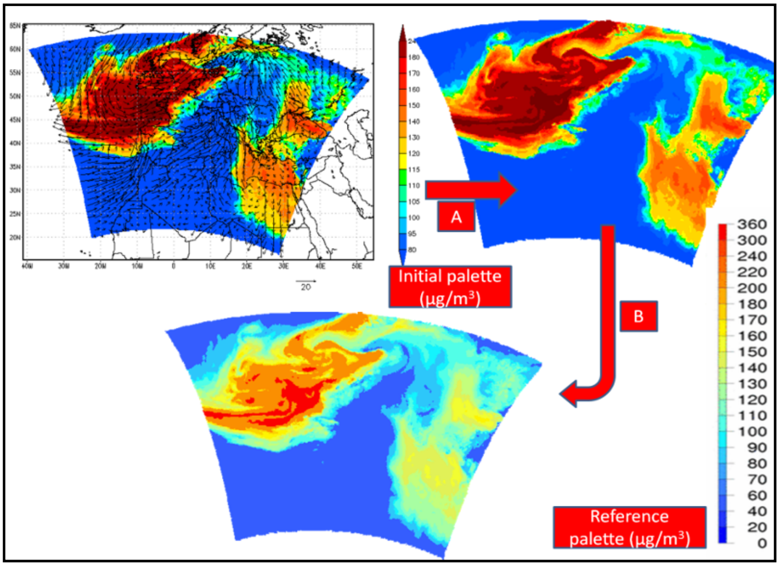


Fig. 1. A schematic representation of the image parsing process. A: Initial image is being parsed. Noise is being removed. B: Reconstruction of missing values. Moreover, a new geographic projection may be applied. The new data set follows another (reference) colour palette. Note how a distinction is made between blank non-mapped areas, and gaps caused by geomarkers.

2.1 Map projection correction

Another aspect of parsing heterogeneous chemical weather data from images is that they correspond to different geographic regions, and that the data might not be in an equirectangular projection which can be directly mapped to the image’s raster. The parsing system developed allows for transforming the data on demand using a variety of input and output map projections. The rasterized CW data, derived from the images, is then effectively treated as geocoordinate point data, as illustrated in Fig. 2.

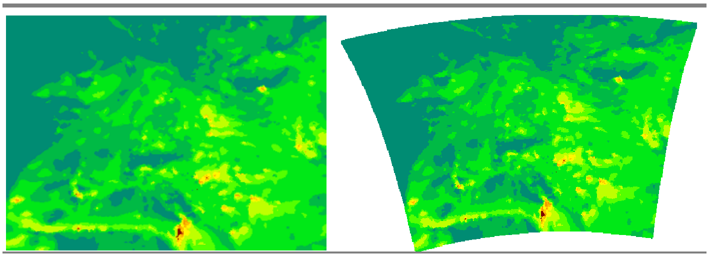


Fig. 2. Forecast by the publicly available EKO Prognoza chemical weather forecasting system, that uses a conformal conical transformation, and its transformation into an equirectangular projection system (right), to be used with the common map projection.

2.2 Reconstruction of missing values and data gaps in the ECheWeFoP portal

A recurring problem during the parsing process is that the CW images usually carry unwanted elements such as legends, text, border lines, contours, watermarks, and uncovered regions which are not part of the forecast area. In order to display the recovered data in a complete, continuous and homogeneous form, the proper colour classification should be applied [5], and, more importantly, the resulting data gaps must be filled-in. Due to the specific needs of the ECheWeFoP,, a rapid, unsupervised and automated method is required for image data interpolation. In the next chapters the used methods are being presented, tested and evaluated, with the aid of sample images.

2.3 Image Data interpolation

The data interpolation algorithms used in the CW screen scraping and data recovery system are designed to operate on indexed data that can be projected on a 2D grid $A \in |m \times n|$ (images, dense arrays etc.) and where 8-directional connectivity can be defined on every element $a(i, j) \in A$, e.g. $a(i-1, j-1), a(i-1, j)$ etc. with the exception of the border elements, which have decreased connectivity and are treated accordingly. The initial data elements (corresponding to the parsed image data) are grouped in two classes: valid and invalid. The algorithms operate by iteratively reducing the set of invalid data until it is empty (or under a certain threshold), and consequently increasing the size of the valid data set. This is achieved by replacing data elements classed as invalid with valid values, based on a variety of decision rules, which have the ultimate effect of expanding valid data regions into invalid ones with a "flood fill" effect.

2.3.1 Procedural/iterative data interpolation approach

The conventional data interpolation algorithms previously described in Epitropou et al. 2010, have some advantages when used in a system intended to process moderately large amounts of data in batches, such as the CW image parsing system of COST action ES0602. The goal of that particular system is to interpolate missing data resulting from the screen scraping images of CW forecasts, which can be due to pixel/value misclassification, watermarks, geomarkings etc. Therefore, they are constrained to work on 2D image data with a limited array of colours, relatively low resolution, and with the requirement that the interpolation must return only values present in the original image's chromatic scale (which correspond to pollutant concentration ranges, in the more general case). In general, the conventional/procedural data interpolation methods are memory efficient (memory usage is $O(mn)$ for images of size $m \times n$), computationally efficient (linear time dependent on $O(mn)$), and most importantly, they are computationally bounded with a predictable running time and guaranteed algorithmic termination.

2.3.2 Neural networks in image processing

Neural networks are used in many fields where classification, pattern matching and recognition is required, especially in the field of image processing as well as data interpolation. Their advantages is that approximate solutions can be found even for complex and "fuzzy" problems for which a full-fledged analytical approach would be too expensive in terms of time and effort, and therefore cannot be easily described by deterministic, conventional algorithms. Their disadvantages, on the other hand, often include higher computational costs compared to conventional direct-solving algorithms for a particular problem, especially if the time required to train the neural network is taken into account, and the complexity of the neural networks themselves grows e.g. multi-layer networks, back-propagation, large numbers of neurons and weights etc. In addition, their performance is directly tied to the quality of the neural training received, which can be inadequate, too specialized or suffer from problems such as redundancy and data overfitting [2; 3; 7].

2.3.2.1 The use of ANN for the interpolation of CW forecasting data

In order to perform better than simple "near neighbor" methods like those previously discussed, and without having access to an archive of past "known good" data, the logical next step is exploiting each dataset's self-similarity in order to fill in missing data. This had been implemented in our NADI algorithm (Neural Adaptive Data Interpolator, [6], which exploits the similarities in small rectangular domains of size 3x3 or 5x5 (or larger) of a CW forecast image to train a neural network, and subsequently using this neural network to produce estimates of missing data.

2.3.3 Performance of algorithms

The performance of the algorithms is evaluated based on the following metrics:

- n'_{err} : The number of pixel errors in the final images. This is obtained by comparing the resulting cleaned image with an uncorrupted version of the original test image..
- n_{err} : The percentage of wrong pixels after cleanup, expressed as the ratio of pixel errors in the final image versus the original number of missing/wrong pixels in the uncorrected image.
- The Peak Signal to Noise Ratio (Peak SNR), which is an expression of the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation (http://en.wikipedia.org/wiki/Peak_signal-to-noise_ratio) Here it is expressed as $PSNR = 20\log\frac{1}{\sqrt{\frac{n_{err}}{n_{total}}}}$ and $PSNR' = 20\log\frac{1}{\sqrt{\frac{n'_{err}}{n_{total}}}}$ where n_{total} is the total number of pixels in the image. Higher values indicate better performance.
- The Structural Similarity (SSIM) index (used for comparing images), modified to evaluate the luminance of each R,G and B components separately. The SSIM index can vary between -1 (totally different pictures) and +1 (totally identical pictures), with higher values closest to 1 being the most desirable. The SSIM is computed on pairs of images (uncorrected and corrected images vs original reference image) on a grid size of 2x2, as suggested in Wang and Bovik, 2009.

3 Results and discussion

We present the results of the applied algorithms, making use of three different test images (Fig. 3, 4, and 5) for testing the performance of the various algorithms.

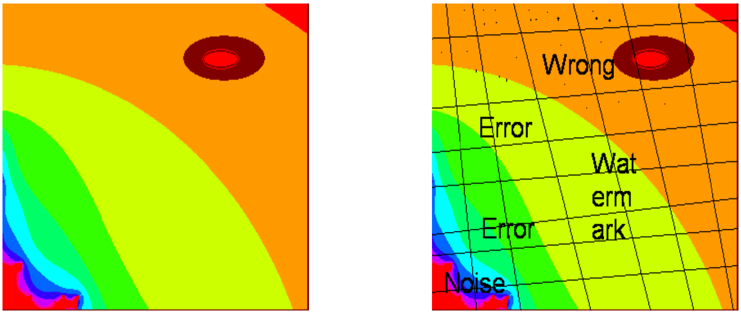


Fig. 3. Low-complexity fractal curves. Original image (left), resolution of 344 by 298 pixels (a total of 102512 pixels). Corrupted image (right) has an MSE (number of wrong pixels) of 6800.

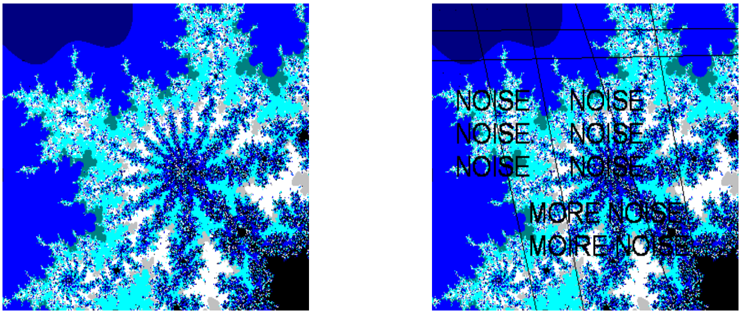


Fig. 4. High-complexity fractal curves. Original image has a resolution of 344 by 298 pixels, for a total of 102512 pixels. The corrupted image has a MSE of 7654.

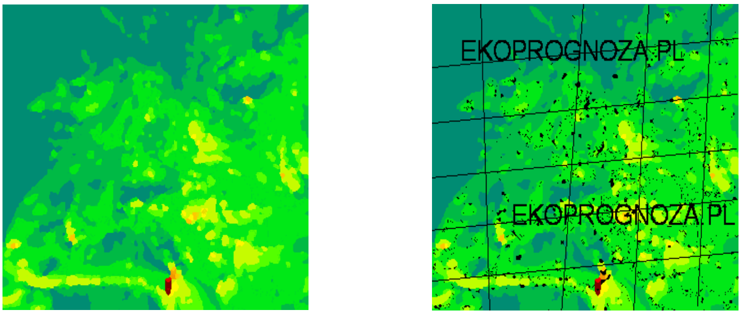


Fig. 5. An image based on a typical CW forecasting system (EKO Prognoza) available on line (ekoprognoza.pl, right picture). Left: cleaned image, right: dirty image. The original image has a resolution of 343 by 297 pixels, for a total of 101871 pixels. MSE of corrupted image: 13703.

3.1 Performance of iterative and procedural algorithms

The performance of these algorithms proved to be satisfactory, especially considering their low computational requirements. The results obtained are reported in the subsequent Tables 1-4.

Table 1. Results for test image 1

Interpolation method used.	n'_{err}	$n'_{err}\%$	$p_{err}(\%)$	$p'_{err}(\%)$	PSNR	PSNR'
Median of all neighbouring values.	6800	153	6.633	0.149	11.783	28.261
Random neighbour chosen (10 runs avg.)	6800	127	6.633	0.124	11.783	29.070
Most common neighbouring value	6800	183	6.633	0.179	11.783	27.483

Table 2. Results for test image 2

Interpolation method used.	n'_{err}	$n'_{err}\%$	$p_{err}(\%)$	$p'_{err}(\%)$	PSNR	PSNR'
Median of all neighbouring values.	7654	3837	7.466	3.743	11.269	14.268
Random neighbour chosen (10 runs avg.)	7654	3717.7	7.466	3.627	11.269	14.405
Most common neighbouring value	7654	3935	7.466	3.839	11.269	14.158

Table 3. Results for test image 3

Interpolation method used.	n'_{err}	$n'_{err}\%$	$p_{err}(\%)$	$p'_{err}(\%)$	PSNR	PSNR'
Median of all neighbouring values.	13703	8886	13.451	8.723	8.712349	10.59344
Random neighbour chosen (10 runs avg.)	13703	8941	13.451	8.777	8.712349	10.56664
Most common neighbouring value	13703	9010	13.451	8.845	8.712349	10.53326

Table 4. Best aggregate SSIM results for each test image

Test Image	Interpolation method used.	$SSIM_R$	$SSIM_G$	$SSIM_B$	$SSIM_{RGB}$
Image 1	Random neighbour	0,9977	0,9991	0,9981	0,9983
Image 2	Median of all neighbouring values.	0.9673	0.9416	0.9461	0.9517
Image 3	Median of all neighbouring values.	0.9741	0.9556	0.9591	0.9629

Results indicate improvement versus uncorrected images, and that given the system's purpose, this approach could be considered sufficient, considering that Image 2 and even Image 3 greatly exceed the average complexity of most actual CW images, so they could be viewed as worst-case scenarios. The median of all neighbouring values proved to be the best interpolation method, outperforming the other methods in two out of the three images on the basis of the SSIM criterion. Nevertheless, we were interested in exploring if potentially more accurate data interpolation results were possible to obtain, in particular using an artificial neural network (ANN) approach, while remaining within the context of the ECheWeFop project, therefore leading to the development of the aforementioned NADI algorithm, which is described in detail elsewhere [6].

3.2 Performance of neural algorithms

In order to perform better than simple "near neighbor" methods like those previously discussed, the logical next step is exploiting each dataset's self-similarity in order to fill in missing data. NADI's performance was evaluated with the same metrics used for conventional iterative interpolation algorithms. Results are summarized below.

Table 5. Aggregate results for the application of the NADI algorithm for the test images

Image used	n'_{err}	$n'_{err}\%$	$p_{err}(\%)$	$p'_{err}(\%)$	PSNR	PSNR'
Test image 1	6800	82	6.633	0.149	11,783	30,970
Test image 2	7654	3381	6.633	0.173	11,269	14,817
Test image 3	13703	8846	8.866	0.124	8,712	10,613

Table 6. Best results for the separate RGB components' SSIM indexes and their average

Test image and method	$SSIM_R$	$SSIM_G$	$SSIM_B$	$SSIM_{RGB}$
Test image 1, Random	0.9977	0.9991	0.9981	0.9983
Test image 1, NADI	0.9990	0.9996	0.9991	0.9992
Test image 2, Median	0,9673	0,9416	0,9461	0,9517
Test image 2, NADI	0.9665	0.9516	0.9500	0.9560
Test image 3, Median	0.9741	0.9556	0.9591	0.9629
Test image 3, NADI	0.9784	0.9577	0.9616	0.9659

Results in Table 5 shown are the best achievable. Detailed results are included in [6]. Results in Table 6 include all test images and all tested algorithms. Only the best conventional interpolation algorithms are considered in this table and compared with NADI results. The performance metrics indicate that the NADI algorithm can be better than the conventional linear interpolators, but only by a small margin. The difference is more obvious by taking SSIM indexes of separate RGB components into consideration, and applying the technique on images with a sufficiently complex structure. Computationally, NADI is noticeably more expensive than an iterative conventional interpolator, and so improving its performance as well as its execution times are the objects of future research, in order to make it competitively scalable.

4 Conclusions

The proposed image parsing and data extrapolation system used in the ECheWeFoP represents a novel approach to the problem of extracting usable data from images. On this basis, it is possible to compare, harmonise, integrate or reuse environmental data in a common framework, thus providing added value to environmental model results and environmental spatial data in general. Future enhancements are planned that are aimed at making the whole procedure more versatile, adaptable to other kinds of rasterized data, providing more accurate interpolation methods, as well as being eventually provided in the form of a user-scriptable web processing service.

Acknowledgments. The authors greatly acknowledge the support of the Finnish Meteorological Institute and of COST Action ES0602

References

[1] Balk T, Kukkonen J, Karatzas K, Bassoukos A and Epitropou V (2010). A European open access chemical weather forecasting portal, Atmospheric Environment, doi:10.1016/j.atmosenv.2010.09.058, in press

[2] Cristea PD (2009). Application of Neural Networks in image processing and visualisation, pp. 59-71, in R. De Amicis et al. (eds.), GeoSpatial Visual Analytics: Geographical Information Processing 59 and Visual Analytics for Environmental Security, © Springer Science + Business Media B.V. 2009

[3] Egmont-Petersen M., de Ridder D. and Handels H. (2002), Image processing with neural networks—a review, Pattern Recognition 35, Issue 10, October 2002, Pages 2279-2301

[4] ECheWeFoP, (2010), European Chemical Weather Forecasting Portal, a GEOSS Component, available at

a. https://geossregistries.info/geosspub/component_details_ns.jsp?compId = urn:uuid:d484b082-45e9-4837-985d-ccb5f207f6ee

[5] Epitropou V, Karatzas K. and Bassoukos A. (2010). A method for the inverse reconstruction of environmental data applicable at the Chemical Weather portal, Proceedings of the GI-Forum Symposium and exhibit on applied Geoinformatics, pp. 58-68, Wichmann Verlag, ISBN 978-87907-496-9.

[6] Epitropou V. and Karatzas K. (2010), NADI: A Neural Adaptive Data Interpolation algorithm for chemical weather data, *Engineering Applications of Artificial Intelligence*, submitted.

[7] Haykin, S. (1994). Neural Networks: A Comprehensive Foundation. New York, NY: Macmillan College Publishing Company, Inc.

[8] Kukkonen J, Klein T, Karatzas K, Torseth K, Fahre Vik A, San José R, Balk T. and Sofiev M. (2009). COST ES0602: Towards a European network on chemical

weather forecasting and information systems, *Advances in Science and Research Journa*, **1**, 1–7, www.adv-sci-res.net/1/1/2009/

[9] San José R, Baklanov A, Sokhi RS, Karatzas K and Pérez JL (2008). Computational Air Quality Modelling, in Developments in Integrated Environmental Assessment, Vol 3, Environmental Modelling, Software and Decision Support Edited by: A.J. Jakeman, A.A. Voinov, A.E. Rizzoli and S.H. Chen ISBN: 9780080568867.

[10] Wang Z and Bovik AC (2009). Mean squared error: love it or leave it? - A new look at signal fidelity measures, *IEEE Signal Processing Magazine* 26(1), 98-117.

Implementation of a detailed shadow model into the EULAG CFD model for urban applications: Madrid case study

R. San Jose[1]*, J.L. Perez[1] and R.M. Gonzalez[2]

[1]Environmental Software and Modelling Group, Computer Science School, Technical University of Madrid (UPM), Campus de Montegancedo,
[2]Department of Meteorology and Geophysics, Faculty of Physics, Complutense University of Madrid (UCM)

* roberto@fi.upm.es

Abstract. The urban energy exchange is a fundamental issue for urban scale meteorological simulations. It is necessary to calculate the transfer of energy and momentum between the urban surface and the atmosphere with more realistic urban geometry. Urban energy fluxes can be obtained applying the surface energy balance equation. A new three-dimensional urban solar radiation model (SHAMO) has been developed to calculate short wave radiation over urban high resolution grids. The model needs the following inputs: sun location and global short radiation which are taken from the mesoscale runs developed with the meteorological model WRF (NCAR, US) and building structures from geographic information databases. The data produced by the urban solar radiation model has been used in large scale numerical experiments to simulate turbulent fluxes for urban areas, over Madrid (Spain) city. We have applied a modified version of the EULAG (UCAR) micro scale model (CFD) which includes an energy balance equation to obtain the urban energy exchange. Results of the micro scale simulations and how sensitivity are the results to the solar radiation approach will be presented in this chapter.

Keywords: shadow model, urban environment, turbulent fluxes

1 Introduction

During the last years, it has been noted that a substantial scientific effort has been done to link the meteorological mesoscale models to microscale models. The computer time involved in mesoscale meteorological simulations has increased importantly during the last decade. The meteorological mesoscale models have experimented a substantial increase in complexity and the resolution has become higher and higher. Numerical unstable conditions appear when mesoscale meteorological models – such as MM5 or WRF – are run with resolutions lower than 1000 – 200 m or so. Several tries have done in the past when mesoscale meteoro-

P. Golinska et al. (eds.), *Information Technologies in Environmental Engineering*, Environmental Science and Engineering 3, DOI: 10.1007/978-3-642-19536-5_62,

logical models have been "urbanized" in order to introduce the urban effects in the mesoscale flow. The last example of such a urbanization process is found on the Urban Canopy Model (UCM) [1] as a module added to the mesoscale meteorological model WRF (Weather & Research Forecasting system) (NCAR and others). The UCM model is using an idealized canyon street approach for the urban area. Those grid cells in WRF model which are classified as urban cells are suitable to be treated with UCM model. The UCM model assumes that the urban canopy is composed by a 2D street canyon approach with a street area, a width of the street and a length for the roof and so on. These UCM parameters can be applied by default or derived from real 3D GIS information after a treatment of the information.

Another group of models called CFD (Computational Fluid Dynamical models) has been applied during many years for solving many engineering problems. A new model called EULAG [2] has been developed from the CFD basis and a turbulence and boundary layer model have been implemented. The EULAG model is using the Large Eddy Simulation (LES) technique instead of the Reynolds-Averaged Navier-Stokes (RANS) technique, which is computationally more demanding but more precise than RANS. EULAG allows to include a 3D GIS structure to estimate the wind and temperature in a 3D grid with a very high resolution (typically 1-4 m). In order to have realistic simulations, boundary conditions (BC's) coming from a mesoscale meteorological model are needed. EULAG model do not include the flux balance calculation and the flux partition for the latent heat flux. In this contribution we have included the flux partition into the WRF/UCM-EULAG system in order to have patterns of sensible and latent heat flux with high resolution in an urban environment. When the grid cell has a non-urban land-use type (natural), the NOAH land-surface model is applied into EULAG. The NOAH land-surface model calculates the latent heat flux partition (Penman) into canopy water, direct soil and total plant evaporation. This model has been also implemented into the EULAG model. Figure 1 shows a scheme of the NOAH model, the energy flux included into the UCM model and transported to EULAG and the idealized 2D street canyon approach in UCM. In EULAG the real 3D GIS has been used.

2 Methodology

The UCM energy balance calculation is transferred to EULAG model to implement the calculation of sensible, latent and soil fluxes. The EULAG domain is limited to 1 km x 1 km with 100 m in height. Our objective is to have a 4 m surface resolution simulation [3; 5; 8; 11]. The vertical resolution is also fixed to 4 m. The EULAG model estimates the wind and temperature at 2 m in height (4 m cubes). The skin and the first level (35 m in height) temperature from WRF-UCM model are used to estimate a new skin temperature when applying the Similarity Theory and the Energy balance equation:

$$Rn - H - L - G = 0 \quad \textbf{(1)}$$

Where, Rn is the net radiation which includes the short and long wave; H is the sensible heat flux; L is the latent heat flux and G is the ground heat flux.

$$H = \rho \, c_p \, k \frac{u_*}{\psi_h} (\Omega - \Omega_0) \quad \text{where}$$

$\Omega_0 =$ air temperature at roughness length height.

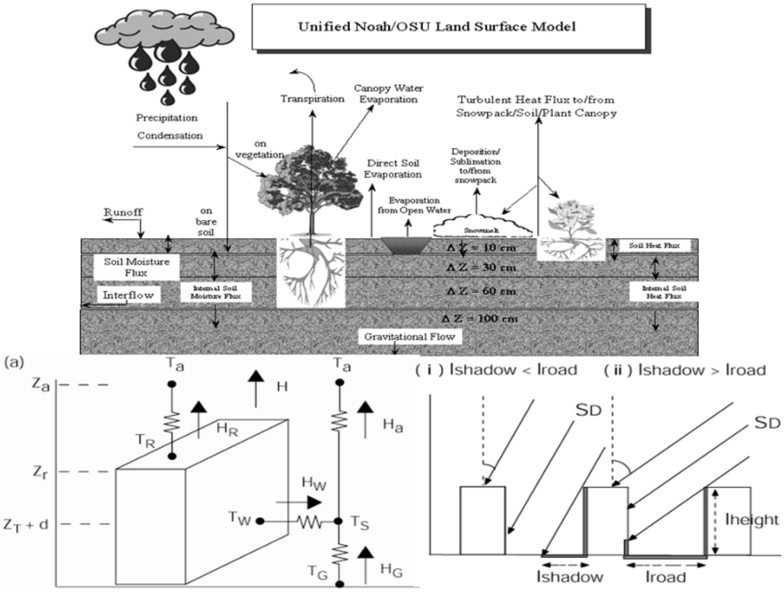


Fig 1. NOAH land-surface model as transferred to EULAG for natural land-use types, the building and street heat flux treatment in UCM as transferred to EULAG. The 2D GIS included into UCM but not transferred to EULAG (in EULAG, we use the real 3d GIS).

$\rho =$ air density. $\Omega =$ air temprature (K).

$\Omega_0 =$ air temperature at roughness length height.

$c_p =$ Heat capacity of dry air. $k = 0.4$ (von Karman constant).

$\psi_h =$ heat integrated universal function. $u_* =$ friction velocity.

From Similarity Theory [4, 6, 7, 9], we obtain u_* and ψ_h using two levels, $Z_{wrf} - Z_{eulag}$. The latent heat flux is calculated as:

$L = \rho \, E1 \, k \frac{u_*}{\psi_h} (q - q_0)$. $\rho =$ air density $q =$ specific humidity

$q_0 =$ WRF surface specific humidity (at roughness length).

El = heat capacity of vaporation.
$q = 0.622 * ES(PS$(saturation pressure)-0.378*ES(saturation vapor pressure)) .

So that:

$$ES = 6.11 * EXP(\frac{2.5*10**6}{461.51})*\frac{(\Omega - 273.15)}{(272.15*\Omega)} \quad \textbf{(2)}$$

$$G = \text{Thermal conductivity*}(\frac{\Omega(surface) - \Omega(layer\ 1)}{(depth/2)})$$

Rn = emissivity * (long wave radiation $-\sigma\Omega^4$) Rn = (albedo, shadow)

Energy balance equation (wall and ground):

Net radiation (Direct, reflected, sky view factor):

$$H = p\ C_p(6.15 + 4.18 * u_{Eulag})(\Omega - \Omega_0) \qquad \text{(Jurge´s formula)} \quad \textbf{(3)}$$

$$L = p\ El(6.15 + 4.11 * u_{Eulag})(q - q_0) \quad \textbf{(4)}$$

The NOAH land-surface model uses a latent heat flux partition into three different fluxes: canopy water, direct soil and total plant evaporation [10, 12, 13]. The total radiation (TR) is calculated as:

$$TR = SOLDN(1 - ALBEDO) + GLW * EMISSIVITY \quad \textbf{(5)}$$

Where SOLDN is the downward short wave flux and GLW is the downward long wave flux. The NOAH model calculates the ground heat flux with the thermal diffusivity, the sensible heat flux using the following approach:

$$SH = \frac{CH * CP * SFCPRS}{R * T2V} * (TH2 - T) \quad \textbf{(6)}$$

Where CH is the surface exchange coefficient (coming from the surface scheme); SFCPRS is the surface pressure; T2V is the virtual temperature (coming from the EULAG model); TH2 is the potential temperature (coming from the EULAG model) and CP and R are constants. The latent heat flux is divided into EC (canopy water evaporation), EDIR (direct soil evaporation) and ETT (total plant evaporation. These values are calculated through the Penman method. Finally, the change in soil moisture content is calculated through the precipitation, runoff and evaporation (the infiltration is calculated as precipitation minus runoff).

The shadow model approach has been done in two ways: a) we have implemented a so called simple shadow model and b) a detailed shadow model into

EULAG system, together with the turbulent fluxes as explained before. The simple shadow model has been implemented by using an ideal canyon street. The short wave radiation has been calculated in each grid cell (in our experiment, the grid cell is 4 m x 4 m). The short wave radiation is calculated as:

$$SWR = SWR_i + SWR_r \tag{7}$$

SWR_i is the incident short wave radiation and SWR_r is the reflected short wave radiation. In this simple approach we have the h parameter: building height, the w parameter: street width and the ls parameter: shadow length. Each grid cell is associated to the closest building in order to obtain the h parameter. We have used the City 3D shape files with the buildings morphology in the GIS file.

The shadow length is calculated as:

$$ls = h * \tan\sigma_z * \sin\sigma_n \tag{8}$$

Where σ_z is the solar zenith angle (as received from WRF-UCM) and σ_r σ_n is the street orientation (from GIS data set) in case ls >w. If ls < w we force ls = w since all street is under the shadow. The short wave radiation from WRF is split into direct (d) and diffuse (q) solar radiation as:

$$SWR_d = SWR\_WRF * 0.8 \tag{9}$$
$$SWR_q = SWR\_WRF * 0.2$$

Where SWR_d is the direct solar radiation and SWR_q is the diffuse solar radiation. The incident solar radiation is calculated as:

$$SWR_i = SWR_d \frac{(w - ls)}{w}(1-\alpha) + SWR_q F_{sky}(1-\alpha) \tag{10}$$

The reflected solar radiation is calculated as:

$$SWR_r = SWR_d \frac{ls}{2h}\alpha_w F_{walltoground}(1-\alpha) + SWR_q F_{sky}\alpha_w F_{walltoground}(1-\alpha) \tag{11}$$

where, α is the ground albedo, α_w is the wall albedo and $F_{sky} = 1 - F_{walltoground}$.

$$F_{walltoground} = \int_o^{H\_building} 1 - \frac{h}{\sqrt{h^2 + w^2}} \tag{12}$$

In the case of a detailed shadow model (b), the final solar radiation has been calculated as.

$$FSR_{i,m} = \sum FSR_{k,m-1} * ALB * FREFLECTION \tag{13}$$

where, $FSR_{i,m}$ is the final solar radiation in the grid cell i, after m reflections; $FSR_{k,m-1}$ is the final solar radiation in the grid cell j after m-1 reflections; the ALB is the surface albedo and finally, FREFLECTION is the reflection factor. If m=0 the initial solar radiation is ISR (No reflections yet). The variables to be calculated to have a full description of the total short wave solar radiation in every grid cell (4 m x 4 m) are: sun location (x, y, z), shadows, sky view factor, direct & diffuse solar radiation, reflections and finally total solar radiation in every grid cell. The process continue by an iterative process until FSR < 1% ISR. The ISR is calculated as:

$$ISR = FSHADOW * DIRSR + FSKY * DIFSR \tag{14}$$

where, FSHADOW is the building shadow effect. The FSHADOW=1 in case the grid cell is receiving full solar radiation and the SHADOW=0 in case the grid cell is full in a shadow; DIRSR is the direct solar radiation (W/m2), DIFSR is the diffuse solar radiation (W/m2) and FSKY is the sky view factor (0-1). From every grid cell, a straight line between sun and the grid cell is traced. From the grid cell, we follow the straight line and if a building is found, the FSHADOW is set to 0, If not, FSHADOW is set to 1. The sun position is calculated by using the declination angle (d), the zenith angle (z) and the hour angle (w) and the celestial coordinate system is applied by using the solar altitude angle (α) (90º -z) and the solar azimuth angle (y) in a way that:

$$\cos y = \frac{\sin(\alpha)\sin(w) - \sin(d)}{\cos(\alpha)\cos(w)} \tag{15}$$

Figure 2 shows the hourly sun position during one day (June, 28, 2008) in latitude 40.24º , the azimuth angle and the altitude angle.

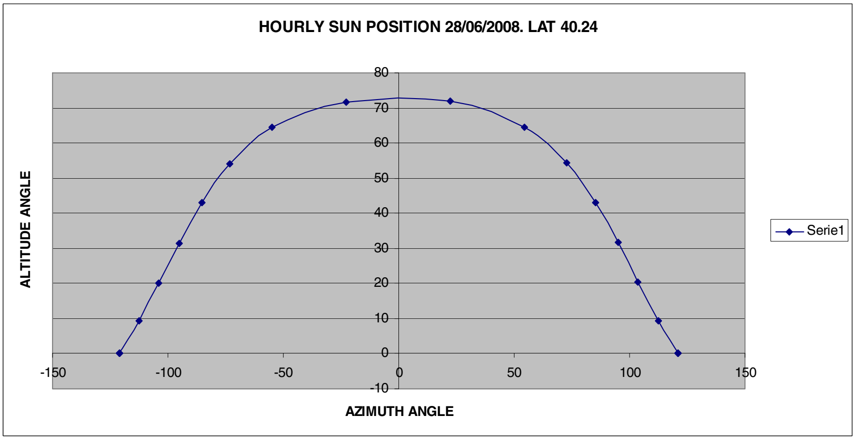


Fig 2. Sun's location in function of the azimuth and altitude angles at latitude 40.24º on 28.06, 2008.

The Cartesian coordinates for the sun's position are calculated as:

$$x = r\cos(\alpha)\sin(y) \qquad y = r\cos(\alpha)\cos(y) \qquad z = r\sin(\alpha) \qquad \textbf{(16)}$$

In Figure 3 we show the directions of the Cartesian axis in our experiment. X-axis: East-West direction; X-axis: North-South direction; (0, 0, 0) is the center of the grid cell.

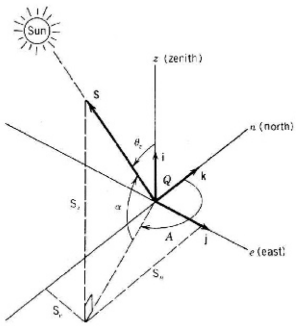


Fig 3. Cartesian coordinates and directions in our experiment

In Figure 4, we show an example of the Madrid shadows in 1 km x 1 km domain (our experiment) with 4 m spatial resolution on June, 28, 2008, 06:00 GMT using our MICROSYS shadow module. White areas are buildings.

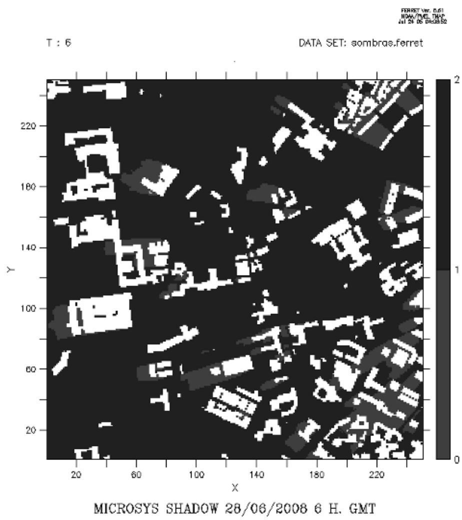


Fig. 4. Shadow module results on June, 28, 2008 over a domain of 1 km x 1 km with 4 m spatial resolution. White areas are buildings.

The FSKY & FREFLECTION variables are calculated as follows: a) 3D tracking method b) casting rays from a hemisphere located on the center of each grid cell c) final point of each ray is located as:

$$X = k\cos(\sigma)\ \ Y = k\sin(\sigma)\ \ Z = (r^2 - k^2)^{\frac{1}{2}}$$

: Ray direction angle [0,180º] k : Ray Height [0,r]

d) counting the number of rays that collide with the building grid cells e) the minimum number of rays is 35000 in a 1 km x 1 km experiment domain, f) the fraction of rays that collide with the building grid cells is the reflection factor (FREFLECTION), g) (1-FREFLECTION) rays are not reflected. This is the sky view factor (FSKY), h) We designed a full parallel approach due to the high computing demand. The computer time with 1 CPU and 34752 rays is 95 minutes; with 50 CPU's and 34752 rays, the CPU time is 2.40 minutes and finally for 50 CPU's and 135014 rays, the CPU time is 6.50 minutes. Figure 5 shows the sky view factor for the experiment Madrid area with 1 km x 1 km and 4 m spatial resolution.

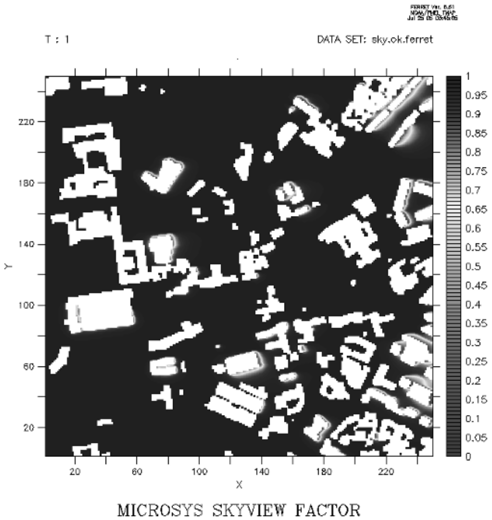


Fig. 5. Sky view factor for the Madrid experiment with 1 km x 1 km domain with 4 m spatial resolution.

The global total radiation is calculated as the direct plus the diffuse solar radiation and the diffuse solar radiation is calculated as the global radiation obtained from the WRF/UCM model multiplied by the turbidity factor defined as the relation between extraterrestrial solar radiation and the incoming solar radiation over the horizontal plane. The turbidity factor is calculated as follows:

$$TF = MIN(1, 1/A)$$

$$A = MAX(0.1, B)$$
$$B = 2.1 - 2.8 * LOG(LOG(SOLTOP/GLOBAL))$$
$$SOLTOP = 1370 * DAYFACTOR * \cos(zenith)$$

Figure 6 shows the ratio DIRECT/DIFFUSE solar radiation which depends on the solar zenith angle and the sky conditions (cloudiness). Under high cloudiness conditions and small solar angles the ratio is close to 0.5 and with large solar angles, the ratio is close to 0.2.

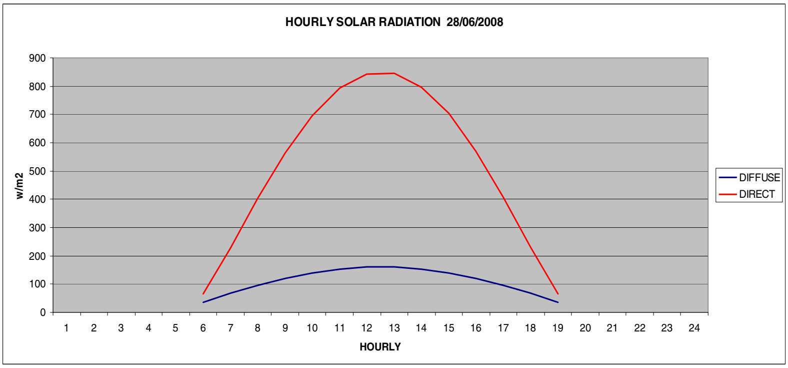


Fig. 6. Diffuse and direct solar radiation on June, 28, 2008 over Madrid experiment area.

3 Results

After the new 3D shadow model has been implemented, the next step is to check the sensitivity of turbulent fluxes in an urban environment using the 2 shadow models available. In particular over an area of 1Km square located on the university campus. Over this area has been simulated winds, temperature and fluxes using the EULAG CFD model. The original EULAG code has been modified to incorporate the fluxes calculations as previously described in the document.

We have performed 2 simulations, one with de simple shadow model (Shadow Canyon) and other with the new 3D shadow model. (Micro Shadow) to test the sensitivity of fluxes to the shadow model.

The results show important differences between different grid cells in the experiment model domain. The Northwest area of the domain has a building density lower than the Southeast area of the model domain, so that when running our shadow models the results show higher differences in the latter area. In Figure 7 we show the results of the total solar radiation in every grid cell (4 m x 4m) in the model domain experiment area (1 km x 1 km) on June, 28, 2008 at 06h00 GMT. The white areas are building top views.

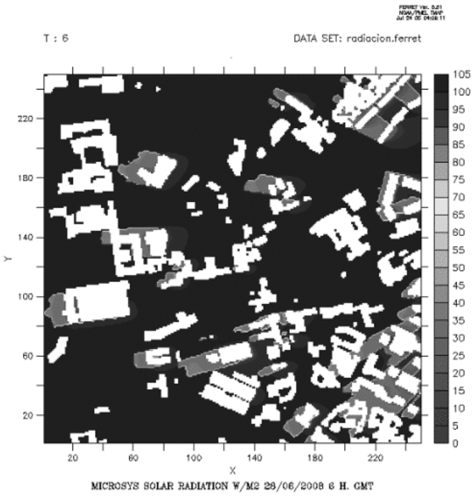


Fig 7. Total solar radiation in the Madrid experiment area on June, 28, 2008 06h00 GMT.

We will show the results to two significant hours of the day June 28, 2008, at 7:00 (sunrise) Figure 8,9 and 18:00 (sunset) Figure 10,11.The differences on sensible heat flux, Figures 8 and 10, and on ground heat flux, Figures 9 and 10, between the detailed shadow model and the simple shadow model (MICROSHADOW – CANYONSHADOW). The differences on sensible heat flux and ground heat flux are very important for both models,

After the results analysis, we can conclude that the positive differences are predominant at sensible heat flux differences. These are located around the buildings. At 7:00 AM the differences can be seen in the eastern part of the buildings and at 18:00 on the west part., which is consistent with the actual sun movement. The maximum differences reach values up to 60 W/m2, this is because some areas are being considered as shadow places by he simple shadow model , with values around -20 W/m2.. But the new 3d shadow model implemented consider that some rays of sun are coming at this area, with sensible hear flux values of 40 W/m2.

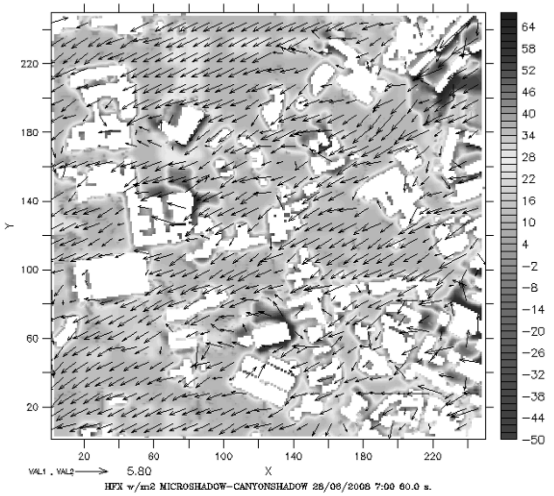


Fig. 8. Differences between the sensible heat fluxes obtained by the detailed shadow model (MICROSYS SHADOW) and the simple shadow model (CANYONSHADOW) on June, 28, 2010 at 07h00 GMT after 60 s simulation time of EULAG model.

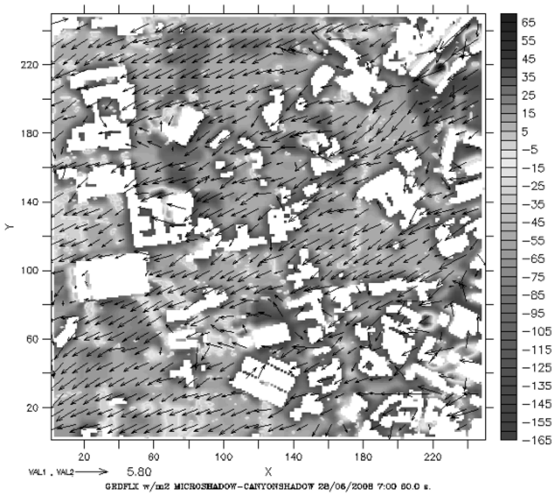


Fig. 9. Differences between the ground heat fluxes obtained by the detailed shadow model (MICROSYS SHADOW) and the simple shadow model (CANYONSHADOW) on June, 28, 2010 at 07h00 GMT after 60 s simulation time of EULAG model.

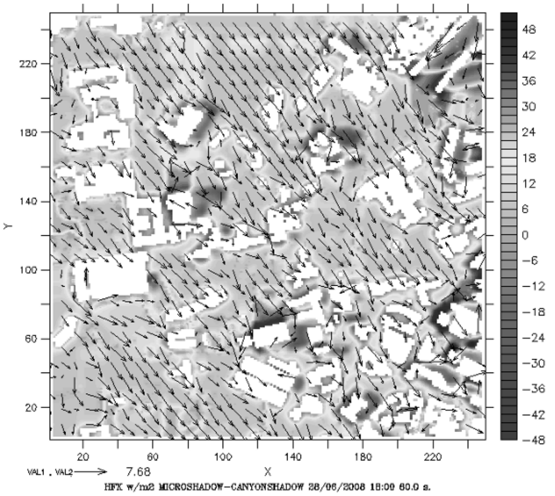


Fig 10. Differences between the sensible heat fluxes obtained by the detailed shadow model (MICROSYS SHADOW) and the simple shadow model (CANYONSHADOW) on June, 28, 2010 at 18h00 GMT after 60 s simulation time of EULAG model.

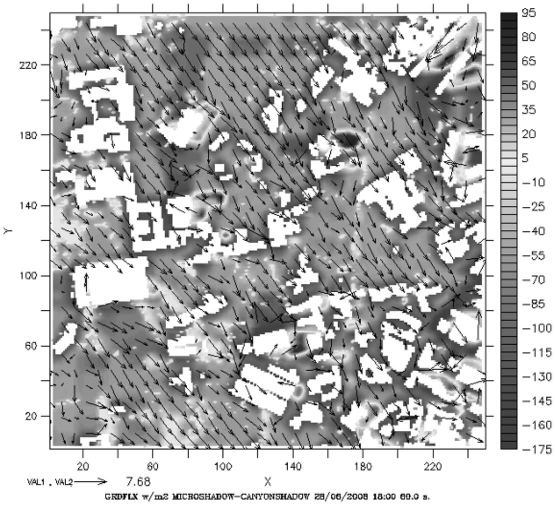


Fig 11. Differences between the ground heat fluxes obtained by the detailed shadow model (MICROSYS SHADOW) and the simple shadow model (CANYONSHADOW) on June, 28, 2010 at 18h00 GMT after 60 s simulation time of EULAG model.

The ground heat flux differences follow the same reasoning for the sensible heat flux, taking into account the sign convention changes. Positive ground heat flux means the heat is moving from the ground into the subsoil. The differences are bigger that the sensible heat flux differences because ground heat flux is more sensible to the final radiation reaching each grid cell, which depend of the calculated shadow degree by the shadow model.

The simple shadow model uses street canyons to calculate shadows. It you apply this methodology over an urban area where there in not clear canyon streets, introduce an uncertainty in the fluxes model. It can be solved by using the new 3D micro- shadow model implemented.

4 Conclusions

We have implemented the turbulent energy fluxes (sensible, latent and ground) into the EULAG code. We have developed a detailed shadow model to take into account the different reflections of the short wave solar radiation over the buildings in a typical urban environment. The approaches have been developed for a high resolution runs of EULAG in an urban environment (in our experiment with 4 m spatial resolution grid cells) The code has been developed according to the structure of EULAG and receiving the information (nesting approach) from the WRF/UCM model. Two different shadow models have been developed: a) a simple shadow model based on a so-called canyon street approach which calculates the short wave radiation in different locations based on height of the buildings and the width of the street b) a second shadow model has been developed based on a much more detailed approach. This approach is based on N reflections of the solar rays over the different building faces until reaching the surface. Casting different rays from every grid cell (4 m x 4m) to sun produces information related to the sky view factor for every grid cell. The results show – as expected – a high sensitivity to the shadow model. The turbulent fluxes reflect a high sensitivity to the shadow model which has been used to determine the amount of short wave radiation reaching every grid cell in surface and building faces.

Acknowledgements. We would like to acknowledge INDRA ESPACIO for the remote data provided from different satellites and sources and for partially funding this research. We also would like to acknowledge the BRIDGE EU project FP7/2007-2013, under grant agreement 211345 which partially funded this research. Authors thankfully acknowledge the computer resources, technical expertise and assistance provided by the Centro de Supercomputación y Visualización de Madrid (CeSVIMa) and the Spanish Supercomputing Network (BSC).

References

[1] Lorenc, A. C., 1986: Analysis methods for numerical weather prediction. Q. J. R. Meteorol. Soc., **112**, 1177-1194.

[2] Todling R. and S.e. Cohn (1994): Suboptimal schemes for atmospheric data assimilation based on the Kalman filter. Mon. Wea. Rev. 122, 2530 – 2557

[3] Pielke, RA. 1984. Mesoscale Meteorological Modeling. 1ª edición, Academic Press, New York

[4] Grell, G. A., S. Emeis, W. R. Stockwell, T. Schoenemeyer, R. Forkel, J. Michalakes, R. Knoche, and W. Seidl, 2000: Application of the multiscale, coupled MM5/chemistry model to the complex terrain of the VOTALP valley campaign. Atmospheric Environment, 34, 1435-1453.

[5] Skamarock W.C., J.B. Klemp, J. Dudhia, D. Gill, D. Barker,W. Wang, J.G. Powers. A description of the advanced research WRF Version 2 . NCAR Technical Note NCAR/TN-468+STR (2005)

[6] Flanner, M. G. (2009), Integrating anthropogenic heat flux with global climate models, Geophys. Res. Lett., 36, L02801

[7] Kusaka H., H. Kondo, Y. Kikegawa and F. Kimura (2001). A simple-layer urban canopy model for atmospheric models: comparison with multi-layer and slab models. Boundary-Layer Meteorology, 101, 329-358.

[8] San José, R., J.L. Pérez, J.L. Morant and R.M. González (2008): "Elevated PM10 and PM2.5 concentrations in Europe: a model experiment with MM5-CMAQ and WRF/CHEM" WIT Transactions on Ecology and the Environment, Vol. 116, pp. 3-12. ISSN: 1743-3541 (on-line).

[9] Chimklai P, Hagishima A, Tanimoto J. 2004. A computer system to support albedo calculation in urban areas. *Building and Environment* 39: 1213–1221.

[10] Aida A. 1982. Urban albedo as a function of the urban structure – a model experiment. *Boundary-Layer Meteorology* 23: 405–413.

[11] Oke TR. 1981. Canyon geometry and the nocturnal urban heat island: comparison of scale model and field observations. *Journal of Climatology* 1(3): 237–254.

[12] Erell E, Williamson T. 2006. Simulating air temperature in an urban street canyon in all weather conditions using measured data from a reference meteorological station. *International Journal of Climatology* 26(12): 1671–1694.

[13] Stewart I, Oke TR. 2006. Methodological concerns surrounding the classification of urban and rural climate stations to define urban heat island magnitude. *6th International Conference on Urban Climatology*. Goteborg University: Goteborg.