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Preface

This year, the CDVE conference celebrated its tenth anniversary at its home on the beautiful Mediterranean island, Mallorca, Spain.

We are excited to see the journey of the innovative research and development in the field of cooperative design, cooperative visualization, and cooperative engineering has reached an important milestone. The research papers published over these ten years convincingly show us that the CDVE technology provides more possibility for the cooperative work in many industrial and scientific fields, in education, and social life. It helps in solving complicated problems, better life cycle management for industrial products, and better cooperation environments for the society.

From this year's papers, we can see that the cooperative technology shows its strength in the cooperation not only among humans but far beyond. The cooperation is now also within the Internet of Things, mobile agents, decision nodes, etc. New situation and development in the information society today brings new opportunities and at the same time, new challenges to our researchers.

There is a group of papers this year dealing with the cooperative issues brought by the Internet of Things. One example is about the situation in the ambient assisted living systems. Such systems have to manage large amounts of generated information and integrate a group of devices and services built by completely different entities and let them cooperate with each other in harmony. The issues also include the evolution of these systems to cooperate with new devices and services without breaking the original configuration and services. A careful design of the system architecture adaptable to most ubiquitous computing scenarios and distributed systems seems to be the key of the success.

Papers reporting wireless sensor networks composed of sensors and actuators under the concept of Internet of Things (IOT) are within this volume. Building modules built with networked sensors, actuators can actively react to the environmental changes as a result of the cooperative group reaction. By applying such technology to building construction it can significantly improve the comfort and minimize the energy consumption in real time.

Factors for successful collaboration among distributed team members are research targets in some of the papers. A system for video based remote collaboration with multi-touch interaction emphasizes the importance of the non-verbal communication. This communication includes eye contact, gestures and facial expressions which were ignored in many remote cooperative working systems. The paper presents a collaboration tool for remote and synchronous interactions to preserve these non-verbal communication aspects.

There are some highlights in the field of cooperative engineering in this year's conference. One important issue in cooperative engineering is how to let the end users participate in the product design. One paper from the model driven engineering proposes an approach for the example-driven, collaborative construction of domain specific languages using an iterative process. Examples familiar by the users are used as a vehicle for the abstraction modeling in their iteration process. The approach can be generalized to tasks in a wide range of domains, not only for web engineering in their requirements specification, business modeling, or data querying but also in many other fields in science and education. Another important issue for cooperative engineering is how companies in the same project can form a virtual enterprise network among them. The ad hoc integration of processes across organizational boundaries to support collaborations is considered as a strategically important issue. A paper in this volume addresses the collaborative business processes in dynamic virtual organizations and proposes their specific solution based on service-oriented workflow systems.

Other papers in the volume cover a wide range of cooperative application topics such as cooperative e-learning, cooperative decision making, and cooperative simulation etc.

As the volume editor, I would like to take this opportunity to thank all our authors for their passion in devoting themselves in this challenging research field all these years. They have done a wonderful job. I would like to thank all our Program Committee Members, Organization Committee members and reviewers for their continuous support to the conference. The journey has begun, the new challenge is in front of us, yes, we will continue!

September 2013 Yuhua Luo

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Using Spatial Augmented Reality in Synchronous Collaborative Design

Applications in Architectural Design Training

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Abstract. This article examines applications of Spatial Augmented Reality (SAR) in architectural and engineering collaboration. These applications can be split into four SAR configurations supported by an innovative software program (SketSha) which enables remote sharing of graphic documents and annotations in real time; remote expert consultation, collaborative design, project review and group evaluation are all implemented in collaborative design training.

Analysis of how SAR affects instrumented training activities is qualitatively conducted on four axes: (1) the status of the object being collaboratively designed; (2) the status of the document as an intermediary object for collaboration; (3) the status of the participants in aiding collective intelligence to emerge and (4) the status of workspace as we question the "co-presence / remote" dichotomy in synchronous relations.

Keywords: Collaborative design, Collaborative learning, Augmented reality, Shared sketches, Awareness, Common ground.

1 Introduction

1.1 Field

The objective of this paper is to discuss the use of Augmented Reality (AR) in collaborative activity. AR is considered here to be the real-time overlay of virtual information on the visual perception of reality (Furth, 2011). In other words, AR supports virtual documents (plan, sketches, blueprints) - created and manipulated by real tools (electronic stylus) - projected on real work surfaces (boards, tables, lecterns). AR is linked here to network sharing capacities and allows real time interactions, both in co-presence and remotely. These devices are implemented in specific spatial configurations; the term SAR - Spatial Augmented Reality - therefore covers the whole spectrum and constitutes a currently little-studied area of research in the CSCW (Computer Systems for Cooperative Work) community (Cardon, 1997; Maher et al., 1993).

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1.2 Context

Our study, rooted in project-based learning, focuses on the application of SAR in advanced training in architectural collaborative design. Training via projects is the result of active learning and aims to position the learners in a problem situation, leaving them the choice of which means to mobilize (both individually and collectively) in order to achieve the objectives they have set for themselves (Hmelo-Silver, 2004). Several authors, including Liu & Hsiao (2002) and Huet & Escribe (2004), have shown how this type of training contributes to the development of the students' general and specific skills. This learning process is well-suited to the integration of knowledge and skills needed to train the learner in mastering the complexity of design activity as it promotes learning through collective reflection on a concrete project. In our study, training is also designed to develop specific skills in annotation and the use of graphic documentation.

1.3 Research Questions

How do these new SAR configurations affect collaborative design? How do the notions of document (shared medium) and artefact (semantic production of collaborative design) evolve? What impact does SAR have on communication between participants? How can the collective workspace be redefined with the use of SAR?

2 Presentation of the Tool: Collaborative Digital Studio (SDC)

The various SAR involved in this study are brought into play via an innovative technological tool - the Collaborative Digital Studio - developed by LUCID at the University of Liege (Safin and Leclercq, 2009). This tool enables the sharing of annotations and graphic documents remotely and in real time. It links two collaborative stations connected by the internet. Each station is made up of a video-conferencing system, a digital surface on which users interact graphically with an electronic stylus, and Sketsha - a graphical interaction software program (Elsen and Leclercq, 2008). The system is based on the metaphor of the traditional meeting with several participants seated around the same table. It enables business meetings in virtual co-presence where discussions can be held via video and any type of document can be exchanged, manipulated and graphically annotated in real time by any participant (Ben Rajeb and Leclercq, 2012). The digital surface can be a large board, a table seating several people or a tablet for a meeting of 2 to 4 geographically separate participants (Figure 1).

Fig. 1. The Collaborative Digital Studio: (1) Projected work surface, manipulated by a physical stylus, (2) SketSha annotation software, (3) Video-conference device

The integration of a system like SDC in SAR requires the redefinition of space and human interactions, as these are brought into play through digital documents made up of graphical information shared both remotely and in co-presence on a real work surface and via a stylus. This pen is used for pointing, drawing strokes, graphical annotations, activating orders (marker selection, eraser, layer creation and other functions offered by the tool) and controlling actions on the various documents (zoom, rotate, move, etc.).

Studies on the indirect manipulation of tools for sharing annotations systematically via a keyboard and a mouse (Beaudouin-Lafon, 1997) have shown that a large number of actions (such as navigation, selection and input of documents) are significantly reduced, while the direct manipulation of graphical documents through a single mediator (here, the stylus) increases human interaction and facilitates appropriation of the technological tool. SDC enables free-hand sketching and constitutes SAR to provide support for project-based design training.

3 Methodology

These various SAR tools were implemented as part of the training for Architectural Engineers at the University of Liege. Our observations are based more precisely on one class (academic year 2012-2013) made up of a dozen students (average age between 21 and 24 years), whose task was to design a large-scale architectural project, both in co-presence and remotely with students from the Nancy School of Architecture (located 300 km from Liege). These students benefited from the support of experts teaching at the Ecole des Mines d'Ales (930 km) to advise them in the design of their project.

Considered as a whole, these situations provided observations that were captured by a video recording device installed in the workshops. From these video data, we observed discussions, annotations, imported documents, appropriation of the tool and how the projects developed over time. Once the data had been gathered, we defined a transcription table for processing and qualitatively analyzing part of the data (the initial corpus was 46 meetings, so approximately 80 hours of video).

This table encompassed various parameters including the spatiality of exchanges (I-space [co-operation], We-space [collaboration] and Space-between [individual or partial collaboration]), action typology (actions made on the project, the tool, the management of human relations, etc.), document typology, the typology of the artefact made (plans, cross-sections, sketches, charts, etc.), and so on. Our results come from our longitudinal observations of different spatial configurations implemented in the context of project-based training and are presented in more detail below (Table 1).

4 Presentation of the SAR Brought into Play

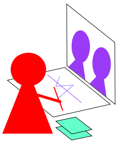
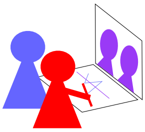
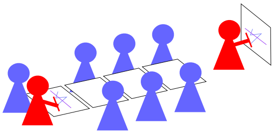
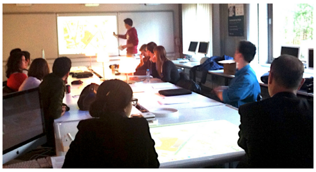
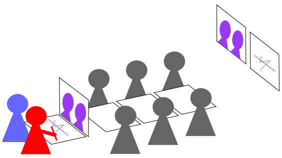
Configuration 1: Remote Expert Consultation. This SAR configuration was established to review the project with remote experts (here, experts in building stability, environment and fire safety) located 930 km from the place of training. In this context, the student using the SDC is alone with the experts, communicating orally with them via the video-conferencing system and sharing annotations via a graphics tablet. In this way, the student can have access to knowledge and expertise from external partners and benefit from direct access to information through real-time interactions, thus facilitating understanding.

Configuration 2: Collaborative Meeting. This SAR configuration brings together two geographically-separate groups of designers to work around a large graphic table seating three people per group for a remote meeting. The participants find themselves in a situation where they can argue and justify their choices via graphical documents they have prepared together before the meeting. The substantial number of participants requires students to take it in turns to speak and handle the stylus in an organised manner. Following their remote meeting, the students retain their annotated files to continue their project design and develop it further.

Configuration 3: Collective Review of the Project. Contrary to traditional project reviews where each student presents his or her project to the supervisor, this SAR is set up so as to gather several students and their trainers to publicly conduct the review of one project. Using a graphic table, the teacher can annotate the document at the same time as it is being presented and sketched by the student on a digital whiteboard facing the other students. Here, both trainers and students can express their views and share their comments, concerns and solutions regarding the project.

Configuration 4: Public Evaluation. Unlike examination juries in traditional training where public presentations take place in co-presence, in front of a display wall and without the possibility of graphic interaction, this SAR configuration enables both co-present examiners and remote experts to evaluate the project. All parties can intervene on graphic productions while respecting the project, given that the annotations produced are sketched and saved on a digital layer specifically created to this end. Students can also complete their plans, explain some of their choices graphically and answer the examiners' questions by sketching additional solutions onto the document shared by all the participants.

Table 1. Presentation of the various SAR configurations

SAR Configuration	Layout	Objectives
1. Remote Expert Consultation 	 Tablet and video-conferencing system	Initiation to the project by integrating other skills; developing knowledge by sharing and accessing expert advice; standardization of representations; prioritizing issues according to the requirements of the project.
2. Collaborative Meeting 	 Table and video-conferencing system	Introduction to coordination: communicating; producing annotations and graphic documents; sharing points of view; generating new ideas collectively.
3. Group review 	 Co-present table and whiteboard	Sharing ideas and generating collective intelligence; reducing competition among students
4. Public evaluation 	 Table and video-conferencing system, co-present whiteboard, remote table.	Reconsideration of the hierarchy between instructors and students via requalification of shared representations: switch from "documents presented" to "working papers".

5 Discussions: New Statuses

Let us now see how the collaborative situations instrumented by SAR change the status of the four key components of collaboration (documents, artefacts, participants and workspaces). The discussion in this paper will enable a qualitative approach for this first evaluation.

5.1 The Status of the Documents

The SAR configurations employed here result in each participant being able to assert themselves, express their thoughts and translate their intentions for the project design by annotating in real-time. Whether the project is being reviewed in co-presence, where each individual reacts directly on a shared digital graphic device (SAR 3) or by a jury composed of co-present trainers and remote experts (SAR 4), learners can easily enforce their points of view and translate their choices into sketches. In a traditional jury situation, the projects produced by the students are either sanctified (for fear of distorting the document presented), or downright degraded by modifications from the teacher, the status of the document is reconsidered in the use of SAR. Indeed, these configurations can strengthen the principle roles of the document (as reminded by Carlile, 2004):

- The student's production is respected while he or she may also modify it during the presentation to better explain any comments and even challenge some of these choices (SAR 1); in this case, the tool supports the pragmatic role of the sketch.
- Each project participant (SAR 2) can evaluate and argue their point of view by acknowledging, and distancing, themselves from their own choices; here, the tool supports the semantic role of the sketch.
- Teachers can shape their reviews (SAR 3) without altering the student's work since a layer is created above it on which to generate corrections; in this way, the tool supports the syntactic role of the sketch.
- The documents produced by the student evolves from the status of "document presented" to that of "working paper" whether the review is conducted in co-presence or remotely and regardless of the degree of involvement of the individual agents (evaluators and student examined) and the observers (other students), (SAR 4).

Whether the SAR involve formal (SAR 1 and 4) or informal (SAR 2 and 3) discussions, they all provide the possibility of intervening on pre-prepared, standardised documents. Each participant may insert notes or sketches drawn there and then - so as to quickly explain their points of view and justify their choices - without distorting the personal productions of the other participants.

5.2 The Status of the Design Artefact

By using SAR, the project designed is handled collectively in co-presence and remotely. It is thus an interactive boundary object shared between the collaborators (Star, 1990). This boundary object evolves from a process of negotiating and building consensus among students (SAR 2), experts (SAR 1) and trainers (SAR 3+4). On the one hand, these artefacts reflect the design project and allow students to construct their own discourse and interpretations; on the other hand, they generate different collective reflections on what has been produced, thus contributing to the genesis of new shared representations. The SAR configurations in which these interactive boundary objects are handled reduce spatial and temporal shifts as the tool allows the user to share and interact synchronously and in real-time. The time interval between the change made to the document and information feedback to the various users is invisible to human perception. Unlike other tools for sharing remote annotations

(Webex, for example), where the user loses the causal link between what is being said by the remote collaborator and what is seen on the shared digital graphic document (Beaudouin-Lafon, 1997), here the "action/perception" loop is immediate.

This immediate loop made possible by the SAR presented here even allows the designers to draw by two, at the same time and remotely on the same shared digital workspace. The importance of this coupling to understand the information transmitted has incidentally been emphasized by several authors (such as Cadoz, 1994). It has been observed that there are two types of graphical representation made by two participants to discuss a choice made regarding the design of the artefact.

1- Both geographically separate students draw - simultaneously, independently and on a shared digital document - two different points of view of the project, basing their ideas on a functional drawing created together previously. For example, one participant may sketch on the right-hand side a cross-section of the project while the other draws on the left-hand side a perspective modelling the overall shape of the artefact. Consequently, from a shared reference, two different graphical interpretations of the project are offered simultaneously. Each of these representations carries implicit meanings for each participant and engages a specific line-of-thought and different perspective for the design of the artefact. This juxtaposition of representations created on the same shared digital interface supports cross-interpretation by the two participants who, while drawing their own artefact, can watch the artefact of the other being built, enabling a new form of cross-interpretation.

2- The two geographically separate students draw - simultaneously, together and on a shared digital document – a sole graphical representation. The artefact is thereby designed by two participants by pooling the ideas previously chosen in discussion. In this way, the designers simultaneously proportion, orient, position and transform the project with the help of the synchrony the SDC provides.

The various SAR presented here therefore support action/perception coupling and enable the students to display their project while learning how to synthesize their ideas and expose them to other points of view.

5.3 The Status of the Actors

Collective activities develop from social interactions between the various designers and can be categorized into two types: vertical collective activity and horizontal collective activity. Each type affects the nature of the relationships between the actors differently. In project-based training, which brings together trainers/experts and learners, collective activity is generally vertical with a clearly identified hierarchical relationship between the actors.

But because the tool allows the user to draw synchronously and remotely, participants can intervene with both hands peer-to-peer (SAR 1 and 2). So in the SAR 1, 3 and 4, we observe a change in the status of the examiner as any other actor attending the project review can also draw over his or her corrections. By giving the opportunity to all to modify the document, the changes made by the teacher are less sanctified, which encourages a questioning of the choices made, regardless of the actor: expert, teacher or student. Whereas in classic project reviews the learner is alone with the teacher without possible interaction with other colleagues, in the SAR 3 and 4 it is clear that the relationship between the students changes, thereby enhancing discussion between them rather than competition. SAR thus enhances the sharing of views, the emergence of common ground and cognitive synchronization; this contributes to building a mutual awareness of the activity.

5.4 The Status of the Co-workspaces

Different classifications have been proposed to index CSCW groupware. One of the most common classifications for spatio-temporal positioning is the matrix proposed by Johansen (1988, taken by Ellis, 1991) which is constructed on two axes: "synchronous/asynchronous" and "co-presence/remote". Observation of the SAR configurations implemented in training sessions requires the "co-presence/remote" dichotomy in synchronous collaboration to be reviewed. Indeed, we have seen a situation of "distance in co-presence" emerge; for example, use of the whiteboard and the digital table in public correction (SAR 3) establishes an interaction that is based both on direct modality (conversation in the same physical space) and indirect modality (annotating a virtually shared document on physical media situated in the same room but differentiated). SAR therefore nuances Johansen's notion of spatiality. Hence, in synchronicity it is necessary to distinguish between real presence and augmented presence, in addition to virtual co-presence.

Table 2. Johansen's spatio-temporal matrix and its evolution in SAR

	Same place	**Diff. places**
Same time	Real presence	Virtual co-presence
Diff. time	Asynchronicity	Remote Asynchronicity

>

	Same place		**Diff. places**
Same time	*Real presence*	*Augmented presence*	Virtual co-presence
Diff. time	Asynchronicity		Remote asynchronicity

This nuance imposed by the SAR also requires questioning of the relationship the actors have with these co-working spaces, simultaneously brought into play in both physical and virtual environments. This relationship forms alongside the transformations brought about between the personal spaces of the actors, the co-working spaces that bring them together and the link between the two (Suchman, 1996). These different areas are therefore distinct relative to how the actors use them:

- I-Space: the personal work that each actor annotates individually.
- We-Space: the workspace that is virtually shared and that the actors annotate and modify collaboratively.
- The Space Between: the workspace that is isolated from We-Space and which requires the actors to work idependently from the rest of the group.

Distinguishing between the various workspaces that make up the SAR is especially important in situations of co-presence and virtual co-presence where teachers and learners alike are involved in constructing common reflections. These types of workspaces are ephemeral and are brought about according to the needs, goals and choices relative to the negotiation, discussion and consensus building that occurs amongst the actors as the project is being designed. The collaborators/students working on a project form a unit, ensuring coherence between choices and interdependence between the different parts that make up each individual's reflections. These areas therefore involve mechanisms to share knowledge, share understanding and synchronize the cognitive processes necessary to construct a mutual understanding of the context of the work, the project, the tasks and the individual contributions of each member of the group.

Adjusting to these different workspaces brought into play in the SAR requires a flexibility that should provide the tool for each individual to handle his or her workspace and organise the interface easily. This flexibility between We-Space, I-Space and Space-Between is only partially managed by the system currently used in the SAR presented here. The graphical annotation synchronous sharing software requires the pooling of all documents created. Video-conferencing does not allow certain actors on either side of the screen to isolate themselves from the group and create their own Space-Between. The system does not offer the opportunity for passive learners in the context of SAR 4 to intervene at any time or to interact with the jury. Generally speaking, these SAR contribute fully to group cohesion by creating these intermediate workspaces between co-presence and virtual co-presence. But they support peer-to-peer sharing between collaborators rather than empowerment of each individual, a result that is well-adapted to project-based training.

6 Conclusion

We have presented here four cases of collaborative design implemented in SAR (Spatial Augmented Reality) configurations based on a remote synchronous collaborative graphical tool (SketSha). These situations, observed in a context of training in a studio for architecture and engineering, have enabled a qualitative description of changes in the main components of instrumented collaboration: the changing status of the activity's artefact; requalification of the notion of shared documents; reconsideration of the hierarchy of agents; and questioning the notion of presence. The latter challenges the spatio-temporal communication of the collaborators and encourages detailed study of the concept of space to better characterize participant cognitive synchronization. The next step of this experimentation will involve a quantitative study of these concepts of I-space (co-operation), We-space (collaboration) and Space-between (individual or partial collaboration) in the new concept of augmented presence hereby presented.

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Collaborative Responsive Façade Design Using Sensor and Actuator Network

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Abstract. The building facade interacts with its neighboring environment as an active element; therefore it is unreasonable to conceive the facade as merely a dividing entity between the interior and the exterior. The envelope system of smart building can dynamically improve dwelling conditions by intelligently reacting to climate changes. This research proposes a collaborative responsive building façade design method using sensor and actuator network. By synchronizing both virtual and physical models, the design state of the change or improve simultaneously. This study reflects the lighting level data among the various environmental elements to design responsive façade prototype. We utilized motion sensors to detect the movement of designer's gestures for creating more intuitive design process.

Keywords: Responsive Façade, Collaborative Design, Kinetics, Interactive Wall, Physical Computing.

1 Background

Modern buildings are heavily dependent on the use of mechanical equipment to maintain the comfortable indoor environment. This inevitably results in an increase of energy consumption. The building envelope has played a major role in manipulating indoor environment condition such as movement of heat, light, air, noise, and the indoor environment load (Lechner 2007). From this perspective, environmentally responsive approach to building design is important and intelligent skin systems have been actively developed nowadays. The envelope system of smart building can dynamically improve dwelling conditions by intelligently reacting to environmental changes. The building facade interacts with its neighboring context as an active element (Rafael 2010); therefore it is unreasonable to conceive the facade as merely a dividing entity between the interior and the exterior. Brand new technologies such as wireless sensor networks (WSNs) composed of sensors and actuators, which are mentioned as the Internet of Things (IoTs) have been merged into building systems. For example, sensory modules which are installed on the building skin can detect external environmental changes and actuators can make it react based on procedural routines (Lee and Yoo 2012). IoTs behave even more intelligently to cope with complicated

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constraints. In short, the responsive façade can function by the help of mechanical system, working with various sensors, actuators, and computer programming. By actively reacting to environmental changes, building skin can significantly improve the comfort of the dwellers and minimize energy consumption in a real-time manner. Also, it is possible to improve the overall building performance.

Responsive façade needs to be designed in different ways because it behaves like mechanical products in comparison with most conventional building system. Therefore if both physical and virtual models function complementarily with each other, designers may better concentrate on their design activities and enhance productivity as a result. This research is a follow-up of the previous study (Yi *et al.* 2012), which proposed an inter-dependent design method between one physical model and one virtual model. There are limitations in the previous study as followings; motion range of facade modules is limited to the simple horizontal direction, it focused on the basic interaction between the virtual model and the physical model, and sophistication lacks because simultaneous reflection of multiple environmental factors was not possible. To overcome these limitations, we propose a framework of cooperative design method in responsive façade design process. Motion sensors are used to detect the movement of both façade components and designer's gestures. The designer's gesture, in this case, can be replaced by the movement of the Sun. When the sensors capture unique features from moving objects, the system receives the data from the sensors and uses it for additional analyses.

2 Research Objectives

The aim of this research is to propose a collaborative responsive building façade design method using sensor and actuator network. This research places an emphasis on the advance of various virtual models by extending previously proposed system as shown in Fig. 1. Decision making process, in general, needs to consider various design factors which are required by many experts (Mueller 2011). On the basis of cooperation scheme with environment simulation models, the proposed system framework will help create rapid prototypes for multiple stakeholders. And it can improve the productivity of responsive façade simultaneously.

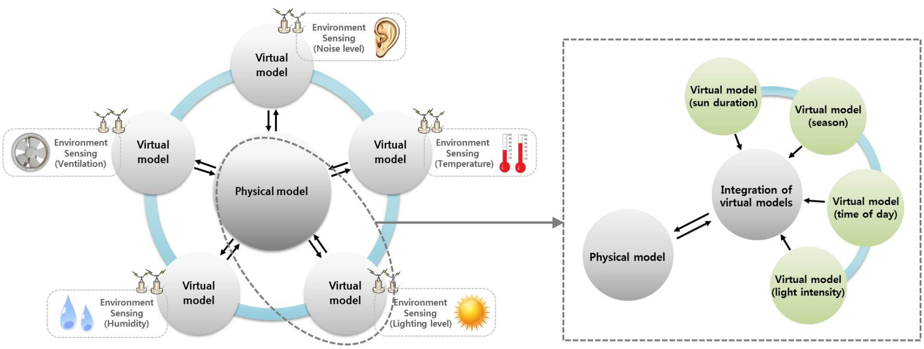

Fig. 1. The cooperative system of environmental elements

2.1 Needs of Interworking between Virtual and Physical Models

The design of responsive Facade should consider several important environmental factors (temperature, lighting levels, etc.) in the early design phase (Moloney 2006). Architects make physical models or virtual models to simulate the environmental properties. However, in the early design phase, virtual model of the ideal form and a physical model of the actual form are utilized independently, which makes design process more complicated (Redundancy and poor performance of analysis).

Physical modeling made of conventional materials such as cardboard has been one of the intuitively favorable methods to understand form, spatial depth, geometric properties, material properties, etc. Therefore, mock-up models have been utilized to figure out physical characteristics and architects made important evaluation by analyzing the physical model.

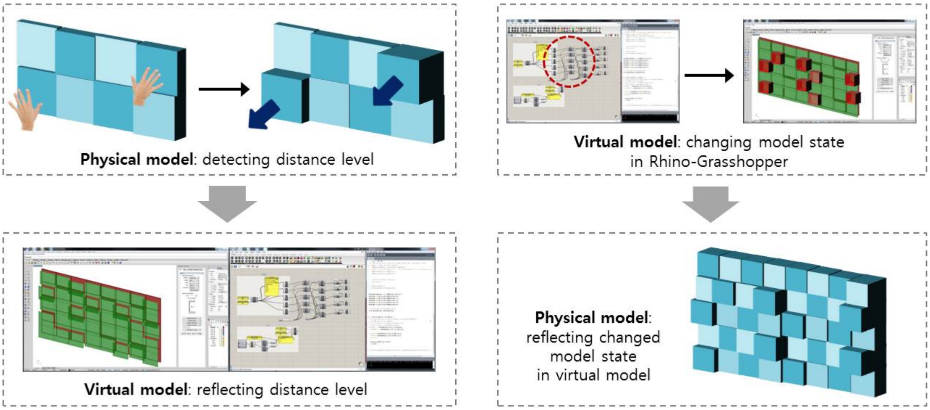

Fig. 2. Interworking between physical model and virtual model (Yi *et al.* 2012)

On the other hand, virtual models are used in all processes from the concept design phase to the construction phase, which are managed as digital data. For further details, it facilitates production automation, project management, structural analysis, thermal efficiency analysis, shape generation or shape-transforming by script, 3D modeling and visualization to construction engineers (Iwamoto 2009). The previous interworking model of Yi et al. (2012) is able to choose optimal architectural designs through two-way interaction between physical and virtual models (Fig. 2). In addition, alternation of element design in the virtual model could be reflected in the physical model by the help of wired data communication. This approach is of importance for the simulation of actual climate phenomena such as rainwater or outdoor wind in determining a detail and shape of intelligent skin (Kim 2012). Using this method, architects playing with these influencing factors of respective models can figure out the simulation results simultaneously and reflect those to their design tasks, and vice versa.

2.2 Scenarios for Using Daylight Data

Daylight is an important element for making sustainable building and is essential to decrease energy consumption (Ko *et al.* 2008). It is important to utilize natural light of indoor environment to increase the productivity and occupants' health (Hansen 2006). This study focused on the lighting level data among the various environmental elements to design responsive façade prototype. It is necessary for the effect of lighting level to be interrelated with virtual simulation and physical model in order to test according to geographical situation and context. To make inner space of a building comfortable and to maximize the aesthetic quality of a building façade by following programmed rules, each element constituting the building façade prototype can react according to the level of sunlight intensity by actively transforming its form. According to changing daylight, the performance of skin could be simulated in a virtual model and its result is reflected on physical model. The dynamic behavior of architect and façade could be re-applied to the virtual model as well. Unlike conventional façade shape, studies on various formal representations which can be systematically operated with the help of sensor and actuator network are conducted by designers.

3 Research Pipeline

This research proposes a system of cooperative design method focusing on responsive façade design as shown Fig. 3. Proposed framework could be divided into four major parts. Through this system, physical and virtual model can work to input and output concurrently.

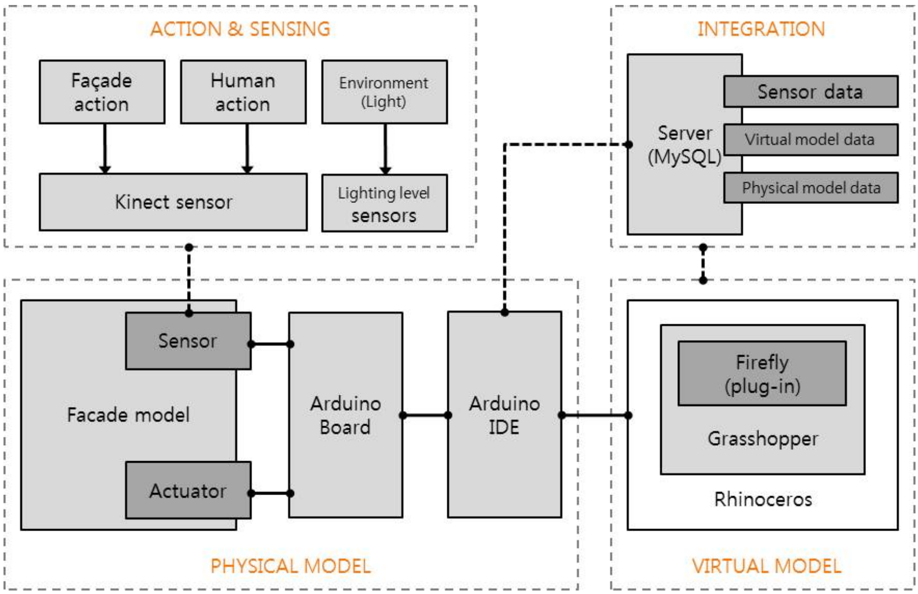

Fig. 3. The system of framework

In the action & sensing section, through installed lighting level sensors, each module receives sunlight intensity data. And motion recognition sensor detects both movement of façade and designer's gesture. Kinect™ of Microsoft™ are used as the motion recognition sensor. Kinect sensor receives depth data from infrared (IR) light. These sensors can measure the distance to the front objects in the range of 0.4 ~ 3m depth. The received depth information can be used for tracking or detecting surrounding objects and gathered data can be processed to comprehend human's pose and gesture selectively. Utilization of Kinect sensor based on NUI (Natural User Interface) makes it possible to detect nearby user's motion precisely. The data obtained by sensors are stored in sensor data server. In the physical model section, the prototype model represents actual movement by installed actuators in the facade model. Actuators reflect the virtual model data through Arduino™ IDE which connects with Arduino board. In the virtual model section, experts model 3D configuration using Grasshopper plug-in of Rhinoceros™ software. Firefly program was used to connect the system with the Grasshopper™. It is possible to connect Grasshopper™ with Arduino™ and Kinect sensor directly without extra coding process using UDP. In the Integration section, for systemic data management, virtual model data, physical model data and sensor data are saved in the MySQL™ platform.

4 Prototype Overview

This framework system focused on the physical facade model to make a prototype (Fig. 4). Each unit of the physical façade model connects with one servo motor and one lighting level sensor each. The behavior of the façade elements are detected by Kinect sensor and synchronized with the virtual model. The units perform a role in integrating between environmental sensor data and physical form to formulate combined conceptual design result in the early design phase. Architect will be assisted to support their decision making through this integrated model because the model system could confirm how well various elements are controlled simultaneously.

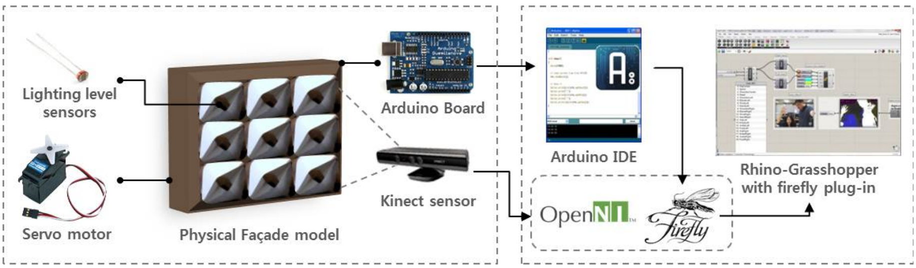

Fig. 4. The framework for the responsive façade design

4.1 Prototype Unit Development

The design idea of the unit is to observe light filtered through slits on the side as shown in Figure 5. Light pass into the inner side straight or overshadowed by broadening its gap. The effectiveness of solar shading could be differentiated depending on angle, size, and direction. These elements work as parameters for shading. For example, the points on a diagonal line of a square are parameterized to track the sun as shown in Figure 6. So the façade model can control the inlet of sunlight by transforming its physical properties. We made concept unit model using thick paper materials for easy crafting and work out a way to folding structure.

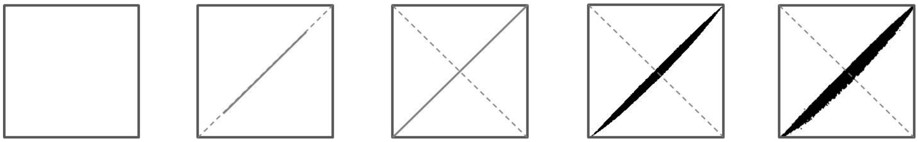

Fig. 5. The design idea for façade unit

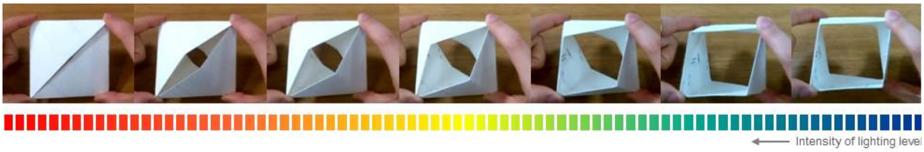

Fig. 6. Conceptual idea for unit opening by lighting direction: Sequential pictures

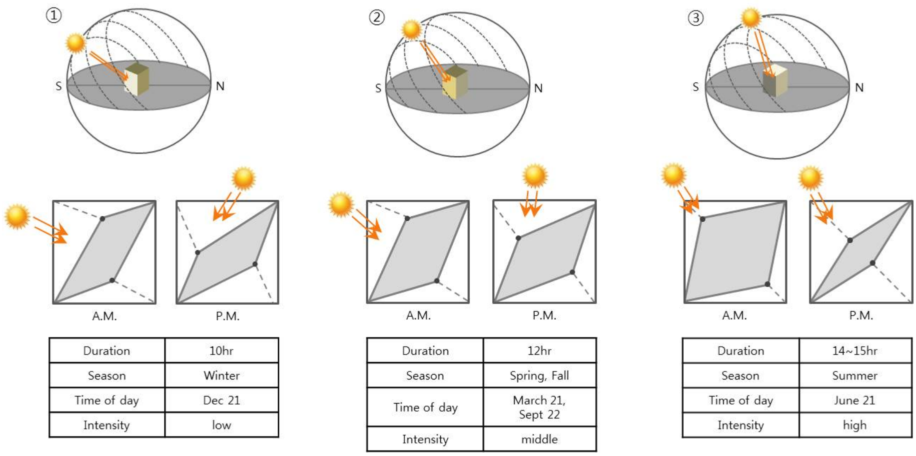

Fig. 7. Movement of the Sun and its effect on façade's state

Defined by the path of the Sun' diurnal motion, the height of the Sun and the duration of the day have influence on the seasonal building performance. The Sun's duration and intensity are most critical factors to understand for deciding the façade states. Figure 7 schematically represents the façade's behavior according to the Sun's movement. Those images from the left represent "the winter solstice", "the vernal and the autumn equinox", and "the summer solstice" that show the façade's reaction to the Sun.

4.2 Motion Data Working with Façade Prototype

In this proposed process, Kinect sensor plays a double role in detecting. First, Kinect™ detect human's gesture shown as shown in figure 8. When a designer decides angles of movement, human gesture could be used as input data. Kinect sensor allows that designer to be a controller themselves. Human gestural inputs are more intuitionally utilized for application the sun's movement. Because of this design process has limitations to control the light, a position of human hands replaces that of the sun. Thus, Kinect sensor is used to calculate the vectors of hands mimicking the sun. Also the gestural input reflects virtual model. And by employing Firefly plug-in, Kinect™ could be connected to Grasshopper™ and even Arduino™.

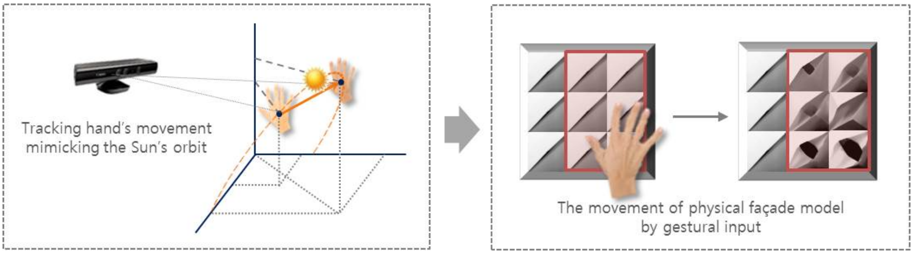

Fig. 8. Detecting human gestural input

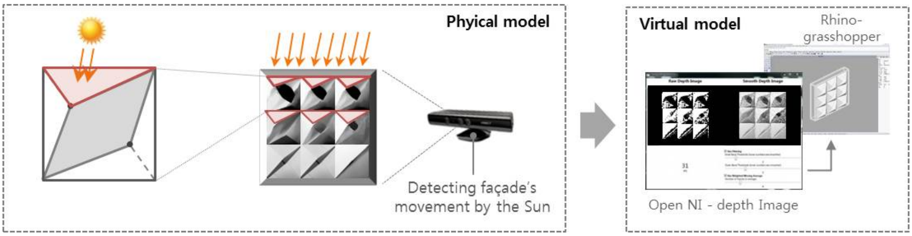

Fig. 9. Detecting physical facade movement

Second, the movement of physical façade model could be presented in Rhino Grasshopper™ as shown in figure 9. Kinect™ can detect movement of physical model and extract depth data and transmit the data to the computer. The transferred data will be applied to the virtual model in Rhinoceros™ platform as well.

5 Outlook

In this research, we propose a system framework to support cooperative design of responsive building facade based on multi-dimensional interactivity. By referencing previous research by Yi *et al.* (2012), several virtual models are interlinked and expanded to correspond to dynamic design constraints. Using this collaborative design system, design feasibility and productivity from rapid decision making can enhance the quality of a design process. Design process become more dynamic so that a real-time feedback is possible through interworking between a physical model and a virtual model, which was hardly shown in conventional architectural design methods. This research has still many limitations. As lighting was the only element to analyze in this prototypic research, we need to conduct a follow-up research which considers other environmental elements. And if rapid prototyping technologies were applied in more detailed manner, it would be possible to go beyond conceptual form. By adapting kinetic elements to physical model of facade skin, we can test aesthetic mobility of the shape. This can be effective when tracking the sunlight is interplayed with shading performance. This system framework can contribute to the design process for responsive facade design and for other architectural design which deal with kinetics as well. Rapid production of early design models can assist various stakeholders who are involved in a project by providing necessary information. And prompt design toolkit for novice designers can be developed targeting at similar design assignments.

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Collaborative Design Process for Encouraging Sustainable Building Design: A Game Theory-Based Approach

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Abstract. Information permeated in a daily life through ambient urban media may have positive effects on people's behavior and consciousness. This approach can be adapted to enhance sustainable building design in an educational environment. In this paper, information about sustainable building design is provided and the visualized evaluation is fed back, as a way to encourage sustainable building design. In addition, to maximize the effect of the interaction between competition and cooperation among students, we have applied a game theory approach called 'prisoner's dilemma'. Information visualization is effective to change the focus of interests in the students' design and a game theory helps produce a variety of design alternatives. The method can improve the design capabilities and change the students' consciousness as well.

Keywords: Design Process, Design Education, Game Theory, Collaboration, Protocol Analysis.

1 Background

Major social problems include lack of natural resources, destruction of ecosystems, environmental pollution and imbalance of the community (Pearce et al. 2012). Accordingly sustainability has become a foremost issue but it can be misunderstood to mean only those related to energy in many cases. However, sustainability is typically illustrated as three intersecting dimensions connecting environment, community and economy. The architecture and architects might be well suited to lead the change toward sustainability in this sense. It is because when design is informed by the knowledge leaned from sustainable systems, it has the potential of changing how buildings, communities, and societies function to sustainable one (Williams 2007). Therefore, designers increase awareness of sustainable lifestyles and are required to realize eco-friendly buildings and sustainable cities. Lifestyles of people are embodied by the nature of the specific individual or may be determined according to the environment (Alexander 1977). Therefore, sustainable design helps change the lifestyles of citizens into sustainable ways to a certain level.

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Designers pass through the design process to derive the design results by solving a variety of design requirements and constraints. A design process is constructed and affected by a variety of behaviors and cognition of designers (Kim and Kim 2007). There are interactions between "the information that has been learned" and "the reasoning of the designer in the process of solving design problems". At this time, design process is more effective when the information (specific data) is delivered to the people naturally through the ambient media in daily life than in a determined way unilaterally such as Web page access and participation to the lecture (Holmes 2007). In a previous study, we had conducted a study that provide the information visualization collected using various sensors to designers and increase the awareness of designers about environment in cities and buildings (Kim et al. 2012). In terms of pedagogic purposes, it can be used to enhance learning by providing the information to novice architecture students who don't have enough knowledge. Moreover, various knowledge acquisitions from effective visualization can help the designer build the sustainable buildings and cities in the long run.

2 Research Method

We carried out preliminary experiments to find out how visualized information affects the design outputs. Every design process has individual unique characteristics (Gough 1981) but also significant portion can be affected by learning and teaching (Akin 1996; Oxman 2001). There are methods of information transmission through the screen visualization as one way to influence the final design output, but the previous research focused on only the visualization of the design process (Kim 2006). In this research, however, sustainable design information is provided to architecture students by ambient visualization. By providing students with visual representations of the evaluation of design, we indirectly encourage the students to design sustainable buildings and urban planning. Especially environment-friendly images that are well known in general as sustainable buildings are provided in the test setting and then we observe how the students design the environment-friendly building naturally.

Like this, we reconsider student's interest on the topic as the visualized information is provided by the ambient way. Also, the experiment is conducted for proving the hypothesis that the competition can enhance the intensity of design activity as well. The interaction of competition and cooperation with others that may occur directly or indirectly in the design studio might affect the design results. Game is a tool with great educational potential (Malgorzata 2007). To facilitate this effect, a game theory is called the 'Prisoner's dilemma' was applied.

2.1 Game Theory: Prisoner's Dilemma

Prisoner's dilemma game has been widely used in experimental psychology to study how people act when faced with situations where conflict exists between self-interest and mutual cooperation (Takai 2010). Prisoner's dilemma is a strategic game between both players. If you cooperate in this case, it illustrates the problem of selecting a disadvantage to each other in personal greed at the time of the situation that will benefit most from each other (McCain 2004). As shown in Table 1, each player has two strategies: ‘cooperate (C, c)’ and ‘defect (D, d)’. The combination of each strategy is defined a payoff pair, like (C, d) for (0, 3). When both players decide to choose ‘defect’ because of strategic dominance, it is only the equilibrium point. However, it is not the optimal choice for both people but choosing cooperate both is the optimal choice. In this situation, whatever the opponent chooses, selecting defect is more advantageous. However, if both players choose defect, the payoff is diminished.

Table 1. Prisoners Dilemma game

	c	D
C	2, 2	0, 3
D	3, 0	1, 1

There are two reasons for applying the Prisoner’s dilemma in this experiment. First, the strategic exchange of information among designers is possible. There is a limitation for students to gain and understand knowledge so as to solve the design problems. In general, if they are faced with difficulties in solving a problem while advancing the design process, they may browse the Internet, gather information from books or resolve through communication with other people in the design studio. People who provide feedback may bring out everything they know to the other. In this case, if information receiver reflects all of design elements passed from information sender, both design results can be very identical. Prisoner’s dilemma can function to prevent this shortcoming. Second, the strategic reflection of design elements is possible. When two people exchange information, there is a possibility for them to come up with design elements that they did not think of before. In general, the designers may not reflect design elements even though they are beneficial if the elements are not agreed with their opinions because they take pride in their works. It is similar to an early fixation in psychology. However when a game theory is applied to trigger psychological competition in this task, reflecting design elements of the opponent in their design can happen. Furthermore, the designer may introduce new design ideas as his or her strategic elements by adapting what is gained from the meeting.

2.2 Experiment Setting

The experiment is targeted for architecture students who enroll in grades 4 or 5 and have basic knowledge of residential buildings. Eight students were tested and two persons organized one team respectively. Each team conducted a complete conceptual design task a day and three design tasks for three days were given. Same consecutive design problem sets were given to each team and each team proceeded design tasks in separate test rooms. The design outputs were evaluated by professional designer and evaluation notes are delivered to each team prior to the next experiment. Whole test process and the outputs were video-recorded for the evaluation and protocol analysis.

Table 2. Team organization

	No information provided	Ambient information provided
Competition Only	A	B
Competition & Cooperation	C	D

The teams, as shown in Table 2, were organized on the basis 1) of the presence or absence of ambient information about the environmental-friendly buildings, and 2) of the competition condition according to cooperation with other team for evaluation result. Team A and C were not provided with any information except for the basic data of the design problem. Team B and C received information about environmental-friendly building designs which are given on the desks and walls to display information without specific orders as if they were part of classroom newsletters to the students. Each team conducted the residential design on the first day and is provided with the evaluation note of the previous design before advancing the experiment on the second and the third day respectively. Team A and B are provided with the evaluation note which displays both the rival team's score and their own score. Team C and D are intended to compete and cooperate simultaneously. Both teams receive the evaluation note of own team, but they do not know the other team's score except for the total score of opponent. They have a meeting time for exchanging information (Fig. 1).

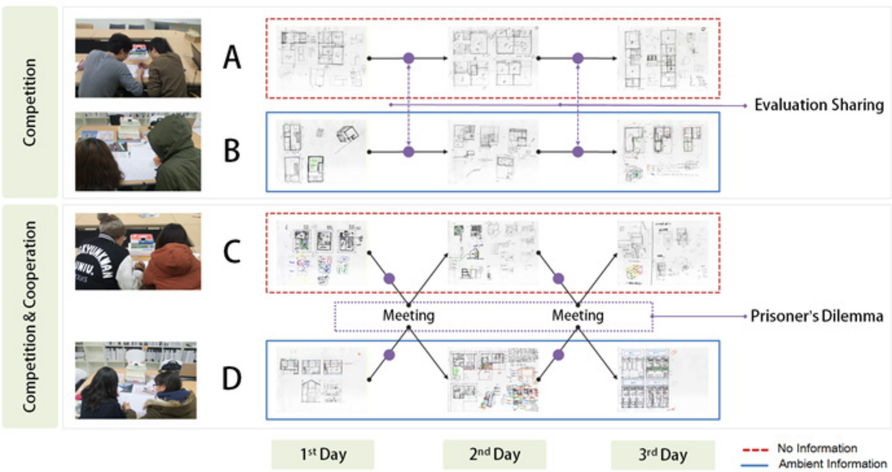

Fig. 1. The design experiment process and the design task results

The information about environmental-friendly buildings is attached randomly on the desk for designers to be able to quickly browse the data such as eco-friendly materials, natural lighting, natural ventilation, and water circulation system, etc.

Relative evaluation method was chosen and various evaluation elements are subcategorized such as aesthetics, functionality, environment, privacy, and so on. Graph scores based on the results of the design were visualized to each team and the score was calculated based on the number of design items per design. The blue bar graph is a score of one' own team and red line graph is that of the rival team (Fig. 2). We brought the evaluation note to students and notified that the incentives will be increased according to the result of the evaluation.

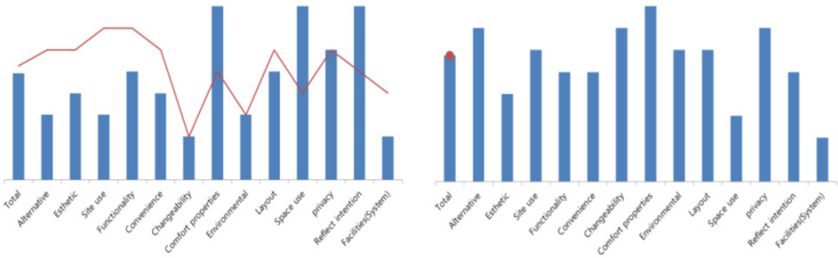

Fig. 2. Example of evaluation in competition (left) and in competition & cooperation (right)

As a part of Prisoner's dilemma implementation, two teams exchange their idea for 30 minutes before conducting the following design. Team C and D have the meeting time and exchange their ideas, views and features of the design. Here the Prisoner's dilemma is applied to allow the strategic exchange of design elements (Fig. 3).

Fig. 3. Meeting of competition & cooperation teams (team C and D)

Table 3. Prisoner's Dilemma: Adapted Score System

	Inclusion	Exclusion
Inclusion	1, 1	2, 0
Exclusion	0, 2	0, 0

The teams in the competitive relation including the cooperation are notified that if both teams contain common elements in their design, they get 1 point each team at the time of evaluation. If one team includes such elements that are not in the rival team, they get 2 points and the other are get 0 point. And if both teams don't include such elements at all, they get no points as shown in Table 3. We conduct experiment on the basis of the above experimental setting. We suggested the three residential design tasks that have different design conditions for 3 days.

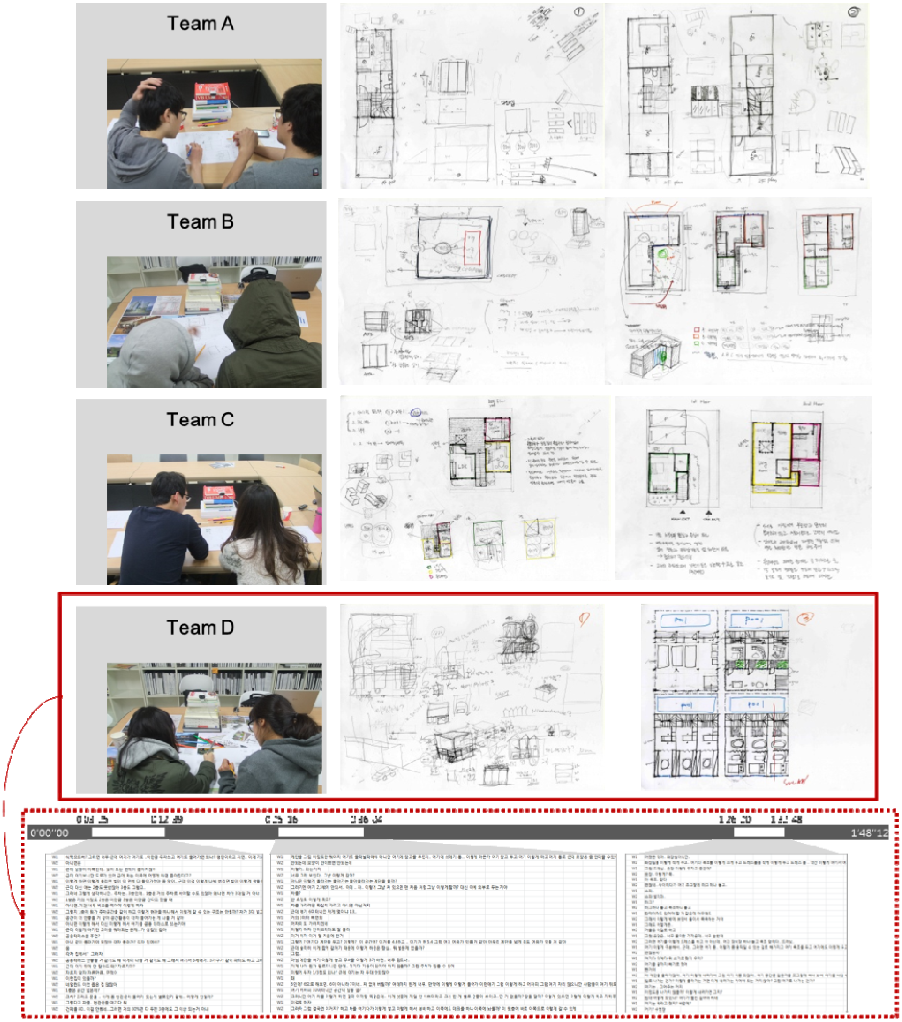

Fig. 4. Progress of design process, design outputs and the script of team D on 3rd day

Students designed the concept of the design of the house. The design output in the drawing cannot represent all the opinions they have exchanged because two members of team resolved the communal problem together. So we take advantage of a protocol analysis method for the delicate analysis. We simultaneously recorded the video and sound to capture the designer`s words and expression. Figure 4 shows the students in the design process and the parts of each team's design outputs on 3rd day. Transcripts for protocol analysis of team D is shown at the bottom of the Figure 4 as well. These records will be used to capture how the students used design contents and how a game theory can influence on their design process in a chronological order. In addition, these findings can be utilized in order to model design learning style and to make collaborative team design strategies.

3 Outcome

Competition condition is more identified that can influence to the design process when the visualized evaluation was used. Especially, while each team which is in the competitive mode designed the house, they paid particular attention to elements which got lower score than those of rival team's design result. In the case of the winning team, it did not carry out analyzing its own previous design and only wanted to know about high scored elements of the other team. Then, they guessed the design of the opponent based on their knowledge of the element and suggested the new design by considering that. And in the case of the losing team, they personally analyzed the weak design part in the previous design, so as not to repeat the same mistake. And they went ahead with a new design.

We can, by looking at the students' behavior during the progress of the design process, find several features as followings; First of all, when they encountered the limits of knowledge in the design process, they show the behavior to try to get information around them. And they try to apply the chosen information to their design as efficiently as possible. Second, they paid a lot of attention to the evaluation of design. They concerned a lot to the elements that they got lower score than the other particularly. And they tried to find a way to improve those of the upcoming design task as much as possible. In addition, the way of graphing the evaluation by design factors attract students' attention considerably. Third, the team situated in the competitive relation does not seriously consider about the high scored design elements. Among design teams, teams that got fewer score promoted a self-analysis of their own lose and this can further increase the possibility of design development. Fourth, when both teams that were situated in the competitive and collaborative relations conducted their design, they can generate various alternatives since it is possible to know the design contents of the rival team. Moreover they suggested a new design by reflecting the criticism from the rival team. When faced with the same problems as the previous design, they showed that they even applied rival team's previous idea to the new problem as well.

4 Conclusion

The ultimate objective of this study is to provide the informatics environment that can change designer's cognition into sustainable way through diverse visualization of information like an environmental-friendly building, the results of the evaluation of design, and information about the surrounding environment by the sensors. We hope that design pattern becomes sustainable ways naturally from the educational viewpoint. Moreover we hopefully conjecture architecture students to propose more sustainable buildings and urban environment. Architecture students will acquire knowledge through education and form a design habit based on this. And they can improve their design quality through communication and collaboration with other students. As a method to enhance the effect of education, the information visualization and game theory-based approach is beneficial. First, it can naturally induce focal points of the design through the information visualization. Ambient visualization can help change people's awareness. In addition, the method of providing visualization can increase the interest in specific areas. Second, using game theory, a variety of alternative designs could be composed actively. When creating design alternatives, people may experience the limits of their knowledge and abandon probable options. Game theory make increase the number of alternatives through strategic competitive and collaboration with others. This would help design new building and future city where citizens have a sustainable lifestyle.

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Preserving Non-verbal Features of Face-to-Face Communication for Remote Collaboration

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Abstract. Distributed working groups rely on collaboration systems that promote working on a project cooperatively over a distance. However, conventional systems for remote cooperative work do not transport important non-verbal cues of face-to-face communication like eye-contact or gaze awareness that would be available in co-located collaboration. Additionally, reference material and annotation tools should be readily accessible for all users. The screen layout should moreover create awareness for the transmitted video of remote participants and reference material alike and allow users to easily follow both at the same time. This paper describes how the presented system Face^{2}Face meets these requirements and thereby supports the collaborative design process. Furthermore, the performance of the system is evaluated in order to validate its practical applicability.

Keywords: remote collaboration, telepresence, face-to-face, multi-touch, awareness.

1 Introduction

Face-to-face conversations contain a large amount of non-verbal communication like eye contact, gestures and facial expressions which are substantial for fluid and natural discussions. However, project team members today often work distributed at different locations and depend on computer-mediated communication. Therefore, a collaboration tool for remote and synchronous interactions should try to preserve these non-verbal aspects, as they are an integral component of successful communication and facilitate collaboration at the same time. In the context of computer supported cooperative work (CSCW), interactive displays have shown to incorporate smoothly in co-located collaboration with small groups (e.g., [1][2]). This is because the technology can easily be integrated into the communication flow, as everyday gestures can be used to include digital material into the discussion. Accordingly, interactive displays naturally enable many aspects of workspace awareness [3].

However, in remote scenarios many of the above mentioned communication aspects get lost due to technological or conceptual shortcomings. In this paper,

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we present our ongoing work with Face^{2}Face, a system for video based remote collaboration with multi-touch interaction. The system aims at making the benefits that interactive displays provide for co-located collaboration applicable for remote scenarios. In previous work, we focused on the system setup [4] and depicted improvements in image quality and application scenarios [5]. Here, we highlight the practical implementation and how the system supports the collaborative design process for distributed groups.

2 Related Work

Understanding activities of other group members is an hugely important factor of collaboration and is commonly referred to as "awareness" in the CSCW context [6]. Gutwin and Greenberg [3] point out the importance of workspace awareness for distributed collaboration and provide a detailed analysis of different communication channels. For co-located scenarios, Hornecker *et al.* showed that the positive indicators of awareness can be increased with interactive displays in comparison to traditional mouse input, as the users can follow other users physical actions on the display more effortless [7]. Different hardware setups were proposed to transfer the benefits of interactive displays for co-located collaboration to a remote scenario. Tang *et al.* proposed a system based on multiple tabletop devices which not only synchronizes the application state among the participating sites but also provides an embodiment of other users' actions on the screen [8]. This is realized by capturing each tabletop device with an additional camera from above. The hand contours are then extracted and visualized for the other users as colored shadows. Additional displays located on chairs around each tabletop show a video stream of the respective other users. By separating the collaborative workspace from the video embodiment, the users have to switch attention explicitly between interaction and conversation. Face^{2}Face in contrast integrates the shared application seamlessly into the video image of the remote participant and thereby follows the concept of "Clearboard" [9]. This system allows two remote participants to create digital drawings in a face-to-face situation. Here, the user is captured from above with a half-mirror installation, thereby gaze directions and eye contact is supported. However, artifacts occur for objects above the display, e.g., the users' hands, as both the objects themselves and their reflection appear in the camera image. Therefore, we use holographic projection screens to capture the user in front of the display through the screen. A similar screen camera setup was used with "TouchLight" presented by Wilson [10]. Here, the transparent projection screen was used to capture user interactions on and before the screen with an infrared stereo camera setup from behind the display. "ConnectBoard" [11] and "HoloPort" [12] use this configuration of camera and see-through display to create systems which provide the remote collaboration features of "ClearBoard". Face^{2}Face enhances these concepts by integrating collaborative multi-touch which naturally extends the interaction capabilities. In order to enhance immersion and to intensify the impression of co-presence, we additionally integrated 3D stereo capturing and display.

3 System Description

Each client installation of Face²Face is basically a vertically mounted touchscreen. The display is transparent so that the user and all of his or her interactions, even on the display surface, can be captured through the screen (Fig. 1). For remote collaboration, two clients from different locations are interlinked: The video streams of each site are transmitted and rectified to the screen geometry of the remote installation. Shared digital material on the screen is synchronized and can be interacted with virtually from both sides using multi-touch gestures. By superimposing the shared workspace onto the transmitted video stream, the illusion of having one transparent interactive workspace in between the two sites is created. The camera is placed behind the screen on eye-level. That way, display and camera are on one axis, when a user stands directly in front of the screen. As a result, gaze directions are preserved and can be displayed correctly on the other client. Moreover, as the whole screen area is captured, on-screen interactions are also captured as a whole.

Touches are recognized using an optical approach called "laser light plane" (LLP): for a LLP setup, several infrared (IR) lasers equipped with a line generator lens span a thin plane of IR light directly in front of the screen surface. An additional camera with an IR bandpass filter is mounted behind the display. Fingers touching the screen are then illuminated with IR light and thus become visible in the camera image. The user video and visual markers are captured with regular consumer cameras (for further details and extension to stereo 3D, see [4]).

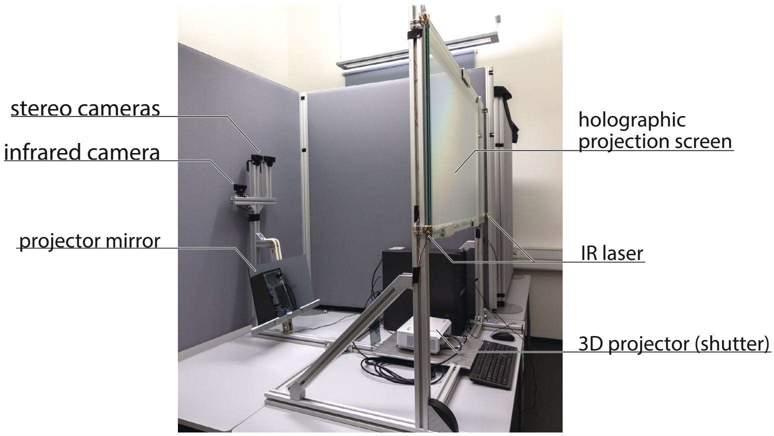


Fig. 1. Hardware components of Face²Face

The application content is synchronized using Adobe® Media Server (AMS) (Fig 2). For each item in the shared workspace, a remote shared object exists on the server and is synchronized with each client. Each of those remote shared objects encapsulates all information that is necessary to describe and share an item: transformation matrix and an annotation layer which is stored as a bitmap. A manipulation on one of the clients triggers the synchronization for the active item which locks the element for the respective other user. Thereby conflicts and accidental interferences are avoided. Different property changes of the remote shared objects are updated separately. To keep the required bandwidth for transmitting annotations low, the data is updated only in adjustable intervals of several milliseconds while one user is drawing. The resulting lag is slightly visible, yet it is the best compromise between quality and induced network load.

Video streams are also transmitted via the AMS. The rectification and image enhancement is performed by the receiving client according to the initially exchanged calibration information of each installation [5]. In order to reduce computational time, image processing of the video stream is performed utilizing the graphics processing unit. A discussion of video latencies with varying compression quality settings and video resolutions can be found in the results section of this paper.

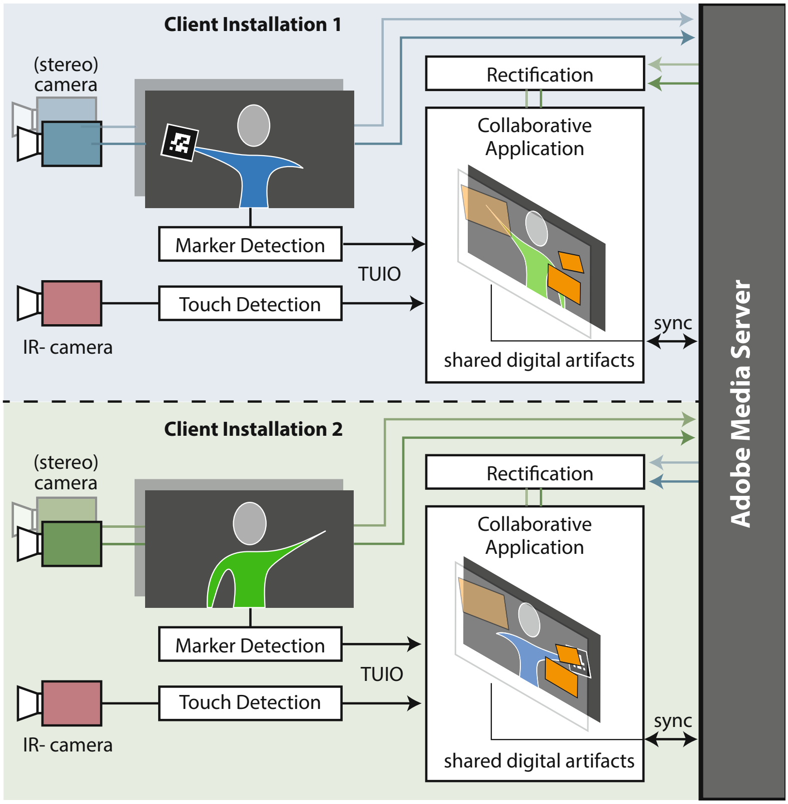


Fig. 2. Schematic system overview and synchronization workflow

4 Supporting the Collaborative Design Process

With Face^{2}Face two remote sites can be connected. To depict the benefits of system for cooperative design, we exemplify the workflow in the context of car engineering: the constructor responsible for the car body (in this example "user blue", see Fig. 2) wants to discuss latest design changes with two co-workers responsible for engine installation space ("users green"). As the team members work at different locations they set up a meeting using Face^{2}Face. As the system requires a fairly complex installation and is quite space consuming, we foresee the system to augment meeting rooms rather than regular workplaces. Due to large screen size and multi-touch interaction, multiple users per site can collaborate simultaneously. In order to integrate Face^{2}Face into the workflow of a distributed group, we propose a simple way to bring data to a digital meeting. User blue can collect digital material like renderings, technical documentations or 3D models in shared cloud storage at his or her workplace. In order to *transport* the content from the workplaye to the Face^{2}Face system, a visual marker that encodes the URL of the shared material location can be genrated on a portable device system that encodes the url of the shared material and that can be generated on a portable device. As the users establish connection, user blue shows the marker to the integrated camera and the shared material is loaded and presented on both installations. Now the users can discuss intuitively the design of the car body. Additional annotations can be applied to the visual material which appear true-sided for all participants.

In order to store the annotations or share the results with other team members via email additional user interface elements are required. In order to avoid consuming further screen space and occluding the video stream of the other user, tangible objects with unique visual markers can be used to select additional program functions. E.g., a tangible object referring to the email function can be used to send annotations to members of the work group that did not attend the meeting. In contrast to a common video conference application, Face^{2}Face extends remote collaboration with the following awareness features:

Presence: For group meetings, it is fundamental to understand who is present and who performs which action. As Face^{2}Face utilizes live video transmission, the presence and identity of participating group members is clear and transparent. In contrast to regular video conferencing, users actions in the shared workspace are also directly visible and thereby authorship of interactions can be determined intuitively.

Eye Contact: With the co-axial arrangement of camera and screen, Face^{2}Face supports eye contact. Thereby, conversation flow is improved as the next speaker can be negotiated by making eye contact. This also works for multiple users per site: Users green can differentiate which person user blue is currently looking at.

Gaze Awareness: The system correctly reproduces gaze directions also for the overlaid digital material. Thereby, the users are implicitly aware of which elements are in the others' focus of attention. This can serve as a visual evidence that the participants are referring to the same material (Fig 3). In order to avoid false sided digital material, the video stream of the respective other installation is vertically mirrored. Thereby, the digital material can be presented true sided on both clients and gaze awareness is still provided (Fig 3)

Gesture / Interaction Awareness: An important aspect of Face^{2}Face is the visibility of other users interactions with the digital content. Also, pointing gestures can be naturally used and serve as deictic reference and thereby reduce the need for verbal coordination.

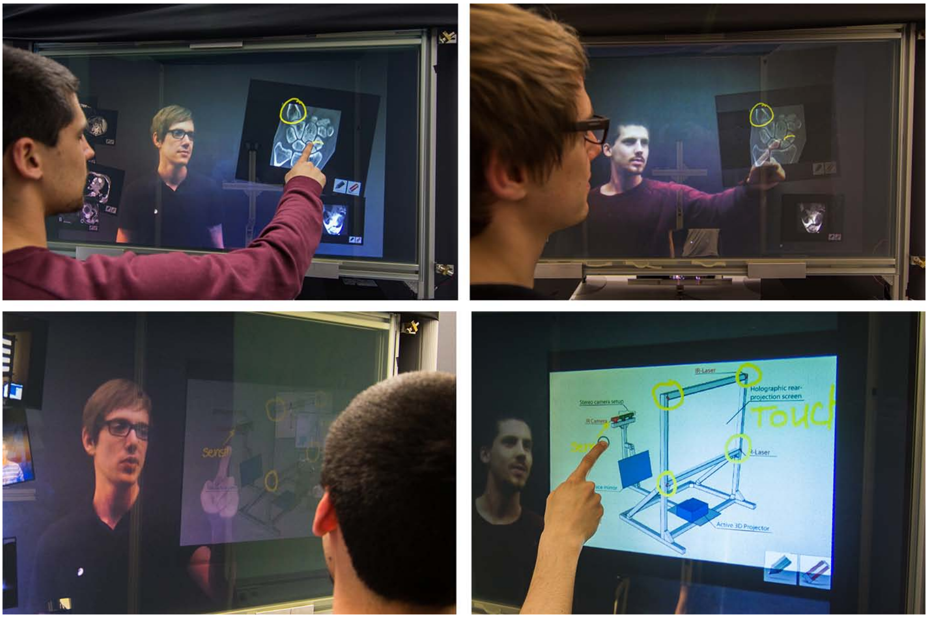
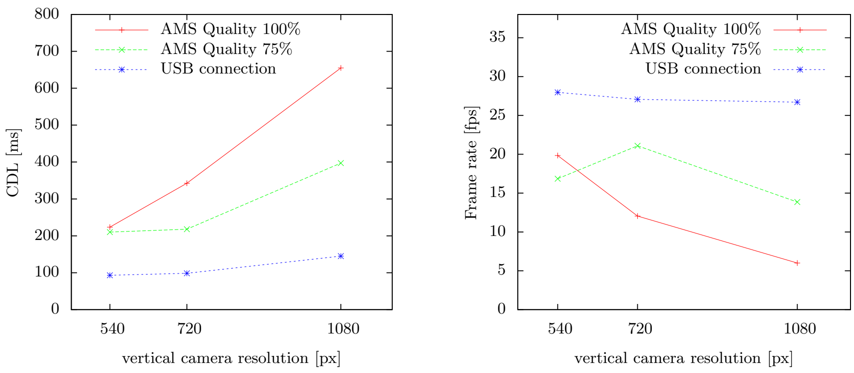


Fig. 3. Gaze direction and pointing gestures are preserved with Face^{2}Face. Annotations appear true sided on both client installations.

5 Results

For a persuasive remote collaboration, Face^{2}Face requires real-time high-definition video transmission and fluid workspace synchronization. Therefore, latency due to network transmission has to be reduced. In order to determine the general practicability of the concept and the system prototype, we measured the video performance transmission for different typical camera resolutions and compression quality settings made available by the AMS. We used the Tool "vDelay" [13] which allows measuring the capture-to-display latency (CDL) and the frame rate with a software based approach by capturing and detection of barcodes which encode the current system time. The measurements were performed using a switched gigabit Ethernet network. One of the two client installations additionally run the AMS. For comparison, the cameras were additionally crossplugged, thereby providing a direct USB transmission to the respective other installation.



(a) Capture-to-display latency (b) Video frame rate

Fig. 4. Performance of video transmission for different resolutions and quality settings

The results as depicted in Fig. 4 show the relationship between video resolution and CDL and video rate respectively. As the video stream has to be rectified a higher camera resolution leads to superior visual quality of the other user. With a direct USB connection the video latency of up to $145ms$ is not observable. In addition, with direct camera connection it can be shown, that the Face^{2}Face applications can potentially process and display also high resolution video streams at high frame rates. Of course, in a real scenario with distributed collaborators, the video stream has to be transmitted using a wide area network. With the AMS, a good compromise between display quality and latency is obtained with a camera resolution of $1280 * 720px$ with a compression quality setting of 75%. Here, the video latency of $217ms$ and the video rate of $21fps$ provide a satisfying user experience.

The bandwidth required for workspace synchronization is much smaller in comparison and is thus negligible. However, in case of higher video latency, the workspace synchronization should be delayed accordingly so that interactions of the respective other users are in sync with the video output. For the prototype implementation we used one of the clients to run the AMS in parallel to the Face^{2}Face application. Therefore, we expect performance improvements by using a dedicated server.

6 Conclusion and Outlook

In this paper we depicted how Face^{2}Face supports the collaborative design process by transporting important aspects of non-verbal communication and thereby increasing workspace awareness. Due to the hardware setup, there is no need for artificial embodiments. The setup creates a natural reproduction of a real face-to-face conversation and incorporates digital material seamlessly. Our performance evaluation moreover showed that the system is suitable for real-world application. A limitation is that Face^{2}Face is constraint to connecting two sites at a time. However, by using larger screen sizes it is possible to have more than one person interact simultaneously at a single client and thus increase the number of participants. For future work we plan to perform user experiments to gather empirical data on how the characteristics of this system affect workspace awareness. Aside from that we plan to implement and evaluate the proposed interaction techniques using the marker system and incorporate a variety of additional collaboration features in order to broaden the system's functional range.

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The Use of Media in Intercultural Dialogue "dialogo_dialog"! Investigation of a Research Event in Terms of Communication without Language

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Abstract. The initiation of a cultural event provided the basis for this research project: An intercultural artistic dialogue connected two almost deserted railway stations in Germany and in Brazil. One band performed in the station hall in Germany which was linked via live stream to the station in Brazil. In this station at the same time one Brazilian band performed.

For this intercontinental event neither language nor translation was required, as other artistic means were used. The room, the music, the lighting and the presence of the people provided an atmosphere for interaction, which exceeded the level of communication that would have been achieved through language. The fast pace of technological progress is intertwined with the rapid development of global networks extending to the whole world. New interactive structures and relationships created a new dimension of intercultural communication, which seems essential for the organization and implementation of global processes. Exchange and communication are primarily based on mutual understanding.

Keywords: live steaming, revitalization of old buildings, transcultural communication.

1 Introduction

A cultural dialogue without direct visual contact and the use of a common language: Is this possible? Which spatial atmosphere has to be created to make sure that such an exchange can take place? What opportunities offer vacant buildings for cultural events? And finally, how can the project *dialogo_dialog* serve as a role model for intercultural communication in the context of globalization?

These questions already indicate the breadth of topics addressed: revitalization of old buildings, communication, cultural understanding, and - besides music - light, video and live streaming as methods of visual culture. The answers to these questions were obtained by analyzing compositions submitted by students.

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Two train stations were selected as the venue for this project, both of which have lost their original purpose due to evolving traffic routes. In Lüneburg the building was previously used for parcel processing, while in São Carlos the venue was formerly a platform of a freight depot. The intention was to link people to one another in the way that travel used to, except that now no trains were leaving the stations, just bits and bytes. The scene was station platforms and concourses that no longer have a purpose but where trains still pass. The time frame chosen was an evening in December, which meant that the time and temperature differences were at the maximum.[1] The project applied the nonverbal communication form music. Musical groups were chosen for both locations to make music at the same time in the two train stations. The concerts were transmitted to the other place with the aid of audio and video links (Polycom©) and suitable projectors. And as the finale, the groups played together: They took turns providing the background sound for the other group. [2]

2 Technical Basis for Live Streaming

Streaming media enables virtual realtime transmission of zipped video and audio files via the Internet.

The audio video transmission was done with Polycom©. This technology was selected because it was available to both groups and provided drastically better results than e.g. Skype, especially in regard to sound transmission of the band music and the room acoustics. The use of multimedia applications like the live link is not at present adequately supported by existing firewalls.[1] Because of this, the computers linking the events were to be self-contained and not integrated into networks. Then the connection can be established without a firewall. For this purpose we tested a wireless USB Modem stick with the following transmission data: 7.2 MBits download rate and 5.7 MBits upload rate. We achieved a transmission delay of less than one second.

With streaming, the data is not downloaded all at once; it is downloaded in batches, applying the store-and-forward principle. "Store and forward is a telecommunications technique in which information is sent to an intermediate station where it is kept and sent, …[before sending them]… to the final destination or to another intermediate station." [2]

Live streaming was used in this case, which means that the respective recipient received the content as it was being created. This method is well suited to live concerts and press conferences.[3]

The live streaming that could not be seen on the screen was conveyed audio-visually by the passing trains - in the sense of "Railroads join people."

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[1] Data on the transmission period: Germany 8:00 - 10:00 p.m. and -10 °C, Brazil 3:00 - 5:00 p.m. and 30 °C.

[2] The participants were a study group from the Leuphana University Lüneburg with the band Parashurama and, in Brazil, a group of researchers from the University São Paulo in São Carlos and Universidade Federal de São Carlos with the band Aquarpa. A making-of video of the event can be found at: `http://www.youtube.com/watch?v=zWbMrQk5R_A`

3 How the Location, with the Atmospheric Component Light, Influences the Transcultural[3] Dialogue

The venue is interpreted as an essential medium for the cultural exchange. Two virtually abandoned station concourses were chosen to span a bridge between Brazil and Germany. The building type train station has a similar connotation in both cultures. The abandoned places are nevertheless unknown spaces for the participating groups, so a location was chosen that is familiar on the one hand and foreign on the other. The objective of exchanging familiar spaces for unfamiliar spaces is to increase to the greatest extent possible the perception of the current surroundings and of the likewise unfamiliar other space transmitted via live stream. Light installations were created to pique the other senses and emotionalize the space.

Fig. 1. Light installations in the stationhall in Lueneburg, Germany (Photograph by the author)

The place that inspires musicians from both countries: The Brazilians used objects found at the depot as percussion instruments, and the Germans integrated the sounds of trains and railroad signals into their composition. Viewed in this perspective, the place with a similar connotation was significant for the choice of contents and for the ultimate musical ensemble. The dialogue ended with the sound of a passing train in Brazil, which sounds similar to a German train but is much louder.

4 Sense of Place

The question arises of whether the cultural event described here created a "sense of place," and what constitutes such a place.

Many people believe that the sense of feeling at home in a certain place increases as one grows accustomed to and familiar with the peculiarities of the place. The degree of comfort that a person feels in a place seems to be a factor of external circumstances, such as the state of nature or appealing architecture.[5]

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[3] Welsch describes transcultural to mean an interwoven model, as opposed to Herder's description of intercultural and multicultural as a spherical model in which each culture is inside of an autonomous sphere. [4]

Fig. 2. With their lighting concept, the students' intention was to initiate a mental journey to Brazil. They used moving shadows as silhouettes, thus conveying the image of crowds of people on the concourse. They correlated the light and shadow theme "Light – object – shadow" to the live streaming principle "Transmitter – medium – recipient." (Photograph by the author).

In contrast to this, Jackson is of the opinion that each person creates his own sense of place: "It is my own belief, that a sense of place is something that we ourselves create in the course of time."[6]

But how can a sense of place be created? Gerard Kyle and Garry Chick say "[...] subjective definitions of place and the attributes contained within reflect self definitions conditioned by cultural affiliation. Rather than a collection of universally defined physical attributes, places are symbolic contexts imbued with meaning. These meanings emerge and evolve through ongoing interaction with others and the environment.“[7]

This definition of a sense of place will be explained on the basis of the cultural action in this following text. When the participants first visited the station concourse, there was no memory, no feeling and no experience that bound them to the concourse in terms of a sense of place.

The students summed it up like this: "It can be confirmed that, as a result of the cultural event, the abandoned concourse became charged with specific emotions and experiences for each of the participants individually. Since the cultural event took place, the station concourse has become more than just a collection of universally defined physical attributes to us – it is no longer just massive steel columns and dilapidated brick walls. The place has assumed a symbolic context charged with new meaning."

A sense of place emerges from the interaction with others and with the environment.[8] The new functional use of the station concourse created a new level of meaning for each participant: A sense of place was created.

The issue of whether for the Germans a sense of place was created in Brazil and vice versa, or of whether a virtual space by means of which the musicians made their music can be a sense of place, has to be explored with additional research.

5 The Challenges of a Transcultural Dialogue

Transcultural communication is firmly linked to the interculturality, the relationships that exist between the different cultures. Entering into a transcultural dialogue means facilitating communication between people and overcoming false interpretations of the group's language symbols and impressions of the environment that already have other meanings. Reciprocally, it is perceived as foreign when in communication codes are encountered that seem strange to one's own (language) conventions.

The following section calls on Francois Julliens' criticism of the dialogue between the cultures to analyze the extent to which the cultural event represents a transcultural dialogue.

Jullien calls the dialogue between the cultures "weak"[9] and "hypocritical"[10] and talks about an imbalance, because the dialogue is "[...] distinguished by power relationships and indirect strategies [...]."[11] A successful dialogue is possible only with a balance of power. However, Jullien concludes that this is not possible because language itself means that the relationship between the different cultures is of disproportionate power. Jullien states that, when communication of the dialogue occurs in the language of one of the two partners, this creates an "imbalance"[12] between the conversation partners right from the start.

Jullien also rejects communication in a third language. Every language has its own logic and works according to its own thought patterns: "[...] Under the pretense of offering itself as a medium, it forces itself upon one."[13]

But what might a balance of power between different cultures and thus an intercultural dialogue look like?

According to Jullien, every culture should hold dialogues in its own language and translate the respective other language.[14] The translation plays the decisive role in Jullien's theory. Our opinion is that the translation is also biased. Since everyone can be articulate only within his own existing language system, it is impossible to overcome one's own structures of perception. Even a translation cannot achieve this, because each individual is restrained by his language system. The translation leaves no opportunity to immerse oneself in the cultural context of the other language.

"Foreign" can be perceived in different ways: as being from a different country as something strange and abnormal, as something not yet know, as unrecognizable, or as something scary and unfamiliar. The best situation in which to begin a successful and thus understandable transcultural dialogue is one in which "foreign" is defined by the dialogue participants as the known – which was the case for this project. And then the transcultural dialogue is applied to approach the unknown, with the objective of getting to know and understand it.

Artistic means were used instead of language in the dialogue *dialogo_dialog*. The music, the light and the presence of people created a dialogue that was able to convey much more than language alone could do.

6 Music as a Global Language

Art is the foundation for initiating transcultural processes. Because it does away with the restrictions posed by language and provides a means of nonverbal communication, music can transcend nationality and language barriers and provide a common language.[15]

Music has the capacity to impact humans and elude the restrictions of ordinary verbal communication. It offers a medium that is virtually free of cultural characteristics and influences. Rhythms, beats and melodies contain forces that affect us humans through universal frequencies, regardless of the culture to which we belong. Music conveys emotions and sensations, enabling communication at an intellectual level without stylistically formulated phrases. "Music is the global language and requires no translation."[16] Also, the brain has regions specialized in the perception of music.[17] Memories and experiences are linked to emotions by associations. Music can activate these associations, releasing emotions that we perceive due to previous experiences. [18]

These characteristics make music a fitting means of communication that, despite different cultural influences and measurable levels of knowledge such as those related to language skills, facilitates communication at a universal frequency and triggers interactive perceptible reactions.

Although Welsch admits that "Music [… has] a universal benefit".[19] His opinion is that it offers little transculturality, which he sees as more prevalent in dance. The concert was a transcultural musical experiment: The musicians from both countries engaged in the music of the other country and composed something new. The extent to which dancing together conveys a feeling of community amongst the groups is something that could be examined in the course of a later event.

7 Conclusion

"Shorts and T-shirts encounter winter coats and hats. Viewed objectively, there are a lot of differences, but the train stations as venues and the live streaming are the imposing means of linking the two locations and groups ... A virtual space in which different sensations ... and trains reverberating with sound encounter one another ... and come together to form something that joins us all ..." This is how one of the students described his experience of the events, leaving nothing out that characterizes the dialogue.

If the effort involved in such a production were not so vast, the event could be repeated several times in the sense of action research. This would technically and transculturally optimize the dialogue, making it accessible to the general public. In the future, the Brazilians would expand the dialogue with audience participation: "for example, viewers of both locations could communicate in parallel via sms messages, via phone, or via written comments, photos or videos posted on websites or social networking service, information that would be projected on the wall of where actions occur." [20]

Different forms of transcultural dialogue would also be conceivable:

- Live streaming of two dance events (people on different continents dancing to the same music)
- Live streaming of simultaneous exhibits on two cities, with the option of allowing visitors to communicate
- Live streaming of skateboarding tracks, demonstrating stunts to one another

Other artitsts can take advantage of the benefits of events that include a live link. On December 21, 2012 – the day the world ends – a "Live link was set up from Dresden to Mexico – the place where the Dresden Codex is presumed to have originated. A Mayan singer stroked up centuries-old stanzas. She bid farewell to the old calendar cycle all alone. In Dresden, her song blended with the sound of the orchestra that joined her in welcoming a new Mayan age.[21]

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Distributed Collaboration in Engineering by Low-Latency 3D Model Sharing

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Abstract. Stereoscopic (3D) models and visualizations are used in many fields of research, engineering and even art. Low-latency sharing of such models can enable distributed real-time collaboration on various topics. We discuss technical aspects to achieve low latency and present our experience during a field trial of distributed collaboration in engineering.

Keywords: distant collaboration, 3D models, video streaming.

1 Introduction

Team work often requires interactive sessions. Computer visualizations and 3D models are now used to assist decision making. An example can be a construction project, involving architects, environmental and traffic experts, etc. Low-latency sharing of 3D models (buildings, utilities, etc.) in real-time can then enable effective collaboration of a distributed team.

Visualization devices can range from a PC or laptop monitor, screen projection to high-definition tiled displays powered by the SAGE [1] software and multi-screen immersive CAVE-like [2] environment.

2 Design Options and Constraints

A 3D computer model is generally specified by a mesh of triangles or quads and bitmap textures. There are two principal sharing strategies.

Sharing of just model data has an advantage of low data volume and using distributed computing resources. However, model intellectual property (IP) rights need to be cleared for sharing and rendering application with synchronization is needed in all locations. On the other hand, sharing rendered visualizations does not require synchronization, IP rights are easier to manage, but large volume of data is transfered.

The choice of strategy depends on a particular case. We have been working in a community of partners interconnected by a high-speed networking environment called GLIF (Global Lambda Interchange Facility, www.glif.is) [3]. We believe that high bandwidth availability will be a part of future networking. Therefore, we inclined towards the second strategy.

For an interactive feeling the limit for the user to feel that the system is reacting instantaneously is between 100 and 200 ms [5]. The network propagation

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delay is approx. 50 ms across Europe or 100 to 120 ms from Europe to Japan. The round-trip delay is twice these values. Therefore, it is important that the added delay for data processing and transmission is as low as possible.

3 Example Implementation

We have implemented a transmission solution based on software - hardware codesign, illustrated in Fig. 1. The sender side is implemented in software, which has an advantage of easy integration with design applications by the capture of OpenGL [4] calls. The receiver side is implemented in hardware, which has an advantage in reducing the overall latency.

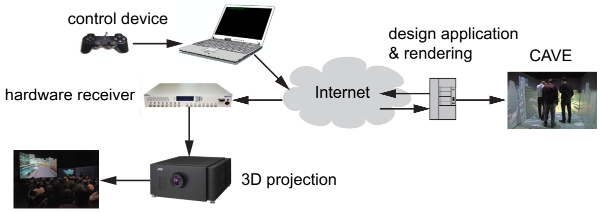

Fig. 1. System architecture

The software sender is formed by the libyuri [7] framework, which is a set of modules for video acquisition, processing and streaming. The modules can be arranged in an arbitrary directed graph by a XML specification. An example of a module graph is shown in Fig. 2. A particular structure of modules is constructed during the application startup and can be easily configured for various source design applications and destination visualization requirements.

Processing latency in the software sender consists of reading from the framebuffer, format conversion and waiting for streaming.

The measured times for selected video formats are summarized in Table 1. The numbers are averages for 1000 frames. Measurements were done by adding checks into the code.

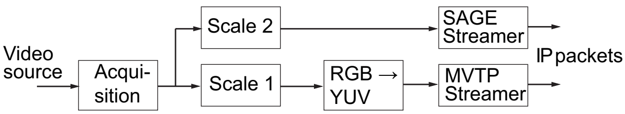

Fig. 2. An example software sender configuration

The hardware receiver is called MVTP (Modular Video Transmission Platform). The name reflects that the video signal passes through a sequence of firmware processing modules, similarly as in the software implementation. It has been developed for very low latency transmissions of signals up to 3D 4K (4096x2160). The transmission is uncompressed, allowing very low processing latency. Bitrate for one channel ranges from approx. 1 Gb/s to 1.5 Gb/s depending on video format.

Table 1. Software sender delay

	Reading from framebuffer	Format conversion	Waiting for streaming	Total (avg / max)
1080p30	16 ms	14 ms	0-33 ms	46.5/63 ms
1080p30 3D	30 ms	14 ms	0-33 ms	60.5/77 ms

In a network with low jitter, such as GLIF links, buffering of only a few picture lines is sufficient. One HD frame includes 1080 visible lines and 45 invisible lines for embedded audio, synchronization, etc. [8]. At 30 fps the transmission of one line takes $1/30/1125 = 0.03\,ms$. 20 lines buffering takes 1.2 ms. The total receiver latency is approx. 1.5 ms.

The internal hardware architecture of the MVTP device is illustrated in Figure 3. It consists of an HD-SDI [8] board with video inputs and outputs, an FPGA board for data processing and a network transceiver board with a replaceable XFP optical transceiver.

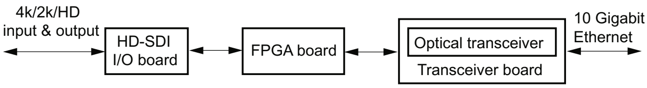

Fig. 3. Receiver hardware architecture

4 Practical Experience

We performed an experiment with a 3D architecture model of a pseudo-random city. The model was stored and rendered in CAVE at the Institute of Intermedia in the Czech Technical University in Prague. It was then transmitted to the Cinegrid workshop in the University of California in San Diego (UCSD), over a distance of approx. 15000 km. The 3D projection was by two JVC projectors and fixed polarising filters and passive glasses (Fig. 4).

People at the venue could use a tracking device to walk through the model, which was rendered remotely and sent back in real time. Bidirectional audio channel was also transmitted. An interactive discussion took place about some

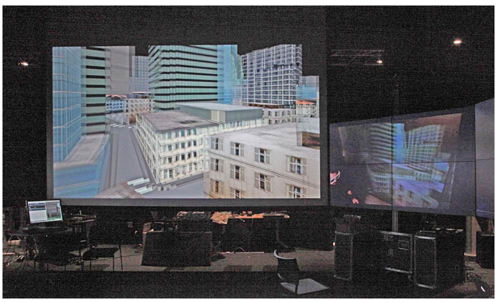

Fig. 4. Remote access to the architecture model

aspects of the proposed building construction, for example, what is the appropriate height and distance of new buildings with changes immediately visible.

The total round-trip delay from control commands to visualization in 1080p30 3D was approx.: 2x85 ms (network) + 60/77 ms (processing avg/max, see Tab. 1) + 20 ms (control keypad device) = 250/267 ms (avg/max).

The delay between a movement of a control device and the corresponding change in visualization was noticable, but it could be well accommodated in thinking and a collaborative design was possible. This can be considered satisfactory given the distance between Europe and the West Coast US.

5 Conclusion

Low-latency remote access to 3D models can enable effective distributed collaboration in research, engineering and humanities. The added value to videoconferencing systems is a higher level of immersion and low latency interaction. Existing OpenGL applications can be used with various visualization environments. Experiments conducted over very long distances have shown that when the low processing delay is added to the network propagation delay, the resulting response time is still acceptable for interactive feeling. The presented solution based on hardware-software codesign reduces latency by removing a Framebuffer from the receiver.

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Monitor, Control and Process – An Adaptive Platform for Ubiquitous Computing*

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Abstract. Monitor, control and process data on top of distributed networks has been a trending topic in the past few years, with ubiquity being adjective to computing and, gradually, the Internet of Things becoming a reality in home and factory automation or Ambient Assisted Living (AAL). Still, there is a general lack of knowledge and best practices on how to build systems that integrate devices and services from third-parties which connect dynamically with each other. Recurring problems such as security, clustering, message passing, deployment and other orchestration details also lack a standardized solution. The authors describe a platform that simplifies the bootstrap and maintenance of such complex systems, presenting its application in an AAL scenario. Such platform could orchestrate most distributed systems, possibly setting a pattern for distributed ubiquitous computing.

Keywords: Distributed Systems, Ubiquitous Computing, AAL.

1 Introduction

The Internet of Things [2] is today a reality. Devices are getting network-enabled and able to ubiquitously monitor and control machines or persons. AAL platforms use such technology to improve life quality for their users by helping disabled to control their house [1] or monitoring users' health status and report it to a caretaker or data analysis service [3,5]. Such systems share common problems. How to orchestrate the large amounts of information generated? How to integrate devices and services built by different entities? How to allow the system to evolve with new devices and services without breaking previous configurations? This paper approaches these questions, describing how the authors orchestrate the integration of independent components developed by third-parties in an AAL ultra large scale system, while keeping the architecture adaptable to most ubiquitous computing scenarios.

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2 The AAL4ALL Ecosystem

Considering the AAL4ALL project, involving 32 partners from industry and academia and whose aim is to develop a national AAL ecosystem, there was the need to design a large scale orchestration platform, able to manage users, products and services and their authorizations for propagating data. Partners deployed sensors which gathered information from patients and services which consumed it in order to provide relevant health information. Such platform was required to connect both. Considering the need to allow subscription of services at any time, the system had to evolve in runtime, both by configuring itself and scaling, so that sensor data would propagate to the right service.

3 Adaptive Distributed Computing Platform

3.1 Overview and Requirements

Section 2 introduced requirements for an ubiquitous computing platform and identified the possible entities in the system: **sensors**, **actuators** and **services**. Sensors are producers of information, while actuators are consumers. Services can be both. Generically, a producer of information would consist of any device or service capable of sending information to the platform. Consumers are either services or actuators who receive data from one or more producer, acting on it. More than one service could exist that required the same data, hence, received data in the platform could be forwarded to more than one consumer, which required a dynamic orchestration approach. A publisher-subscriber pattern was adopted. Runtime configuration provided the information of where information should be forwarded to.

Opposed to client-server architectures, which keep functionality static, this platform embraces change at any time through, allowing the addition or removal of producers or consumers. Observation quickly identified a set of requirements common to multiple scenarios: a) integration of third party sensors, actuators or services at any time, b) propagation of data from producers to consumers, c) detection and recovery from errors in the system without compromising the whole architecture, avoiding single points of failure, d) portability and interoperability between components and e) simplified deployment and scaling.

3.2 Architecture and Technology

This architecture integrates proven technologies for distributed and parallel computing in order to create a *network node*, able to cluster with others. Message subscription, publishing and node clustering is achieved through the AMQP protocol [4], enabling an increased throughput of data and the ability to manage a large number of clients per node. In order to guarantee data validity, publishers communicate with an HTTP server, which evaluates the message header, discarding those invalid. The system is agnostic to the message body, validating only the header, allowing the body to be encrypted for additional security. The Scala

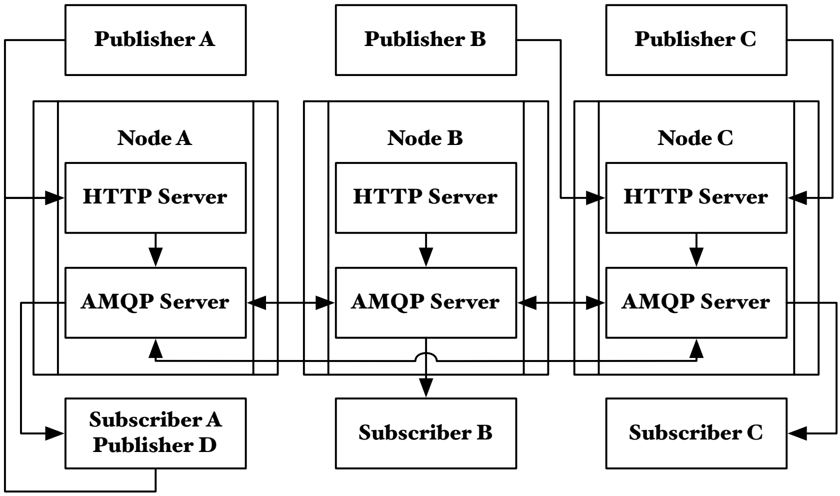

Fig. 1. Network Node Architecture

programming language and the Actor concurrency model are used to implement an asynchronous HTTP server. A *shell* script downloads and configures the required software in a new Linux machine, simplifying the process of creating a single node or also configuring it to join an existing cluster.

Figure 1 shows a clustered platform with 3 network nodes, 3 sensors on top (producers) and 3 services on the bottom (consumers), one of which is also producer of information. Producers publish their data via HTTP to the embedded HTTP server in the node which validates and propagates the message to the AMQP server. Consumers subscribe messages in the AMQP server and get them delivered to them as soon as these arrive. Nodes can be physically separated and clustered using the AMQP servers. If Producer A publishes a message with a type that Consumer C has subscribed to, the message will propagate from Network Node A to Network Node C and there delivered to Consumer C. If a message is published in a node and no consumer has subscribed it outside the receiving node, the message never leaves that same node.

3.3 Usage in the AAL4ALL Project

This platform will support the aforementioned AAL4ALL project. Developers of sensors and services have integrated their software using the provided API. Currently it is being deployed in three physically separated livings labs which host sensors and actuators that simulate the equipment in the AAL environment. Services consuming this data are hosted in the cloud. A *Caretaker Service* developed by Fraunhofer Portugal is one of the integrated components, subscribed to the data generated from the available devices and providing a web interface for monitoring them. It is also able to detect potential health conditions from data gathered from biometric sensors and raise alarms for doctors or caregivers when appropriate.

3.4 Other Usages

At its core, this platform is an highly adaptable message passing interface, enhanced with services for additional functionality. Adopting it for a different project would require only to configure the deployment script to properly cluster the new network nodes together and provide developers with the API for posting data to it and allow third-parties to integrate their components by publishing and subscribing to data in the platform.

4 Conclusions and Future Work

This paper described the requirements and preliminary work at designing and implementing a reusable platform for building ultra large scale systems.

Current work in the context of the AAL4ALL project provides a network node that handles communication using the publisher-subscriber paradigm for routing validated data. Every publisher and subscriber must be authorized within the system and data flows only to those who should have access to it, which is managed by the platform itself. Routing nodes can be clustered, scaling horizontally.

Future work, will consist on formalizing identified patterns used in distributed systems and integrate these in the framework. Some generic services should also be implemented, such as the central configuration of all nodes, which is expected to become completely web based, allowing non-technical administrators to manage the system.

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Exploring Collective Architectural Conception: Cooperation, Coordination and Collaboration via Basic Online Tools

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Abstract. Online technologies are already fully integrated into almost every domain of activity. We want to better understand if and how these tools assist groups of people in their architectural conception process. By looking at cooperation, collaboration and coordination moments from the architecturological point of view we hope to associate cognitive operations of conception to the use of certain online tools. The purpose of this research is to build a theoretical model of the collective architectural conception process in relation to the use of basic online tools.

Keywords: collective architectural conception, basic online tools, architecturology, cooperation, coordination, collaboration.

1 Introduction

Internet is opening a world of possibilities for diverse collective constructions. In architecture, its uses modify the manufacturing process thereof introducing new relationships between designers, workspace and tools. Therefore these uses in architecture lead us to ask three questions in order to better understand contemporary mechanisms of architectural design process conducted through Internet: how do online technologies assist people within the process of architectural design? How does the use of online technologies shape the design process itself? What is the impact of online technologies on the final architectural project?

This paper presents the ways in which we address these issues from a specific scientific French field called Architecturology [1]. The first part presents the scientific anchor of our research, the second one approaches collective architectural conception and the third, online tools in collective architectural conception. The last part presents some first results and a preliminary conclusion of this first stage of the research.

2 Architectural Conception

For this research, we distinguish two stages of architectural production: conception and manufacturing. Architectural conception consists for us in a series of cognitive operations that transform the project model in order to obtain a final state that is then

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manufactured. This point of view is based on Simon's definition of conception that considers it as a general process in which someone imagines a series of dispositions in order to change an existing situation into a desired one [2].

Architectural conception is for us a specific process dealing with space, a projection in future concrete space. According to architecturology, the architectural conception process can be modeled as a number of evolving operating relationships between spatial models and what are called scales, i.e. classes of cognitive operations by which shapes and measurements are given to the future space [3].

If this scientific model makes the architectural conception process intelligible, it does not include the participants of the process nor the collective work that grows more and more with the use of online technologies. Who are the conceivers and how they work together within architectural conception process? This is the question we would like to approach.

3 Collective Architectural Conception

To understand this question, we must explain our approach on collective architectural conception. Collective conception is for us an activity undertaken by a group of people who works on the same artifact and who has a common goal. Within this framework, we can distinguish between two main types of activity categories: collaboration (synchronous collective activities which include operations of actual conception as well as co-conception) and cooperation (mostly asynchronous collective or individual activities which include operations of distributed conception and of coordination) [4].

Allwood, Traum and Jokinen define cooperation as the sum of coordination and collaboration moments, which enable the actors to share a common goal [5]. Panitz meanwhile, defines the conception process as a strategy of interaction between actors, composed of collaboration and cooperation [6]. Cooperation, coordination and collaboration are then three keys to question collective architectural conception.

From the Architecturological viewpoint, our research consists in questioning how cooperation, coordination and collaboration are implied in the architectural conception process conducted with online technologies. In other words, it comes to understand how these three spheres of collective work participate within the conception process in the following modeling.

... > M1 $-^{1}$ E1 > M2 $-^{2}$ E2 > M3 $-^{3}$ E3 > ... > ME

Fig. 1. Modeling of the architectural conception process [7]

This schema (Fig. 1) represents the architectural conception as a succession of models (M1, M2, etc) which are transformed by a series of cognitive operations of conception, called scales (E1, E2, etc.). What we understand here by models are the different references and the graphical or textual productions that showcase the project. Our question consists in understanding the symbols -1, -2, -3 in order to know how the cognitive operations of conception are associated to the process : by cooperation, coordination or collaboration and in relation to online tools.

To identify the activities and the online tools at work in architectural collective conception we have first explored diverse online tools which are able to support it. This first exploration has been made to understand how online tools assist collective architectural conception.

4 Use of Online Tools in Collective Architectural Conception

We have chosen to focus on what we call "basic online tools", such as e-mail, chat, file transfer systems, blogs and Wikipedia platforms. These tools are for the most part fully developed services that have widespread use over different populations of Internet users, in different domains, for all types of activities. This means that the tools are used within all age groups, by all genders, in all different group sizes and at various use intensities. Basic online tools are non-specific to the architecture domain but are the subject of appropriation and adaptation to better assist the collective conception process.

For this exploration we can distinguish between different uses of online tools: the basic use (mainly for which the tool was designed) and the use within the collective architectural conception process.

The basic use of online tools can be a key factor in the realization of a project. For example, Telecomix (a community of online hackers) has used Internet Relay Chat (IRC) in order to collaborate online and build an Internet connection for the Egyptian and Syrian protesters during the Arab Spring. Another example would be the Transition Network (a community of local ecological movements) where members use Blog and Wikipedia platforms in order to post solutions to different architectural, technical or ecological problems.

As it has been shown by Earl, Kimport, Prieto, Rush and Reynoso in a study on online activism, the use of web technologies has the potential to fundamentally change the collective organization process [8].

The use of basic online tools within collective architecture requires an adaptation of these tools to the conception process. For example, Arquitecturas Colectivas is a network of architecture and design groups that created an online platform containing file transfer systems, chat rooms and discussion groups in order to coordinate and cooperate on the network's common projects: festivals, collaborations on different urban projects, etc.

5 First Results and Preliminary Conclusion

The first stage of the research presented here, allows us to associate basic online tools to the moments of architectural conception. For example, the main strategy for the Dreamhamar project was to engage two communities, local and international, in the conception process for the main square of the city of Hamar, Norway [9]. Therefore, the architects from Ecosistema Urbano developed two devices: a physical lab, for onsite conception workshops with the local community, and a digital lab, for online conception workshops with the international community. By using a combination of blogging features, website features and live streaming, Ecosistema Urbano developed a debate platform, a database of ideas and a coordination tool for all the participants of the conception process (inhabitants, institutions, academia, designers). All the gathered information was synthesized into the Future Hamar Book which later became the base for the architecture project. Thus, we could assume that the basic online tools have been used to create the conception space for the participants in the architecture project.

While we have seen at first that basic online tools have the capacity to support collaborative conception (by video conference for example), from our research we have seen that in architecture they tend to be used more for cooperation and coordination moments. What is more, conceivers also build collaborative conception spaces through cooperation and coordination via online tools or in real space. Thus, further investigation will question the relationship between collaboration, cooperation and coordination in order to better understand the orchestration of these rare collaborative moments within the general conception process [10].

At the same time, we have observed that basic online tools can be used differently within the conception process. They can be used individually (the one tool for all online activities) or in combination (multiple tools that make a platform). They can also be used as such (without any modification) or can be altered in order to better assist the process. The tools can be used long-term or can be implemented only within a particular situation.

Our first findings listed enlighten the uses of online tools in collective architectural conception but do not answer all the questions raised above. We have to observe practices of collective architectural conception conducted with the tools evoked above in order to situate coordination, cooperation and collaboration in the process. We also have to interview the actors of collective architectural conception in order to enlighten their profiles (architects, engineers, managers, politicians, citizens, inhabitants, etc.) and to know what kind of architectural conceivers they are.

All observations and interviews will be analyzed with methods of Applied Architecturology [7] in order to explain:

- the cognitive operations of architectural conception implied in coordination, cooperation and collaboration;
- the cognitive operations of architectural conception implemented by each profile of conceiver;
- the cognitive operations of architectural conception supported by each online tools.

The aim of this study is to develop a theoretical model of collective architectural conception in terms of cognitive operations in relation to the use of basic online tools. The model could serve the general understanding of how online tools assist the conception process in architecture as well as in other similar domains such as design, urban planning or project management. This theoretical model could be later developed into a teaching instrument, a meta-tool for use of online platforms or as a resource for online tools development.

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Tablet-Based Synchronous Mobile Learning System

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Abstract. Since most of the existing smartphone-based learning systems are asynchronous, smartphone-based synchronous learning systems became available recently. However, the display of smartphone is not large enough for students to recognize lecture slides with annotation, which can lead to the poor learning experience. Thus, we propose a tablet-based synchronous mobile learning system that allows users to watch the ongoing lecture video and presentation slides with annotation as well as to send text feedback to an instructor on a tablet in real time. Most of the students mentioned that they felt more focused during the lecture with the presented tablet-based learning system because the slide and annotation is easier to recognize and typing questions is easier and quicker than smartphone-based learning system.

Keywords: tablet, mobile learning, synchronous collaboration, distance learning, mobile application.

1 Introduction

Most of the traditional distance learning systems have been based on desktop computers. However, as mobile devices such as smartphone and tablet have become popular, researchers became interested in running mobile learning systems on them since they are not only portable but also provide as much computing power as desktop computers from a few years ago[1].

Unlike desktop-based synchronous learning systems, the high mobility of the smartphone-based system allows students to join the lecture from anywhere with their smartphone. In contrast to the most of the existing mobile learning systems that are asynchronous, there are a few synchronous mobile learning systems that provide real-time learning. MLVLS [2] is a live mobile learning system that allows students to watch live video and slides on their Symbian OS-based smartphone. But it doesn't provide real-time interaction between an instructor and students.

Previously we had developed a smartphone-based real-time mobile learning system that enables students to watch video and slide with annotation as well as to send text feedback to an instructor on a smartphone [3].

But these smartphone-based synchronous mobile learning systems have their own drawbacks. One of them is that the display of smartphones is so small that it is not comfortable to look at the lecture slides with annotation. The slides are usually produced with a presentation program running on a desktop PC or a notebook that are equipped with a display which is normally between 13 inches and 24 inches.

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However, figures and texts on a slide that are large enough to look at comfortably on the display of a PC or a notebook are no longer easily recognizable on the small display of the smartphone of normally 4 to 5 inches. The annotation on a slide made by an instructor with a display of a PC or a notebook can also be too small for a student to recognize in the smartphone display. Sometimes it is hard to recognize real-time interaction messages such as questions and answers between a lecturer and students. It is also awkward to type on a small on-screen keyboard of the smartphone for interacting each other. These problems become more serious to elderly people or people who have poor eyesight.

As a result, the small display of a smartphone-based system makes it hard for students to concentrate on the lecture. These problems of the smartphone-based system can lead to the student's poor learning experience. Classroom Presenter [4] is a tablet-based synchronous learning system that supports sharing of lecture slides and annotation between an instructor and students in a classroom. Since it requires an instructor and students to collocate in the same classroom, it doesn't provide video and audio of the instructor nor questions from students.

Thus, we propose a tablet-based synchronous mobile distance learning system that allows users to participate in an ongoing lecture session and watch the video and presentation slides with annotation as well as to send text feedback to an instructor in real time on a tablet. The slide with annotation and the text feedback on the screen of the proposed system is large enough for students to look at comfortably. Typing questions on a large on-screen keyboard of the proposed system is also easier and quicker than the smartphone-based counterpart.

2 Approach

Fig. 1 shows the architecture of the presented tablet-based synchronous mobile learning system that consists of two parts: a desktop server for instructor and a tablet client for student. The tablet client runs as an app on an Apple iPad. The desktop server runs as an application on a Windows PC.

The desktop server acts not only as a server for encoding and broadcasting lecture to tablet clients, but also as a client for instructor. The desktop server encodes lecture video, audio, and slide with annotation. The video is encoded with H.263 [5] and the audio is encoded with G.723.1 [6]. The slide is encoded with JPEG. Annotation events that occurred during a short period of time is grouped and packed into a packet.

The desktop server also broadcasts to tablet clients various types of data: encoded lecture video, encoded audio, encoded slides with annotation, text feedback from a tablet client and session update (e.g., joined a lecture session). Each type of data is sent to a client through a separate socket.

As a client for instructor, the desktop server renders the video of the instructor from a webcam, plays the audio from a microphone, renders the slide with annotation, and displays the text feedback.

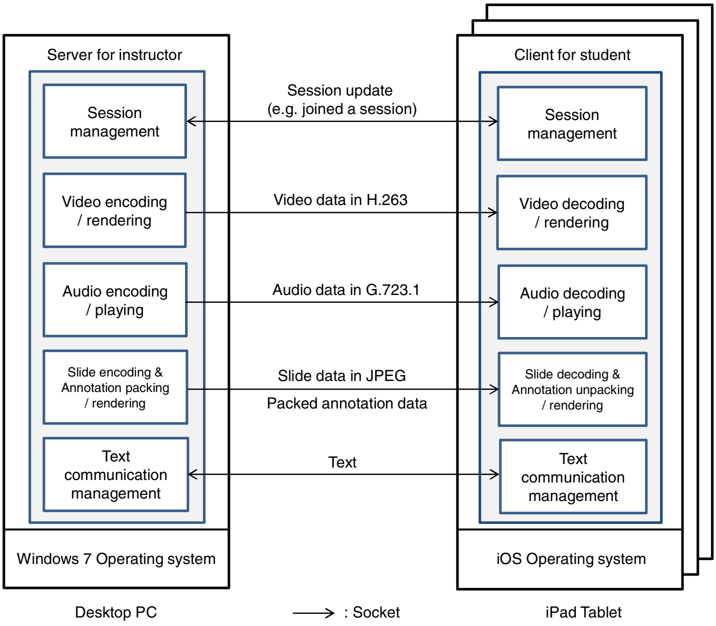

Fig. 1. Architecture of the tablet-based synchronous mobile learning system

When a tablet client receives lecture data from the desktop server, it decodes them and renders the video and slide with annotation or plays audio. The client can send the text feedback and session update to the desktop server which, in turn, broadcasts them to all the clients as well as displays the feedback and updates its own session state.

The development platform for the presented system is as follows. The tablet client is being developed in Objective-C with the Xcode 4.6 integrated development environment [7] and iOS SDK 6.2 [8] on Mac OS X Mountain Lion 10.8.3. The desktop server is being developed in Microsoft Visual C++ 2010 with MFC on Windows 7.

3 A Use of the Prototype and Discussion

Fig. 2 shows the current prototype UI of instructor's desktop server (upper figure) and student's iPad tablet client (lower figure).

The UI of the instructor's desktop server consists of the following panels: video of the instructor, participant list, lecture title, slide, slide control command panel and feedback from students. To start a lecture, the instructor clicks the Open Slide button in the slide control command panel and selects the lecture slide file. Then, he clicks Start Lecture button, which makes the server creates a lecture session and start waiting for the client to connect. The instructor can move to the next or the previous slide by clicking the arrow buttons. He/she can also annotates on the slide by selecting the pencil button and drawing on the slide panel.

The UI of the student's iPad tablet client consists of the following panels: slide, video of the instructor, participant list, and feedback from students. When a tablet client starts running, it connects to the instructor's desktop server, joins the current lecture session and starts receiving video/audio, slide/annotation, and feedback from students from the server.

A student can enter a question in the feedback-from-students input panel and press the send button. When an instructor sees the question in the feedback-from-students panel, he can answer to it by video/audio, slide/annotation, and text.

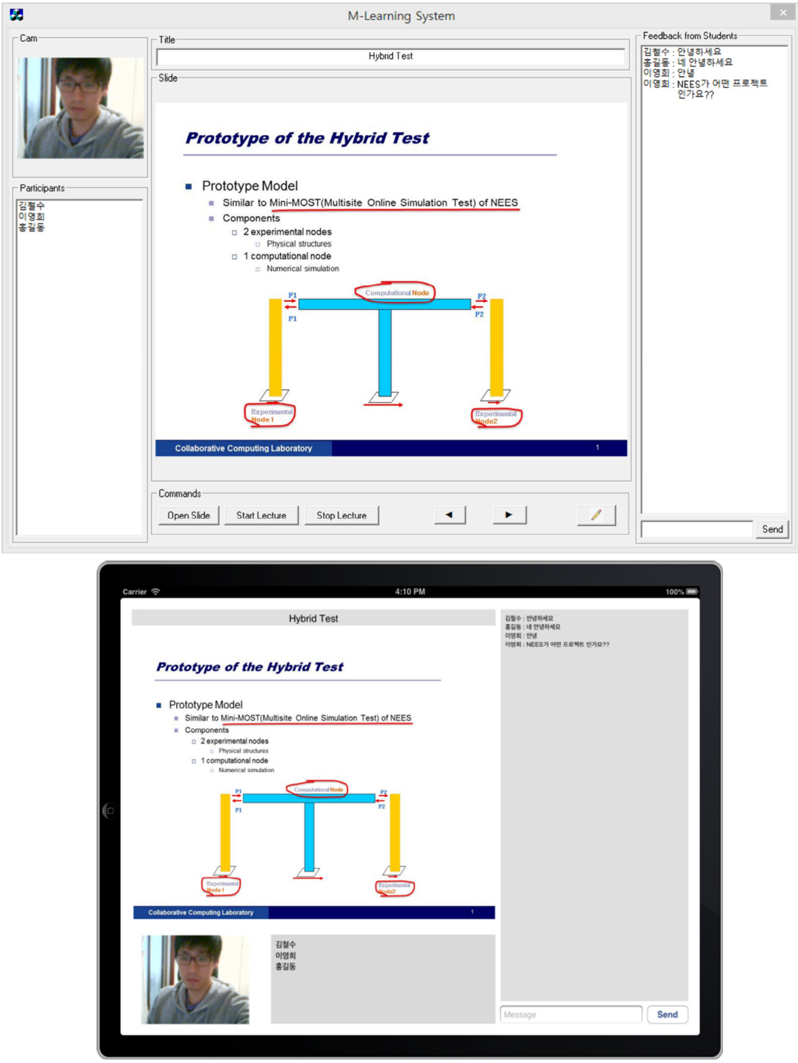

Fig. 2. Prototype UIs of instructor's desktop server (upper) and student's tablet client (lower)

We showed the current tablet-based prototype to a small group of students and asked them to compare it with our previously-developed smartphone-based system.

They mentioned that the slide/annotation and the text feedback are easier to recognize than the smartphone-based system that suffered from its inherent small display. In fact, most of the students said they felt more focused during lecture with the tablet-based system than they did with the smartphone-based one. They also mentioned that typing feedback to the instructor is easier and quicker with the bigger virtual keyboard on a tablet than smartphone-based system.

However, they also pointed out tablet is not as portable as smartphone since it is thicker and heavier. We believe this portability issue will lessen as new thinner and lighter tablets become available in the market in the near future. In overall, most of the students said they felt that the presented tablet–based system provides better learning experience and higher satisfaction than smartphone-based system.

4 Conclusions

We present a tablet-based synchronous mobile learning system that allows students to watch video and slides with annotation as well as to send text feedback to an instructor in real time during the lecture with their tablets.

Most of the students commented that they were able to focus more on the lecture with the presented tablet-based system than with smartphone-based system.

We are currently working on the optimization of decoding and rendering of the video/audio and slide with annotation on an iOS-based tablet. We plan to conduct more detailed user evaluation when we complete our prototype. We hope that the presented system will contribute to students' better distance learning experience.

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Designing and Evaluating Collaborative Learning Scenarios in Moodle LMS Courses

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Abstract. The main purpose of this paper is to present a service called Teaching Assistant. The aim of the assistant is to facilitate the task and assessment management in collaborative learning scenarios. This assistant intends to help instructors to design and to evaluate collaborative learning tasks in this type of scenarios. For the development of the Teaching Assistant we defined an instructional model based on the Group Investigation method. The implementation of the assistant is embedded into the Learning Management System Moodle. Nowadays, a research study has been performing with students and instructors at the Universidad Pontificia Bolivariana, UPB-Montería (Colombia). The objective of the study is to identify the effect of the Teaching Assistant in the design process of the collaborative learning scenarios scripted by the instructors in Moodle. Specifically, how the assistant decreases the time used in this process. Due to this improvement, the learning experiences can be better.

Keywords: Collaborative Learning Scenarios, Computer Supported Collaborative Learning (CSCL), Teaching Assistant, Task management, Assessment management, Moodle.

1 Introduction

Collaborative learning is a tendency which has many advantages and it is being widely used in the academic field. This type of learning is appropriate when the main objective is that the students learn in a group manner. There are several environments, systems and applications to support collaborative learning in traditional learning methods. It is known as Computer Support Collaborative Learning (CSCL) [1]. In this context, we have considered that a collaborative learning scenario comprises three interconnected entities, such as: i) the users: students and instructors, ii) the learning systems which support the collaborative learning tasks and iii) the collaborative learning tasks performed by students and instructors.

From the mentioned entities, the learning systems are frequently used to support the learning tasks scripted by the instructors and completed by the students. In this context, the Learning Management Systems (LMS) are powerful systems employed

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during the e-learning processes. The instructors use a LMS to create and evaluate courses, and the students use it to perform the learning tasks, to submit content and to communicate with their classmates and the instructors.

One of the more popular and extensively used open-source LMS is Moodle (Modular Object Oriented Developmental Learning Environment) [2]. Moodle is been used for the last seven years in the learning processes at the Universidad Pontificia Bolivariana, UPB-Montería (Colombia). This system supports the management and learning tasks without replacing the instructors. In this sense, the instructors from UPB have been using the tools and the services of the Moodle system to assist the face-to-face traditional learning. However, this system presents several boundaries specifically to support collaborative learning tasks between students.

The mentioned lack motivated us to propose the service called Teaching Assistant that intend to facilitate the task and assessment management in collaborative learning scenarios developed into the Moodle system.

The paper is structured as follows. Next, we present the related work. Section 3 is a description of the implemented Teaching Assistant in the Moodle system. In Section 4 we explain the experimentation. Finally, the paper ends with some conclusions and future research issues (Section 5).

2 Related Work

The LMS have been used as powerful platforms to support learning-teaching processes in the academic context. As we mentioned in the introduction, the Moodle system is one of the more important and widely used free LMS. In this system the instructors can design web-based courses and to create effective online learning sites [2].

In the literature, we can find a great number of important issues related to the LMS, and specifically with Moodle system. These issues have emerged from the use of the Moodle to improve the face-to-face courses and to build online learning community [3]. Some researchers have been exploring about how students' evaluation supported by Moodle can facilitate the preparation of assignments, the auto-evaluation and to contribute to the formative e-assessment in LMS courses [3, 4].

Additionally, others research studies have been focusing in the emergence of the commercial LMS and their evolution to open-source systems. These studies emphasize in the results of the comparative evaluations between Moodle and others LMS such as Blackboard, LAMS, Sakai and DotLRN [5, 6, 7, 8]. Although Moodle has many advantages compared with others LMS. This system presents several limitations. For instance, this system is not yet a full collaborative learning system.

Moodle is continually evolving due to the instructional designers, developers and researchers have been improving this system through the development of services that allow add new functionalities to the system. These works are tested with students and instructors communities in several universities [9, 10, 11].

3 The Teaching Assistant

For the implementation of the Teaching Assistant we defined an instructional model based on the Group Investigation method [12]. This is a collaborative learning teaching method that includes four important components: i) investigation, ii) interaction, iii) interpretation and iv) intrinsic motivation.

The developed Teaching Assistant has been embedded in the Moodle system through the development of one workspace integrated by five tools as follow: i) the Task Manager, ii) the Assessment Manager, iii) the Motivation Booster, iv) the Notification Manager and v) the Report Manager.

The Task Manager allows the instructors to design the collaborative learning scenarios in the Moodle system. The instructors can set several learning tasks. S/he defines the task name, description, deadline, number of required tasks, etc. And the students can carry out the collaborative tasks when they participate in a group way in the learning scenario.

The Assessment Manager helps the instructors to set the assessment criteria for the collaborative learning scenarios. This manager suggests the instructors the final grade obtained by the students when they complete the collaborative learning tasks in the system. The instructor revises the students' grades and s/he decides to accept or to adapt the automatically generated grades by the manager.

The Motivation Booster is an awareness service that provides feedback information to the students and instructors. This information is related to the progress of the collaborative learning tasks performed by the students. This service shows the information through the motivational messages to students and these same messages are sent via e-mail [11, 13].

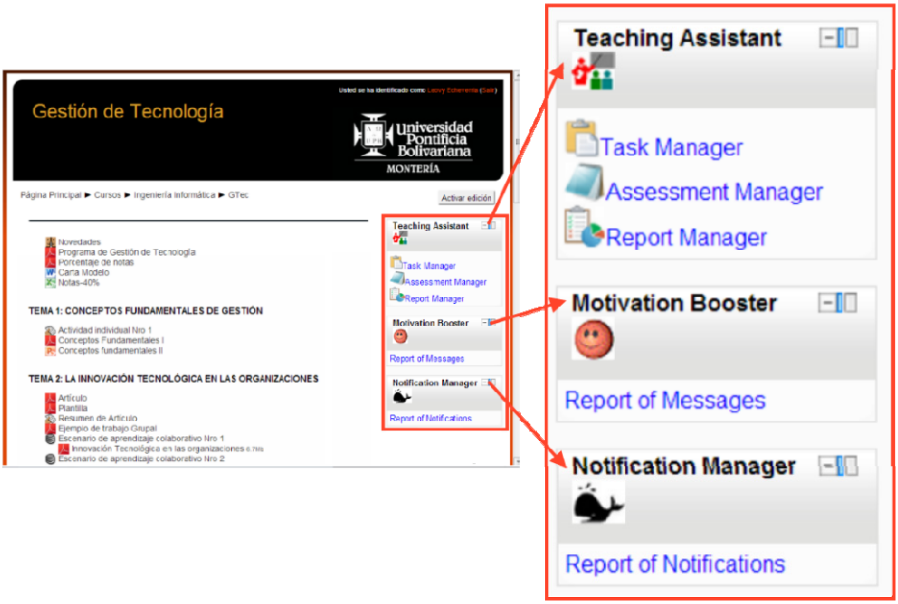

Fig. 1. Screenshot of the Teaching Assistant in Moodle

The Notification Manager is an awareness information service to support student to student interaction when they perform collaborative learning tasks in the Moodle system.

The Report Manager presents detailed information about the students' interactions with the Teaching Assistant. The students and the instructor can read a students' report.

The Teaching Assistant was implemented by developing three new “block” plugins which were integrated to the Moodle system. These plugins were developed using PHP (Hypertext Pre-processor) and HTML5 (Hypertext Markup Language).This structure allows us to use the plugins as components individually. The Fig. 1 shows a screenshot with the three plugins embedded in the Moodle system.

The Fig. 2 presents a screenshot with the Report Manager. This report shows information about the students’ performance. The performed tasks, the completed tasks on time, and the grades obtained by the students are shown.

Users	Entries	Entries on time	Grade	Comments	Comments on time	Grade	Ratings	Ratings on time	Grade
Carlos	3	2	4.0	15	13	4.5	8	6	3.5
Mariamne	3	1	3.5	12	11	4.3	9	8	4.2
Andres	2	2	3.8	15	15	5.0	8	7	3.8
leovy	3	2	4.0	11	11	4.2	8	7	3.8
buendia	3	3	5.0	12	11	4.3	9	9	5.0

Fig. 2. The Report Manager of the Teaching Assistant

4 Experimentation

With the aim to perform an exploratory data analysis, one individual questionnaire was applied to thirty-three instructors of four faculties from the UPB-Montería (Colombia): i) Informatics Engineering, ii) Bussiness Administration, iii) Architecture and iv) Economy. The objective was to know the instructors’ interest factors when they use a LMS. Specifically how the instructors of UPB-Montería have been using Moodle.

The results of the binomial test with a confidence level of 95% showed that between 45.1% and 79.6% of instructors of UPB-Montería use Moodle. Specially, the instructors belong to the Informatics Engineering and Architecture faculty. From these instructors between 38.4% and 81.9% of them use Moodle to design web-based courses. Finally, between 83.9% and 100% of the instructors that design courses in Moodle would like to use a service to support the design of tasks and assessments in the system (i.e. that this service could provide the Teaching Assistant facilities). This allowed us to corroborate the necessity to develop and to integrate one assistant in the Moodle system.

Currently, at the UPB-Montería, one group of instructors has been participating in one experiment. These instructors have been designing collaborative learning scenarios without the assistant in a specific topic, and otherwise they will use the assistant embedded in the Moodle system to support the design of scenarios in another topic. In both topics three dependent variables will be recorded from the instructors’ interactions with the system: i) The average time taken by the instructor in the design of a collaborative learning scenario, ii) The average number of collaborative learning scenarios designed by the instructor and iii) The average number of learning tasks scripted as part of a collaborative learning scenario. The main learning tasks that the students can perform in a collaborative learning scenario are: i) add entries, ii) submit comments to other classmates' entries and c) submit ratings to other classmates' entries.

The aim in this experiment is to corroborate the follow hypothesis:

- H1: The average time taken by the instructor in the design of a collaborative learning scenario when s/he uses the Teaching Assistant is lower than the average time taken without the assistant.
- H2: The average number of collaborative learning scenarios designed by the instructor using the Teaching Assistant is greater than the average number of collaborative learning scenarios designed without the assistant.
- H3: The average number of learning tasks scripted as part of a collaborative learning scenario using the Teaching Assistant is greater than the average number of learning tasks scripted without the assistant.

At the end of the experimentation, by means of the paired T-test, the mentioned hypotheses are corroborated. And we will expect that the assistant helps the instructor in the design of the collaborative learning scenarios in an easy manner. Especially, it supports the tasks and assessment management. In this way this assistant would enhance the learning experiences. Finally, the students and the instructor will answer a survey in order to evaluate the impact of the Teaching Assistant used in each learning scenario.

5 Conclusions and Future Work

In this paper we have presented a Teaching Assistant. This assistant is a service to support the design and evaluation of collaborative learning scenarios. The assistant was integrated into the Moodle LMS through the development of one workspace composed by five tools. For the implementation of the assistant, we created an instructional model founded on the Group Investigation method.

An experimentation, which has been carried out with students and instructors at the Universidad Pontificia Bolivariana, UPB-Montería (Colombia) was presented in this paper. The results that are being obtained from this experimentation allow us to corroborate the established hypotheses. In this manner, we are testing the implemented assistant.

As future work, we propose to improve the implementation of the assistant through the development of news Moodle components. Finally, we will evaluate the implementation doing other research studies with students and instructors at the Universidad Pontificia Bolivariana (Montería, Colombia) and others Colombian universities.

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Towards the Extension of a LMS with Social Media Services

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Abstract. The Social Media is a term used to define a wide range of network tools or technologies, which deal with the social aspects of internet as a channel of communication, collaboration and creative expression. This type of environments has been used for educational practices in different areas, competing sometimes with e-learning institutional environments, such as the Learning Management Systems (LMS).

This paper proposes the extension of a specific LMS, Moodle, through Social Media services. This plugin provide the interaction and collaboration of all users. The main aim of the proposed approach is to enrich the existing educational process provided by this LMS.

Keywords: e-Learning, Computer Supported Collaborative Learning (CSCL), Learning Management System, Social Media, Moodle.

1 Introduction

The Web 2.0 allowed that the content and the applications are no longer created and published by individuals, but instead are continuously modified by all users in a participation and collaborative mode. Users use this platform to deploy different types of sites, such as: networking sites, blogging, microblogging and internet forums, which are social media applications. These websites offers the possibility to create and exchange the user generated content. Studies show that undergraduate students increasingly use social media services, to communicate, express and interact. This success of social media tools could take advantage in learning [1].

Nowadays, e-learning is one of the most used trends in teaching-learning initiatives, both in companies as in educational institutions. These organizations principally use LMS (Learning Management System) to support learning activities. Spanish universities are an example, because the 100% use LMS [2]. An LMS provides to students and instructors with a set of tools to improve the learning process, but there are certain limitations. The platform doesn’t allow the interaction among students; it only offers services which the instructor can use to interact with them. The institution has the control of the LMS, the faculty and administrators, leaving not much space to the students to manage and maintain the learning space and to facilitate his own activities. Moreover, the connection between his/her friends and social networks is inexistent [3].

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It is known that LMS have a limited functionality to support educational activities from a socio-constructivist perspective. Moreover, LMS are focus on the organization, furthermore educational materials and opinions about them are provided only by instructors, and it is not promoted the communication and interaction among students.

These limitations of the LMS show that the formal learning is present, but informal learning is absent, though important and considered as vital to education [4].It has been argued that these social networking sites facilitate informal learning for the participants. Researchers have analyzed interaction that has taken place in social networking sites and have identified sharing of ideas, providing of peer feedback, and engagement in critical thinking [5]. The educational institutions are based in on traditional LMS and not take advantage from social media applications to stimulate informal learning.

The majority of students use social networking sites, blogs and wikis offering unprecedented opportunities to create, share content and to interact with others. The communication features in the LMS are poorly utilized in most institutions, the LMS being used primarily as storage facilities for lectures notes and PowerPoint presentations [7]. The LMS must evolve to provide communication where users can interact in this platform and don't use an alternative environment.

Social Media is increasingly supporting informal learning becoming an important element of education. Learning in the context of social media has become highly self-motivated, autonomous, and informal, as well as an integral part of the college experience. The e-learning has now been shifted into a new generation that focuses on more learner engagement and social learning [6].

This paper proposes an extension of the Moodle LMS that aims to promote interaction between students and instructors on the platform. This plugin for Moodle is a new course format which provides features that usually can be found in the social networking websites. We named this plugin Social Media Format (SMF).

2 Background

There are several approaches in the educational context for the integration of social media and LMS. The first scenario is that the LMS and social networks exist in parallel. Instructor can use social networks without a real connection, for example create a hashtag in Twitter for the subject or a group in Facebook where anyone can join. Shiu[8] proposed the use of social networking websites for conducting courses. His example is the creation of photo albums as a format to post lectures notes, taking advantage of comments services to ask questions and the instructor being notified immediately. In this work also described the use of a tool to facilitate the evaluation process through multiple choice quizzes using the application QuizMaker (http://apps.facebook.com/quizmaker) that allow the definition and management of forms.

The second scenario is when the LMS and the social media application are connected among themselves. For example Labus et. al.[6] developed an Edutainment Application with API Facebook where the students can enter into the application if the email account is the same with who enrolled in Moodle.

The last stage would be the extension of the LMS that the students and instructor are trained to use. The main advantage is that the LMS wouldn't depend on an external platform to provide these services, such as social networks, that can change the configuration. Other affordance is the extension of a platform that students and instructors are highly engaged using it to support sessions face to face. An example of Social LMS is Kenexa Learning Suite 3.0 provides social networking, collaboration and knowledge sharing capabilities, as well as interactive elements that allow users to rate learning content and share their experiences with other users. (http://www.kenexa.com)

3 Approach

Moodle (Modular Object-Oriented Dynamic Learning Environment) is an open source system that has numerous plugins to provide specific functionality. There are different types of plugins such as: activities, blocks, authentication plugins and course format. Our approach consists in proposing a new course format that has the characteristics to make social Moodle. We named this plugin Social Media Format (SMF).

We chose Moodle because is a widespread platform, for instance Spain is the second country with more Moodle sites registered among 229 countries (https://moodle.org/stats/). Besides that we took into account the use in Spanish Universities, approximately more than half use it to create their courses [2].

We identified different services that the social networks offer and are appropriate for the educational platform. For promoting the interactivity among students and instructors we defined a mechanism where they may rate and commenting resources. The user can evaluate a comment as useful or not useful, also giving a rate among 1 to 5. Those mechanisms allow the asses and the manipulation of resources, leading to negotiation and criticism, which are the basic processes of social interaction.

For stimulating the interaction among students we implemented a notification service, where a BBS (Bulletin Board System) is the way for summarizing the set of users actions the group are performing. The event notification is a mechanism to know what others are doing. Through these notifications maybe the users interact and work in the same direction. The board wasn't created to remove standard course formats that appear in Moodle such as: weekly, topics and social format, therefore they would exist in parallel. That means, it is possible the combination of SMF with course formats which are by default in Moodle.

This course format was used for the first time in a course Social Networks and Collaboration on the Internet (SNCI) of master's degree in Research and Innovation in Information and Communications Technologies (I2-ICT) at Higher Polytechnical School at the University Autonoma of Madrid. In this course were planned activities in which students and teachers had to interact with the platform, proposing events, giving comments about resources, activities or comments. They also had to share resources they could rate and vote. The test of the SMF was end with a questionnaire. When they enter into the site of the course, they found a BBS that is shown in Fig. 1.

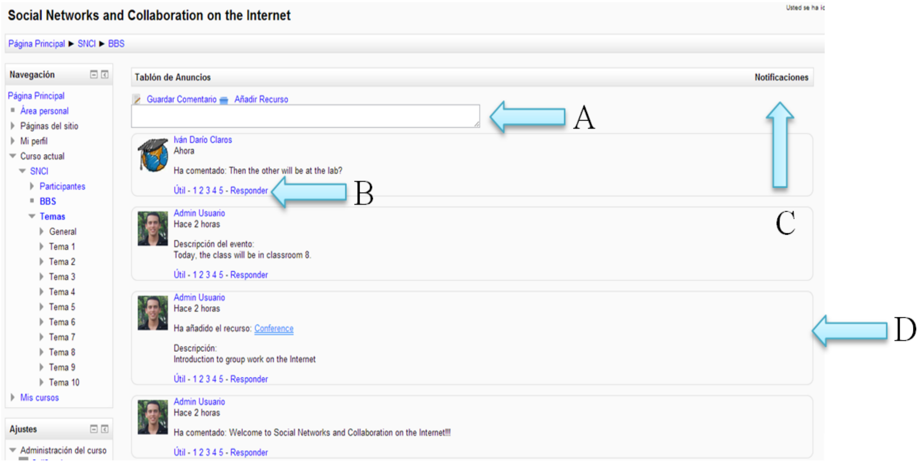

Fig. 1. Show the BBS developed for SMF

The BBS is integrated by four areas: A) There is a space, that provides the user to insert comments and resources B) mechanism of interaction are shown C) the notification area D) the list of events, comments and resources that have been inserted along the course. The BBS was developed using with PHP and YUI3 (Yahoo! User Interface) is a free, open source JavaScript and CCS library. We picked this library because has been chosen as the official Javascript framework for Moodle.

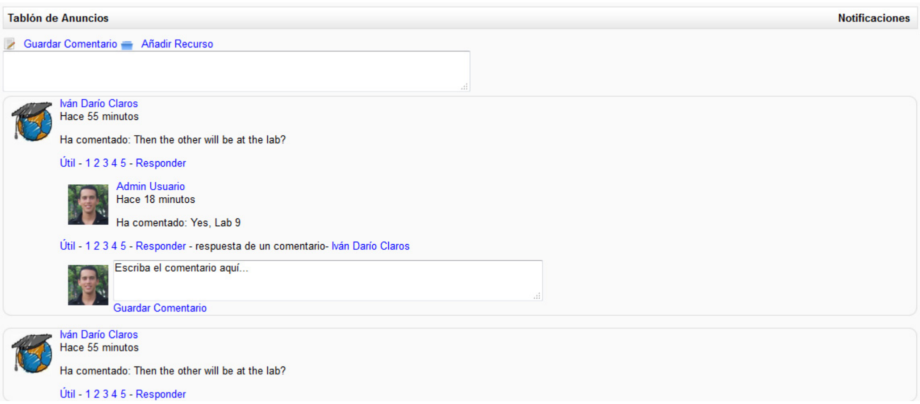

Fig. 2. Show the reply structure for SMF

The area A) allows us to insert comments and resources. The resources can be added in two ways, the first one from a local folder and the other through a URL. To stores the files, we used File API (Moodle API for managing the files). Using the mechanism of interaction we can rate and evaluate the resources, events and comments, and also reply to ask a question or propose a subject. The notification area will show the last activities occurred on the platform and indicate which ones the user has not seen. Some notifications will be sent by email the user can deactivate or allow receiving it.

In Fig. 2 we show the configuration we chose for the reply and publish an answer. We rely on Youtube for developing this kind of structure, being used for more than 1 billion unique users each month. [9] We think that the application of this model of comments can enhance the interaction among users in the learning platform.

At the end of the semester the students felt comfortable according the questionnaire. The new way of showing the course in the e-learning platform according with the students with the addition of social services influence to them in the following ways: i) they were motivated to ask about their doubts and answers to others classmates through comments, because they recognize that they can help each other in this way, ii) they were all the time informed about the new actions from everybody, and moreover they were continuously accessing to the course.

4 Conclusions and Future Work

Moodle is an e-learning platform open source in which the implementation of social media services is feasible. In this paper, an extension of Moodle through a plugin is proposed. The development of this plugin allows users not use an alternative tool to communicate each other. Through this course format they can share their doubts, propose solutions and resources complementing the lectures notes provided by the instructor.

This paper proposes a course format for Moodle with social media services for the use in the e-learning process. The increasingly use of social networks to post comments and pictures took us to provide this services but in an e-learning environment. The addition of tools of communication like a social network allows students and instructors interact in a LMS. With this approach we get close to a social LMS.

The LMS Moodle was transformed in a platform where the interaction among students and instructors is possible and the users felt comfortable using it. We will continue our work giving to Moodle not only features that benefit the communication, also to provide a collaborative scenario. Will working on trying to connect Moodle with collaborative tools such as: GoogleDocs and Dropbox.

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Efficient Usage of Collective Classification Algorithms for Collaborative Decision Making

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Abstract. Collective classification algorithms with underlying network structure of related entities are a powerful modelling tool that can address collaborative decision making problems. The paper presents the usage of collective classification algorithms for classification problem in which unknown nodes are assigned with classes based on the classes of known nodes. In such problem the classification decision for particular node is inferred from collaborative knowledge of nodes with known classes and underlying network connections. The paper considers Iterative Classification (ICA) and Loopy Belief Propagation (LBP) algorithms applied in various network configurations for collaborative decision making. The experimental results revealed that greater number of output classes decreases classification accuracy and LBP outperforms ICA for dense network structures while it is worse for sparse networks.

Keywords: Collaborative Decision Making, Collective Classification, Iterative Classification, Loopy Belief Propagation.

1 Introduction

Traditionally, collaborative decision making (CDM) was recognized as a process of debates and negotiations among a group of people in order to make a decision. Therefore, CDM can be considered as problem with collaborative outcome that is a result from argumentative discourse and joint cooperation of human beings. It can be usually observed, that expected consensus emerges through the consideration of all alternative competing interests, priorities and constraints. In order to model CDM formally the underlying approach have to be articulated in a concise and agreed upon manner. One of a very powerful representations of collaborative environment, that can be utilized to undertake the collaborative decision is a network. This representation may be given in a various types of graphs. Depending on the assumed property these can be undirected, oriented or directed graphs organized in multigraphs, hypergraphs or pseudographs [1]. Additionally graphs can be unlabelled, edge-labelled, vertex-labelled or vertex and edge labelled. Using networks allows to represent the humans as vertices and all the relations between them as edges. Additionally, labels assigned to vertices can reflect particular standpoints.

It is addressed in the paper a very specific collaborative decision making problem - collective classification accomplished in network. Solving collective classification task

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it is expected to obtain the class of unknown network's nodes based on the available classes of known nodes. As the structure of connections is accessible for all nodes (with known and unknown class labels) it is utilized in the label inference process.

In general, there have been proposed several types of collective classification approaches. This paper provides an experimental comparison for Iterative Classification Algorithm (ICA) and Loopy Belief Propagation (LBP) algorithms that can be applied in order to solve the collaborative decision making problem.

The paper provides concise presentation of related work in the field of collective classification in Section 2, short description of considered algorithms in Section 3, experimental results and comparison of the methods together with evaluation of the algorithms' accuracy for different contributions of the known labels in the entire network are gathered in Section 4 and concluded in Section 5.

2 Related Work

There exist a variety of methods for collective classification. However, it can be distinguished two distinct types of them: local and global. The former methods use a collection of local conditional classifiers successively applied to the unknown nodes whereas the latter are defined as optimization of one global objective function [2].

Additionally classification of nodes in network can be solved using two distinct approaches: within-network and across-network inference. Within-network classification [3], for which training nodes are connected directly to other nodes, whose labels are to be classified, stays in contrast to across-network classification [4], where models learnt from one network are applied to another similar network.

There are related several problems with collective classification that have been currently addressed by researchers. One of them is the problem of what features should be used to maximize the classification accuracy. In approaches which use local classifiers the relational domain needs to be transformed to standard notation by application of proper aggregation operator. It has been reported that precise solution strongly depends on the application domain [5]. The previous research showed that new attribute values derived from the graph structure of the network, such as the betweenness centrality, may be beneficial to the accuracy of the classification task [6]. It was also confirmed by other research discussed in [7].

Another interesting problem in collective classification based on iterative algorithms is the ordering strategy that determines, in which order to visit the nodes iteratively to re-label them. The order of visiting the nodes influences the values of input features that are derived from the structure. A variety of sophisticated or very simple algorithms can be used for this purpose. Random ordering that is one of the simplest ordering strategies used with iterative classification algorithms can be quite robust [8].

One of the most popular local collective classification methods is Iterative Classification Algorithm (ICA) introduced by Geman & Geman in the image processing context [9]. It belongs to so called approximate local inference algorithms basing on local conditional classifiers [10]. Another technique is a Loopy Belief Propagation (LBP) [11] that is the global approximate inference method used for collective classification. As in the literature it was not found the comparison of predictive accuracy of mentioned methods across datasets from distinct domains we examine these algorithms using eight distinct datasets and present the comparison in the paper.

3 Collective Classification Techniques

3.1 Iterative Classification

The basic idea behind ICA is quite simple but reasonable. Considering a node $v_i \in V^{UK}$, where V^{UK} is a set of nodes with unknown label, $V^{UK} \subset V$, we aim to discover its label l_i. Having known labels of v_i's neighbourhood ICA utilizes a local classifier Φ that takes the attribute values of nodes with known labels (V^K) and returns the best label value for v_i from the class label set L. If the knowledge of the neighbouring labels is partial the classification process needs to be repeated iteratively. In each iteration labelling of each node v_i is done using current best estimates of local classifier Φ and continues until the label assignments are stabilized. A local classifier might be any function that is able to accomplish the classification task. It can range from a decision tree to an SVM in its place.

Algorithm 1 depicts the ICA algorithm as a pseudo-code where the local classifier is trained using the initially labelled nodes V^K only. It can be observed that the attributes utilized in classification depend on current label assignment (lines 8 and 9 in Algorithm 1). Thus there need to be performed the repetition of classification phase until labels stabilize or maximal number of of iteration is reached.

Algorithm 1. Iterative Classification Algorithm (ICA), the idea based on [10]

1: **for** each node $v_i \in V^{UK}$ **do**
2:     compute x_i, i.e. v_i's attributes using observed nodes V^K
3: **end for**
4: train classifier Φ by Θ optimization using attributes of V^K nodes
5: **repeat**
6:     generate ordering O over nodes in V^{UK}
7:     **for** each node $v_i \in O$ **do**
8:         compute x_i, i.e. v_i's attributes using current assignments
9:         $l_i \leftarrow \Phi(x_i, \Theta)$
10:     **end for**
11: **until** label stabilization or maximal number of iterations

3.2 Loopy Belief Propagation

Loopy Belief Propagation (LBP) is an alternative approach to perform collective classification in comparison to ICA. The main difference is that it defines a global objective function to be optimized, instead of performing local classifiers optimization.

Intuitively, LBP is an iterative message-passing algorithm. The messages are transferred between all connected nodes v_i and v_j, $v_i, v_j \in V$, $(v_i, v_j) \in E$, and might be interpreted as belief of what v_j label should be based on v_i label.

The global objective function that is optimized in the LBP is derived from the idea of pairwise Markov Random Field (pairwise MRF) [12]. In order to calculate the message to be propagated the calculation presented in Equation 1 is performed.

$$m_{i\to j}(l_j) = \alpha \sum_{l_i \in L} \Psi_{ij}(l_i, l_j)\phi(l_i) \prod_{v_k \in V^{UK} \setminus v_j} m_{k\to i}(l_i) \tag{1}$$

where $m_{i\to j}(l_j)$ denotes a message to be sent from v_i to v_j, α is the normalization constant that ensures each message sum to 1, Ψ and ϕ denotes the clique potentials. For further explanation see [10].

The calculation of believe can be concisely expressed as in Equation 2:

$$b_i(l_i) = \alpha\phi(l_i) \prod_{v_j \in V^{UK}} m_{j\to i}(l_i) \tag{2}$$

The LBP algorithm consist of two main phases: message passing that is repeated until the messages are stabilized and believe computation, see Algorithm 2.

Algorithm 2. Loopy Belief Propagation (LBP), the idea based on [10]

for each edge $(v_i, v_j) \in E, v_i, v_j \in V^{UK}$ **do**
  for each class label $l_i inL$ **do**
    $m_{i\to j}(l) \leftarrow 1$
  end for
end for
//perform message passing
repeat
  for each edge $(v_i, v_j) \in E, v_i, v_j \in V^{UK}$ **do**
    for each class label $l_i \in L$ **do**
      $m_{i\to j}(l_j) \leftarrow \alpha \sum_{l_i \in L} \Psi_{ij}(l_i, l_j)\phi(l_i) \prod_{v_k \in V^{UK} \setminus v_j} m_{k\to i}(l_i)$
    end for
  end for
until stop condition
//compute beliefs
for all $v_i \in V^{UK}$ **do**
  for all $l_i \in L$ **do**
    $b_i(l_i) \leftarrow \alpha\phi(l_i) \prod_{v_j \in V^{UK}} m_{j\to i}(l_i)$
  end for
end for

4 Experimental Study

4.1 Experimental Scenarios

In order to evaluate the considered collective classification algorithms in the context of collaborative decision making modelled as collective classification the predictive accuracy of ICA and LBP algorithms was examined. For this purpose an experimental environment has been developed in Java language. The ICA approach was provided with C4.5 decision tree as a base classifier. The experiments were carried out on original dataset with primary prepared splits between nodes with known and unknown labels. Each dataset was split into known and unknown node sets in nine distinct proportions (from 10% to 90% unkown labels). The split was accomplished by node sampling using uniform distribution. In order to assess distinct classification approaches standard measure of classification accuracy was recorded.

4.2 Datasets

The experiments were carried out on six datasets. The AMD_NETWORK graph presents seminary attendance at conference. The dataset was a result of a project that took place during The Last HOPE Conference held in July 18-20, 2008, New York City, USA. At this conference RFID (Radio Frequency Identification) devices were distributed among participants and allowed to uniquely identify them and track in which sessions they attended. The data set is build from information about descriptions of interests of participants, their interactions via instant messages, as well as their location over the course of the conference. Location tracking allowed to extract a list of attendances for each conference talk. In general, the most interesting for experiment information included in dataset are: information about conference participants, conference talks and presence on talks. The genealogy dataset CS_PHD is the network that contains the ties between Ph.D. students and their advisers in theoretical computer science where arcs points from an advisers to a students [13]. The dataset NET_SCIENCE contains a co-authorship network of scientists working on network theory and experiment [14]. It was extracted from the bibliographies of two review articles on networks. The biological dataset YEAST consists of protein-protein interaction network [15]. The PAIRS dataset is a dictionary from The University of South Florida word association, rhyme, and word fragment norms. This graph presents correlation between nouns, verbs and adjectives. Additionally, collective classification approaches were examined on artificially generated graph: CRN. The dataset was created according to simple sampling procedure constructing edges between nodes in accordance to the frequency of given class label in whole dataset. Namely if the the node is of a frequent class it has small degree and if the class is rare it has high degree. For CRN it was used 4 classes with highly skewed distribution. The profiles of the datasets were shortly depicted in Tab. 1.

4.3 Results

The accuracy values for various contribution of known nodes (from 10% to 90%), for both classification algorithms (ICA and LBP) were presented in Fig. 2.

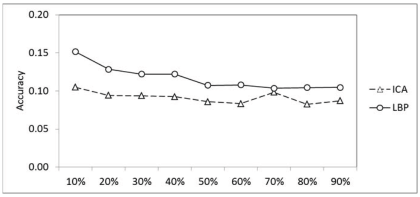
As we can see the average accuracy is at different level for various datasets. For the NET_SCIENCE dataset, it exceeds 10% only once, whereas for PAIRS_FSG, it is regularly above 70%. Overall, better results can be achieved if the problem is simpler, i.e. the greater the number of classes the worse results. It means that the quality of collective classification, like other, regular classification methods, strongly depends on the problem and sometimes it is hardly to obtain very good results.

Table 1. Basic properties of datasets utilized in experiments

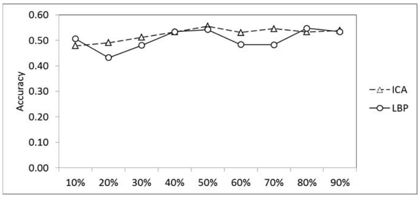
Dataset	Nodes	Edges	Classes	Avg. node degree
AMD_NETWORK	332	69092	16	208.108
CRN	327	324	4	0.990
CS_PHD	1451	924	16	0.636
NET_SCIENCE	1588	2742	26	1.726
PAIRS_FSG	4931	61449	3	12.461
YEAST	2361	2353	13	0.996

In almost all cases Iterative Classification (ICA) outperforms Loopy Belief Propagation (LBP), especially where it works worse for the sparse networks, i.e. with the small average degree value about 1 (CS_PHD, YEAST, CRN, NET_SCIENCE). However, the LBP's results are boosted for dense networks - average degree above 6 as for AMD_NETWORK and PAIRS datasets. These differences were smaller for artificial dataset CRN than for real ones. The difference in accuracy for smaller contribution of unknown nodes (e.g. 10%) and for most nodes unlabelled (90%) is not significant.

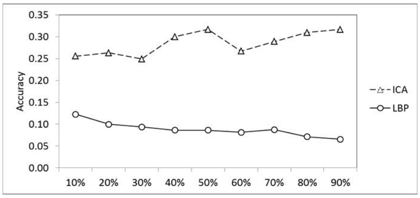
Table 2. Accuracy of collective classification performed by ICA and LBP algorithms for particular datasets



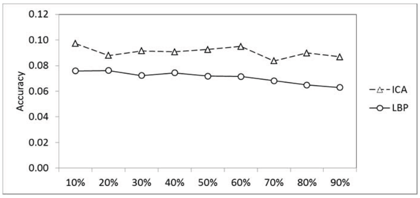
(a) AMD_NETWORK



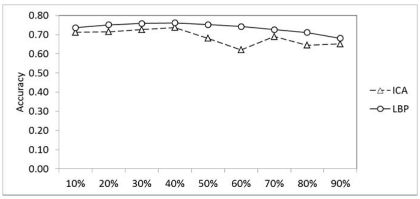
(b) CRN



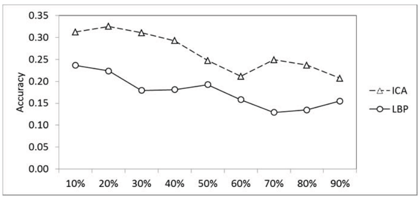
(c) CS_PHD



(d) NET_SCIENCE



(e) PAIRS_FSG



(f) YEAST

5 Conclusions and Future Works

The main goal of the paper was to present and investigate various algorithms for classification of nodes in the network (collective classification algorithms) in the context of collaborative decision making. The selected methods that were considered in the paper represent two distinct approaches to collaborative modelling of classification. Whereas the Iterative Classification (ICA) utilizes local classifiers the Loopy Belief Propagation (LBP) algorithm optimizes global objective function. This makes the latter algorithm more intuitively applicable for collaborative decision making.

The general conclusion derived from the experiments carried out on 6 datasets revealed that LBP outperforms ICA for dense networks and it is worse for sparse structures. Generally, better results can be obtained in case of smaller number of classes.

Summarizing, the usage of collective classification algorithms as well as underlying network representation of collaborative environment is a powerful modelling tool that can address collaborative decision making problems.

The future work will focus on further analysis of collaborative schemes in collective classification problems as well as on the analysis of computation efficiency of considered algorithms.

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User-Driven Data Preprocessing for Decision Support

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Abstract. Decision trees are helpful decision support tools, due to their graphical nature and the easiness to obtain them from data. Unfortunately, decision tree size tends to grow according to the complexity of the learning data, which may be problematic in real world settings. This paper proposes an original solution to reduce the size of decision trees by taking user preferences into account. More specifically, we present a user-driven algorithm that automatically transforms data in order to construct simpler decision tree. A prototype has been implemented, and the benefits are shown on several UCI datasets.

Keywords: decision tree, data preprocessing, user-driven.

1 Introduction

Originally used as an analytical decision support tool, decision trees are a convenient way to model the logic behind the data. They provide an overview of the rules underlying the data by using a form which is intuitive and easy to understand for domain experts [1]. In order to support decision making, trees can be built from data by using well-known induction techniques [1, 4] or by using recent algorithms [8].

From a pragmatic point of view, decision trees are known for their tendency to grow excessively large [6], due to the complexity of real world data (size, outliers, missing values, etc.). On the one hand, a fit solution to this problem is decision tree pruning; even if it is an old domain in the classification area [5, 6], recent works have tried to use pruning to build simpler models according to user preferences [7]. On the other hand, reducing decision trees size can be done by using data preprocessing before decision tree induction [6]. Commonly used as a preliminary for machine learning [2], data preprocessing transforms a dataset so that its use in a given task (visualisation, knowledge extraction, support for modelling etc.) is facilitated. More precisely, data preprocessing is a generic term which regroups several kinds of data manipulation tasks [3]: '*cleaning'* (treatment of noise/extreme/redundancy/unknown value, etc.), '*dimensionality altering*' (construction/transformation/filtering of features, etc.) and '*quantity altering*' (selection/sampling of the data records). As data preprocessing generally causes information loss (example: feature or records deletion, etc.), it has to be carefully used, and a user has to be able to control information loss.

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2 Contribution

This paper presents a method to find an ordered combination of data preprocessing operations which transforms a given dataset so that the modified dataset leads to a decision tree with a lower complexity [6].

The method is driven by the user's preferences, materialized by the *acceptable data completeness factor*. This indicator reflects the acceptable loss of information for the user, which can occur when using data preprocessing methods (records removal, loss of precision after discretization, etc.). As an example, if the user accepts to lose up to 10% of information, then he should specify 90% as the acceptable data completeness factor.

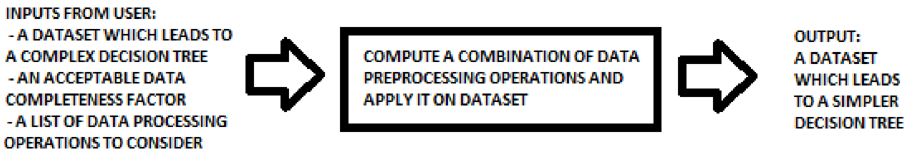

Fig. 1. Method overview

In practice, the current data completeness of a modified dataset is obtained by computing the count of values (i.e. the count of cells) which are not modified during data preprocessing.

Given the user's inputs (Fig 1), the method consists of trying to apply on the dataset different combinations of data processing operations (the cardinal of possible operations is small, and data-independent, so a backtracking approach is applied). After each operation application, the current data completeness is checked; if it is still lower than the acceptable data completeness factor, then the method tries to apply another preprocessing operation. If not, then a decision tree is built from the modified dataset set, by using a decision tree induction algorithm (like C4.5 [1, 4]).

Table 1. Pseudo code to find data preprocessing operations according to the user preferences

```
foreach operationsList in possibleOperationsSet
 modifiedDataset = copy of dataset
 currentCompleteness = 100%
 appliedOperations = empty list of data preprocessing operations
 foreach operation in operationsList
   modifiedDataset = apply operation on modifiedDataset
   currentCompleteness = computeCompleteness(modifiedDataset,dataset)
   if (completenessFactor < ACCEPTABLE_DATA_COMPLETENESS_FACTOR) break
   else appliedOperations = add operation into appliedOperations
 foreach
 decision_tree = compute decision tree from newdataset
endforeach
select appliedOperations for which decision_tree.size is minimum
```

With this algorithm, the combination of operations that leads to the simplest decision tree within acceptability bounds is finally obtained. If several combinations lead to decision trees with the same size, then the error-rate of the decision tree is used to make a choice: it is a measure which reflects the accuracy of the decision tree [7]. In this case, the error-rate is related to the whole transformed dataset.

As a result, a sequence of data preprocessing operations is obtained: for instance, the result can be 'discretize numeric features + remove duplicates'. The dataset is then transformed according to the sequence of operations into a modified dataset with acceptable information loss, and leading to a simple decision tree.

3 Experiments and Discussion

In order to validate the approach described in this paper, a standalone tool has been developed in Java. It takes advantage of the Weka data mining library [10], especially its implementation of the C4.5 decision tree induction algorithm.

This prototype was used according to the following procedure: using a selection of ten datasets from UCI [9], tests have been performed for several data completeness factors in order to check the impact on decision tree size (Table 2).

Table 2. Impact on decision trees in each case

Dataset (size)	Data completeness factor										Min/ max error-rate (%)
	100% (orig. data)	90%	80%	70%	60%	50%	40%	30%	20%	10%	
anneal	40	40	40	40	24	22	22	22	22	3	0/0.9
vehicle	151	137	129	129	107	87	83	83	83	83	6.5/20.1
soybean	90	90	90	90	81	75	73	73	72	72	4.9/11.3
autos	64	64	64	64	45	39	23	17	9	9	4/10.7
colic	23	8	8	6	6	6	6	6	6	3	10.9/18.5
dermatology	37	37	37	37	29	29	29	29	25	25	2.7/3.3
diabetes	39	35	35	35	17	17	11	1	1	1	15.9/33.7
glass	43	41	41	35	35	21	19	19	15	5	7.7/56
segment	81	71	71	71	69	29	29	29	13	13	1.1/17.2
sick	51	43	43	24	24	24	24	24	5	5	0.4/2.1

For this evaluation, the following preprocessing operations were used: deletion of meaningless features, numerization of nominal features, supervised and unsupervised discretization of numeric features, and deletion of outliers, extreme values, or duplicates. This list covers different kinds of preprocessing operations (cleaning, dimensions altering, quantity altering), with variable impact on information loss.

According to the results, the method provides a way to progressively reduce the size of the decision tree by transforming the dataset. For the majority of the checked datasets, the size reduction appears with 90% of data completeness, and for all the checked datasets, the size reduction is really effective from 60% of data completeness.

As expected, decreasing data completeness allows at simplify decision trees. We may interpret this parameter as the user preference regarding the compromise between model complexity and information loss.

In addition, the error-rate has been computed in each case from the respective transformed dataset. Thus, it has been observed that the error-rate tends to grow during simplification: it is normal and the tradeoff between decision tree's accuracy and simplicity has been deeply studied in the past [5, 6, 7].

4 Conclusion

In this paper, a method has been proposed in order to reduce the size of decision trees constructed from data. Given a factor which determines the acceptable loss of information for the user, the method aims at finding an ordered list of transformations: by applying these transformations, the user obtains a dataset which leads to a simpler decision tree, independently of the used decision tree algorithm.

An implementation of the method has been developed, and its effectiveness was demonstrated on well-known UCI datasets. The data completeness factor is shown to command a compromise between complexity of decision tree and information loss, allowing a user to set his preference to this respect.

As a real world use-case, the method could be used to discover knowledge from raw business data: the method would enable to interactively obtain variable granularity levels of a given decisional business model.

In future works, we will try to optimize the method by using other techniques like genetic algorithms.

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A Cooperative Decision Making Algorithm for Wireless Location Systems Using Interlinking Data

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Abstract. Nowadays, several wireless location systems have been developed in the research world. The goal of these systems has always been to find as greatest accuracy as possible. But, if every node takes data from the environment, we could gather a lot of information, which may help us to know what is happening around our network. In order to obtain the correct conclusion, we have developed an algorithm based on interlinking data. These data come from several nodes, and each node can give us one or several parameters. Our algorithm deals these data cooperatively in order to find the connection between them and provide the environmental behavior. This algorithm is based on statistical methods due to the fact that it involves an observational experiment. Finally, our cooperative decision making algorithm is tested on a wireless location system. The results show that this algorithm works properly and we are able to know what is happening around our wireless location system when we use it.

Keywords: cooperative decision, interlinking data, wireless location system, wireless networks, cooperative communications.

1 Introduction

Currently, wireless networks can be used in many types of scenarios and for many types of purposes. One of them is the location systems, particularly in indoor spaces because in outdoor environments the most useful location system is GPS [1]. At this time, there are many indoor wireless location systems [2] and algorithms [3] that let us know where a device is placed [4]. But, this is not enough because only with our position we may not be able to know many things. For this reason, we should introduce cooperation processes in our network.

Cooperation is the strategy of a group of entities working together to achieve a common goal [5]. Cooperation could be important because it let us join several data provided from our devices in order to take a better decision which may imply to select the better action for this purpose. Nowadays, cooperation in wireless networks can be approached from different angles, and in fact, it has different meanings and connotations. An example could be the cooperation of wireless nodes, as a way to improve the coverage of our wireless network [6]. For instance, some authors use cooperation techniques to add several antennas in a device for having a better signal-noise rate (SNR) level and/or coverage.

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Another important issue that can be included in communications is several techniques exploiting the joint collaborative efforts of some entities in the system. We can use algorithms to interact with the data collected from our devices in order to enhance the performance of the system. In order to improve the resources (human resources and material resources) used in an environment, we propose to process the information collected by every device of our system. We need to join all data to deduce what it is happening in our system. For this reason in this paper we present an algorithm, which deals these data cooperatively. We use this data processing to find the connection between all information and then we can deduce what is happening in the environment.

The rest of this paper is organized as follows. Section 2 shows some related works about indoor location systems and cooperation networks. Section 3 explains briefly the main features of our wireless location system. Then, we present our proposal in Section 4. Firstly we introduce a cooperative decision making problem and then we present our algorithm to collect and process data from our location system. Next, in Section 5 we explain the test bench used to perform our test and the results obtained. Finally, we show the main contributions and our conclusion in Section 6.

2 Related Work

The main problem in indoor environments is the appearance of walls and obstacles that make difficult to predict the signal loss, signal path and even the signal variation due to external factors [7]. We split this section in two parts. First, we show some works related to location systems for indoor environments using wireless local networks and, then, we will provide some proposals on cooperative networks or communications.

In [2], authors give us a comprehensive survey of numerous indoor positioning systems (IPSs), which include both commercial products and research-oriented solutions. Evaluation criteria are proposed for assessing these systems, namely security and privacy, cost, performance, robustness, complexity, user preferences, commercial availability, and limitations. They compare the existing IPSs and outline the trade-offs among these systems from the viewpoint of a user in a personal network.

We presented a hybrid stochastic approach for self-location of wireless nodes in indoor environments in [8]. This paper proposes a new stochastic approach which is based on the combination of deductive and inductive methods whereby wireless sensors could determine their positions using WLAN technology inside a floor of a building. Our goal was to reduce the training phase in an indoor environment, but, without the loss of position accuracy.

Finally, another paper related with indoor location systems is [9]. This paper presents an experimental study of the feasibility of using multiple wireless technologies simultaneously for location estimation. They collected signal strength information from both IEEE 802.11 and Bluetooth wireless network technologies, they developed and applied algorithms for determining location using data for each wireless technology, and, then, they used a simple algorithm for fusing the data from both technologies to try to enhance the accuracy of the location.

When we talk about cooperation in networks, it is difficult to associate this feature with network broadly speaking. For example, authors of [10] present a class of cooperative decode-and-forward protocols for arbitrary N-relay wireless networks, in which each relay can combine the signal received from the source along with one or more of the signals transmitted by previous relays. Each relay coherently combines the signals received from the source and m ($1 \leq m \leq N-1$) previous relays.

Another field, where cooperative communications are used to improve the network, is when it is desired to save the energy of the nodes. In [11], the authors propose a novel selective single-relay cooperative scheme, which combines selective-relay cooperative communication with physical-layer power control. Based on the MAC-layer RTS-CTS signaling, a set of potential relays compute individually the required transmission power to participate in the cooperative communication, and compete within a fixed length window.

We also presented a solution to increase the lifetime of the sensor nodes in [12]. In this work, we showed how organizing sensors in cooperative groups can reduce the global energy consumption of the WSN. We also showed that a cooperative group-based network reduces the number of the messages transmitted inside the WSNs, which implies a reduction of energy consumed by the whole network, and, consequently, an increase of the network lifetime. Moreover, we presented a cooperative network in [13]. This paper shows an application for environmental monitoring from a cooperative group-based wireless sensor network. It is based on the use of different alarm levels to define which level of danger or importance has an event.

Finally, we present the only paper [14] we have found that uses cooperation in location systems. This article is intended to emphasize the basic statistical signal processing background necessary to understand the state-of-the-art and to make progress in the sensor network localization research. In cooperative localization, sensors work together in a peer-to-peer manner to make measurements and then form a map of the network. Various application requirements will influence the design of sensor localization systems

3 Wireless Location System

In this section we explain our wireless location system. It is based on several nodes, which are located in strategic points in order to take relevant data from people.

In this first step we have placed 8 nodes around the most important buildings in our campus (see Fig. 1). Node 1 is located at the secretariat, where a lot of people go to check their documents. Node 2 is at the canteen. Nodes 3 and 4 are at the library, but node 3 is at the entry, where the students can take some books to consult at home, and node 4 is at the study room. Node 5 is placed at the entry of computer, communications and electronic science building and node 6 is at the entry of natural science building. Finally, we have node 7 and 8 at the classroom's building. Node 7 is very near to the classrooms, where there are many students and node 8 is on the main entry on this building.

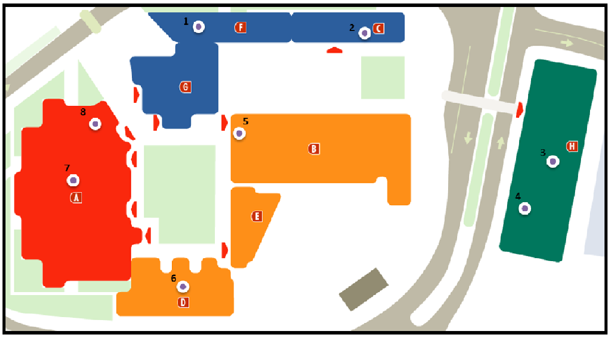

Fig. 1. Wireless Location System developed in our Campus

Our nodes have been programmed to record what is around it, and how much time it is inside its coverage. The data related to node's identity is obfuscated in order to keep the privacy of the users. Every node has 2 network interfaces. One of them is a Bluetooth interface in order to know how many people are near of each node and the other one is a Wi-Fi interface, which is used to send all data to a server. This server will be responsible to run our cooperative data processing and to execute our cooperative decision making algorithm.

4 Cooperative Decision Making

4.1 Introduction

A cooperative decision making problem describes a situation involving several opinions or information. In our case this information is the data from nodes, which can be used when they are cooperating. The problems they face are who will cooperate with whom, and how will the corresponding benefits be divided. Obviously, a node shares its information taking part in a coalition. But, it depends on the benefits offered by that cooperation. So, a coalition is only likely to be formed if all the members of this coalition agree on a specific distribution of the benefits. Finding such agreement, however, it could be troublesome when these members have conflicting interests.

In order to analyze this situation, we are going to use a general mathematical framework [15] that describes the cooperative decision making problem. Let $N = \{1, 2, \ldots, n\}$ be a finite set of nodes. The benefits of our cooperation will be explained by Y. It is a topological space representation of outcome space. Its representation depends on the decision making problem that is under consideration. Moreover, this outcome space Y provides the benefits made by each coalition $S \subset N$. It can be represented by a subset $Y_S \subset \prod_{i \in S} Y$. An outcome $(y_i)_{i \in S} \in Y_S$ then produces the cost y_i to node i. In order to evaluate several outcomes, each node $i \in N$ has a preference relation $\gtrsim_i$ over outcome space Y. So, node i is only interested in what it receives. It does not takes into account other data. After that, given any two outcomes $y, \hat{y} \in Y$, we assume $y \gtrsim_i \hat{y}$ if node i finds the outcome y at least as good as the outcome $\hat{y}$. On the one hand, if node i finds the outcome y strictly better than the outcome $\hat{y}$ we say $y \succ_i \hat{y}$. On the other hand, if node i is indifferent between the outcomes y and $\hat{y}$

we can write $y \sim_i \hat{y}$. To sum up, a cooperative decision making model could be described by a tuple $(N, \{Y_S\}_{S \subset N}, \{\succsim_i\}_{i \in N})$.

4.2 Cooperative Decision Making Algorithm

As we have seen in Section 3, our wireless location system is more focused on recording how much time a device is near to a reference node than to have a more or less accurate position. For this reason, we do not pay special attention to the accuracy of our wireless location system. Otherwise, we are going to use the cooperation between collected data to make a decision about the behavior of the system.

There are some places where people spend more time than other places. Usually, these places are classrooms, study rooms or the canteen. Other places, where people only pass or do a task, spending less time, could be called passing places. In figure 2, we can see the collected data from every node of our network. In this figure, we represent the data of 10 users gathered in a morning. We can state that our nodes placed on point 3, 5 and 8 are totally passing places, so we cannot take so much conclusions from this. On the other hand, point 2, 4, 6 and 8 are interesting because people spend much time in these places. Point 1 is an extraordinary place. It is the secretary, where students manage a lot of things related with these degrees. People spend a lot time but only at the beginning or at the end of each teaching course. These data were obtained in April of 2013, for this reason there are few users.

This information has been processed in a cooperative way in order to obtain the best pattern related to the amount of time spent by each person in a particular place. This cooperative data processing is based on [16]. We have used statistical methods such as mean values, weighted mean, variance, standard deviation, etc. Data is gathered from each node, but it is processed together with other data coming from other nodes of our wireless location system. Applying these methods we have obtained figure 3.

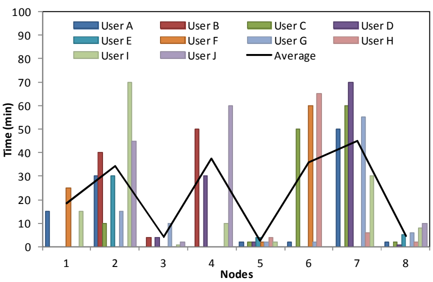

Fig. 2. Spending time in each place per user

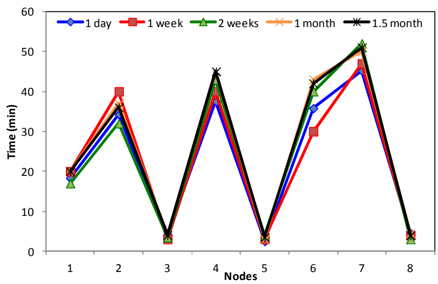

Fig. 3. Cooperative data processing of spending time in each place

In figure 3, we can see the evolution of data while we are applying our cooperative data processing for several periods of time. We can observe from this figure that obtained values have the same pattern than the average value of figure 2. There are light changes between the values obtained in each place, but according to our system, the more trained the system is more accurate the values are. For this reason, we have to focus on the values obtained during 1.5 month because these values have been collected for a longer time.

When our cooperative data processing system has been trained correctly for more than a month, we are able to run correctly our decision making algorithm. The cooperative process manages this information in order to improve the behavior of the users in our campus. Our algorithm is shown in figure 4. The wireless location system collects data from its nodes. This information is stored in a server. This server is the backbone of our system because it records the location information and makes the cooperative processing. Our algorithm will find two thresholds as a result of cooperative data processing. If current data is inside the threshold 1, this means that everything is working correctly. So, our system continues processing more information. In case of having the data outside threshold 1 but inside threshold 2, our system will send a notification. Finally, if data is outside of both thresholds, our system will send a warning message.

This algorithm could be implemented in several applications, but probably in the resources management would be a good solution. For instance, we could implement an automatic system to manage the human resources needed in each place of our university campus. Normally, in a secretary's office there are several secretaries, but only some of them are attending people. If the average number of users increases in a moment, the system will detect this event and it will send a notification. This notification will inform to some secretaries to alert that the performance is changing. If the quantity of people around place 1 is greater than threshold 2, our system will send a warning message in order to add some secretaries for attending people. This would improve the system's behavior automatically.

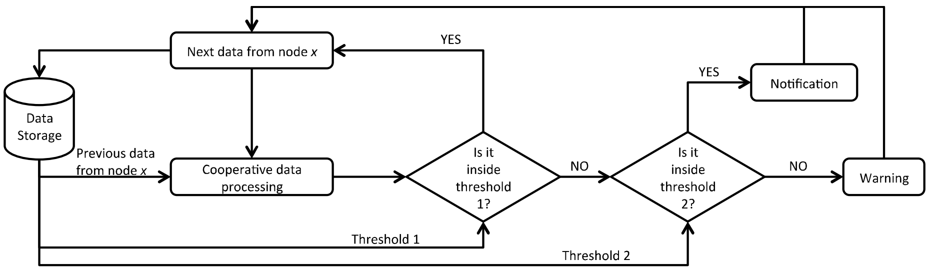

Fig. 4. Flowchart of our cooperative decision making algorithm

5 Performance of Our Cooperative Decision Making Algorithm

Our system has been tested in a real environment. We have installed this system in Gandia's Campus, which belong to Universitat Politècnica de València. Our installation is represented on figure 1. Nine sensor nodes have been located in places, which are interesting because they are placed where people stay more time or because people pass more times. Probably, the most important data of our cooperative system are threshold 1 and 2. For this reason in this section we are going to show these thresholds.

In figure 5, we have represented the values of these thresholds when our system is trained badly. We can see that in some cases these values are higher compared with the same threshold in figure 6 (system with a correct training phase). For example, if we pay attention to place 7, we can notice that when our system is bad trained. Threshold 1 will be between 36 and 48 minutes and threshold 2 will be 31 and 56 minutes. These thresholds confuse us a little bit because if we take notice on figure 2 in place 7, 4 users out of 6 are more than 50 minutes, so threshold 1 is not making decisions correctly. Our system will send 2 notifications or 2 warnings, some of them without sense. Now, we are going to focus on figure 6 in the same case (place 7). When our system is well trained, threshold 1 is between 38 and 52 minutes and threshold 2 is 34 and 61 minutes. In this case, if we pay attention to the same data of figure 2, we would only send 1 notification and 1 warning. These solutions would be more correct than the previous ones.

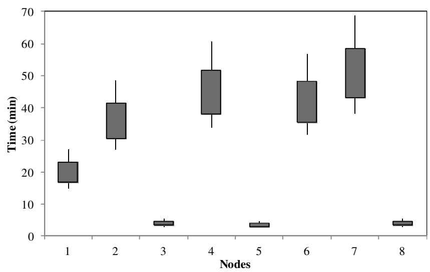

Fig. 5. Thresholds calculated with a bad training phase

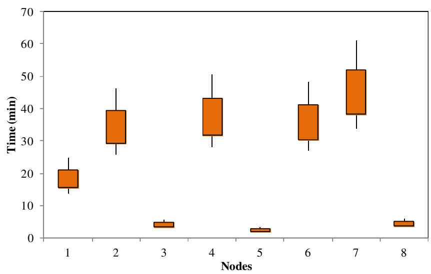

Fig. 6. Thresholds calculated with a correct training phase

6 Conclusion

In this paper a new cooperative decision making algorithm has been presented. It is based on statistical methods. Firstly, this algorithm needs a training phase to create a correct environment in order to calculate some thresholds, which are essential for the proper operation of the system. During this training phase our algorithm uses cooperative statistical operations to have updated thresholds. The system sends notifications or warning messages to the management point in order to develop some activities, which can help the behavior of environment. We have tested this algorithm is a real environment and we have seen that it works properly. In future works we will use this system in other type of paces such as rural areas and underwater environments.

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Product Lifecycle Management Model for New Technology Based Enterprises

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Abstract. This research is focused in a Product Lifecycle Management (PLM) strategy for New Technology Based Enterprises (NTBE) for solving difficulties for integrating the product requirements and for improving the collaboration with the external contributors that occur in almost all the PLM stages, considering the limited resources of a Small Enterprise. In this work, we analyze a case study of the collaboration between a New Technology Based Enterprise, its Suppliers and Customers and we present a Product Requirement Representation considering the International Standard ISO 10303-0239. After the analysis and with the presented product representation, we propose a PLM Reference Model and an implementation of Open Source Software as a low cost solution for enabling PLM in this kind of business collaborative environment.

Keywords: New Technology Based Enterprise, Product Lifecycle Management, Collaborative Engineering, Product Requirement.

1 Introduction

The new global economic scenario, characterized by high competitive and low cost production, has forced the enterprises to start new strategies of continuing improvement of their New Product Development Process (NPDP), considering the available collaborative engineering technologies [1]. The New Technology Based Enterprise (NTBE), characterized as a Small Enterprise (SME) in Early Stages, has similar needs as the Large Enterprises (LEs) but they are more informal and less structured [2]. The weakness of the New Technology Based Enterprise as a SME don´t justify cutting corners and leaving out important steps of the New Product Development Process because it may increase change of product failure or a reduction of the quality of the process [3]. Differences between NTBEs and LEs include their larger research resources and broader technological knowledge [4]. For solving this necessity, the New Technology Based Enterprise creates alliances for Collaborative Engineering with external Technology Based Suppliers through buying, licensing or outsourcing Technologies [1]. This Collaboration is defined as cooperation between independent enterprises that accept a temporary aggregation of all or part of their resources in order to achieve a specific goal [5]. The benefits of the collaboration are: Access to new markets by realizing products that are out of feasibility for the sole New Technology

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Based Enterprise and increased productivity, by accumulating and optimizing the individual collective capacity [5]. The main obstacles to the collaboration are the individualistic nature of the SME management, the lack of suitable methods and tools for distributed production management; for this reasons the New Technology Based Enterprise needs specific coordination tools to link together collaboration activities processed by different firms through the Product Life Cycle [5].

2 Literature Review

Villarreal *et. al* [5] studied the risk of collaborative networks of SMEs indentifying four risk domains: Structure, Organization, External Environment and Project Internal Processes; and suggest the implementation of procedures and protocols for distribute and use the risk information. Mosey [4] showed that the principals competitive advantages of the SMEs are the flexibility to learn and adapt to the market environment, and suggest that the Technology Based Enterprise in conjunction with the Technology Based Supplier should be studied independent of the Non-Technology Based ones. Owens [1] studied the problems trough the Product Development Process and identified as principal reasons for product development delay the following: poor definition of product requirements, continually changing requirements and poor internal communication. Siller *et. al* [6] studied the implementation of PLM in an extended enterprise and suggest that is needed not only a web-based tool for collaboration, but also a reference architecture that could help to identify the needs of integration and coordination of each product life cycle processes, and the exchange of information among involved agents. Vila *et. al* [7] suggests that in the field of Product Design and manufacturing, internal resources and external suppliers are required to perform specialized operations, which increase the complexity of the collaborative environment. Le *et. al* [8] proposed a generic PLM model for mechanical SMEs in a conceptual way making a decomposition of three principal components: the product, the activity developed by the product and the resource of the companies. Aziz *et. al* [9] tested four different PLM systems for a collaborative project environment and suggests that Open Source Systems are the evolution of product development management systems because of the elimination of software license costs and freedom to modify the application. The previous investigations showed two similar topics but with different approaches, in one hand we have a strong effort for understand the Product Development Process in Small and Medium Enterprises and identify its opportunities and weakness; in the other hand could be seen a deep study for achieving an efficient relationship among involved agents in each Product Life Cycle stages of a Large Enterprise. In this study we propose that the Product Development Process of NTBE can be benefited if we implement the strategies for Product Life Cycle Management (PLM) as in the LE but considering the limited resources of a SMEs; the two lines of investigations that we found will be merged in order to obtain a Reference Architecture and a Product Life Cycle Management Reference Model for New Technology Based Enterprises.

3 Methodology

To reach the actual situation of the initial stages of Product Lifecycle Management in New Technology Based Enterprise (NTBE), known also as the New Product Development Process (NPDP), we analyzed the literature review and applied a survey to 30 NTBE about their NPDP in order to understand patterns of behavior and activity. The enterprises were selected by identifying those cases that have a product in the market on sale, developed by them or licensed from a well-known Technology Based Supplier. We choose a NTBE manufacturer of wooden cabinets made to order as a case of study because of the importance of the customer in the product development and the Technology Based Supplier in the production; this knowledge was modeled using a Business Process Model Notation 2.0 (BPMN), for analyzing the workflow and decision making of the entire NPDP and the interaction between the Customer, New Technology Based Enterprise and Technology Based Supplier. The final contributions are a Product Requirement Representation and a PLM Reference Model for solving issues regarding Collaborative Engineering in the first stages of a NTBE.

4 Results and Implications

Around 60 percent of the enterprises in this study don't have any kind of standardized workflows for PLM. These entrepreneurs (76%) are convinced about the need for improving their New Product Development Processes (NPDP). After analyzed the results of a depth interview with our NTBE case of study about their NPDP and their interaction with the customer and the suppliers as well and we identified the next situations:

- The Customer only interacts with the New Technology Based Enterprise at the beginning and at the end of the process, leaving the Technology Based Supplier out of the interaction.
- The New Technology Based Enterprise could be divided in three main areas: Administration, Design and Manufacturing.

These results were considerer to create the next BPMN 2.0 (Fig. 1). In the Model we can observe that if the product requirements were not obtained correctly at the beginning of the process and are not managed correctly trough the entire process the final product could be different to the customer needs, meaning that if the New Technology Based Enterprise does not understand the customer needs the prevalence of the incipient company could be in risk. The results show that the main break-point at the New Technology Based Enterprises are to capture the Customer needs as Product Requirements and how this information is shared among the staff of the company and with the technology suppliers.

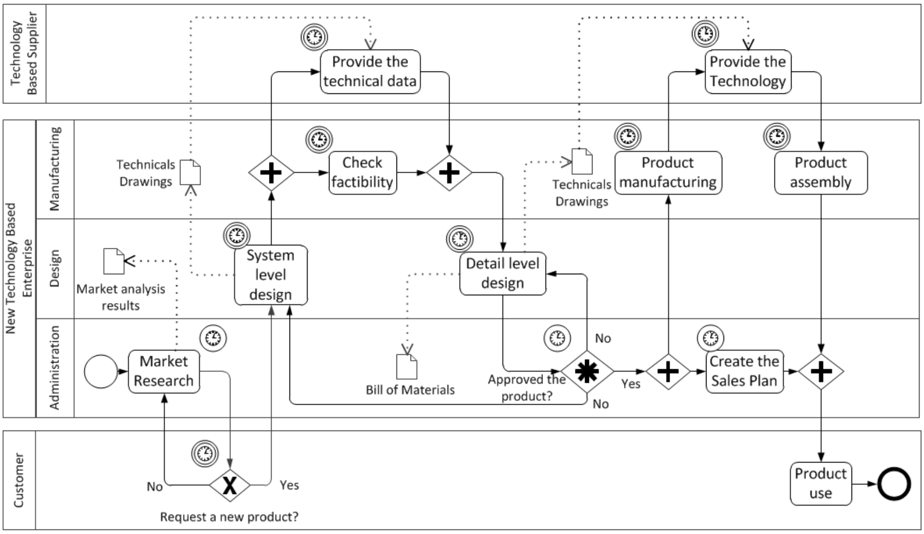

Fig. 1. Actual BPMN in New Technology Based Enterprises, based on a manufacturer of wooden cabinets made to order

4.1 Product Lifecycle Management (PLM) Reference Model

PLM is an integrated approach that includes a series of methods, models and tools for information and process management during the different stages of a product lifecycle [6]. It was introduced in Europe in the early 90s by Dupinet and Krause [8] and has been studied in recently years its implementation on LE by many authors. In the field of New Technology Based Enterprise internal resources and external suppliers are required to perform specialized operation, which increase the complexity of the collaborative environment [7]. The implementation of PLM should attempt Knowledge, Information and Data (KID) sharing in a standardized way for improves its success; to solve this issue the standard ISO 10303, normally known as STEP (STandard for the Exchange of Product model data) can be used. STEP is designed to handle a much wider range of product related data covering the entire life cycle of a product. We made a selection of the ISOs that have a closely relation with PLM and data sharing (Table 1).

Table 1. ISO 10303 Standards for PLM and data sharing

ISO Standard 10303-xxxx	Description
Part 0011	The EXPRESS language reference manual.
Part 0022	Standard Data Access Interface (SDAI).
AP 0203	Configuration controlled 3D design of mechanical parts and assemblies.
AP 0239	Product Life cycle support.

The ISO 10303 is divided in different “Parts” according to the issues in the way of ISO 10303-xxxx, where xxxx is the number part [10]. The descriptions of the selected ISOs are presented as follows: *The Part 0011* is a formal language for specification of technical data, it has a clear object-oriented foundation, it allows data inheritance, and it permits the creation of user-defined types and the definition of complex entities [11]. *The Part 0022* provides normalized functions to access and manipulate the resultant information system from repositories containing STEP neutral information [11]. *The AP0203* is concerned with the transfer of product shape models, release status, and configuration control information [10]. *The AP0239* provides a comprehensive capability to capture all aspect of the product lifecycle, and it’s oriented for the exchange of information via Internet. The key areas addressed by AP0239 are [10]: Product Description, Work Management, Property State and Behavior, Support Solution and Environment, Risk assessment and risk management [10]. Considering the ISO´s that we selected and previous efforts for characterized the product description [8] we propose a Product Requirement representation in a UML class diagram (Fig 2).

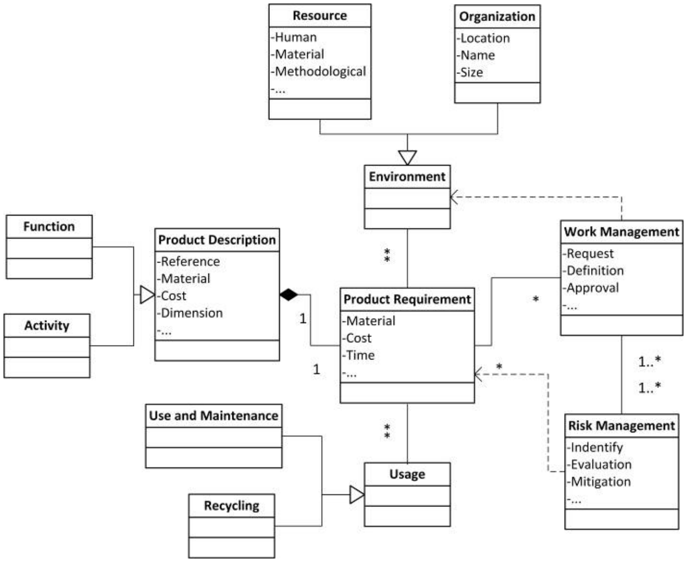

Fig. 2. Product Requirement representation according to ISO 10303-0239

The diagram is described as follows: considering the results of our first contribution in this work we identified that The Product Requirement is the key factor that will be managed through the entire Product Life Cycle and consists of: The Product Description is the definition of Product Requirement [10] and considers the Activity and Function of the product [8]. The Environment is the definition of support required [10] and considers the Resources and Organization [8]. The Work Management are the request, definition, justification, approval, scheduling and feedback capture for product life cycle activities and their related resources [10] and is linked to the Environment because of its depends the resources. The Risk Management is the representation of risk related data associated with the product life cycle [10] and is related to Work Management. The Usage considers the Use and Maintenance and Recycling because they´re the last stage of Product Lifecycle and at the same time are the beginning of it [7].

4.2 PLM Reference Model for New Technology Based Enterprises

The quick expansion of the Internet provides the infrastructure by which information can be simultaneously available to all those involved in Product Lifecycle activities [7] but is needed not only a web-based tool for collaboration, but also a reference model that could help to indentify the needs of integration an coordination of each product lifecycle process collaboration, and exchange information among involved agents [6]; because of this the final contribution in this research is a proposal PLM Reference Model (Fig. 3) in the context of the seven Stages of a Generic Product Life Cycle (Product Requirements, Conceptual Design, Detailed Design, Product Development, Manufacturing, Use and Maintenance, Recycling) [6]. In the model we represented three main entities: *the Customer* who expresses his needs in the form of product requirement, including the information extracted from the usage, maintenance and recycling; *the New Technology Based Enterprise* that interprets these needs as product description and continues through the stages of Product Lifecycle (Conceptual Design, Detailed Design, Product Development and Manufacturing) and *the Technology Based Supplier* that supports them supplying the technology resources according to the product requirement.

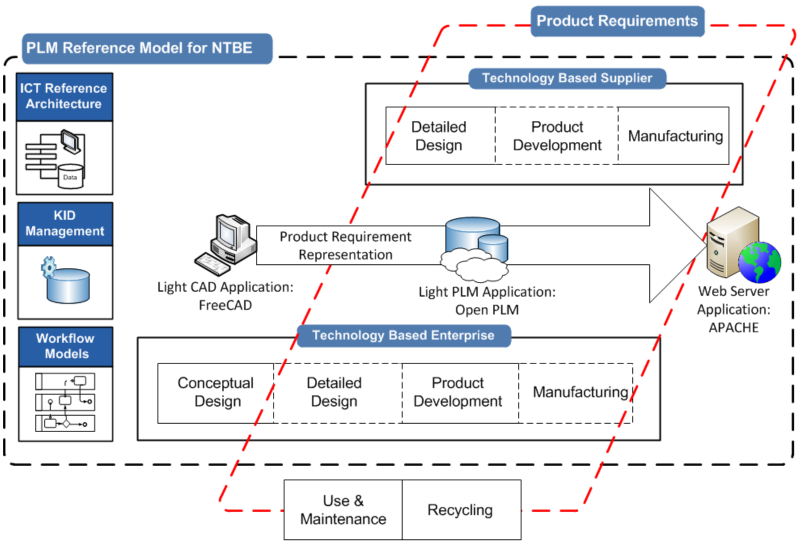

Fig. 3. PLM Reference Model for New Technology Based Enterprises

Considering the complexity of the implementation of the prevalent commercial PLM solutions in New Technology Based Enterprises [9] we proposed the implementation of Open Source Software: *The FreeCAD* is a general purpose 3D CAD feature based parametric modeler, its development is completely Open Source with

OpenCascade as a CAD Kernel [12]; *Open PLM* is a product oriented open source PLM solution featuring a full web interface [13] both of the proposed Open Source Software have the capacity of create and manage STEPs files (.stp); and *Apache* as the web server application. The collaboration occurs inside the frame of the PLM considering the three main factors [6]: Knowledge, Information and Data, Workflow BPMN Model and ICT architecture involving a Light CAD Application tool and Web Based Applications; the communication problems can be solved using well-established Internet standards [6].

5 Conclusions

Although the collaboration between the New Technology Based Enterprise and the Technology Based Supplier already exist a PLM solution must be implemented to assure that the final product satisfy the Customer Need as Products Requirements. Its implementation can be made considering the International Standards ISO 10303-0011, 0022, 0203 and 0239 for programming, displaying modeling and managing the New Product Development Process. The Product Requirements Representation proposed consider all the basic elements to satisfy the customer needs and that will be consulting through the entire Product Lifecycle; for interest of PLM implementation a PLM Reference Model for New Technology Based Enterprises proposed as a framework to improve the collaboration of the three principal actors: Customer, New Technology Based Enterprise and Technology Based Supplier. The proposed Model includes the Stages of Uses & Maintenance and Recycling as Customer Needs connecting the end and the beginning of the Product Lifecycle in aims to satisfy the entire Product Requirement. Considering the actual situation of the New Technology Based Enterprises as SMEs the implementation of Open Source Software could be an available solution for the PLM implementations because of its low costs and its freedom of customization, even already exist Open Source PLM Solution they are not focused to solve the collaborative problems in the New Technology Based Enterprises context. The next contribution will be implementing the PLM Reference Model for New Technology Based Enterprise and the Product Requirement Representation as a solution of New Product Development Process in a particular case of New Technology Based Enterprise.

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Engaging End-Users in the Collaborative Development of Domain-Specific Modelling Languages

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Abstract. Domain-Specific Modelling Languages (DSMLs) are high-level languages specially designed to perform tasks in a particular domain. When developing DSMLs, the participation of end-users is normally limited to providing domain knowledge and testing the resulting language prototypes. Language developers, which are perhaps not domain experts, are therefore in control of the language development and evolution. This may cause misinterpretations which hamper the development process and the quality of the DSML. Thus, it would be beneficial to promote a more active participation of end-users in the development process of DSMLs. While current DSML workbenches are mono-user and designed for technical experts, we present a process and tool support for the example-driven, collaborative construction of DSMLs in order to engage end-users in the creation of their own languages.

Keywords: Model-Driven Engineering, Language Engineering, Domain-Specific Languages, Cooperative Engineering.

1 Introduction

Model-Driven Engineering (MDE) emphasizes the use of models to raise the level of abstraction and automation in the development of software. This is achieved by defining Domain-Specific Modelling Languages (DSMLs) [1, 2] specially designed to perform tasks in certain domains, like web engineering, mobile app development, or gaming. By using DSMLs, end-users can solve problems in their domain more easily, thus becoming an important asset to improve productivity.

Interestingly enough, end-users have a very limited participation in the development of their own DSMLs. They are normally only involved in providing domain knowledge or testing the resulting language [2, 3]. This means that the MDE technical experts and not end-users (i.e., the real domain experts) are the ones in control of the DSML construction and evolution. This is a problem because errors in understanding the domain may hamper the development process

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and the quality of the resulting DSML. Thus, it would be beneficial to promote a more active participation of end-users in the DSML development process.

To make effective this participation, some technical barriers need to be overcome and means to foster the collaboration in the community of end-users of the DSML are needed. First, end-users should be liberated from doing development tasks requiring too technical, specialized MDE abilities (e.g., the identification of abstract concepts or their implementation in platform-specific meta-models). To this aim, we propose supporting language development by means of examples [4]. Thus, users are able to draft language examples from which a language definition (i.e., language domain and syntax) can be automatically derived. Second, given that a language targets a community of end-users, it is crucial to drive the participation of its members in a collaborative fashion where each member cooperates with their peers to make the language development process progress. The discussions arisen as a result of this participation drive the development process and become a valuable documentation of the design decisions [5].

For this purpose, this paper provides an approach for the example-driven, collaborative construction of DSMLs, which combines the works described in [4, 5]. We propose an iterative process, which starts with a set of examples that are refined in each iteration. Refinement consists of providing language modifications by means of new examples, which are discussed by the end-users to reach agreement to drive the language development process. Furthermore, to help making design decisions, the approach also incorporates a recommender system which identifies and proposes changes in the language according to meta-model quality patterns [6–8].

The rest of the paper is organized as follows. Section 2 describes how DSMLs are built nowadays, using a running example. Section 3 overviews our approach and Section 4 its main technical aspects. Section 5 compares with related work and Section 6 concludes the paper.

2 Engineering Domain-Specific Languages

DSMLs are languages tailored to a specific task or domain, capturing its main primitives and abstractions [1, 2]. Examples of DSMLs include dedicated languages for web engineering, requirements specification, business modelling, or data querying. DSMLs are not only specific to computer science, but are useful in many diverse areas and disciplines, like biology, physics, management or education, where the domain experts are not necessarily computer scientists, and may not have knowledge of MDE platforms and tools.

A DSML is defined by its abstract syntax, concrete syntax and semantics. The abstract syntax describes the concepts of the domain, their features and relations. In MDE, the abstract syntax is built through a meta-model, normally a class diagram with additional constraints. The concrete syntax describes the representation of models, either graphically (e.g., an electrical circuit), textually (e.g., an SQL query), or a combination of both. The semantics describes the meaning of models by providing, e.g., a description of their execution, or a

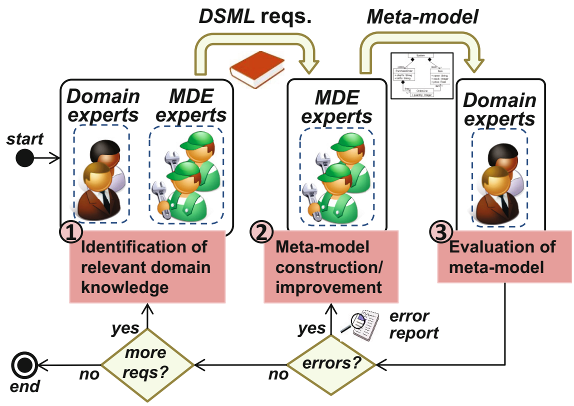


Fig. 1. Traditional process for meta-model construction

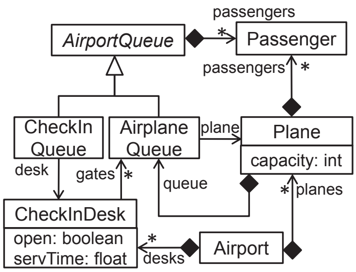
mapping into a semantic domain. While a DSML covers these three aspects, in this paper we concentrate on the process of constructing the abstract syntax.

There are many workbenches for developing DSML editors [1, 2, 9], but they suffer from some drawbacks. First, they are directed to computer scientists with a background in MDE, as the first activity is creating a meta-model. While building meta-models is natural to software engineers, it can be challenging for end-users, who may prefer drafting example models first, share and discuss them with their peers, and only then abstract them in a meta-model. Asking end-users to build a meta-model *before* drafting examples is often too demanding. Moreover, these frameworks do not foster the active participation of the domain experts in the DSML design process. Their role is limited to providing background knowledge of the domain, and evaluating the DSML proposals created by the MDE experts. This may lead to misunderstandings of the domain concepts, omissions or non-optimal solutions.

A scheme of this "traditional" process is shown in Figure 1: first, there is a requirements gathering meeting *(1)*; then, a meta-model is built *(2)*; and next, this meta-model is reviewed by the end-users *(3)*. If defects are found, feedback is provided and the meta-model is reworked. This process is iterated until the meta-model gathers all domain concepts and then the DSML tooling can be developed. Note that, sometimes, defects can only be found once the tooling is available, when end-users detect missing elements, thus requiring rebooting the process.

As an example, consider the construction of a DSML to describe the passenger entry process of an airport, with the purpose of performing a queue-based simulation to optimize this process. The stakeholders include therefore terminal operator supervisors, airport management staff, and terminal managers of specific airlines. A possible meta-model is shown in Figure 2(a), where the check-in and airplane queues are identified.

The traditional process has some drawbacks at every stage. In step *(1)*, domain knowledge is documented in natural language. However, having this knowledge in



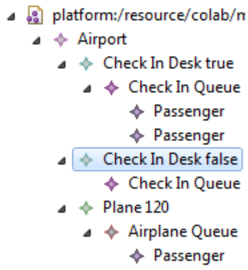


Fig. 2. (a) Sample meta-model. (b) Sample model.

the form of computer-processable models would be more effective. Unfortunately, this is not possible as, at this point, no meta-model exists yet. Second, evaluating the meta-model in step *(3)* is difficult, as the end-users may need to build testing models using "raw" abstract syntax, with no intuitive support for the concrete syntax. For example, in the case of Eclipse EMF [10], end-users need to build models using a tree-based editor (see Figure 2(b)). Moreover, domain experts are demanded to understand a meta-model that includes conceptual modelling elements like inheritance, composition and textual constraints, which might be difficult to grasp to non-experts. In addition, some meta-model elements, like concept Airport, are only needed due to the implementation platform of the meta-model. For example, EMF requires a root concept in order to generate a tree-based editor. Finally, this process may lead to heavy iterations that could be optimized with a more active involvement of end-users in the meta-model design, at stage *(2)*, which in turn could help to get a meta-model fitting the end-users' needs and ready to be used to develop the DSML tooling. Hence, in the next section, we present a collaborative process aiming at alleviating these problems.

3 A Collaborative Process Driven by Examples

The drawbacks identified in the previous section prevent end-users from participating effectively in the creation of DSMLs. To promote their engagement, we propose a collaborative development process driven by examples. The use of example models liberates end-users from doing too demanding technical tasks for their expertise (e.g., defining abstract concepts), thus enabling their active participation in the process. Moreover, the development process evolves in a collaborative fashion where any end-user cooperates and discusses about the changes to be made in the language. End-users involved in the creation of the DSML become *the community*, and as a result of their collaboration, the community as a whole decides the changes that will be eventually added to the DSML.

We propose a process to build the abstract syntax of DSMLs composed of five phases: (1) process bootstrapping, (2) meta-model induction, (3) evaluation and discussion, (4) voting phase and (5) language development. Next, we describe in detail each phase, which are illustrated in Fig. 3.

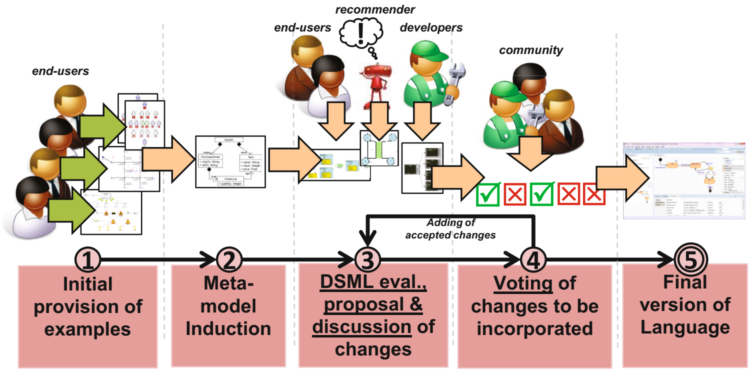


Fig. 3. Process for building DSMLs collaboratively driven by examples

To bootstrap the process, end-users initially provide a set of examples (full models or fragments) which illustrate the DSML to develop (see step *(1)*). These examples are only sketches (i.e., they do not conform to any meta-model) where icons are named and arranged, but give the end-users the power of tailoring the DSML to their needs without performing too demanding tasks. A reasoning procedure on these examples generates automatically the abstract syntax of the language (step *(2)*), which is defined by means of a meta-modelling language. In our case, we use the Ecore meta-modelling language, thereby abstract syntax models conform to the Ecore meta-model, where concepts are represented as instances of `EClass` elements and their attributes and references are represented as instances of `EAttribute` and `EReference` elements, respectively. Once a first version of the language is obtained from the examples, an iterative process starts to collaboratively develop and refine the language.

In the next phase (step *(3)*), the generated meta-model is evaluated through examples, which may trigger the proposal and discussion of changes. The DSML can evolve due to three main inputs: (1) community members, (2) virtual assistant and (3) technical experts. Community members can propose ideas or changes to the DSML, e.g., after checking the examples they can ask for modifications on the language. A change proposal includes a description of the problem and, optionally, a set of new model examples illustrating the issue. Internally, the changes to be performed in the meta-model to accommodate the new model examples are automatically derived, thus liberating end-users from the task of devising how the language definition should be modified to include their proposals. A virtual assistant can also propose some improvements based on a set of predefined design patterns, thereby assisting end-users in increasing the quality of the DSML. Finally, technical experts can also collaborate to support the language definition process. All change proposals can then be discussed and eventually accepted/rejected.

The decision to accept or reject a change proposal depends on whether the community reaches an agreement. For this purpose, community members can

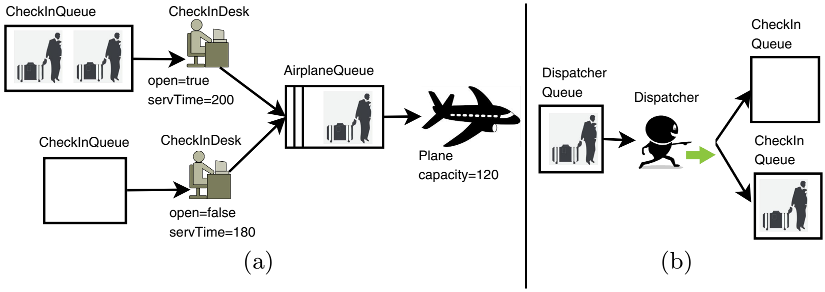


Fig. 4. (a) Initial example. (b) Corrective example.

vote the proposal (step *(4)*). A decision engine analyses the votes committed to calculate (according to agreed collaboration rules such as majority, unanimity, etc.) which proposals are accepted/rejected. The accepted proposals are then incorporated into the language and a new iteration is performed. The process keeps iterating until no more changes are proposed. At the end of the process, the language can be implemented with the sureness that the meta-model fulfils the end-users' needs (step *(5)*).

To illustrate the process, Figure 4 shows the outcomes of a possible collaboration scenario for the running example introduced in Section 2. The process starts with a set of model fragments from which a first version of the meta-model is automatically obtained. One of the provided examples is shown in Figure 4(a), which is actually the same as the one in Figure 2(b) but using a much more intuitive, user-friendly graphical syntax. The obtained meta-model matches with the one presented in Figure 2(a). The meta-model and the examples are then shared in the community to be validated. Validation can be done by looking at the existing examples but also giving new ones and then an automated procedure checks whether those fragments are accepted by the current meta-model.

At some point, an end-user detects a problem because the concept of Dispatcher (a welcome agent that redirects passengers to appropriate checkin queues) is not included so he submits a corrective model fragment including this concept (see Figure 4(b)). Examples do not need to be full-fledge models, but may be partial models focussing on some interesting aspect. The new example becomes a new change proposal to which an automatic process attaches the modifications that should be performed in the first version of the meta-model. This change proposal must be validated by the community, who vote for/against it. Let us consider that eventually it is accepted, consequently, the change proposal is realised, resulting in the meta-model shown in Figure 5(a).

Concurrently, technical experts and the virtual assistant can also propose modifications. For instance, a technical expert can detect the need of including an attribute in the concept CheckInDesk to specify the initialization time. This change is also proposed to the community, who eventually agrees on its incorporation into the language (see Figure 5(b)). On the other hand, the virtual assistant analyses each version of the meta-model to recommend possible improvements and refactoring opportunities. For instance, since Dispatcher,

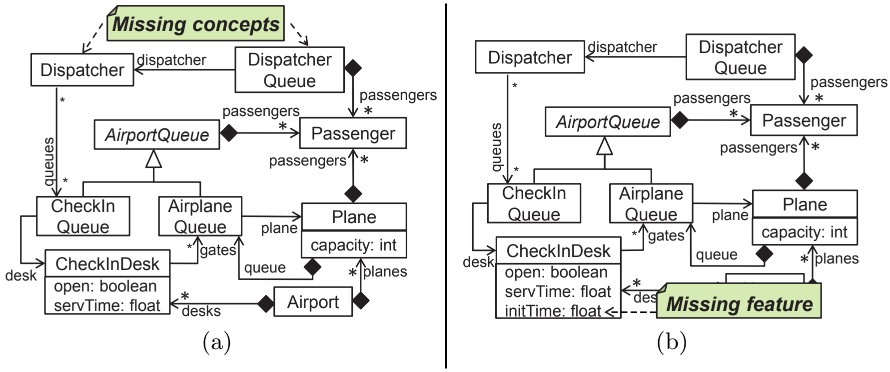


Fig. 5. (a) Resulting meta-model after discussing the corrective example. (b) Resulting meta-model after including changes from technical experts.

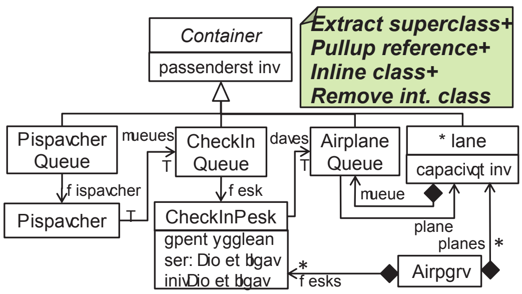


Fig. 6. Resulting meta-model after including the change proposals of the virtual assistant.

AirportQueue and Plane have a reference to Passenger, the assistant recommends creating a new concept as superclass of the first three elements thus factorizing the reference. This recommendation is included in the process as a new change proposal so it is also submitted for debate and eventually for acceptance/rejection. Actually, the recommender also proposed to inline class Passenger (as it does not have attributes) creating the integer attribute passengers, and to eliminate the abstract class AirportQueue (see Figure 6).

4 Technical Solution

The proposed process has been implemented on top of Collaboro [5], an Eclipse-based tool to develop Ecore-based DSMLs collaboratively. Collaboro allows modelling the collaborations among community members when developing a DSML: proposals describe language changes, solutions specify how changes should be implemented in the language (e.g., adding concepts, removing attributes, etc.), and comments can be added to both of them. The tool also allows community members to vote change proposals and includes a decision engine which analyses these votes to calculate which collaborations are eventually accepted/rejected. However, Collaboro only allows modelling collaborations at the meta-model level (i.e., in terms of abstract elements). Our proposal extends the tool to support the collaborative definition of DSMLs by means of examples.

The example-based induction of meta-models is realized using the *bottomUp* tool we presented in [4], which was integrated in Collaboro. As Collaboro needs a model of the changes to be incorporated to the meta-model, we extended the *bottomUp* tool with: (i) a mechanism to record and serialize the changes produced by the induction algorithm, (ii) a virtual assistant and a mechanism to record and serialize the changes produced by its recommendations, and (iii) an importer of Ecore meta-models. The latter is needed in order to process the current version of the meta-model, provided by Collaboro. Collaboro was therefore extended to integrate both the *bottomUp* tool and the virtual assistant as part of the DSML definition process.

Figure 7 shows a snapshot of our tool when the end-user proposes the corrective fragment in the running example. The snapshot includes the meta-model automatically generated from the initial example (left) and the change proposal created by the end-user. The change proposal includes a reference to the file with the fragment (as a child element of the proposal), as well as the set of changes to be done in the meta-model (right bottom part), which are automatically derived from the fragment. The snapshot also shows the contextual menu which allows voting for/against a collaboration as well as commenting them (left top part).

Our implementation supports defining examples as DIA[1] diagrams, as it contains a rich palette of over 1000 icons. End-users can therefore create new proposals and attach the corresponding diagram. For each example-based proposal, Collaboro invokes *bottomUp* to automatically derive the changes to perform in the meta-model of the language, thus creating a solution in the proposal describing these changes. These proposals are then shared with the community to be voted and eventually accepted/rejected. If accepted, they are incorporated to the meta-model by Collaboro.

Our approach also includes a virtual assistant, which analyses the abstract syntax meta-model under development and recommends possible improvements. The implementation of the assistant is integrated in *bottomUp* and incorporates some heuristics to detect errors and modifications. These include refactorings [8] like extracting a common super-class when a set of classes share features, different ways to in-lining or merge classes, and eliminating intermediate abstract classes.

5 Related Work

End-user collaboration is a key feature in software development methods such as agile-based ones as well as in user-centered design [11]. The advantages of collaborating in the development of software have been studied in works such

[1] `http://dia-installer.de`

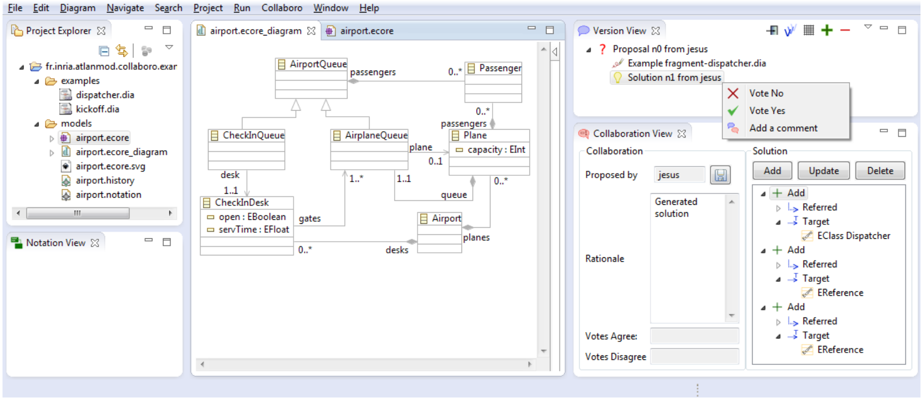


Fig. 7. Induced meta-model (left). Providing example-based proposals in Collaboro (right).

as [12, 13] and they are also illustrated in fields such as requirements elicitation [14] or global software development [15] but neither of them focus on creating DSMLs.

In [16], a collaborative modelling environment is presented, based on EMF Eclipse framework. While it supports the collaborative use of modelling languages, it does not support their collaborative construction. On the other hand, the COMA tool [17] allows collaborating in the definition of UML diagrams, however, it does not provide support for creating DSMLs and does not present the collaboration as a process of discussion, argumentation and voting.

While several works emphasize the benefits of using examples when developing modelling abstractions [18], our proposal is unique in combining an example-based and collaborative approach to define DSMLs.

6 Conclusions

In this paper we have presented a process and tool support[2] for the collaborative development of DSMLs, where end-users are engaged and play an active role in the development of their own language. This is possible by the use of example models and fragments as a mechanism to drive the process, on the explicit support for discussion and collaboration, and on automated technical advice by a virtual recommender system.

In the future, we plan to apply our approach in the context of projects with our industrial partners. This will enable an empirical study of our solution, with the goal of checking whether end-users actually prefer it instead of the existing traditional solutions for defining DSMLs, and assess the quality of the produced DSML. We also plan to provide support for the automatic detection and solution of conflicting change applications, and for the collaborative construction of the

[2] https://code.google.com/a/eclipselabs.org/p/collaboro

concrete syntax and semantics of DSMLs, resulting in the generation of a full-fledged modelling environment.

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Conflict Coordination Based on the Transformation Bridge for Collaborative Product Performance Optimization

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Abstract. To quickly coordinate conflicts in product performance design, a transformation bridge method was proposed. Specifically, the design problems of performance conflicts were analyzed in terms of the quantification and collaboration. Based on the analysis, the mathematical models for conflict resolution and correlation function were developed. Thus the relationship between performance and design variables could be identified, and then used for searching similar cases from a repository. In addition, a core solution was developed by identifying the correlation among performance, combining the collaborative resolution method and case-based reasoning. The transformation bridge method was leveraging the extensibility of the basic-elements. Furthermore, the method for obtaining revised solutions was developed based on extension theory in particular the transformation operator and the cyclic transformation based on performance constraints, as the core of the approach to product performance optimization. The viability is evaluated in a case of screw air compressor design.

Keywords: cooperative design, case based-reasoning, extension theory, conflict resolution, fuzzy matter-element, retrieval.

1 Introduction

Production design holds the key to the development of the manufacturing industry [1]. In the context of modern design, customers' requirements for a product are to a large extent fulfilled by the performance it can achieve, raising the need of study performance-driven design [2]. As performance improvement for modern products becomes increasingly demanding, it is hard to meet this requirement by simply adjusting some design parameters as it may adversely affect other performance factors. Many methods

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have recently been performed by researchers from all over the world to address design conflicts. For example, Lee [3] developed a ship design system in which Case-Based Reasoning (CBR) was applied to conflict resolution by effectively utilizing similar experiences in the past. Wang [4] developed a conflict resolution module in the Pro/E CAD system based on the CBR method through analyzing the reasons of conflicts in smart CAPP. Resolution methods based on rules and CBR can effectively and quickly resolve some conflict problems which are common and involve low degree of coupling [5]. They, however, cannot deal with the conflict problems that involve coupled correlation in the design process [6]. To solve this problem, Zhou etc. [7] developed an interactive consultation conflict resolution method and Beheshtietc [8] established a consultation mechanism by applying multi-objective genetic algorithm to the application of conflicts. These methods, though, are not effective in terms of product design time. Conflict resolution based on TRIZ theory has been proposed as the main solution in product design [9, 10], but the methods proposed tend to focus on specific problems and thus generalization becomes a challenge.

Performance-driven product design has typical features of multiple-input-multiple-output tightly coupled performance, requiring collaborative performance optimization as a core solution and conflict coordination as a key enabling method. Hence, it raises the need of researching the complexity of the mapping between product performance and product structure, the uncertainty of changes in design variables and the viability of transforming solutions to address conflicts. Transforming bridge is a technique for researching how to transform conflict problems into solvable ones in the extension theory [11], which aims to achieve conflict resolution in the design process by establishing extension model, affair-element analysis and extension transformation.

2 Collaborative Product Performance Optimization Based on Similarity Matching

To achieve product performance optimization, it is firstly necessary to develop a formalized model for product performance based on the meta-model of product requirements. Product performance design unit is such a model that aims to meet customer's performance requirements by adjusting the properties of its key parameters and the constraints imposed on them. It is based on matter-element representation [11] and can be used to describe the correlation between product structure and product performance as well as to construct a case base for existing design solutions. The formalized model of product performance can be expressed using the following formula Mark case O_m as an object (matter), c_m as its properties and v_m as the values of c_m ($v_m = c_m(O_m)$), then the model of performance requirements can be described as $P=[O,c,v]$ and the product performance model can be described as a multi-dimensional matter-element model as follows.

$$PC = \begin{bmatrix} CaseName, & ID\_Confidence, & v_1 \\ & ID\_Class, & v_2 \\ & PE\_Performances, & v_3 \\ & PE\_Modules, & v_4 \\ & PE\_Functions, & v_5 \\ & \vdots & \vdots \end{bmatrix}$$

ID_Confidence: the product element; *ID_Class*: the product class element; *PE_Performances*: the product performance set element; *PE_Modules*: the number of module *PE_Functions*: the product function element.

Based on this formalized model, similar cases can be retrieved by matching the *ID_Class* and the values of performance factors against those required by a designer. The measure for evaluating similarity can be obtained by using the extension distance [12]: $sim(v(P),Y)=1-|d(v,Y)|$. If the interval about the value of a performance factor in the case base is $v(P)=[y_1,y_2]$, then the left side-distance and right side-distance are shown as follows.

$$d_l(v(p),Y)=\begin{cases} y_1-v(p), v(p)\le \frac{y_1+y_2}{2} \\ v(p)-\frac{y_1+y_2}{2}, v(p)>\frac{y_1+y_2}{2} \end{cases}, \quad d(v(p),Y)=\begin{cases} \frac{y_1+y_2}{2}-v(p), v(p)<\frac{y_1+y_2}{2} \\ v(p)-y_2, v(p)\ge \frac{y_1+y_2}{2} \end{cases}$$

After retrieving some cases by evaluating similarity using the above distance-based measures, these cases can be quickly used as a reference for new solutions. In terms of the performance requirements met by them, the cases can be divided into two classes: (1) those successfully meeting performance requirements with $sim_i>0$; (2) those requirement further optimization with $sim_i<0$.

3 Analyzing the Conflict Problem in Collaborative Performance Optimization

Mark product performance as an object element G which represents the optimization objectives and product structure as a condition element L which represents the variables to be transformed to eliminate conflict and find optimal solutions. The conflict resolution problem for collaborative performance optimization, then, can be denoted as $CQ=G*L$ where * means a logical operator. The key issue in this problem is the correlation function $k(v(P))$ which quantifies the changes made to the problem as well as the resultant changes in performance. The deviation of the formula for this function is out of the scope of this paper and has been published elsewhere [11, 13].

Collaborative performance optimization based on the formalized model discussed above may incur three kinds of conflicts as follows:

1) Independent performance conflict which can be formally denoted as $CQ_{11}=\{CQ_{11}|G_{P_i}\uparrow L, P_i\in simP<0\}$

2) Conflict between different performance factors, which can be formally denoted as $CQ_{12}=\{CQ_{12}|(G_{P_i} \wedge G_{P_j})\uparrow L, P_i, P_j \in simP<0\}$

3) Conflict between a performance yet to be optimized and other factors that have been optimized denoted as $CQ_2=\{CQ_2|(G_{P_i} \wedge G_{P_j})\uparrow L, P_i \in simP<0, P_j \in simP>0\}$

Generally, there are three methods to solve *CQ* as follows.

1) Perform transformation T_G on G and mark ϕ as the threshold of the corresponding product performances, then the range of the application of this method is: $k(v(P)) \in (-\phi,\phi) \in k'(v(P))$.

2) Perform transformation T_L on L, and then the range of the application of this method is $k(v(P)) \in (-\infty ,\varphi)$ with the transformation result $k'(v(P)) \in (-\phi,\infty)$.

3) Perform transformation $T_{CQ}=(T_G, T_L)$ on both *G* and *L*. This method will only be selected when correlation function keeps in the range $k'(v(P)) \in \pm(\phi,\infty)$ in the condition of cyclic transformation.

4 Reasoning Based Transformation Bridge for Collaborative Performance Optimization

4.1 Constructing the Core Conflict Problem

The relationship between the performance of a product and its structure is not as explicit as the relationship between its function and its structure as a specific performance is resulted from several different functions. Performance design is not as explicit as functional requirements. There are generally two different situations in the mapping process from performance and structure.

1) The mapping from performance and structure is explicit. For instance, the displacement and exhaust pressure of a screw air compressor are dynamic performance of the compressor as well as noise the dynamic performance of the nose, and thus can be mapped to the parts of the noise.

2) The mapping relationship between performance and structure is complex and fuzzy. For instance the noise of a screw air compressor is the green performance of the compressor but involves many complex parts. The noise of the compressor, then, may include aerodynamic noise, mechanical noise and electromagnetic noise.

There are several rules of implication analysis as follows.

Implication rule 1: If *R* is achieved, then R_1 and R_2 are achieved at the same time. This is the case where *R* implicates *R1* and *R2*, being denoted as $R \Rightarrow R_1 \wedge R_2$

Implication rule 2: If R_1 and R_2 are achieved at the same time, then *R* is achieved. This is the case where R_1 and R_2 implicate *R*, being denoted as $R_1 \wedge R_2 \Rightarrow R$

Implication rule 3: If *R* is achieved, then R_1 or R_2 is achieved. This is the case where *R* implicates R_1 or R_2, being denoted as $R \Rightarrow R_1 \vee R_2$

Implication rule 4: If R_1 or R_2 is achieved, then R is achieved. This is the case where R_1 or R_2 implicates R, being denoted as $R_1 \vee R_2 \Rightarrow R$

Many transformation programs for product structure can be obtained through implication analysis and the case-based reasoning method in the extension theory. This program is denoted as $A_i = \{A_{i1}, A_{i2}, A_{i3}, \ldots, A_{in}\}$ where $i = 1, 2, 3, \ldots, m$ and n denotes the transformation programs for product structure. If there are n^{th} characteristics, it contains dominating object, application object, accepting object, time, address, degree, manners and tools. Core problem of CQ can then be denoted as $KCQ = G * A_{ij}$.

4.2 Structure Transformation Reasoning Based on the Core Problem

The normal extension transformation methods, priority, weight of these methods are denoted, and then, the basic transformation can be expressed using the matrix [11].

Three transformation results will be obtained due to different transformation directions. There are meeting requirements direction, not meeting requirements, and no effectiveness to the results. So the process model of conflict coordination based on transformation bridge method can be given as in

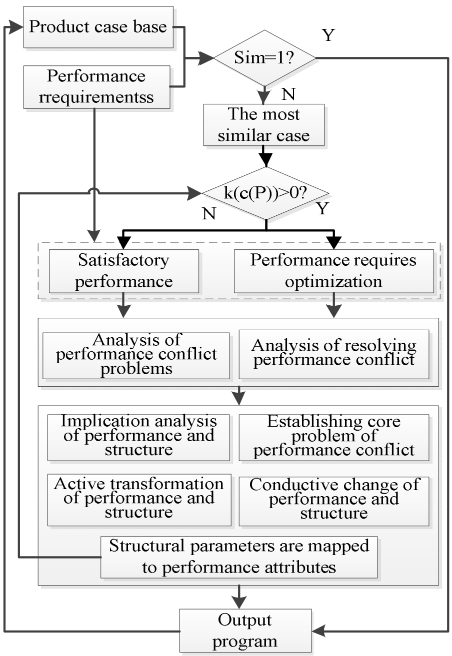


Fig. 1. Flowchart of the process of conflict resolution based on the extension theory

5 Application and Example

Air compressor is widely used in the industrial sectors oil extraction, chemical engineering, electricity generation and mechanical engineering. The structure of a screw air compressor is shown in Figure 2.

The components of the compressor are explained as follows. 1-55kw motor (10- absorber component, 11-motor vibration damper); 2-center resting; 3- coupling component; 4- nose assembly(12- absorber component, 13- host damping frame, 14- male and female rotors, 15 air filter assembly, 16- inlet valve component); 5- oil and gas separator component; 6- minimum pressure valve; 7- inner cooler; 8- thermostat valve; 9- oil filter components; 17- axial flow fan assembly.

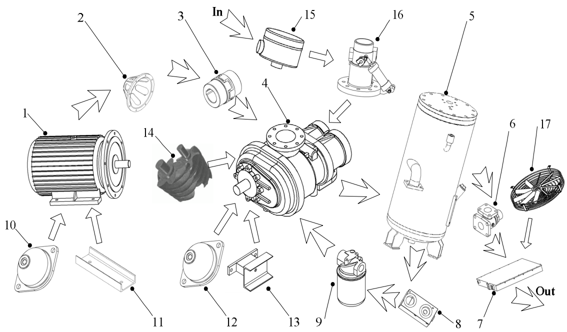


Fig. 2. Main components and schematic diagram of the screw air compressor of LG-6.7/10

Then a set of correlation functions of evaluation characteristics are established and denoted as $k_1(x)$. And the condition of transformation can be determined by judging by judging $K(P)=\overset{n}{\underset{i=1}{\wedge}} k(x_i)$. Take the noise performance as an example to illustrate how to calculate correlation functions. A correlation function can be constructed as the following equation with X (dB)=(50,107), X_0 (dB) =(60,70) and optimal value x_0=62 dB. So $k_4(x)$ can be established seen in [11]. The noise of a similar case retrieved from the design case base is 80dB, then the correlation degree between this case and the desired value is given as in $k_4(80)$= -0.27<0. So the case base can be calculated as $K(CQ)=k_1 \wedge k_2 \wedge k_3 \wedge k_4 \wedge k_5 \wedge k_6 \wedge k_7 = 0.075 \wedge 1 \wedge 0.91 \wedge (-0.27) \wedge (-1) \wedge (-0.25) \wedge 1 < 0$. This indicates that the attributes of noise, weight and lubrication oil need to be transformed. So the conflict problem can be resolved by applying collaborative performance optimization in terms of the three attributes, as shown in the following.

$$P = G * L - \begin{cases} g_4 * m_4 \text{Þ} A_1 = \begin{bmatrix} reduce & dominating\ object & noise \\ & application\ object & designer \\ & accepting\ object & LG\text{-}6.3/10 \end{bmatrix} \\ g_5 * m_5 \text{Þ} A_2 = \begin{bmatrix} lighten & dominating\ object & weight \\ & application\ object & designer \\ & accepting\ object & LG\text{-}6.3/10 \end{bmatrix} \\ g_6 * m_6 \text{Þ} A_3 = \begin{bmatrix} reduce & dominating\ object & lubrication\ oil \\ & application\ object & designer \\ & accepting\ object & LG\text{-}6.3/10 \end{bmatrix} \end{cases}$$

Set the effect size of the correlation function as ϕ=0.5 , α_1=1.2 , and α_2=1.1 , then it is obtained k_5=0.83>0 and k_6=0.65>0, which means weight and lubrication oil meeting customers' requirements. Comparing this with the matter-element method which can achieve noise properties requirement, the conductive contradiction path of different structures can be obtained. Through the comparison of several aerodynamic noise characteristics and the noise values, noise conflict problems are resolved by several main matter-element solution paths in this work, as shown in Table 1.

Table 1. matter-element method to reduce noise of screw air compressor

performance characteristic	matter element method	Configuration element set
aerodynamic noise A_{11}	A_{111} reduce intake noise	Inlet strainer PE1 ∧ inlet muffler PE3
	A_{114} reduce fan noise	electrical machinePE5 ∧ cooling fan PE6

The inlet noise of the screw air compressor belongs to low-middle frequency noise, for which resistance muffler is generally selected. Formula about noise reduction of resistance muffler is described. Some types of screw air compressors in the case base contain the intake muffler while some do not. The most similar case is retrieved the noise performance of which, however, does not meet the requirement. Moreover, intake muffler is not installed in this compressor because different types of air inlet have different fundamental frequency and the fundamental frequency of its inlet noise is 99HZ. Thus the muffler configuration element in the case base cannot be applied to this type and the extension transformation (the different transformations for this case are listed in Table 3) is needed with the condition matter-element of muffler structure parameters shown in the following equation.

$$l = \begin{bmatrix} expansion\ type\ silencer & material & corrosion\ resistant\ plate \\ & shape & circle \\ & the\ diameter\ of\ entrance & 60mm \\ & outlet\ diameter & 60mm \\ & expansion\ type\ diameter & 180mm \\ & expansion\ type\ length & 140mm \end{bmatrix} = \begin{bmatrix} l_1 \\ l_2 \\ l_3 \\ l_4 \\ l_5 \\ l_6 \end{bmatrix}$$

A set of transform operators is generated randomly by computer. Transformation control is done through the implication relationship between noise reduction, cost and product configuration. Then the following three groups of transformation operators $\{T_L\}$ are obtained. As a result of a series of transformations, a group of programs about product structure is obtained, as shown

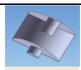
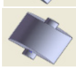
$$l' = (t_{29}^{2} \wedge t_{110})l =$$

$$\begin{bmatrix} \textit{Expansion type silencer} & \textit{Material} & \textit{Glass steel\&Galvanized steel sheet} \\ & \textit{Shape} & \textit{Circle} \\ & \textit{Entrance diameter} & 85mm \\ & \textit{Exit diameter} & 85mm \\ & \textit{Expansion type diameter} & 340mm \\ & \textit{The first} \exp \textit{ansion chamber} & 161.5 \\ & \textit{The} \sec \textit{ond} \exp \textit{ansion chamber} & 58.4 \end{bmatrix}$$

At present there is no precise method for calculating noise, so the overall noise is not the result of simply adding the noises from all the sources. Assume the noise intensity in k^{th} noise, overall noise z_n can be obtained as: $z_n = log(10^{n1} + 10^{n2} + L + 10^{nk})$. Some measures will be taken to reduce noise since it exists in the compressor, then the overall actual noise, denoted as f, after noise reduction is the difference between the total noise intensity and the noise reduction z_r, i.e.: $z=z_n-z_r$.

Based on the analysis of the above transformation operators, the muffler $-P_N$ and P_N after transformation can be calculated using noise theories and the correlation degrees of the noise performance after a series of transformations can be obtained. The resultant configuration program set is shown in Table 2.

Table 2. The muffler configuration schemes after transformations

new muffler	Configuration schemes	view muffler cutaway model	$-P_N$ dB	P_N dB	$K(CQ)$
1	$T_4 \wedge T_1 \wedge T_1 \wedge T_1 \wedge T_1 \wedge T_2 \wedge T_2$		14.3	71.3	-0.058
2	$T_4 \wedge T_1 \wedge T_1 \wedge T_1 \wedge T_1 \wedge T_2 \wedge T_2 \wedge T_1 \wedge T_3$		18.1	68.5	0.088
3	$T_4 \wedge T_1 \wedge T_1 \wedge T_1 \wedge T_2$		12.1	74.2	-0.148

6 Conclusion

In this paper, a method for coordinating conflicts in collaborative performance optimization is described in detail, which is based on the extension model, affair-element analysis and extension transformation. Through developing quantitative analysis methods of correlation function and several affair-element solution programs, a method for performance optimization is developed, with which, designers can search for similar cases in the past that will be transformed by the design system automatically. As demonstrated in the application, the method is successfully used in the optimization of a screw air compressor. In our future work, I will further improve the method and develop a computer-based decision support system to help designers in complex engineering systems with complex performance requirements.

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Towards a Performability Analysis for Environmental Sensor Networks

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Abstract. Wireless sensor and actor networks constitute one of the supporting technologies for cooperative applications. Particularly, in the case of environmental monitoring systems, ambient conditions can be conveniently modified by means of the so-called actuators (actors), which are driven by commands issued by a decision-making process on the basis of the information gathered by sensor nodes. In this context, sensor nodes are typically deployed at strategic locations on the basis of application requirements. These locations may be far apart from each other, leading to unfeasible or highly energy-consuming transmission distances. This paper provides an assessment of the impact of relay node insertion on performance and reliability.

Keywords: Sensor network, data-gathering tree, TDMA (Time-Division Multiple Access), network delay, packet loss rate, reliability.

1 Introduction

Figure 1 shows the architecture (semi-automated version) of an environmental monitoring system supported by a sensor network. This kind of systems are based on a continuous and dynamic cooperation between the application running on top of sensor nodes, the decision-making process at a remote data management center, and the application running on top of actuators. Among these three system components, the sensor segment represents the weakest part. This is due to the resource limitation of sensor nodes in terms of processing, communication and energy availability.

The sensor networks supporting the cooperative systems just described belong to the proactive or time-driven class. More specifically, in *proactive* or *time-driven* sensor networks (TD-WSN), nodes take readings of the environment and report the corresponding data following a regular or periodic pattern [1]. This data flow model makes the traffic generated by these networks very predictable, fact that recommends the use of the so-called contention-free scheduled MAC protocols. Some interesting scenarios of sensor networks for environmental monitoring are described in [1].

It is also common that TD-WSN are manually deployed [2], either by placing nodes at strategic locations that are of special interest, or according to some regular sampling pattern. In any case, the resulting locations are not necessarily close to each other, thus generally giving rise to large inter-node distances. However, large

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inter-node distances require long communication ranges, which are impractical or unfeasible for sensor networks. Hence, in order to make such wide-area deployments feasible, it becomes necessary to introduce additional nodes that mitigate the energy waste experienced by regular nodes. These supplementary resources can be introduced either randomly or following a structured approach. In the first case, relay nodes are randomly scattered over the sensor field until certain design requirements are fulfilled. However, the disadvantage of this approach is its poor scalability, since the total number of nodes to be deployed in case of large and sparse networks may be excessive. On the other hand, the structured approach, either over the field or along critical links, exhibits better balance between connectivity and lifetime enhancement and number of relay nodes. Examples of this approach are [3]-[5] and references therein.

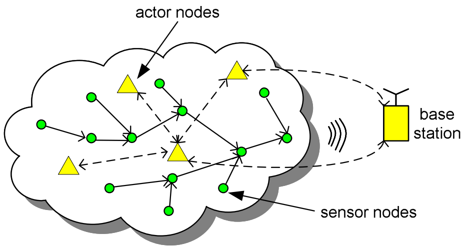

Fig. 1. Basic architecture of environmental monitoring systems based on sensor networks

However, deployment of supplementary nodes also has an impact on the *performability* of the cooperative system. Accordingly, in this paper, in contrast to the previous works, an assessment of both performance and reliability effects of relay node insertion is carried out.

2 Insertion of Relay Nodes

As stated in [2], it is common that packets in structured (and possibly sparse) sensor networks are routed through multi-hop pre-determined paths, forming the so-called *data-gathering tree* [6]. On the other hand, the predictability of the traffic pattern generated by these networks makes contention-free scheduled MAC protocols specially appropriate [1] [6]. To analyze the benefits of introducing additional nodes on lifetime, it is first necessary to characterize the dependence of energy consumption on transmission distance. Assuming a sensor network with N nodes accessing the communication channel via TDMA, and the radio model proposed in [6], it can be shown that the energy consumed by node i per communication round is as follows:

$$E(i) = \big(g(i) + 2\sigma(i)\big)\cdot E_e \cdot m + \big(g(i) + \sigma(i)\big)\cdot E_w \cdot m \cdot d^f(i)\ ,\ i = 1 \ldots N \qquad (1)$$

Here, E_e is the energy dissipated by the transceiver circuitry to transmit or receive a single bit, E_w is the energy radiated to the wireless medium when transmitting a single bit over a distance of 1 meter, f is the path loss exponent, m is the packet length in bits, $g(i)$ is a measure of the *traffic intensity* per node, which is defined as the number of packets generated by node i per round of communication, and $\sigma(i)$ is the *forwarding degree*, that is, the number of packets forwarded by node i during every round of communication.

The simplest way to introduce relay nodes in the network is by inserting them into critical links, that is, links that exceed the transmission range of nodes or that do not allow to achieve a minimum network lifetime, even if their length is below the maximum range. The reference scheme is shown in Figure 2, where several relay nodes are inserted in the segment (hop) between node i and node j. Correspondingly, the following algorithm provides an iterative method to determine the number of relay nodes in every link of the network:

```
program Relay Node Insertion
for i = 1 to N do
  n(i) = 0 //variable that will contain the number of nodes
           to be inserted in link i
  Evaluate l(i) //expected lifetime of node i
  while (l(i) < L || d(i)/(n(i) + 1)) < R_max do
    n(i) = n(i) + 1
    Evaluate l(i)
  end while
end for
```

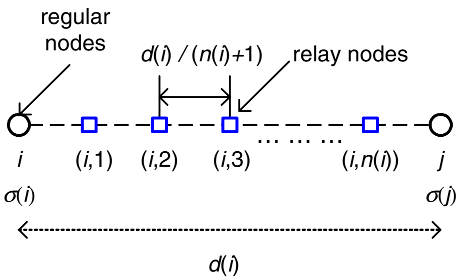

Fig. 2. Insertion of equally-spaced relay nodes in the link between two regular nodes

As it can be noticed, it is assumed that nodes are equipped with an initial battery level B and have maximum transmission range R_{max}, whereas L is the requirement on network lifetime, defined as the time until first node death. When the lifetime requirement is more restrictive that the maximum transmission range (that is, all link distances are below the maximum transmission range), the number of relay nodes to be inserted in the segment headed by node i can be expressed as follows:

$$n(i,L) = \left\lceil \left(\frac{L \cdot E_w \cdot m\big(\sigma(i) + g(i)\big) d(i)^f}{B - L \cdot E_e \cdot m\big(2\sigma(i) + g(i)\big)} \right)^{1/f} - 1 \right\rceil, \; i = 1 \ldots N \tag{2}$$

A proof of the cost-effectiveness of relay node insertion is provided in Figure 3, which plots the amplification of lifetime of regular nodes in terms of the number of relay nodes, for different values of the link distance. The values for the workload-based parameters are set as follows: $g = 1$ and $\sigma = 5$. The rest of parameters are taken from [7] and typical operating conditions: E_e = 50nJ/bit, E_{fs} = 10pJ/bit/m^2, E_{mp} = 0.0013pJ/bit/m^4, $f = 4$, d_0 = 75m, B = 15kJ and m = 125B. As it can be noticed, node lifetime can be significantly amplified just by inserting a relatively low number of relay nodes. For instance, by inserting 4 nodes in a 300m-link, the new lifetime for the node is about 80 times greater. Also, it can be observed that the effectiveness of relay node insertion increases with the target distance.

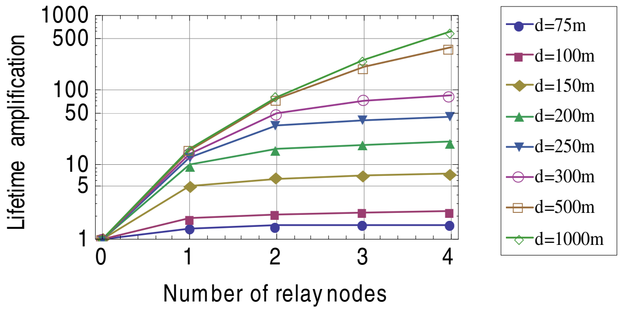

Fig. 3. Amplification of node lifetime versus number of relay nodes, for different values of the target distance

3 Performability Plot

Unfortunately, the insertion of relay nodes for network lifetime enhancement degrades system performability. As a first-step approach to this problem, the performance in terms of packet delay and packet loss rate, and the dependability formulated as reliability, are analyzed separately. To perform this analysis, let us first define τ as the duration of packets, q as the packet error probability at the receiver of any node in the network, and $r(t)$ as the node reliability function, that is, the probability that a node (regular or relay) remains operational at time t, given that it started working at time 0. Considering again the reference segment shown in Figure 2, the increase in delay, the packet delivery rate and the reliability at segment levels can be respectively formulated, for the segment headed by node i, as follows:

$$\Delta D(i) = \tau \cdot n(i)\ ,\ i = 1 \ldots N \tag{3}$$

$$PDR(i) = (1-q)^{n(i)+1}\ ,\ i = 1 \ldots N \tag{4}$$

$$R(i,t) = r(t) \cdot \prod_{j=1}^{n(i)} r(t) = r(t)^{n(i)+1}\ ,\ i = 1 \ldots N \tag{5}$$

In particular, expression (4) is based on three assumptions: (a) Homogeneous electromagnetic environment, (b) power control capability enabled (already adopted in the formulation of energy consumption), which guarantees the same signal-to-noise ratio at all receivers, and (c) packets received in error are discarded and not retransmitted. The latter assumption is common in time-driven sensor networks, because subsequent packets refresh the lost information, though up to some level beyond which the reconstruction process can be severely distorted.

In order to visualize the trade-off between the above segment-level metrics and network lifetime, the performability plot shown in Figure 4 can be constructed. In this plot, the segment index is omitted for simplicity and the dependence on the required lifetime is explicitly indicated. Most parameter values were already used in Figure 3: E_e = 50nJ/bit, E_{fs} = 10pJ/bit/m^2, E_{mp} = 0.0013pJ/bit/m^4, f = 4, d_0 = 75m, B = 15kJ, m = 125B, σ = 7, g = 2, d = 500m and q = 5%. For the node reliability, a constant failure rate is assumed, with an $MTTF$ of 15 million rounds [8]. This means that $r(L) = r(t)\big|_{t=L} = \exp(-t/15\cdot 10^6)\big|_{t=L} = \exp(-L/15\cdot 10^6)$.

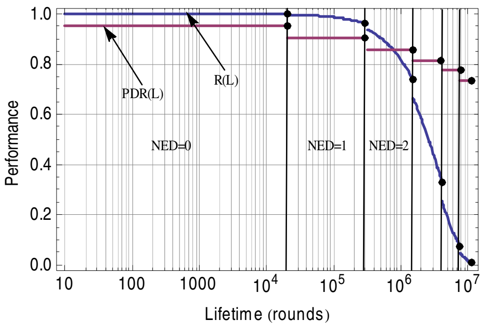

Fig. 4. Performability plot. NED stands for the extra delay normalized to the packet duration.

Specifically, the figure shows the degradation at segment level of both reliability and packet delivery rate as the required network lifetime increases. The metrics at segment level (and the performability plot) can be easily extended to other scales, like a path along the network or the overall network.

4 Numerical Results

In order to illustrate the effects of relay node insertion, the test scenario shown in Figure 5 is considered, which represents a medium-size network constituted by 20 regular nodes and a base station. Link distances (in meters) are shown as link labels. Since the link layer protocol is assumed to be TDMA, the geographical distribution of node locations that would allow the construction of an interference map, is not relevant. Thus, the logical network shown in the figure suffices.

With no loss of generality, all nodes are supposed to generate 1 packet per communication round, that is, $g(i) = 1\ \forall i$. Accordingly, the forwarding degrees for all nodes are also indicated in the figure. Again the radio model parameters used in the previous sections are adopted, and a time interval of 15000 slots is considered. With 125B-packets transmitted at 250Kbps, this time interval would correspond to a reporting period of 1 minute. Then, considering precisely m = 125B, and B = 15kJ, the energy consumption model given by (1) leads to a network lifetime of 127552 rounds, which is determined by node 17. For the reporting time of 1 minute, this corresponds to roughly 2 months. Now, let us assume that a network lifetime 20 times larger is required. By applying the technique described in Section 2, 8 relay nodes should be inserted as also shown in Figure 5. The new distribution of node lifetimes is shown and compared to the previous one in Figure 6. It can be noticed that the new distribution of node lifetimes is more uniform, since a significant subset of nodes were below the lifetime requirement and thus had to be enhanced. The new network lifetime is 3437932 rounds (around 27 times larger than the lifetime of the original network), and it is now determined by node 5. This enhancement has been achieved with just 40% theoretically inexpensive additional nodes.

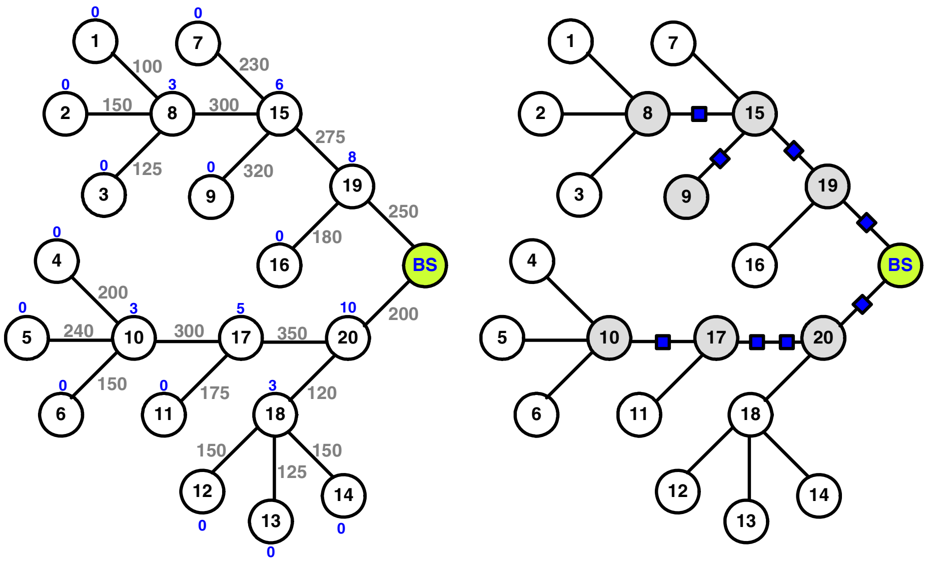

Fig. 5. Test scenario: before relay node insertion (left), and after relay node insertion (right)

In contrast to the benefits in energy consumption and lifetime, performance metrics are degraded. The impact on some path delays and network reliability can be easily derived from the enhanced network shown in Figure 5. In particular, the increase in path delay is rather unimportant for most environmental monitoring applications, which generally do not impose severe time constraints. However, the effects on packet delivery rate need more careful attention, as signal reconstruction in some parts of the sensor field might be damaged. Figure 7 shows the variations in packet loss rate per node as a result of node insertion. This variation reflects the increase in packet loss rate for the full path between every node and the base station, so it accounts for all segments along a path. It can be shown that this variation can be mathematically expressed as follows, where a path is represented by a sequence of p regular nodes $(i_1 \ldots i_p)$:

$$\Delta PLR(i_1, i_2 \ldots i_\mathrm{p}) = (1-q)^p \cdot \left(1-(1-q)^{\sum_{\lambda=1}^{p} n(i_\lambda)} \right), i_1, i_2 \ldots i_p = 1 \ldots N, i_1 \neq i_2 \ldots \neq i_p \qquad (6)$$

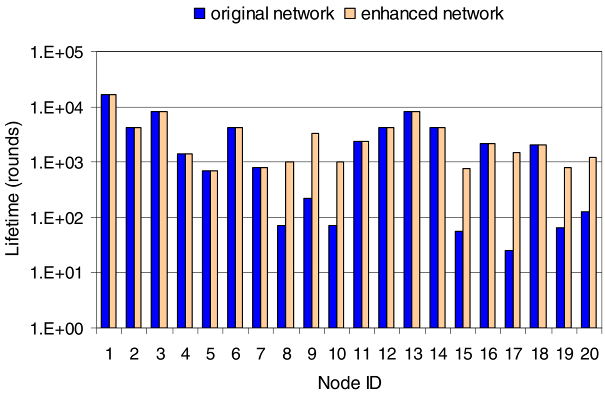

Fig. 6. Distribution of node lifetimes before and after relay node insertion

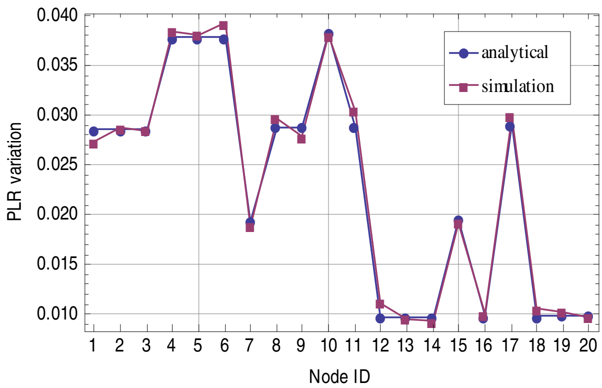

Fig. 7. Packet loss rate variation due to node insertion in the test network

As it can be noticed, Figure 7 also includes simulation results, which almost perfectly match the analytical ones. The former have been obtained after 150 runs, by assuming a Depth First Scheduling (DFS) TDMA slot assignment scheme with no slot reuse (see [6] for more details) and a battery of just 3J. This small battery value is intended to reduce the simulation time (as long as the battery value allows the simulated network to achieve its steady state and persist in this state for sufficient amount of time, so that any transient-based bias can be neglected).

5 Conclusions

In this paper, the effects of relay node insertion on lifetime, performance and reliability of a time-driven sensor network supporting a cooperative system have been analyzed. The obtained results are part of an overall work that can be accomplished in two directions: (a) analysis of performance and reliability when clusters instead of single nodes are deployed at locations of interest, and (b) formulation of a performability metric and its characterization by means of a Markov Reward model.

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Cooperative Mobile Agents for Swarm Behavior Simulation

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Abstract. Quad-copters, sometimes called quad-rotors or quad-rotor helicopters, are currently a very popular platform for robotics research, primarily due to their properties, such as small size and mechanical simplicity. Coordination in multi-robot systems is one of the open issues of swarm robotics. Space exploration and mapping are crucial abilities of mobile robots for the intelligent autonomous systems. This paper proposes a solution for space exploration and surveillance based on several biologically inspired methods and algorithms. The best form to represent the results form research simulations is the 3D visualization. The paper also describes the developed tool for visualization of more than one quad-copters as mobile agents during simulation.

Keywords: Quad-copter, cooperative visualization, visualization tool, swarm intelligence, distributed algorithm.

1 Introduction

In multi-robot systems, coordination is one of the open issues of swarm robotics. Space exploration and mapping are crucial abilities of mobile robots for forming an intelligent autonomous system. The concept of **swarm intelligence** is well-known and can be found in numerous of applications in many different domains. Algorithms and methods are being modified, transformed or combined to meet specific requirements. A common application exploiting biological inspiration is in cooperative multi-robot systems, where rules from biological systems are applied to the artificial systems, in order to form an organized society with intelligent behavior.

This paper presents a new method for coordination of a group of mobile agents that can be used for unknown area exploration and monitoring. It is organized as follows. Section 2 introduces problem formulation and the related work. Section 3 formulates the proposal of method and section 4 describe the 3D Visualization tool. Conclusion is outlined in the last section 5.

2 Problem Formulation and Related Work

Nearly all of the work in cooperative mobile robotics began after the introduction of the new robotics paradigm of behavior-based control. This behavior-based paradigm

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has had a strong influence in much of the cooperative mobile robotics research. Because the behavior-based paradigm for mobile robotics is rooted in biological inspirations, many cooperative robotics researchers have also found it instructive to examine the social characteristics of insects and animals, and to apply these findings to the design of multi-robot systems [1].

The concept of *Swarm intelligence* is known and famous and can be meet them in lots of applications in many different areas. The applied algorithms we can see on the research of V. Ramos, J. Handl, M. Dorigo, E. Bonabeau, E. D. Lumer, B. Faieta [4] and lot of researchers of the famous swarm intelligence science community. Thiemo Krink group is the research group which have used and implement in simulation systems by using the algorithms of the current research projects of Ramos, Dorigo et al. In addition Thiemo Krink-group [9] have developed various interesting extensions to the original systems. It was before dynamic pheromone evaporation, object switching while carrying another object. Very interesting is dynamic picking and dropping probabilities. Varying border conditions. Two and three world dimension changes and the elegant answer for some problems in concerning orientation and boundary conditions.

Hereford and Siebold [3] presented a version of PSO called physically embedded PSO, which was designed to control robots in the process of finding a target in the environment. A PSO modification for the purpose of space exploration was introduced in [1].

Ant colony optimization (ACO), proposed by Dorigo and Stützle in [5], is a probabilistic technique for solving computational problems which can be reduced to finding good paths through graphs. The keystone was the deposition of virtual pheromones by virtual ants. The pheromones were used to select next node in graph as waypoint.

A combination of PSO with digital pheromones for constrained optimization problems has been described in [6]. In [7] virtual pheromone based communication mechanism to decrease communication cost in the map coverage task was introduced. In 1986 Reynolds created a computer simulation of artificial bird flocking. Artificial birds (boids) were able to model the motion of a flock of birds following simple rules [8].

Our applied algorithms are based on the research described in [4] and some further researchers from the swarm intelligence science community.

The goal is to create a swarm of mobile agents that can search a two-dimensional space and create a model of this environment. The agents should be able to coordinate their actions, to communicate, and to create the map of the environment interactively. After exploring the whole environment, robots should continue in a surveillance of the explored space. The robots are equipped with sensors, so the goal is not to visit every single bit of the two-dimensional array, but to cover the whole area with the sensors.

Mathematical formulation is as follows. Let us suppose two-dimensional rectangular array A:$\{m \times n\}$ with a size $m \times n$ square cells, where each square cell $s[i][j] \in A$ is uniquely determined and initialized with value 0. Position of the robot n is $R_n(x_n, y_n)$. The movement of the robot in the space is described by changing its coordinates in time. If the range of the sensor is ε, we can define the operation radius O_ε of robot R_n as:

$$O_\varepsilon(R_n) = \{X \in A : \rho(R_n, X) < \varepsilon\}, \quad O_\varepsilon(R_n) \ll A \tag{1}$$

where *X(i,j)* is the middle of a square *s[i][j]*. When the middle of the square *s[i][j]* occurs within the operation radius O_ε, its value is set to 1. The goal is to achieve the state where:

$$\forall X \in A\{m\ x\ n\}, i < m, j < n : X(i,j) = 1 \tag{2}$$

This is the state, where each element of the array is set to 1, i.e. it has been explored by any of the group of robots.

3 Proposal of Method

In our approach, the behavior of each robot is influenced by two vectors. The first one is the influence vector, which is mostly responsible for coordination in a group and the second one is the vector denoting the position of a virtual pheromone in the surroundings.

As a symbolic representation of the environment, the proposed method uses grid maps. The space is divided into a grid containing $m\ x\ n$ square cells. The grid itself does not restrict the movement of the robots to the edges or square centers. Robots move over the grid continuously. The square cells hold the information about virtual pheromone, which is distributed by the robots. In the case of real application, they hold information about the obstacles in real environment. From these reasons, the size of virtual square impacts the behavior of the system.

All of the work in cooperative mobile robotics began after the introduction of the new robotics paradigm of behavior-based control. This behavior-based paradigm has had a strong influence in much of the cooperative mobile robotics research. Because the behavior-based paradigm for mobile robotics is rooted in biological inspirations, many cooperative robotics researchers have also found it instructive to examine the social characteristics of insects and animals, and to apply these findings to the design of multi-robot systems [1].

A circular zone of influence (Z1) is set around each agent. When other agent occurs within this zone, it influences the behavior of agent in the center (central agent). This influence is bilateral attraction or repulsion and is determined by influence function. Generally speaking, when the robots are very close, they tend to repel each other; when the distance is greater, they are attracted to each other. This influence is represented by vector computed by influence function. Fig. 1 depicts the influence function.

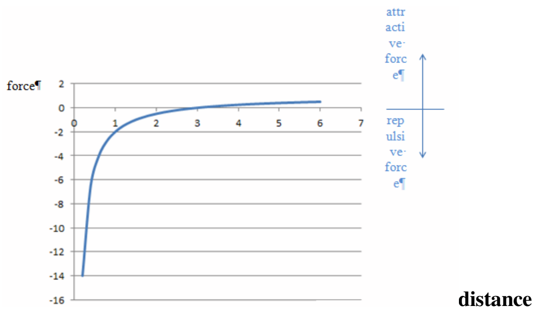

Fig. 1. The influence function. The spot where the function crosses x-axis defines the equilibrium distance

This figure shows that the closer the robots are, the greater the repulsion force is. With attractive force, the situation is similar. In fact, the influence function is designed in such a way, that for input variable (distance of two robots) it outputs the force vector with the magnitude which navigates the robot to the equilibrium position. Equilibrium position is the distance between two robots, when they do not attract or repel each other. In the case of Fig. 1, the equilibrium distance is set to *e=3*. The influence function crosses the *x* axis in the equilibrium distance and the magnitude of the output vector for input value three is zero. Mathematical formulation of influence function is:

$$t_a = \frac{|\overrightarrow{d_{an}}| - e}{|\overrightarrow{d_{an}}|},$$

where $\overrightarrow{d_{an}}$ is vector denoting position of the robot R_n relative to the position of the central robot R_a. The output of this function is transformation coefficient t_a, which transforms vector $\overrightarrow{d_{an}}$ to the vector that defines shortest way from the current position to the equilibrium position of both robots.

$$\overrightarrow{d_{an}} * t_a + \overrightarrow{d_{an}} = e,$$

Graphical interpretation of this equation is in the following figure.

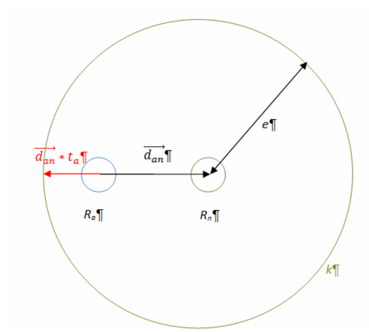

Fig. 2. Circle *k* with the radius *e* defines equilibrium distance between agent R_a and R_n.

Transformation coefficient is used to determine the influence vector $\overrightarrow{y_{an}}$ as follows:

$$\overrightarrow{y_{an}} = \frac{\overrightarrow{d_{an}} * t_a}{2}$$

Influence vector is computed using relative vector $\overrightarrow{d_{an}}$ and transformation coefficient t_a and determines a trajectory to equilibrium position of both agents. In order to achieve equilibrium distance between two agents, it is required that each of the agents travels a half of the distance, therefore there is number 2 in the denominator. The range of the influence function is limited by the range of the influence zone. The robots outside this range do not influence the central robot.

3.1 Pheromone Vector

Robots deposit virtual pheromone markers while traveling in the environment. These pheromones are used to determine which square cell of the map has been visited so far. If we implement pheromone evaporation, it is possible to determine how long it is since the last visit. Pheromone is deposited immediately when a robot reaches new square cell. The use of the pheromone is similar to the use in ACO method, but unlike virtual ants, the robots are searching for the square cell without any pheromone marks. Virtual pheromones are not used to construct paths, but to mark explored space. A circular zone Z2 of pheromone detection is defined around each robot. Robot searches for the closest unexplored square cell within this zone. When it is found, the second vector influencing behavior of the agent is created. The vector $\overrightarrow{p_h}$ is called pheromone vector. The perimeter of pheromone detection zone may or may not be fixed. In the second case, when no unexplored square cell is found within this range, the perimeter is extended.

The probability of selecting square *s(i,j)* is derived from its pheromone value $\boldsymbol{\tau_{ij}}$.

$$\mathrm{p_{ij}} = 1 - \frac{\tau_{ij}}{\sum_{ij}^{z} \tau_{ij}} \qquad for \qquad (i - x_r)^2 + (j - y_r)^2 < {r_p}^2,$$

Where x_r, y_r are the coordinates denoting position of an agent. Robots do not always select the square cell with the lowest pheromone value. The p_{ij} probability of selecting square cell *s(i,j)* as a preferred square is inversely proportional to its pheromone value. Denominator represents the sum of all pheromone values within pheromone detection range Z2. This rule is the same when robots are exploring the environment, but in a simpler form, because the probability of selecting any unrevealed square cell within range is the same. In this case the probability is as follows:

$$p_{ij} = \frac{1}{n_p}$$

where n_p is the number of the pheromone marks within zone Z2. After selecting a pheromone, vector $\overrightarrow{p_h}$ is constructed. It determines a position of selected square relative to the position of the agent.

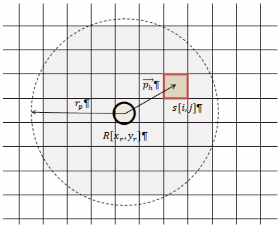

Fig. 3. Gray area represents squares fitting the equation$(\boldsymbol{i} - \boldsymbol{x_r})^2 + (\boldsymbol{j} - \boldsymbol{y_r})^2 < \boldsymbol{r_p}^2$

There is a limit for the length of the vector $\overrightarrow{p_h}$, in order to maintain influence balance between this vector and the first vector $\overrightarrow{y_a}$. There for, it is good idea to set the same limit for the length of $\overrightarrow{p_h}$ as the equilibrium distance. If pheromone evaporation is presented, it is not derived from the time. It is only dependant on the movement of the agents. All pheromone values are decreased when any agent crosses a border between two adjacent squares. So there is no need to use any synchronization tool and the communication requirements are lowered.

3.2 Movement

After specifying pheromone vector $\overrightarrow{p_h}$ and influence vector $\overrightarrow{y_a}$, the next position of the robot is computed using vector sum.

$$\vec{v} = \overrightarrow{y_a} + \overrightarrow{p_h}$$

Since the influence function outputs scaled influence vector, there is no need to adjust it with additional weights. We also use the limit v_{max} which defines maximum length of the vector $\vec{v}$. Adjusted vector $\overrightarrow{v_n}$ is the resulting vector determining the following movement of the agent. V_{max} is a parameter set by user and determines the frequency of selecting next action to perform. The higher the frequency, the higher the decision rate. It is like having the higher sample rate of the environment changing in time to get more accurate response. Agents reflects the changes in environment more often, but high frequency may lead to the chaotic movement, because agents will not be even able to reach the destination square and the will be forced to select another one. Determining this parameter is therefore important process, which should reflect environmental aspects and the abilities of robotic platform (speed, reach of the sensors, etc.)

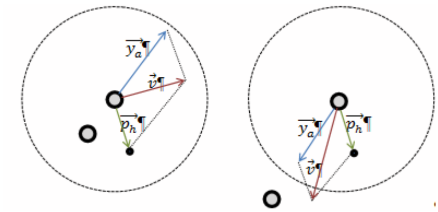

Fig. 4. The left figure shows the situation in which robots are too close and influence vector (blue) causes repulsion. In the right figure robots are further away and the influence vector causes attraction. Outer circle shows the equilibrium distance. In the case the second robot was directly on this circle, the influence vector would have zero magnitude.

Fixation of the pheromone detection range and the pheromone evaporation are two parameters which lead to two different behavior of a swarm as follows:

- if the pheromone does not evaporate and the perimeter of the zone of pheromone detection is not fixed, the behavior of the robots is aimed strictly towards space exploration,
- if the pheromone does evaporate and the perimeter is fixed, the behavior of the swarm resembles environment surveillance.

4 3D Visualization Tool (VT)

We consider the best form to represent the research simulations results is to use 3D visualization in virtual reality. We started with 2D visualization. For the visualization of the swarm environment we used two - dimensional worlds, as well as varying three dimensional worlds (e.g. cube, dish and tube) [8]. We have analyzed the swarms sorting behavior in the environments, and also evaluated the main swarm features: flexibility, robustness, decentralized organization and self-organization of the swarm [5]. *The platform independence feature* can be used for different types of robotic platforms, such as mobile vehicles, flying quad-copters, etc. We have decided to use the final results from research simulation to test the virtual quad-copters. Virtual reality and 3D animation provides better representation of the final result of the simulations. This was our main reason to develop the 3D visualization tool.

We have started with designing of 3D model of the quadcopter, which is converted to several 3D formats. The VRML model can be seen in Figure 5. After spinning the four screws of quad-copter we can start the 3D visualization of the final results from the simulations.

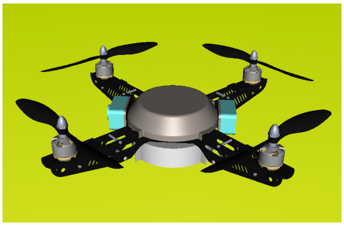

Fig. 5. 3D Model of Quad-copter

Final data outputs from simulations are stored in the output storage elements. Data are input to the module and sorted. One module is responsible to create VRML-syntax from the sorted data and to compute and regulate the routes with respect on size of the 3D quad-copter models. The other modules are responsible for the background simulation. The background is shown as a 3D model of the objective environment in which the quad-copters can fly in [3]. The agent boundaries are differentiated by colors. Snapshot of the animation video can be seen in Figures 6.

Fig. 6. Visualization output results of 5 quad-copters with boundaries of different color

5 Conclusion

This paper describes a biologically inspired method focused on autonomous multi-robot coordination, especially on space exploration and surveillance over the environment. The most important features of the presented approach are:

Flexibility - different parameters setting results in different behavior of the system.

Scalability - the algorithm works for any number of robots. The only limitation is communicational ability of individual robots.

Adaptability - the presented approach can be used in any environment; however it was tested on indoor robots moving over a flat surface. The adaptation of our approach depends on specific mobile agent's realization,

Robustness - a failure of a robot does not cause the failure of the whole system.

Platform independence - can be used for different types of robotic platforms, such as mobile vehicles, flying quad-copters, etc.

Parallelism - (the algorithm is distributed. Each agent performs its own operations in parallel.

The simulation results prove that our approach has space exploration and surveillance ability and potential to emerge into formation creation. Switching from exploration to surveillance mode is done via changing two features only. Effective map coverage was achieved, while still maintaining low communicational and computational costs. A virtual pheromone-based communication mechanism is adapted to decrease the communication cost and optimize the cooperation within the swarm. The task for the future work is to determine for each robot when to switch independently from others between exploration and surveillance mode. There might be a case in which some robot is in the area of the map which is fully explored and it is effective for it to begin with the surveillance. We plan to expand the VT tool to become an on-line working tool, which will be able to animate the simulation results as a part of parallel computing [6], [7].

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Relational Propagation of Word Sentiment in WordNet

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Abstract. Sentiment analysis is a relatively new engineering problem in the domain of Natural Language Processing. Its crucial tool are sentiment polarities assigned to synsets (synonym sets) corresponding to abstract meanings existing the natural language. Synsets, together with their lexico-semantic relations are the essential components of every WordNet. The main idea of a new approach to sentiment assignment in WordNet based on relational propagation is presented in the paper.

Keywords: sentiment analysis, classification, wordnet, sentiwordnet, relational machine learning, relational propagation, lexico-semantic relations, cooperative applications.

1 Introduction

Sentiment analysis has become a popular research topic for last years. It is usually based on simple tagging of linguistic blocks (words, sentences, paragraphs, etc.) with sentiment polarity. In its basic form, every term is manually flagged as positive or negative and then used to evaluate sentiment level for whole textual content.

Sentiment analysis is practically very important for modern business, especially in marketing. Especially, reviews or opinions about specific products published on the Internet are targets for sentiment analysis. This, in turn, enables to evaluate if a given product is liked or disliked and even what are the general customer expectations towards its specific features.

2 WordNet and SentiWordNet

WordNet is a lexical database for a given natural language. There are WordNet bases for many languages like English (the largest) or Polish (the second largest) [8]. Every WordNet groups the terms into sets of synonyms called synsets, provides short, general definitions, and records the various semantic relations between synsets. The purpose is twofold: (i) to produce a combination of dictionary and thesaurus that is more intuitively usable, and (ii) to support automatic text analysis. The first WordNet was created in Princeton University.

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The main relation among terms in WordNet is synonymy, as between *shut* and *close* or *car* and *automobile*. Synonyms – words that denote the same concept and are interchangeable in many contexts – are grouped into unordered sets (synsets). Each of English WordNet's 117 000 synsets is linked to other synsets by means of a small number of *conceptual relations*. Additionally, a synset contains a brief definition (*gloss*) and, in most cases, one or more short sentences illustrating the exemplary use of the synset members. There are as many distinct synsets as word forms with distinct meanings. Thus, each form-meaning pair in WordNet is unique [3].

In 2006, Esuli and Sebastiani created a WordNet with sentiment annotations for English (SWN) [1]. Their idea was to tag every synsets with values such as *Obj*(*s*) – objective (neutral), *Pos*(*s*) – positive and *Neg*(*s*) – negative. SWN has over 117 thousand synsets in its database, i.e. as many as in Princeton WordNet, however, not all of them have additional sentiment annotations.

As an example Chamlertwat et al. devised a method of using SWN as a base for sentiment analysis of tweeter messages [7]. The basic idea is to detect polarity of a sentence by measuring polarity of component words.

Sentiment analysis of opinions can provide an insight view of market trends. It can be used to tell manufacturers about opinions of their buyer concerning specific products [2].

3 Relational Propagation of Word Sentiment

3.1 Problems

There are some problems concerning creation of sentiment tags for synsets:

- It is not possible to assign sentiment tags to translated words from SentiWordNet to any other language.
- Some WordNets are not a perfect representation of Princeton WordNet capabilities. A lot of relations between synsets are not present. The whole lexical database is not complete.
- SentiWordNet in its later stages of tagging is using gloss as a method to add sentiment to synsets. In some cases this information is not present in multilingual WordNets, e.g. in recent Polish WordNet.

Differences between features and relations of Princeton WordNet and multilingual ones can be significant, lack of *gloss* texts is one of them and *gloss* is the basis for English SentiWordNet. As a result, to assign sentiment to multilingual WordNets, either they need to be made as in the same way as in English SWN or a separate method of sentiment tagging must be developed.

Esuli and Sebastiani based their work on findings made by Turney and Littman [4], who manually classified some terms as descriptive for positive and negative categories:

$$S_p = \{good, nice, excellent, positive, fortunate, correct, superior\}$$
$$S_n = \{bad, nasty, poor, negative, unfortunate, wrong, inferior\}$$

It would be necessary to find a similar collection of paradigms for negative and positive categories in a specific language for multilingual WordNets. This would be starting point (seeds) for sentiment propagation. These seeds would be limited by the range parameter telling the algorithm how far it can propagate from the seed set. The sentiment tagging starts with those small seedsetand proceeds to create larger sets using *gloss* texts for propagation. The method for that would be essentially the same as described by Baccianella, Esuni and Sebastiani [5].

However, in some WordNets like in Polish one there is no *gloss* so another methods based on more general propagation mechanisms needs to be worked out.

3.2 The Method for Relational Propagation of Sentiment

The proposed method of relational propagation of sentiment is based on the concept of collective classification [6]. This is a new method, which performs cooperative assignment of sentiment annotation based on structure of connections between synsets. First, we need to manually annotate some terms – initial seeds. Based on lexico-semantic relations between particular terms (e.g. synonymy, antonymy, hyponymy, meronymy, derivation, etc.) as well as partial sentiment annotation (seeds), a collective classification method is able to propagate the sentiment polarity over the whole graph of terms. The most popular local collective classification method is Iterative Classification Algorithm (ICA). It belongs to approximate local inference algorithms based on local conditional classifiers. Another representative methods are Gibbs Sampling Algorithm (GS) and Loopy Belief Propagation (LBP) [5].

In ICA, we have the set V^U that contains graph nodes (synsets) with unknown labels and the set V^K with nodes of known labels. Both sets complement each other into entire set of synsets V: $V^U \cup V^K = V$. The aim is to discover sentiment labels l_i (e.g. *positive*, *negative*, *objective*) of all unknown nodes $i \in V^U$. In other words, the set V^Ucontains synsets with no sentiment annotated and V^K – the annotated ones. ICA uses a local classifier Φ, which is trained with synsets that are already annotated with sentiment. Then using the trained classifier, it iteratively infers a sentiment for all nodes from V^U, Fig. 1. Usually the classifier is trained based on features derived from quantification of neighbourhood consisting of nodes from the V^K. In case of multiple relations (like in WordNet), the ICA algorithm needs to be invoked many times, independently for each relation type. Then, the final class (sentiment) results from the fusion of results for each individual relation. Alternatively, the fusion is performed at neighbourhood quantification, i.e. neighbours are described by many features derived from all relation types and are simultaneously respected at reasoning; at every ICA iteration.

In the perfect case, the algorithm ends up with nodes assigned with two basic annotations: *positive* or *negative*. However, it may happen that particular synset would not be able be assigned with such annotation due to lack of information required for inference and its sentiment would be classified as *neutral* or *objective*.

Current research and evaluation are being accomplished on WordNet 3.0 with sentiment annotation used from SentiWordNet 3.0. This combination allows us to have an extended gloss annotation for each synset and sufficient comparison of results.

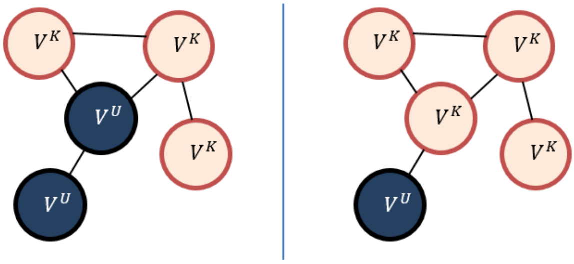

Fig. 1. Sentiment propagation between following ICA iterations, V^K – a seed set (synsets with the known sentiment), V^U – unknown synsets (without sentiment assigned)

4 Conclusion

The idea of new approach to sentiment assignment in WordNet based on relational propagation was presented in the paper. It applies the collective classification concept for discovery of term sentiment by means of lexico-semantic relations existing in the WordNet.

Further studies will focus on pre-processing and aggregation of relations between terms in WordNet for more accurate sentiment assignment.

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Cooperative Design and Communities of Practice

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Abstract. The focus of teaching and learning within Coventry University's Automotive and Industrial Design course is to equip students with a passport to enter their professional community of practice [1] [2].

One of the core competencies contained within this passport is co-operative working and teamwork - seen as a fundamental aspect of the creative design process, from concept to production - and this is seen as a threshold concept within the course.

Therefore, to provide designers for industry it is imperative the discipline of co-operative working is part of the learning process as designers will be expected to interact with a wide range of disciplines 'such as engineering, business, sociology, and psychology, among others'. [3]. And, in today's global world, designers will often be expected to do so across geographical boundaries.

This paper presents four case studies, underpinned by feedback and work outputs designed to foster co-operative learning, from each year of the automotive and industrial design course.

Keywords: Teamwork, Cooperation, Design, Reflection, Community.

1 Introduction

At Coventry University, cooperative and collaborative learning - in this case defined as group work that aims to 'accomplish shared goals' [4] - is seen as the cornerstone of the Industrial Design activity. As such it underpins the course, preparing students for the world of work and beyond.

New students often struggle with accepting that designing is a team effort, and acceptance of this is considered akin to a threshold concept within the course. Threshold concepts are defined as '... akin to a portal, opening up a new and previously inaccessible way of thinking about something. They represent a transformed way of understanding, interpreting, or viewing something without which the learner cannot progress.' [5]

Specifically, the threshold concept was identified with third year students in 2008 and defined as the moment they realised they have to concede their design is perhaps not the design that should be pursued [6]:

One of the big ones is working in groups – if their personal piece of work isn't the bit that gets chosen – a big one is to recognise is 'that idea is better than mine and

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I have to stop making that one work, and try and make this one work'. (3rd year tutor)

In essence, students may cling to the notion of individual creativity and so are reluctant to share their ideas within a team, or allow the ideas of other students to go forward. This is typically due to the fact that the majority of students enter the course from secondary education, where the focus tends to be on an individualistic and linear teaching model, rather than on co-operative learning. This attitude further manifests itself in early group work on the course, evidenced by a reluctance to share concepts, often because they feel that other students may 'steal their ideas'. This often results in students struggling with the concept of the discipline of Design, which is characterised by a non-linear cooperative team effort.

However, when entering professional life, students will be expected to operate in a cross-disciplinary environment and have the requisite skills to interact with a wide range of disciplines, 'such as engineering, business, sociology, and psychology, among others'. [3] Furthermore, in today's global world, designers will often be expected to operate across geographical boundaries. Therefore, it is imperative that the discipline of working in a cooperative manner is part of the learning process, as industry requires graduates to be ready and prepared to 'hit the road running'.

In consequence, it is recognised that students need to engage more deeply with their theoretical learning and apply it in co-operative activities [7]. Thus, over the four-year study period of the Industrial Design course, there is encouragement for students to move towards accepting co-operative working - for example, emphasising an 'my idea is not always the best' focus, and thus creating opportunities for the production of innovative and creative work.

Peer groups tend to develop quite early in the course and they are expected to form cohesive units which are prepared to 'learn by doing' [8] bouncing ideas off each other and even allowing failure to occur through experimentation if it assists in the development of their critical thinking skills.

This paper presents four cases studies, underpinned by feedback and work outputs, designed to foster co-operative learning taken from each year of the automotive design course.

2 Case Study 1: Design Roots

The Design Roots assignment is introduced to first year students to familiarise them with the historical context of automotive and transport design whilst providing an introduction to the key skills of investigation, written assignments, referencing and citation. A major component of the exercise is co-operative activity.

Traditionally, the department has encountered challenges when delivering systematic and chronological forms of design history teaching to students. Historical and theory based subjects were often taught in a very linear lecture-based situation with each learner acting as an individual and engaging at a 'surface' level of learning. In addition, because design theory is not often perceived as an 'active' or relevant subject, engagement was often minimal.

To invigorate the subject, a more co-operative learning style was required to promote identification and integration of individual skills and capabilities with a shared learning experience. The aim was to give the students the opportunity to open up a discourse, break down the complexities of the subject material, and work together to draw out theoretical concepts. This would then help to embed learning, develop confidence around the subject of design history and encourage creative engagement with thinking in applied terms.

Thus, an intensive two-week assignment (not formally assessed) was introduced in 2011/12. Each day was themed around topics such as ‘Technology Meets Art’, The Modern View’, ‘Utility and Design’, Material Culture’, and ‘Responsibility and Design’. The day included a film and two lectures from a range of specialist lecturers in order to deliver ideas and interests from within and beyond the studio environment. To reinforce this, the end-reward for the students was a ‘launch event’, and an exhibition of the results of their activities to people outside the department and across the University.

Students worked in twenty groups of five and each group was allocated a different design movement, character or event to study. These included Harley Earl and General Motors, The Industrial Revolution, Futurism, Birth of the Styling Studio and Bauhaus. The groups were required to investigate their chosen design movement, era or professional designer and then interpret their collective knowledge as a visual response in the form of a hanging three-dimensional sculpture constrained by a $1m^2$ cube. The twenty sculptures were to be displayed in a studio and hung approximately 8 feet from the floor (Figure 1). Each sculpture was accompanied by a written summary, including references and citations.

Fig. 1. Design Roots Sculptures: Dreyfuss, Pop Art, Eco Design, Loewy (Bull, 2013)

To help organise their research activities, the students were instructed to manage their investigation around six key questions, exploring aspects such as visual principles, philosophies and characteristics, drivers and influences, key players and contemporary interpretations. The students were introduced to the library and other study skills in ‘bite-size’ form so that they could engage with tasks with confidence. The students were also required to develop a project plan recognising individual skills, capabilities and potential contributions from the research stage to the design, construction and installation of their work in preparation for the ‘launch event’.

The students actively engaged in this assignment, and after a day or two, the staff saw an energy amongst students to work together and manage their tasks. Over the two weeks the studio took on a more active feel and students were keen to experiment with ideas and potential sculptural possibilities: at the heart of this was student dialogue and conversation about the principles and influences of design. Guided by tutors, students were encouraged to reflect on some of their creative decision making which promoted dynamic group discussions. This encouraged relationship building within the student groups who - for the first time - were reliant on good cross-team communication and co-operation to succeed.

Previously, tutors would have found it challenging to engage students in this manner via a singular lecture-based approach, and they also found that it was challenging to teach study skills, which the students deemed outside of their interests as designers - for example, writing and referencing. However, in this context this became integral to practice and the groups shared the responsibility to write, edit and check the work in a peer context.

As a result of this activity, tutors have observed that this peer support attitude has been maintained through social networking spaces, such as Facebook. Tutors also confirmed that this became a transformative learning experience where students demonstrated a new ‘confidence’ with design learning. The students happily left their work on display for the rest of the year and it became a constant reminder and addition to the studio environment.

A small feedback exercise was conducted with five Level 1 students, and they responded positively to questions that centered on working co-operatively. The most positive experiences identified included being able to gain more knowledge by sharing tasks and covering more research territory, experiencing the varied nature of tasks - from research to sculpture, working with different student views and contributions (which led to more outcome alternatives to explore) and strengthened peer bonding.

This activity was repeated in 2012/13, and similar effects achieved. Again, students demonstrated pride in their work and produced a diverse and exciting range of responses to the task. Only small logistical refinements were made to the module, and It has now become an established part of the first year Automotive and Transport curriculum, giving tutors room to build upon and enhance their teaching materials in line with the objectives and themes of the assignment.

In summary, the active and cooperative approach to learning and engaging with the history of design appeared to encourage a stronger collective view of learning which helped students approach their second term of study with a more proactive attitude and a stronger appreciation of the value of discussing work with peers. As such, this activity is seen as a building block towards a greater confidence to engage in teams, as well as an appreciation of the context of the world they are designing for.

3 Case Study 2: Student to Student and Student to Tutor

The second year of course is seen by tutors as a year of consolidation and bedding down of the skills and capabilities encountered during the first year. However, there is an increased focus on collaboration activities, both between students and between students and tutors.

Beginning with a pilot project in 2009, co-operative activity has taken place across geographical boundaries, through the building of a relationship between Coventry University and EAFIT University in Colombia.

The pilot project involved several groups of students from each institution speaking face-to-face once a week about a design assignment for an all-terrain vehicle, with communication facilitated by bespoke video conferencing equipment. The students also scaffolded this communication with a closed Facebook group, Skype, MSN Messenger and email. The outcome of the project was an exhibition of a series of posters (Figure 2) at the 2009 Coventry University Inquiring Pedagogies Research Network Conference [9].

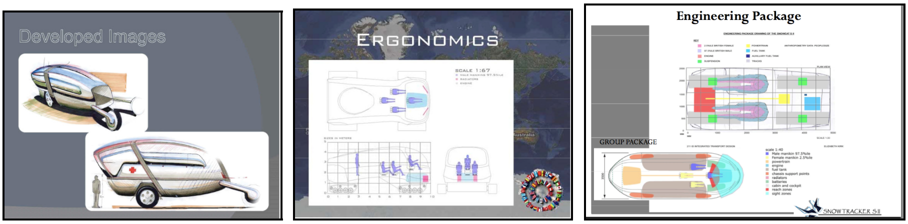

Fig. 2. Coventry University/EAFIT posters (Atkinson, P., Sierra Zuluaga, L., Osmond, J. (2009)

A series of focus groups carried out after the pilot found that that the students identified that involvement in such a co-operative project could enhance their career prospects, as they recognised that ‘as designers they couldn’t be the lone guy with the sketchpad’. For the Colombian students this career enhancement was underlined by the recognition that working with an English institution using the English language would have a positive impact on their attractiveness to Colombian employers.

In terms of creative interactions, the Coventry University students emphasised that they felt they had gained access to a ‘wider mindset’, and different ideas: in particular they mentioned that having access the EAFIT students’ greater engineering experience was very useful. In the same vein, the EAFIT students felt that having access to the Coventry University students’ expertise in vehicle design enhanced their aesthetic understanding of their work. Another motivating theme mentioned by both sets of students was the exposure to different cultural ideas and ways of working: for one Coventry group this led to ‘taking different directions that otherwise we would have completely missed’. Similarly, for the EAFIT students one of the attractions of the project was the opportunity to ‘see other people doing the same thing that we do here but in a different way’ and also the opportunity to experience ‘a little bit of a real feeling’ of ‘how it is in Europe’, rather than getting information from programs or books.

All the students felt that they had benefited from participation in the project and in some cases - despite being skeptical to begin with - felt it had ‘exceeded their expectations', and therefore would be happy to participate in any future collaborations. In addition, the EAFIT students indicated that they would take advantage of any future opportunities to participate in projects in other design subjects, such as product design. Finally, the Coventry University students confirmed that if they had the opportunity they would happily travel to Colombia to work on another co-operative project. Today, the link with EAFIT University is routinely considered when thinking about co-operative projects, and June 2012 saw students working on a co-operative boat design project, which included two members of the Coventry University group visiting EAFIT University to build models of their co-operative designs.

Another aspect of co-operative working felt to be important for students is between student and tutor. This particular form of collaboration is seen as crucial to the students' progression towards entry into their professional community of practice and ideally is modelled on industry methods.

Beginning in 2010, a second year tutor, after considering the traditional 'pin-up and leave' style of assessment to be somewhat lacking in constructive and co-operative feedback, developed a new system of assessment, which privileged the dialogue between student and tutor [10].

Introduced as part of the Automotive and Transport Design Specialist Skills module, the 'Assessment Buddies' system aimed to foster a spirit of co-operation and progression through the use of formative, rather than summative, feedback. The system hinges on the use of assessment 'buddies' - students who volunteer to take part in the end of year crit and record the feedback between student and tutor during the final presentation of work. The idea is that this frees the tutor from both talking about and writing down the assessments, thus enabling eye contact to take place and allows the tutor to 'walk round' the final piece of work. The written feedback is given to the students immediately after the session, with the summative mark conveyed three weeks after the event (with the second iteration including a backup audio file).

Focus groups were then carried out with the students who took part in the first and second iterations of the system to gauge how successful it had been and to fine-tune the method.

The results showed that the students who had experienced the first and second iterations of the system displayed a clear understanding of what 'good' and 'bad' feedback' is:

> *It is probably a general critique of a project or a piece of work that you have done, so receiving positive comments as well as negative and how you can improve on what you have done.*
> *I think the worst bit of feedback I had was with the […] module and we were all sent a letter with a sheet of adjectives on that they circled… it was just not very personal to your project.*

In terms of co-operative working before the final crit, the students appreciated the formative feedback offered, in this case one-to-one tutorials with the tutor, and also 'round-table' events which took place in the studio. These round-table events involved groups of students discussing their ideas and work in progress with each other and then with the tutor as he worked his way around the studio.

When taking part in the final crit, the students who were assigned as ‘buddies’ appreciated the chance to watch several presentations by their colleagues and found this useful in terms of their own work.

The immediacy of the feedback was also appreciated by the students as ‘you instantly know where you have gone wrong’ and also that the comments were tailored to the actual work, rather than having to fit into pre-determined outcomes:

> *[the] comments that were made [were] tailored and bespoke to the person’s project [so] you are not being shoehorned into categories.*

The students also appreciated the lengthy, face-to-face and interactive formative feedback they were given during their own presentations, having previously been used to pin-up and leaving their work and receiving a written outcome sometime later, or having to interact with ‘someone with their head down writing’. In addition, the immediacy of the feedback was felt to be constructive, and because the summative mark was not given until three weeks after the crit they had time to inculcate this. For many of the students interviewed, the summative mark assumed much less importance as a result, with one student commenting:

> *If I am honest the marks are not really my biggest concern – it is just a bit of paper at the end of the day what degree classification - marks for me are not hugely important it is whether I have learned something, moved forward, pushed myself further.*

As expected there were differences between the experiences of the students from the first and second iterations of the system, and these were reflected in the results of a questionnaire (Table 1), modelled on the UK National Student Survey [11].

Table 1. Assessment and Feedback

Assessment and Feedback: agreement[1]	Year 4 (%) 1st iteration	Year 3 (%) 2nd iteration
5. The criteria used in marking have been clear in advance	43	50
6. Assessment arrangement and marking have been fair	14	75
7. Feedback on my work has been prompt	71	75
8. I have received detailed comments on my work	28	75
9. Feedback on my work has helped me clarify things I did not understand	57	50

The most significant differences were found in the fairness of comments received and how detailed those comments were, with the year 4 students evidencing a much lower level of agreement. This can be explained by the inconsistent nature of the comments written down by the buddies in the first iteration, which was addressed by a

[1] ‘Definitely Agree’ and ‘Mostly Agree’ answers aggregated.

more clearly designed form for the second. In addition, the second iteration of the system provided an audio file of the sessions, so the students could remind themselves of exactly what had been said, thus minimising the possibility of students being so overwhelmed by the session itself that they blanked out what had been said. This nervousness is reflected by the ‘unnerving culture of the crit’ when students can become anxious about losing their ‘competence, control and confidence’ [12] and also by students not hearing feedback due to their nerves [13].

In summary, this new assessment method has opened up a dialogical space for students and tutors which allows both parties, and the student buddies, to engage in constructive commentary and thus enabling an iterative progression of students’ thinking processes. This space speaks to how important critical assessment and feedback is both to the individual student and also to institutions who are conscious of the consistent criticism made by students about this in the annual UK National Union of Students’ satisfaction survey. It also addresses some of the complexities that assessment within a creative subject can bring – often this relies on tacit knowledge in order to judge the solving of ‘wicked problems’ [14] in a discipline that privileges creativity and originality. Therefore, summative marking systems tend to offer little value in this area and a system that takes students’ eyes off the ‘marking’ ball, and where creativity and originality can be discussed, disagreed with, re-iterated, revised, debated and fine-tuned has much more to offer in the formation of the professional design identity.

4 Case Study 3: Professional Placements

As previously explored, the first and second year of study are considered the ‘building blocks’ in student progression towards becoming a professional designer. In contrast, the third and final years are where engagement with outside industry and agencies takes place.

The third year is the start of a professional gateway where students are required to interface with the real world. A major portion of this year is given over to a co-operative project and students are required to respond to definite deadlines, compete and collaborate with each other. These important co-operative projects are treated as ‘live’ and clients, especially from major OEM’s, expect the results to be of an extremely high standard. The projects are high profile and always carried out in groups, creating an internal market place where the students are required to cooperate with each other and decide amongst themselves who will be responsible and best suited for a specific task. If the formative development in previous years has been successful, this self-imposed allocation of roles works well with little, if any, argument.

The final semester of the third year is a twenty-week plus period of industrial engagement in a design studio or a related industry. This tends to be the first time students have worked within an established design team on live projects and cooperating with different disciplines such as engineering and human factors, and also interacting with their peers. As one tutor comments, the importance of the work placement activity cannot be underestimated:

The placement experience is about being able to turn on creativity at 8.30am on a wet Monday morning when they may not have been in the mood, and being able to deliver professional quality work to immovable deadlines. It is not necessarily what they learn or do on placement, though this is very valuable, but the networking opportunities, the chance they get to engage with the 'active' community of practice and the way that 'designing for a living' changes their mindset during the experience. This usually manifests itself in terms of improved time management, the ability to work with others and, in most cases the ability to accept in-project critique/guidance and act upon it. For most the placement provides the final threshold to becoming a professional designer.

In addition, a major component of the third year is a reflective journal - a visual record of a project which includes drawings, photographs and commentary from each member of the group, thus giving a snapshot of every aspect of the project and an insight into the challenges and solutions documenting why a particular direction was taken.

It is also worth noting that students are actively encouraged to retain every piece of work across their years of study in chronological order. Over time, these journals reflect the students' journey and provide an insight into how cohesive a particular group has been and also give an accurate overview of their progress, motivations and challenges encountered during the course of a project. Just as with the reflective journal, this enables them to understand the journey they have been on and recognise their capabilities as they enter the community of practice.

5 Case Study 4: The Final Year

As Individuals on design placement in their third year, the students discover that the necessity for cooperation is integral to the process of designing. As one tutor comments*: "Most come back with the thousand yard stare, not sure if it was a dream. Most definitely they all go into that world of "I thought I knew it all.* This real world experience becomes a valuable extension to everything they have already learnt. These new found experiences are brought back and shared in the fourth year with the rest of the cohort, in particular the sharing of experiences and specialist techniques they have learnt and absorbed. They also compare methodology from separate organisations and their portfolios of work will have improved considerably over the period due to observing professional designers at work. As a consequence this raises the aspirations of the whole group.

In addition, due to the process of co-operative learning that the students have undertaken throughout their years of study, they are, by this stage, able to speak the language of design and create the best form resolution in 3D with confidence. Further, as the students have now learnt to behave in a less individualistic manner it is notable how much they are prepared to help each other with the organisation and preparation of the end of year degree show and the construction and finishing of models.

Finally, due to the previous building blocks on the course and their experiences of external co-operative learning, the students will have developed their own design identity and concomitant community, which will, in all probability, overlap the professional community of practice. This means they are able to engage with visiting professional designers on their own terms. The result of this is that professional designers enjoy coming in to contribute to the process. This is the last phase before they fully join the wider community of practice.

6 Discussion

As this paper has detailed, cooperative learning is seen as an important gateway for students to become designers, and each section of this paper has highlighted several methods of fostering such learning. Returning to the threshold concept mentioned in the introduction – 'design as a team effort' – it is possible to identify several characteristics from the threshold concept framework (detailed in Table 2) within each year of the course.

Table 2. Threshold Concept Characteristics (Adapted from Meyer and Land 2003)

Characteristics	**Transformative**	Involves personal as well as conceptual change.
	Irreversible	Once understood is unlikely to be forgotten.
	Integrative	Opens up connections between things students have been learning enabling them to look forward to the possibilities that have emerged from this new understanding.
	Troublesome	Likely to involve forms of "Troublesome Knowledge": "That which appears counter-intuitive, alien or seemingly incoherent."
	Liminal Space	Uncomfortable intermediacy / Identity shifts / Unsafe journeys.

6.1 First Year: Troublesome

When students first start out on the course they think in a linear fashion usually due to previous educational experiences. As such, they tend to carry out their projects as individuals as opposed to cooperating with their peers. By introducing the Design Roots assignment, it is possible to begin breaking down these singular and linear modes of working and thus encourage students to work together. This can be troublesome for students, as they tend to display a natural resistance to change.

6.2 Second Year: Transformative

The gains made by introducing cooperative working in the first year are further reinforced and enhanced in the second year activities. Co-operative projects such as those with EAFIT University in Colombia and involvement with the Assessment Buddy system enable the students to move away from the 'lone guy with a sketchpad model' and also away from a laser focus on the summative mark. As such, this can be seen as transformative for students in that they are beginning to let go of their previous focus on the 'what do I need to pass' mentality.

6.3 Third Year: Liminal Space/Irreversible

The change in the student's thought processes are most visible in the third year, particularly as a result of external work placement activity. Often exposure to the professional world of design places the students in a liminal space, which can be uncomfortable and unsafe, but it is here when they finally realise that co-operative working is not a choice. As such this stage of their learning can be seen as irreversible.

6.4 Year 4: Integrative

The forth and final year is a consolidation of all the students have learned to date and thus the need to work co-operatively becomes integrated within their design identity. They are now multifaceted in ability across their skills sets and are no longer afraid to take risks or accept challenges whilst working cooperatively within their chosen and developing community of practice.

7 Conclusion

This paper has considered the importance of co-operative learning for industrial design students by outlining some of the building block activities designed to encourage such working practices within each year of the industrial design course at Coventry University.

By using the threshold concept framework it has been possible to identify how these building block activities move students away from a linear and individualistic mode of thinking towards a co-operative model of designing, seen as essential in today's global world.

Use of the threshold concept framework is particularly pertinent within the field of art and design, as creative subjects typically resist empirical measurement. Creative outputs cannot - by definition - be marked against one 'right answer' as they are often based on tacit knowledge applied to wicked problems, and so the threshold framework offers a lens through which tutors can identify and pinpoint transformational moments in student development.

Consequently, this paper has identified some of the ways that the industrial design course equips students for entry to their global community of practice, ready to 'hit the road running'.

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Optimization of Engineering Design Cycles in Enterprise Integration

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Abstract. The paper presents the concept of project life cycle optimization, which is based on the formalization of domain knowledge and decomposition of the controlled system into subsystems. The formalization of knowledge concerns each of the individual subsystems by describing its states and functions. Such an approach can greatly reduce costs and time, which is needed for multiple iterations during the project life cycle. This is because the formalization of knowledge simplifies modifications of the control system software and architecture, which means that there is no need to commence the designing process again. Moreover, owing to the presented approach, creation of ontology and more advanced control systems (e.g. multiagent based algorithms) are significantly shortened and simplified. The presented solution is currently being implemented in the designing process of a real micro-grid.

Keywords: Collaborative design, Project life cycle, Concurrent engineering.

1 Introduction

One of the main tasks of the autonomous micro-grid is to provide electricity from various independent sources, often including renewable energy resources [1]. Due to the various factors affecting the power supply system (e.g. cloudiness when using solar panels or no wind when using windmills) the amount of electricity that can be produced at the moment may significantly vary. Reliability of the power supply system and energy production costs are also important factors that must be taken into account. As a result, the power supply system requires more complex control algorithms and management. According to [1,2] the following features of the control system should be taken into account:

- architecture allowing for the design of distributed control system, which is able to coordinate its actions for the proper resources distribution and optimization
- properties of the power generating system, for example, its condition or the amount of electricity that can be produced at the moment
- simulation capabilities to verify the effectiveness of the proposed control strategy

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To design the control system, a good approach is to decompose a large power supply system into several smaller subsystems, which are easy to automate [1]. A large number of small subsystems makes the whole control system more flexible, but much more sophisticated and difficult to design. On the other hand, the smaller the number of subsystems, the less flexible the control system is, but simpler to design. It means that the designers have to find an optimal number of subsystems, which makes the designing control system both sufficiently flexible and not too complex.

However, the design process of the control system software and architecture consist of subsequent stages that are characterized by the distinct evolution of technology. This is due to the obvious fact that the individual stages are realized by the distinct teams, and quite frequently, in various time periods [3,4]. The process engineers are not able to predict the end result and efficiency of the control system software, hence, the designing process is often cyclically repeated as shown in Figure 1.

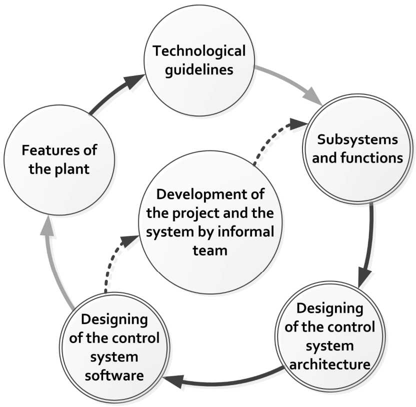

Fig. 1. Project life cycle coordinated by informal team. The stages that are strictly related to the control system are distinguished by double circles. The grey arrows represent "interactions" between technological requirements and automation systems.

The informal team of experts is responsible for project coordination and compensation of errors resulting from the imprecise project specifications. If it is possible, the team of experts may decide to shorten the project life cycle, which is indicated by the dashed arrows in Figure 1. In practice, the designing cycle is often repeated, which is time consuming and generates extra costs. Moreover, the interdisciplinary groups of experts (or designers) are rarely created due to the financial constraints.

Based on our previous results (see e.g. [5-7]), an alternative approach can be an appropriate formalization of the domain knowledge on the controlled power supply system. This idea will be explained in the next section.

2 Idea of Project Life Cycle Optimization

The documentation created during the life cycle of the project contains the domain knowledge, which is distributed among the designing teams responsible for realization of the project assumptions and for taking into account the technical requirements.

In the proposed approach, the major idea is the formalization of knowledge at the designing stage according to a common standard. The formalization of knowledge concerns each of the individual subsystems by describing its states and functions. The initial number of subsystems is determined at the beginning of designing process and results from the preliminary assumptions and technical guidelines. It means that the structure of the control system can be described by a hybrid model including states and transitions between those states.

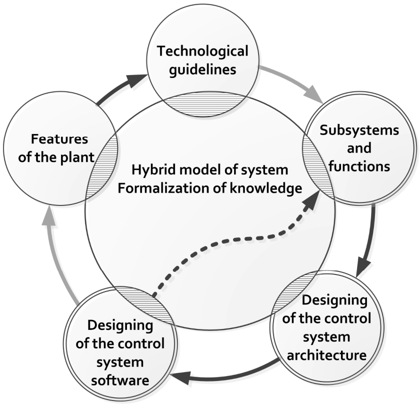

Fig. 2. Optimization of project life cycles based on decomposition of the system, its hybrid model and formalization of the domain knowledge

The designed control system has a hierarchical structure and consists of at least two layers: direct control and supervisory control layers. The direct control layer is the most distributed and complex layer, because it comprises: controllers, technological plants, control equipment, actuators etc. In turn, the supervisory control layer is responsible for maintenance and supervision of the distributed control system.

Figure 2 presents the same project life cycle as shown in Figure 1, but the main difference lies in access to the domain knowledge. The decomposition into subsystems allows for presenting the knowledge in a more formalized way, thus making it more intelligible for teams of designers and experts from different fields. In the case of making any changes to the structure of control system within a single subsystem (e.g. a change in description of the subsystem or its functions), there is no need to discuss the proposed changes with the group of experts from each of the cooperating companies (which is time consuming) or commencing the designing process again. Such an approach can greatly reduce costs and time, which is needed for multiple iterations during the project life cycle. The changes made within a single subsystem can be easily adapted by other interconnected subsystems, for example, by changing their functions, instead of changing the structure of the whole control system. Hence, any future modifications in the structure of control system, (e.g. emerging during its exploitation), can be easily applied. Moreover, the control system designers are provided with only the necessary data, which minimizes time of these modifications.

The latest researches have shown that the modern control systems for optimal energy management and distribution in micro-grids are often based on the multiagent technology [1,8]. Owing to the formalization of the domain knowledge at the designing stage, the creation of ontology and the designing process of the multiagent system are significantly shortened and simplified.

3 Concluding Remarks

The presented solution is currently being implemented in the designing process of the control system for a real micro-grid using renewable energy resources and polygeneration techniques. The realization of the project is coordinated by a non-profit company KMB-Inwestko in close cooperation with research institutions having high achievements in this field. The decomposition into subsystems and formalization of knowledge will allow for obtaining more effective design and cooperation between several companies. By the formalization of the domain knowledge, there is no need to create an interdisciplinary team of experts or designers from several companies within the same business cluster. Moreover, the creation of ontology and multiagent-based control applications for optimal energy management and distribution is greatly simplified. The presented results can also be extended to design control systems for complex biological processes operating under unstable regimes.

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Collaborative Design of Advanced Vessel Technology for Offshore Operations in Arctic Waters

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Abstract. The paper presents the requirements and challenges to collaborative design related to the design of vessels for offshore operations in the Arctic area. We look into the design process of offshore service vessels in environments characterized by high volatility and complexity. Due to increased complexity as to functionality, the number of stakeholders and uncertainty as to environmental aspects more information from different sources have to be included, also encompassing long trial periods with user feedback. This has implications for the construction processes and the open interplay with partners in an open innovation approach.

Keywords: cooperative design, shipbuilding, optimization.

1 Introduction

Shipping companies face harsh competition in most markets and have to continuously improve both their cost-efficiency and quality to survive and prosper. Maritime operations may take place in environments with special turbulent features. Business innovation is important to improve performance in shipping companies. To achieve this preparedness, we may have to look closer into the activities of each partner in the value chain, from the design phase. The center of gravity for the Norwegian petroleum activities is moving gradually north into the Norwegian Sea, the Barents Sea and the rest of what is termed Arctic waters. The area contains perhaps as much as 25% of the remaining oil and gas resources in the world [1].

The paper is organized as follows. The next section presents theoretical issues related to cooperative design in shipbuilding. Then the requirements for the ice-going ships and IT-tools for cooperative ship design are presented. The paper terminates with conclusions.

2 Cooperative Design in Shipbuilding

The research on cooperative design is increasing in importance. This is due to the increased technology level of the products in most markets, the increased complexity including a broad range of components provided by an increasing number of

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sub-contractors, and the increased pressure towards a fast construction and building process. This calls for new models of organizing the design process where cooperative links and partnership is crucial. In the process of work on the creation of a new ship or modernization of the existing vessel, information and knowledge is exchanged among several actors. Traditionally, several key participants contribute to the collaborative ship design: shipowners, ship designers, classification societies, shipyards, suppliers, shipbrokers, and national and international maritime organizations. In case of design of ice-going ships for Arctic areas, the number of participants is increasing following the complexity of operations in the High North. For examples the challenges related to communications due to the high latitude require participation of specialists in telecommunication.

Cheng [3] argues that the collaboration design literature can be divided into two main categories. One part of study concentrates on information technology issues assisting collaboration, such as information flow and data organization. The second group of researchers investigates the organizational and social issues of cooperative work. Kvan [8] suggests two modes of collaborative design. First, close coupled design process, when parties interface tightly on design. Second, loosely coupled design process, when each participant contributes within his/her scope and expertise. We can find examples of both close and loosely coupled design processes in collaborative design in the area of shipbuilding. Ship design is a knowledge-intensive industry. Knowledge possessed by a firm's engineers is the main resource leading to a competitive advantage. The internet and intranet allow for new forms of collaboration between contributors who may be geographically remote and operate in different time zones. Much time, efforts, and resources are spent by all parties, especially by shipowners, shipyard engineers, and naval architects in coordinating all design details of the vessel under construction.

We may talk about five main phases in ship design: (1) conceptual design; (2) preliminary design; (3) functional design; (4) transitional design; and (5) detail design [2]. Different software tools are used in each stage. In the first stage IT instruments are applied marginally [10]. At the same time some studies find it useful to apply software in the early design stages. For example, Krömker and Thoben [7] proposed a computerized system for the ship pre-design process.

3 Design Demands for Ice-Going Ships

The industry standard for the design of ice going vessels concerning hull strengthening and propulsion in ice is set by the Finnish-Swedish Ice Class Rules [4] for the lower polar, i.e. Baltic sea, ice classes. These rules have been adopted by all major classification societies. Under these rules, vessels are engineered on basis of vast experience with single year ice, which appears to be applicable to large extent for the Barents Sea, also given the fact that the Baltic Sea ice is considerably harder due to its low salinity. Concerning the higher polar classes, the IACS polar code [5] seeks to harmonise a variety of different approaches into a single framework. Given the fact that the Barents Sea is not ice-covered during most of the year and the consequent need for vessels to compete with open-water vessels during the ice-free season. In general, ice class compliance is concerned with the following aspects: hull form, propulsion machinery, ship systems, stability, navigation and communication equipment, as well as supplies and emergency facilities. Vessel specifications are dependent on the choice of route, expected ice conditions and operational window requirements. Where winterisation is an issue, for example to avoid icing down of equipment or the freezing of cooling and ballast water, Det Norske Veritas (DNV) has established a set of notations in addition to the ice classes. These include "winterisation basic" for ships operating for a limited period in cold climates, "winterisation cold" for ships with Baltic ice classes or lower polar notations operating for longer periods in cold climates, and "winterisation arctic" for vessels with high ice notations that operate in cold climates and harsh environments. The latter also includes additional requirements for accident consequence reduction. Furthermore, special requirements concerning cargo heating and insulation may need to be taken into account, depending on the mission of the vessel. Also, comfort efforts may be necessary to protect the crew from the negative effects of coldness, noise, and darkness.

A Model of Cooperative Design within Shipbuilding

In this study we claim that that collaboration in the process of ship design include three blocs: operational context, vessel types, and collaborative design process. The first is the internal and external up-linking. On the one hand, there is intra-organizational or interdisciplinary collaboration between divisions and branches of the same organization and perhaps subcontractors, if the party does not have enough capacity or expertise to fulfill a part of their work on time. The ship design company is usually a central part of the collaboration team. As for intra-organizational cooperation inside the design firm, it is divided into collaboration between the steel structure department, the machinery and piping section, the electrical design unit, the subdivision for 3D-drawings, and a sector of workshop drawings. The collaboration inside each department favors knowledge and expertise sharing [9].

On the other hand, there is inter-organizational cooperation between the shipping company, shipyard, naval architects, classification society, model basin, suppliers, etc. this connection may take a formal contract approach with loose couplings, or it may become a long term partnership with strong ties based on trust and reciprocal exchange. Third, the collaboration may take the form of an open innovation approach, where the company enters into R&D cooperation with knowledge providers such as universities and research institutions, and towards competitors, customers and suppliers.

Fourth, we have the use of special collaboration system for knowledge and information exchange between parties. These may vary according to if they are real-life systems or not. A tool called Kronodoc [6] was developed by IT-specialists from a ship design company together with a software vendor as a collaborative platform and an information management system. This is a real-life design tool. This software tool allows the firm, firstly, to cope efficiently with a large information flow that has a tendency to grow; secondly, to create, share, and disseminate internal and external knowledge; thirdly, to transfer a part of the personnel that were previously involved in information sharing work to other departments; and, finally, to save money and to reduce the amount of paper-based drawings. There are three parts in the Kronodoc system: solution set, applications, and functional modules. The latter part is optional and may be obtained if the customer has a demand for the additional functions. The 'Hours Reporting' tool is used for time registration. Each time when employees log in and out of the system, the number of hours worked for the particular project is recorded automatically. The purpose of this instrument is twofold. First, it allows the accounting department to know the exact time and overtime performed by individual employees. Second, it serves the purposes of planning and control in the design process.

4 Conclusions

In this paper we have emphasized the importance of a collaborative ship design approach for the development of vessels for the offshore operations in the High North. Operations in the High North are very complicated compared to well-known oil-extraction offshore operations in the North Sea. All these specific features set special requirements to the technical features of the ice-going ships and land bases which operate the vessels from the shore. The number of cooperative partners is increasing. This makes organizational models and IT tools which will support collaboration. Of special importance is the interplay between loose and strong cooperative ties both internally and to external partners. Also, a critical element is the development of an open innovation approach where research and development efforts are done in close reciprocal relationships with external knowledge providers.

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Collaborative 4D/nD Construction Simulation: What Is It?

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Abstract. Planning is crucial in the success of construction projects and 4D/nD simulation is an innovative approach to improve it. Because construction planning is mainly a collaborative activity, the collaborative use of 4D/nD simulation is growing in the Architecture, Engineering and Construction (AEC), following the implementation of Building Information Modeling (BIM) workprocesses. Multiple scientific research works have been devoted to collaborative 4D/nD simulation. Major software editors in the industry are also proposing solutions to develop it. But many challenges remain such as adapting visualization or optimizing collaboration processes. To be able to address these challenges, it is important firstly to conceptualize the notion of collaborative 4D/nD construction simulation. This article is based on an understanding of collective activity in the AEC industry, and theoretical elements from Simulation and CSCW scientific fields. It provides a generic definition and identifies the key components to consider in the improvement of collaborative 4D/nD simulation tools.

Keywords: CSCW, 4D simulation, nD simulation, collaborative simulation, Architecture, Engineering and Construction.

1 Introduction

4D simulations link tasks from the construction schedules to objects of 3D models. The aim is to simulate the construction process over time [1]. In nD simulations, other parameters (costs, resources, etc.) to simulate can be added to the 4D model. 4D/nD modelling is part of the Virtual Design and Construction approach [2]. Many research works addressed the interest of such simulation to improve communication, site coordination, and collaborative scheduling. It is shown that 4D/nD simulations are useful to support collaborative construction planning. Indeed if 4D/nD tools of the first generation are not necessarily collaborative, the next generation is more interactive and collaborative.

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The use of collaborative 4D/nD construction simulations is increasing and become a commercial argument for CAD tools and BIM platforms editors in the industry. Many scientific research works have focused on different aspect of such tools. But so far, the concept remains vague and no exact definition is provided.

This paper presents a research that aims to propose a better understanding of the notion of collaborative 4D/nD construction simulation. It firstly introduces the collaborative simulation. It then explores the collective activity in the construction industry and finally proposes a definition and the main components of the concept.

2 Collaborative Simulation

According to Maria [3], a simulation of a system consists in developing a “model of the system”. The model is similar, but simpler than the system it represents. It can then be more easily experimented and reconfigured in order to assess the performance of an existing or a proposed system “in different configurations of interest over long periods of real time”. Computer simulation consists therefore to design a model of a system, to execute the model on a computer, and to analyse the execution’s result [4]. Eleven steps are distinguished in a simulation [3] and these steps contribute to the three main phases of the simulation : realization of the model, execution of the model, and analysis of the model [4].

Collaborative simulation modelling, following Taylor et Robinson, includes “the study of the human-to-human interaction, computer-to-computer interaction, and the synergies between these interactions, to support practices for modelling simulation” [5]. Taylor and Robinson identified five main roles played in a collaborative simulation activity. These roles are: the doer (the one who performs the simulation), the done for (the one for which the simulation is performed), the done with (members of the simulation team), the done to (those who provide the necessary information for the simulation), and the done without (those who do not participate in the simulation, but are nevertheless directly interested in the results).

One important aspect about simulation is related to visualization. Indeed visualization is essential in simulation process [6] and it is therefore important in a collaborative simulation, to use the most adapted visual representations related to the needs of each participant. According to Kuljis and Paul [6] if inadapted representations are used, it could be very difficult for user to make the mapping between the simulation content and the reality it is supposed to represent; the concepts used can have no direct and natural association with the simulated problem; and the tasks to be performed during the modelling process could be not appropriate for the problem.

3 Collective Activity in Construction Industry

To understand the collaborative 4D/nD construction simulation, it is important to understand the collective activity in the field of architecture, engineering and construction. A peculiarity of the sector lies in the heterogeneity of work structures that are fragmented and legally independent, with very different interests [7, 8]. The different actors involved in a construction project (architects, engineers, owners, contractors, suppliers, etc.) come from various organizations and have to work together on a temporary basis, in order to achieve a common goal. Needs to manage are then both inter-organizational and intra-organizational because if the participants come from different organizations, the project itself implements its own organization [8]. This organization is conditioned by the legal context, the contracting arrangements and the complexity of the project.

A building life cycle is generally divided into many phases. Several sets of phases with different scopes have been described in the literature [9, 10]. From these divisions, it appears four main phases: the pre-project phase (assembly, feasibility, research of funding), the pre-construction phase (design, allotment, tenders, site preparation), the construction phase (realization of the construction works) and the post-construction phase (acceptance of the works, commissioning, demolition or rehabilitation as appropriate). 4D simulation can be useful throughout these phases, including for communicating ideas [11–13], logistics and site planning [14–16], constructability analysis and conflicts identification [17, 18], and site monitoring [19, 20].

Throughout the project phases, different needs of collaboration can be identified, involving specific coordination mechanisms. The information needs of stakeholders vary according to the role they have on the project. It is important to remember that the same people do not always have the same roles in construction projects and each project implements a different context of collective activity. The main coordination mechanisms used are the following ones: hierarchical configuration, adhocratic configuration and transverse configuration [8]. Conceptual models have been proposed to describe the context of collaboration in a construction project. Sunke [21] proposed a model to describe the basic configuration of a typical production chain in the sector, focusing on the different actors involved, project milestones, activities performed, and flows between these activities. This model is extremely simplified and does not take sufficient account of the complexity of this type of collaboration. And the metamodel proposed by Kubicki [8] shows that such a model must take into account not only the collective dimension activity, but also the technological dimension, the technical dimension, and the ergonomic and cognitive dimensions related to the tools that actors use.

Understanding this context is very important in the framework of a conceptualization of the notion of collaborative 4D/nD construction simulation.

4 Main Components of Collaborative 4D/nD Construction Simulation

Collaborative 4D/nD construction simulation consists to develop a 4D/nD virtual model of a building, in a collaborative way or to assist collaboration among construction project stakeholders. Collier and Fischer [1] illustrated notably the use of a 4D model to assist collaboration among the actors of a construction project. The collaborative model realization can be done by the different actors co-located or in a networked environment, synchronously or not. Each involved actor works on a particular aspect or part of the model. On the basis of the literature review presented above, it is important to focus on a certain number of components:

- The types of roles involved: aside the roles that traditionally exist in a construction project (architect, owner, engineer, contractor, etc.), it is useful in the context of collaborative simulation 4D/nD to identify a second level of roles. These new roles are related to what the actor is really doing in the framework of the simulation (doer, done for, done with, done to, done without).
- The 4D/nD development approach: in general, the 4D/nD model is the result of the collective activity of simulation. Three main approaches have been identified [22] : manual linking, automation, and manual assembly. In manual linking, the elements of the 3D model are manually linked to the construction schedule, using third party software. Automation approach automates the connection between the 3D model elements and the schedule activities. A predefined schedule and an existing 3D model are used, but their connection is automated. Manual assembly approach proposes to use 4D simulation as an initial planning tool, and not just for an existing schedule review. The main interest is to interactively build a schedule from a 3D model.
- The device used and the interface: this is an important component to consider. Indeed, knowing its properties is crucial to ensure an optimal display and use of the 4D/nD model. The main types of devices are computer, laptop, smartphone, touch pad, etc.. The interface proposed to each participant must take into account the device he uses, his information needs, and also his physical context.
- The physical context: it is location in which the user interacts with the simulation. This can be at office, on construction site, in mobility, etc. The device used is strongly linked to this context. The space-time matrix taken from Computer-Supported Collaborative Work (CSCW) theories [23–25] is used to study the participants' arrangement in the time and space. The aim is to know if they are in the same location or dispersed, at the same time or not.
- The context of the collective activity: this context must be clearly defined in order to identify the actors involved, their roles, and their needs. A major difficulty lies in the fact that each construction project implements a different collaborative context. It is then very challenging (if not impossible) to define a collaboration process-type, using traditional CSCW approaches. Some authors have proposed description approaches that are dedicated to construction industry [8, 26].

These various components are for the most summarized on the Figure 1.

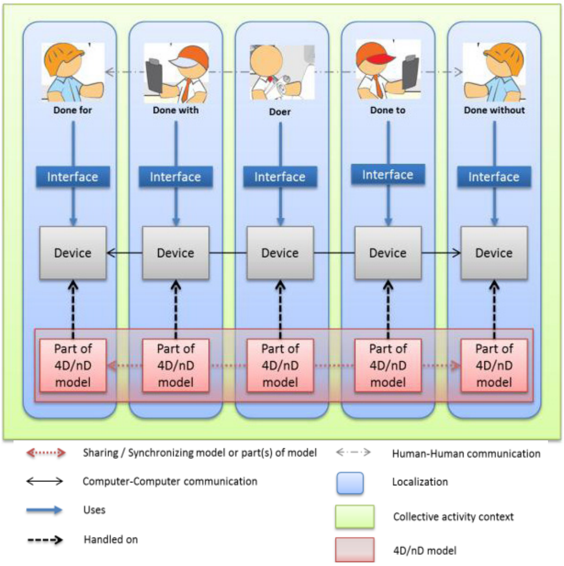

Fig. 1. Main components in a collaborative construction 4D/nD simulation

5 BIM, Collaborative 4D/nD Simulation and Scientific Research Works

4D/nD modeling generally relies on the Building Information Modeling (BIM) approach to allow the use of a global 3D model integrating building information used by most project stakeholders, in an interoperable manner. But the greatest benefit of BIM for 4D/nD simulation lies in the support of collaboration. Indeed, the use of BIM is very useful for 4D/nD software to support collaborative simulation. It must be said that the integration of BIM (in various ways) by major software sector allows users (stakeholders in a construction project) using a single 3D model for multidisciplinary collaboration throughout the project life cycle [27]. Zhou et al. [28] cite for example the integration of worksets in Revit by Autodesk to allow many people to work simultaneously on different parts of the same project; the use by Bentley of i-models as containers for an open information exchange; the application of master/working models by Tekla Structures to control the model in its client/server applications; and the adoption by Gehry Technologies of a system for version control called Subversion, to allow participants to independently control their read/write operation on the project models.

More generally, Zhang et al. [29] have identified five potential benefits of the contribution of BIM in the sharing and exchange of information in virtual construction systems such as 4D/nD simulation: *1)* the possibility to adopt a 3D model derived from the work of architects and engineers for the simulation; *2)* the possibility to share information about scheduling and costs generated in planning and cost estimation systems, by importing them via neutral IFC files; *3)* the possibility to use realistic information of IFC interfaces from CAD applications, in order to perform a better rendering in 4D/nD simulation applications, *4)* the possibility to dramatically improve the interoperability of different virtual construction systems, and *5)* the possibility to integrate the 4D/nD model in a complete BIM as part of the project information once the project is completed, which increases the interest of BIM for the post-construction phase. So, the growth of BIM has technically contributed to the development of the collaborative 4D/nD construction simulation.

Several scientific studies have (before and after the advent of BIM) investigated various aspects of collaborative 4D/nD simulation. The Center for Integrated Facility Engineering (CIFE) from Stanford University developed the iRoom, presented as an integrated system to support collaboration between different construction practitioners [30]. In its original version, the iRoom consists of a server and three PCs connected to projectors and large screens. The screens can be viewed simultaneously and the system includes several applications (MS Project, Excel, 4D Modeling, etc.) and viewers, so that users can view at the same time different aspects of a 4D scenario on different screens. Collaboration between the actors involved in the planning happens at the same place synchronously. The views proposed in the applications are synchronized and by clicking on an activity, the user can highlight the same information or related information in other applications.

Waly and Thabet [31] have proposed a virtual construction environment (VCE) for pre-construction planning. To this end, they introduce an Interactive Virtual Interface (IVI) defined as a dynamic virtual disposition allowing project team to simulate and to repeat the construction process, in a quite realistic way. With a manual simulation approach, this repetition is based on the virtual manipulation and editing of a predefined 3D model. Users can graphically "drag and drop" assemblages from the 3D model and rebuild the building by putting side by side the components in the perceived order for the actual construction. Users can also check for spatial conflicts.

Recently, Zhou et al. (2009) have proposed a method for defining a 4D model, in a collaborative way. The method is based on the principle of distributed and interactive collaboration between the actors involved in the 4D simulation. A 3D model is used as a starting point for collaboration and the opportunity is given to multidisciplinary practitioners to focus on this model, in order to analyze the design, to discuss the planning strategies, and to examine possible solutions. Each of them, depending on his role, focuses on a particular aspect of planning. The proposed method is based on a workflow that defines the interactive collaborative sessions.

More recently, Boton et al. [32, 33] proposed a method and metamodels to address the issue of adaptation of visualization in collaborative 4D/nD construction simulation. The aim is to consider 4D/nD simulation as coordinated multiple views system, and to design adapted views to each actor involved in a collaborative 4D/nD construction simulation, basing on his role and his visualization needs.

6 Conclusion

The collaborative use of 4D/nD simulations is growing in the architecture, engineering and construction sector. In this article, elements are proposed to rigorously understand it. Main components to consider are presented, on the basis on theories from different scientific fields. Scientific research works on collaborative 4D/nD simulation in construction are studied as well as the link with the Building Information Modeling (BIM) is explored. Such a work can be considered as a basis for future works aiming to improve 4D/nD tools, especially the visualization issue. Indeed, because visualization is very important in a simulation activity, the challenge of visualization adaptation will be one of the next crucial ones to solve in order to propose tools adapted to the real practitioners needs.

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Planning Urban Microclimate through Multiagent Modelling: A Cognitive Mapping Approach*

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Abstract. The phenomenon of Urban heat islands (UHI) is most pronounced in areas with high urbanization and complex phenomena, in which the domains of interaction between humans and the environment are not standardized. In this context, an approach fairly attentive to agents' (particularly human) behaviors represents an interesting research perspective. The paper works on analyses carried out in a case-study of public condo housing owned by the Institute of social housing (IACP) in Bari (Italy), starting from a knowledge base collected through focus-group experimental sessions. Fuzzy cognitive mapping (FCM) is particularly dealt with, and a model based on *FCMapper*® tool allows the use of local knowledge of stakeholders' analysis for ecological modelling and environmental management in a bottom-up-decision-making process. The paper follows and completes a previous work presented and discussed in CDVE 2011.

Keywords: Urban microclimate planning, Decision support system, Multiple agents, Fuzzy cognitive mapping, Behavioural knowledge.

1 Introduction

Natural human and non-human agents together increasingly characterize urban spaces and ecosystems. The complex thermodynamics of human settlements connected to complex natural-artificial systems produce high impacts on the environment. The decisions of human agents on building, air conditioning, urban materials, mobility and transportation and other spatial productions do impact microclimate pollution.

The issue of Urban heat islands (UHI) is greater in areas with high urbanization and complex phenomena, in which the domains of interaction between humans and the environment are not standardized. In this context, an approach toward agents' (particularly human) behaviors represents an interesting research perspective. The present study looks at human-agent typologies and operational rules to build models on the significant connections between UHIs and human activities and behaviours.

The work is carried out within the EU-financed *Ecourb* project, aimed at building up hybrid scenarios for the management of urban microclimates in the area of Bari,

* The present paper is a result of the authors' common research work. Nonetheless, D.Borri and D.Camarda jointly wrote sections 1 and 4, D.Camarda wrote section 2, whereas I.Pluchinotta wrote section 3. Warm thanks to R.Giordano for his useful research suggestions.

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Italy. It follows a previous work presented and discussed in CDVE 2011, and tries to work out if and how agents with different roles and behaviours can affect urban microclimates while performing their single and/or collective (particularly mutually interacting) activities [1]. This suits *Ecourb* framework, concerning the identification of models to support urban environmental decisions, through the analysis of multi-agent processes and the identification of variables, parameters, indicators useful in system architectures. Indeed, a deep knowledge of cognitive/social characters is needed for an effective model of environmental behaviours and interactions.

The paper works on a case-study of public condo housing owned by the Institute of popular housing (IACP) in Bari, starting from a knowledge base collected through focus-group experimental sessions. This process aimed at formalizing the perception of energy consumption in homes and the behaviors of users toward UHIs in the management structure and systems, with a multi-agent systems approach [2][3].

This approach is framed on future studies and scenario building methodologies, trying to identify the reciprocal effects of events, beliefs and attitudes that in complex systems are only apparently unrelated [4]. It is then necessary to define the relationships between environmental behaviours and/or to examine the impacts between events or trends. For these reasons in our study we investigate on the potentials of cognitive-mapping-based tools, particularly on cross impact evaluations.

Fuzzy cognitive mapping (FCM) is particularly dealt with here, since a good number of applications have been implemented with fair interest [5][6]. In our case, a model based on FCM allows the use of local stakeholders' knowledge for ecological modelling and environmental management in a participatory management schemes. Subsequently, the FCM-based model is included in the general system architecture supporting policy decision making on urban microclimate [1]

Within this general framework, the paper will be structured as follows. After the present introduction, a second chapter will introduce the project framework beyond the study and lay out the main research issues dealt with. A subsequent chapter will describe the case study and the experimental layout, whereas brief remarks conclude the work, by discussing general results and envisioning further research perspectives.

2 A Multiple-Agent Framework

The quest for models able to support public decisionmaking on urban microclimate has received increasing attention during the last couple of decades. The awareness on global warming effects on human settlements and the uprising problem of urban heat islands are structurally informing the strategic agenda of public managers and administrators. This is not a simple task, though, as occurring for all decisions involving complex systems, particularly in the environmental domain [7]. Additionally, social issues themselves affect (and are affected by) environmental microclimate problems, inducing their own complexity essence to a complex-system context [8]. Such situation does actually occur in urban contexts, both at the social aggregate level and at the single-agent level, in different ways. From the viewpoint of knowledge management, for example, there is a consolidated aggregate approach, fairly based on regular microclimate surveys with increasingly detailed datasets. Indeed, such surveys are traditionally well available at the macro level on large regions, but more and more available also at micro level of cities and even neighbourhoods. Yet, just the micro level of attention has nowadays boosted an increasing interest to disaggregate forms of knowledge and data raising, oriented at exploring the cross-impacts between micro behaviours and climate [9][10].

In open spaces, some public funds are for example devoted to the installation of sensors in particular parts of the cities. Such surveying agents are frequently aimed at monitoring concentrated pollution as an output of human activities (transportation, industry etc.) in urban areas for safety policies. In residential buildings, on the other side, heating and conditioning systems monitor and manage temperature, humidity and the thermal comfort of human agents. Yet, disaggregate approaches allow a reverse and quite important viewpoint, shading lights on a traditionally latent although critical issue of microclimate management, that is agents' behaviours [10][11]. Starting from the mere regulation of devices by human agents, to opening windows for lighting or refreshing, to shutting doors because of other agents' noise, a number of mutual, multiple or single-agent behaviours impact on microclimate management and shows uncommon features and relations that cannot be set apart from a formal process of microclimate management.

However, the increasing awareness of an inclusive approach mirrors the awareness of its complexity as a 'wicked' intertwined problem, intrinsically hard to be surveyed, monitored and managed [12].

The answer to this managing problem is investigated in the ECOURB project through resorting to multiagent system approach [2]. In this context, a major effort is to build models based on ontologies of agent types, roles and different tasks, linked by mutual relations and formal connection rules, at different scales and aggregation levels [1]. The taxonomy of involved agents includes natural as well as artificial agents, with diverse intelligence levels and prerogatives. Consequently, they perform a number of tasks, either routinary (near/remote sensing, quantitative data transmission, numerical computing etc.) or intelligent (spatial cognition, data interpretation and exchange, analogical behaviour, coordination etc.). As a matter of facts, routinary tasks are normally modellizable by formal rules and/or algorithmic functions where relevant, as consolidated case studies and literature show [13][14]. On the contrary, cognitive and behavioural tasks often rely on qualitative features and informal languages, so implying an inherent difficulty in extracting formal functions, structures and datasets, in the quest for a manageable multiagent model [15][16][17].

Therefore, drawing features and relations out of cognitive agents' actions/ interactions toward the definition of formal functions and rules becomes a critical research issue. Machine learning is a major research area in this concern, particularly effective when languages are averagely uniform and sentences are closely structured [18]. However, real-life contexts are often based on forms of low language structuring, and there is the need of more hybrid and controllable approaches.

Accordingly, the present paper is the result of an investigation on a knowledge interaction arena, focused on the behaviours of residential agents in terms of climatic and thermal comfort. The complex interactions between human agents and between human and artificial (e.g., equipment) agents are investigated with the aim of modelling informal knowledge as a module of a more general decision support system architecture for urban microclimate policymaking. The general task of this module is to visualize possible behavioural modification outputs consequent to the modification of one or more behaviours as inputs, basing on the behavioural framework resulting from the knowledge model.

3 Description of the Case Study

Many types of ecological or environmental problems would benefit from models based on people's knowledge. This paper presents the use of a semi-qualitative tool, Fuzzy Cognitive Mapper (*FCMapper*), applied to stakeholder representation of environmental problems. FCM can be described as a qualitative model that portrays how a given system, particularly a complex system operates [5], or as a representation of a belief system in a given domain [19].

The domain of interest of the present paper is the study of impacts among events or trends originating from the variation of some elements of the system. The attempt is to evaluate related possible modifications of decisions and policies, so as to envision impact areas. This approach is useful for the analysis of informal relations and the singling out of the most desirable future visions in a model for environmental management. This is located in a context of generation of the agent's knowledge base, through the investigation of the relations among environmental behaviours. The aim of such approach is to single out actual dictionaries connected to each agent's cognitive frame and to characterize correlations among the elements of a complex system, through a relational model made up of an adjacency matrix with its related cognitive map [6].

In particular, in this case study FCM allows the singling out of relations among factors with a priority role in an agent's decisional process, as well as the examination of mutual impacts toward the recognition of useful elements of the environment-building-device-users system. Such methodology makes it possible to draw out the qualitative effects of a changing action on actual elements analysed on the map.

In the present case study a focus-group interaction has been set up, with the aim of investigating visions, criticalities and strategies related to environmental themes. In particular, the first stage has been developed broadly using a *future workshop* approach, with one preparatory and three operational stages (*critic*, *fantasy*, *implementation*, see [20] and [21]). Each stage has been carried out for the building scale, the neighbourhood scale and the city scale levels, involving a number of tenants of social housing units (IACP) in the city of Bari. The aim of the workshop was to collect a knowledge base toward the formalization of personal perceptions and behaviours on energy use and management, as well as on UHI and microclimate management. The workshop was further aimed at achieving more information of tenants with both indoor and outdoor environments, by using a multi-agent cooperation approach [2]. More details on this modelling activity are available on an earlier CDVE paper [1].

After the workshops, results were studied and organized for subsequent formalizations, and a sample was used for the aims of the present study. In particular, a cross-impact matrix was built up, filled with the results of the *fantasy* stage of the household-scale level, dealing with freely generated conceptual images of desirable features of the daily living context (building). They were “A cleaner house” (C1), “A prettier house” (C2), “More tranquillity” (C3), “A more comfortable house” (C4), “A greater house” (C5), “A brighter house” (C6), “A warmer house” (C7), “Greater balconies” (C8), “No wall humidity” (C9), “An autoclave because there isn't enough water” (C10), “Structural stability of residences” (C11), “Saving electric energy” (C12), “An elevator for disabled” (C13), “A new elevator” (C14), “A new and working main door” (C15), “Modern technology to save money” (C16).

Subsequently, images resulted have been analysed by a group of scientific researchers (considered ‘experts’, as compared to ‘non-experts’ participants, see [22]) in order to define relations among concepts in the matrix, with related impact weights. The strength of a connection between two concepts indicated the intensity of their correlation, and *FCMapper* allows the assignment of -1 (inverse), 0 (absent), 1 (direct) values to correlation.

In order to verify the potentials of the FCM approach, the outcomes of the *fantasy* stage at the household scale were used as an initial layout scenario (Scenario n.1) to be compared with further elaborated scenarios coming from the variation of some variables related to decisional alternatives (Scenarios n.2,3) . In particular, the first example analyses the impacts coming from a well focused and aware strategy, whereas the second example deals with a strategy characterized by high levels of ambiguity and generality. The comparison allowed an ad-hoc verification of the decision support model, through emphasizing an convergence and coherence in the first case, and a substantial lack of convergence in the second case. The tool carries out comparisons starting from the relations among items identified in the initial scenario. Subsequently, through a graph partition, it allows the singling out of sectoral elements involved in positive or negative changes (from 2 = high positive change to 9 = very low neg. change; 10 = no change).

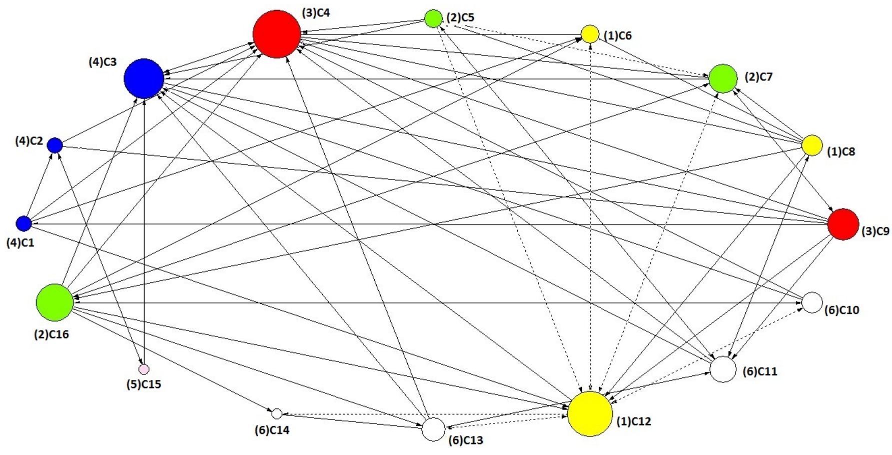

Fig. 1. Fuzzy map with graph partitions of scenario n.2, by *FCMapper* (2D projection of the 3D map: size of centers related to the values of concept centrality in adjacency matrix)

The first example hypothesizes a policy decision toward encouraging energy savings for the improvement of indoor microclimates. This is achieved through non-technological environmental and structural solutions, such as, e.g., larger balcony and the like (Fig. 1). The derived graph partitions shows that scenario n.2 includes positive as well as negative change impacts, with similar items are aggregated in colour and/or spatial location.

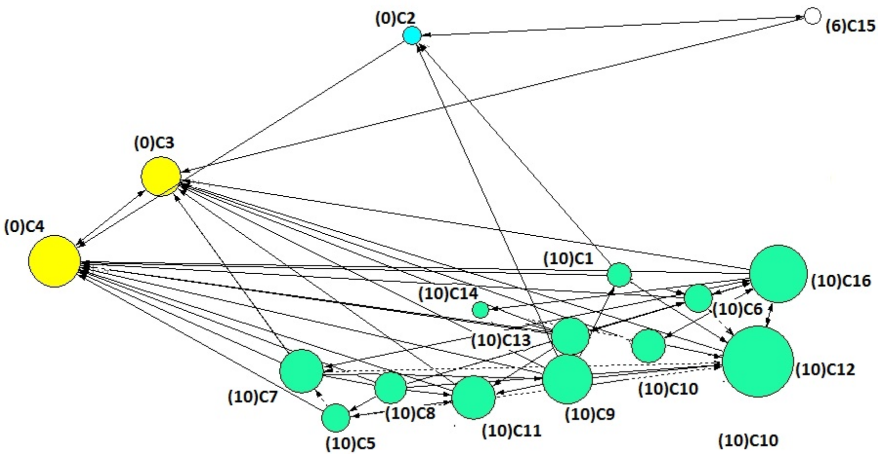

Fig. 2. Fuzzy map with graph partitions of scenario n.3, by *FCMapper* (two-dimensional projection of the 3D map, optimized through showing cluster mapping only).

In the second example the initial scenario has been compared to the more general scenario n.3. This example hypothesizes a policy decisions enhancing unfocused, general issues such as "more tranquility", "more comfort", "a prettier building". The resulted graph partition shows that there are no clustering elements, whereas primary items are affected by no change (value = 10) (Fig. 2).

As a whole, the above experimentation is aiming at better explaining the proposed methodology. Through fuzzy graph mapping it allows an easy identification of elements deriving from human agents' perceptions toward indoor microclimate. This makes such knowledge accessible and easily comprehensible by decision makers and agents themselves, so simplifying the discussion and consequent analysis and decisions.

4 Final Discussion Notes

The main aim of this paper is to show the potentials of using FCM-based formal models to manage complex knowledge involved in multi-agent behaviours within a system architecture supporting decisions affecting urban microclimate. Human/artificial as well as human/human agents interacting behaviours in indoor spaces have been investigated with a social science (focus-group-based) approach and subsequently modelled by using a cognitive mapping approach.

The *FCMapper* tool allowed the setting up of a simulation framework oriented to single out possible areas impacted by selected policy decisions on urban microclimate. Through an iterated simulation process, the sensitivity analysis carried out by *FCMapper* is supposed to integrate formal data coming from the general system architecture previously defined (see [1], p.131, figure 1) toward the definition of cooperative policy scenarios of UHI management –a pretty novel achievement compared to [1]. In fact, the fairly interesting result is that the approach allows the inclusion of informal, qualitative, behavioural ontologies in the typically formal models of quantitative knowledge management of climate decision support systems.

Of course, the experimentations are affected by initial and ongoing simplifications that could not drive to formal rules. It is significant in this context that the cooperative experiments involved a quite low number of stakeholders both in the item generation and evaluating phases, so generating mainly raw visions and cooperative evaluations. Additionally, visions generated by cooperating stakeholders were not free from direct references to obstacles and criticalities, so hampering free vision generations [20][21]. Also, the domain of knowledge interaction is limited to indoor behaviours, whereas a great interest is related to outdoor and borderline domains when dealing with UHI [10].

Yet this significant number of limitations appears as a preliminary price to pay to highlight the actual potentials of the *FCM* cooperative approach. Therefore, it certainly needs to be overcome, but the interesting suggestions achieved do represent a stimulus for the enhancement and enrichment of the research project in the future.

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IEC 61499-Compliant Cooperative Dynamically Reconfigurable Run-Time Environment

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Abstract. The paper presents the work-in-progress on a Group Support System for cooperative implementation of control algorithms according to IEC 61499 standard that also enables integration with experimental pilot-plants. The state-of-the-art of the presented problems is presented and the already completed parts of the framework. The described work-in-progress concentrates on industrial connectibility, downtimeless dynamic reconfiguration and conflict resolution. The described project is promising due to the increasing role of the IEC 61499 standard in the industrial practice and because of the lack of similar educational solutions.

Keywords: collaborative learning, control algorithms, IEC 61499, multiuser software.

1 Background and Motivation

The purpose of the IEC 61499 standard is to enable intelligent automation. The intelligence is genuinely decentralized and embedded into software components, which can be easily distributed across networked devices. With the recent emergence of professionally made software tools and a number of hardware platforms, IEC 61499 is getting recognition in industry [1]. For the education process to follow the industry practice and to adequately prepare students for their job, the learning of automation system development must be carried out according to this norm. Students should learn the semantics of event driven software and should cooperatively test their knowledge using experimental pilot-plants. In the Control Systems and Control Instrumentation (CSCI) Group at the Silesian University of Technology, six pilot plants from the following domains are available: biological, heating, pH control, sedimentation, combustion, and hydraulics (see [2], [3]).

Therefore, a Group Support System (see [4]) is needed to support the cooperative implementation of control algorithms according to the IEC 61499 and to enable integration with the existing pilot-plants. The authors decided to design such a framework based on their previous work. This paper presents the work-in-progress, that is: the basic design assumptions and current solutions that will be adapted. The key part of this paper is the presentation of the theoretically designed mechanisms for conflict resolution to ensure the consistency of the software.

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2 State-of-the-Art

The software implementing the standard concepts is being developed on many levels. Programming environments designed especially for research are available, for example the reference environment FBRT or the 4DIAC. Other environments are more suitable for applications in production processes, for example ISaGRAF and NxtStudio. Vyatkin in [1] presented an excellent review of all the platforms and the trends in development. However, no development environment is currently available that would meet the requirements set for the Group Support System (parallel work without turns, egalitarian way of working [4]). In the CSCI group a lot of work has already been done creating solid foundations for the development of such a framework. Those include, but are not limited to:

- IEC 61499 compliant FBLV runtime [5]: a fully functional runtime environment for applications developed in the event-triggered-blocks convention. National Instruments LabVIEW is the runtime platform enabling easy integration of this environment with industrial grade automation instrumentation.
- Control theory teaching Group Support System [6]: a LabVIEW based platform enabling the cooperative design, running and verification of control algorithms.
- Web-based application for visualisation of inter-user associations in cooperative environments [7]: enables a graphical presentation of the systems structure in a well-known block diagram form.

3 Work in Progress

A number of aspect must be carefully analysed. First, the runtime environment must be connected to industrial hardware. Students should learn by using real systems with a number of technical aspects rather than simulators. Secondly, the runtime must be dynamically reconfigurable. In order to serve as a Group Support System it should be possible to change the blocks configuration at runtime, preferably in a downtimeless manner, so that the group work is not interrupted. And finally, the runtime must resolve conflicts during the simultaneous work of a number of students.

3.1 Industrial Instrumentation Connectibility

The industrial instrumentation connectibility is ensured by using the LabVIEW environment. It has great potential for integration with both dedicated hardware like the compactRIO platform but also with desktop PCs. Details of LabVIEW-based solutions have already been published for example in [5], [6] and [7]. The previous version of the IEC 61499 runtime [5] used a specially developed method to brake the IEC 61499 concepts into procedural programming concepts because LabVIEW at that time did not support the object-oriented programming (OOP). Since OOP is currently available in LabVIEW, this project needs to be upgraded by translating the norm concepts into the programming concepts (function block definition implemented as a class, block instance as an object, etc.).

3.2 Downtimeless Dynamic Reconfigurability

This aspect is the subject of research of active research groups working on IEC 61499 (see e.g. [8]). Some of the work is focused on ensuring synchronization of the reconfiguration of physically distributed devices [9], but in the presented case only the users are distributed and there is only a single resource (as in [6]). Therefore, it is necessary to design a sequence for a dynamical modification of the connections between functional blocks in such a way that the reconfiguration does not disturb the controlled process. Therefore, at no time a wrong stimulus is given to the process and no state change in the process is missed [10].

3.3 Conflict Resolution

It is assumed that an independent communication channel will be used (for example chat or VOIP), so that students can state the strategy and divide work. The conflict resolution mechanism in the runtime environment should maintain the integrity of the software. Conflicts will arise in a complicated network of functional blocks. A transaction mechanism is proposed that is based on an a-priori reservation of the selected part of the network. Only when the reservation is confirmed, the connections between blocks are modified. The proposed mechanism is schematically presented in Fig. 1.

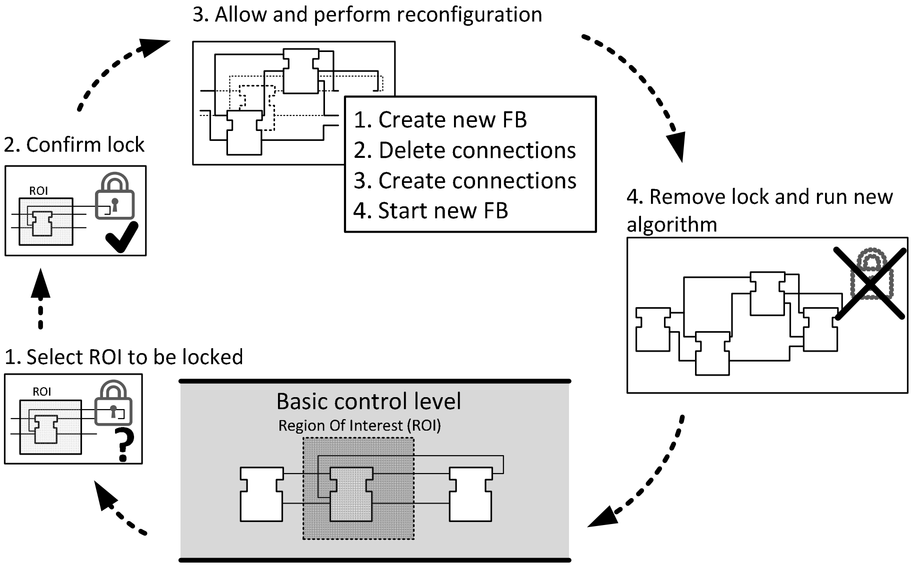

Fig. 1. Transaction-based reconfiguration of control algorithm structure

4 Concluding Remarks

The current state of work is as follows: the particular software modules are implemented, the design concept is specified and our work will concentrate on the integration of all those parts into a working system. A master's thesis is currently being realized that concern the OOFBLV (object oriented FBLV). The described project is promising due to the increasing role of the IEC 61499 standard in the industrial practice and because of the lack of similar educational solutions.

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Practice and Usage-Oriented Service Adaptation: An Integrated Design Method for Collaborative Work in Construction Projects

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Abstract. Practitioners of the construction sector require improved Information Technology (IT) Services to support their collaborative work. In usual service design processes, business experts gather requirements and collaborate with designers (e.g. Software Engineers or HCI experts) through modeling phases to develop adapted solutions. Our main hypothesis is that improving modeling and mapping of these different perspectives will enhance such service's design processes. Based on the analysis of parallel research fields, this paper addresses this issue, and proposes a method to adapt IT-supported services to business practices. This method is based on a structured approach aiming at (1) identifying Collective Practices, (2) focusing on actors' Individual Practices and Operations, (3) distinguishing different technology-related Usages and finally (4) selecting or designing adapted IT services relying on previous analysis. An example based on sustainable project practices illustrates the approach.

Keywords: Computer-Supported Collaborative Work, Architecture Engineering and Construction, Service system, Service adaptation, Usage-centered design, Building Information Modeling.

1 Introduction

AEC (Architecture, Engineering and Construction) projects are characterized by the highly collaborative context of practitioners work. In order to respond to the customer's requirements (i.e. architectural program), teams of heterogeneous actors (architects, engineers, contractors, material providers, etc.) have to cooperate temporarily. According to the role they have in a project, each team makes use of different types of information related to their own internal processes, methods and IT infrastructures. This context changes from a project to another: each project generates its own "cooperation context".

Previous works were dedicated to the characterization and visualization of this context through modeling [1]. The research work described in this paper aims to use

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this knowledge in a design process to adapt IT services for the construction sector. Collaboration IT services (e.g. groupware systems) are useful to manage such a complex context of work. But without an accurate knowledge about what the practitioners require, services designers can't really fit the service offer to them. Moreover their design work will be long and expensive.

In so-called "service design projects", IT services adaptation consists in selecting pertinent services according to identified requirements, but also in innovating by the development of new ones [2]. Therefore such processes rely on Software Engineering approaches with a particular interest to Business Practices analysis and their expression through Usages of technology.

The section 2 presents a brief analysis of related research fields. Then, in section 3, the authors introduce their approach based on elicited issues from previous analysis. A case study illustrates the opportunities of this approach. Finally other perspectives are discussed in conclusion.

2 Designing Services: From Generic to Specific Methods

A typical software deployment process like the RUP (Rational Unified Process) [3] follows iterative cycles composed of different activities: business modeling, requirements engineering, analysis and design, implementation, tests and deployment.

Model-driven methods explore models' transformation and mapping in order to design software services. For example, the Symphony method [4] combines organizational (i.e. business tasks oriented) and interactional requirements (i.e. human-computer tasks oriented) with technical requirements (considering software and hardware). It is performed through the production of coherent models during a structured process.

Our particular interest is about the relationship of such methods with parallel works on business modeling and service design for the AEC sector.

In AEC, BIM models aggregate building-related data (i.e. about building elements and processes) through smart objects. The IFC (Industry Foundation Classes) standard ensures the reliability of such objects along the project lifecycle, through disciplines and software applications. But there is a need to express requirements for the exchange of this data, in order to improve BIM-related IT services.

The NBIMS approach (National Building Information Modeling Standard) focuses on information exchange processes during an AEC project lifecycle [5]. Organizational and interactional aspects are also analyzed, through Information Delivery Manual (IDM) processes. Then services are defined in a specific technical context: the aggregation of all project information into one single BIM model through the IFC exchange format. The design approach based on the IDM defines the mapping between "exchange requirements" and IFC business objects for the software implementation.

An IDM process, at the organizational level, describes the collaboration of few actors (identified by their roles in the project) in order to achieve business specific objectives [6]. Then, considering the use of BIM services, IDM are refined in "use cases". In this resulting process, business tasks are decomposed into user interaction tasks in the one hand and system responsibilities (i.e. automated tasks) in the other hand (fig. 1). In figure 1, the arrows illustrate the decomposition of the business activities "design building" (red) and "validate design and make estimation" (green).

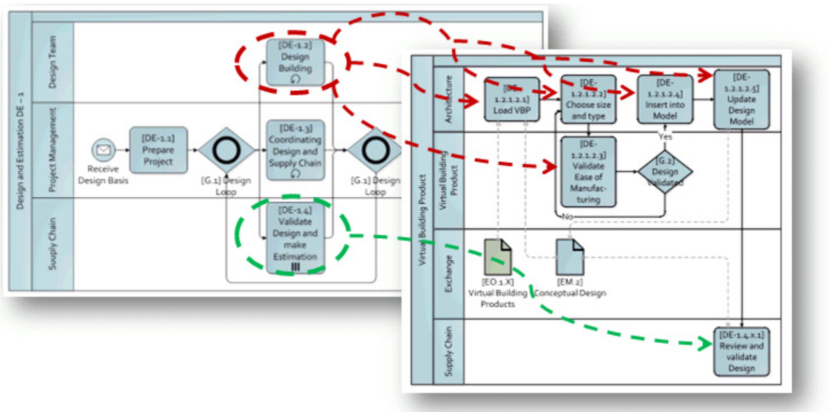

Fig. 1. The IDM process, from organizational to interactional perspective (adapted from [6])

3 Hypotheses and Approach

Our research hypotheses state that a more generic framework can be inspired from the IDM approach, in order to specify requirements for IT services design. Main issues have been identified:

- Graphical models are understandable, and are particularly adapted to the mapping between different concepts. However, literal description shouldn't be forgotten because of the quality and the quantity of information that it can provide.
- The late binding between requirements and technical aspects ensures the generality of the approach and the possibility to extend it to different domains and different technological contexts.
- The transformation of business processes and objects into interactional ones helps at defining a system from the "front end" to the "back end".
- Many interactional spaces (processes and objects) can be mapped into one organizational space, depending of the variation of contexts (i.e. the activity context as well the user one).

The modeling of perspectives (or viewpoints) as well as the mapping of their discipline-related concepts is at the center of the proposed approach. The objective is to make explicit these perspectives and their relations in order to facilitate collaboration, understanding and traceability in software service design. The perspectives identified are [7]:

- through the concepts of Practices and related Business Objects: the “group-related” and the “actor-related” behavioral perspective (WHY) (e.g. Design document exchange, Execution tasks planning, Building defects management) [8]), and the informational perspective (WHAT) (according to Bjork’s “information process activities” [9])
- through the concept of Usage (according to Usage-centered design [10]) and related Interaction Object : the interactional perspective (HOW, WHERE, WHEN)
- through the concept of Service, defined by processes and technical objects [11] : the technical perspectives (HOW in the system)

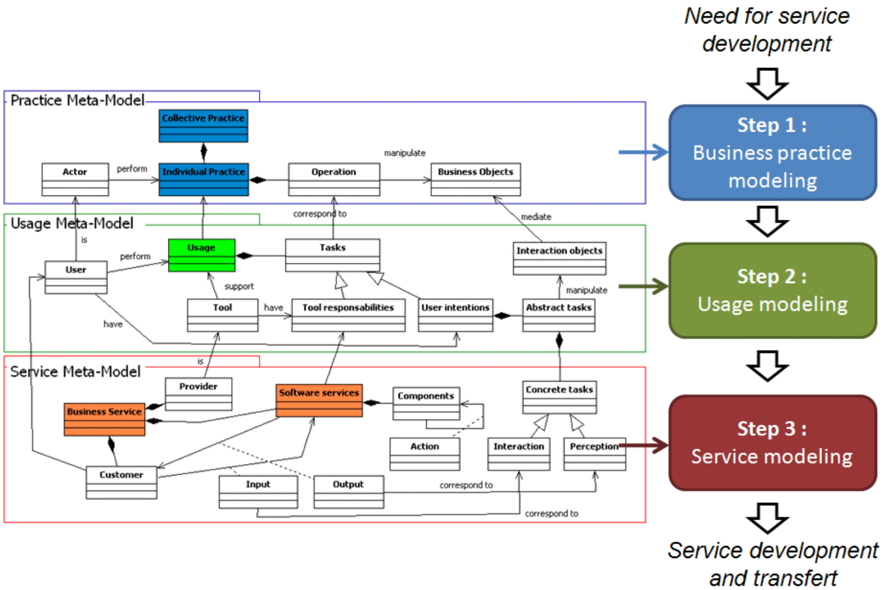

Fig. 2. Mapping of the perspectives through complementary UML Meta-Models in a 3-steps method

One can adopt one (or more) of these perspectives independently in order to analyze and characterize a specific situation with recurrent concepts. In our research work, we propose to integrate these perspectives in a method for the adaptation of IT services in three steps. This approach addresses two challenges: fitting the designed service to business-related requirements and exploring technology-related opportunities.

The characterization of each perspective by meta-models is expressed through UML class diagrams, and the mapping of these diagrams (through relations between concepts from one diagram to another) defines their integration in the method (fig. 2).

According to model-driven analysis techniques, it is considered as the meta-model (M2) level. A meta-model contains all conceptual attributes that will be used to create a model (M1) of a real world situation (M0), i.e. to describe it. In our approach, meta-models are instantiated through different types of models: diagrams (essentially graphs and UML diagrams) and tables (which enable structuring literal descriptions). The Graphical Modeling Framework (GMF) of Eclipse has been used to create diagrams editors for business activities and human-computer interactions modeling. For more classical UML models (use cases and sequences), we used the StarUML editor. We will describe the method and the related models considering the improvement of one particular service.

4 Application of the Method through a Service Design Example

CRTI-weB is a groupware designed and provided by the CRP Henri Tudor for practitioners of the Luxembourgish AEC sector. It comprises two “business services”: a document sharing service and a meeting report management service, accessible through any web browser. Each of these business services are composed of many software services like for example the “file upload” service.

The accurate management of the exchange of design/construction documents ensures the quality of the coordination within and between business teams of any collaborative design project, including AEC projects.

In this particular business context the following section shows how perspectives models are domain-specific and how CRTI-weB “file upload” service could be improved by applying the proposed method.

4.1 The Business Practices Model (i.e. Behavioral and Informational Perspectives)

This is the perspective of business experts. Priority is given to a hierarchical approach for perspectives modeling (from a generic to a specific description, in a “vertical” way) instead of a procedural one (modeling concepts with the same level of detail as following events, in a “horizontal” way). Indeed, we argue that each practice has to be considered “as it is”, considering the related objectives and the information manipulated, and not as an element of a complex process. In this way, we ensure that our method really improves cooperative work (i.e. design and also management) in the specific context of an AEC project.

The diagram ❶ in fig. 3 describes the business situation of an architectural design project. Concepts are distinguished through graphical attributes (like nature of shapes, colors, icons…).

In a collective practice of “design choices validation” (CP), a designer of the project executes his own individual practice of “documents diffusion” (IP). Then, the execution of this IP is detailled in two operations : “share” and “inform”. That is the behavioral perspectives modeling (both group and actor-related). The informational perspective concerns the design documents (“geometral”) that have to be shared and the actors “targeted” by the operations (i.e. with whom documents are shared).

4.2 The Usage Models (i.e. Operational Perspective)

This perspective is related to Software Engineers and HCI experts work. In order to match with their own modeling habits, “use case diagrams” and “task trees” are used. Then, these two modeling approaches are enhanced in order to ensure the mapping between models (and perspectives), to enhance the understanding and to complete with useful information (fig. 3):

- The “contextual use case” is inspired from the “essential use case” approach of Constantine [10] in the sense that it aims to be abstract (it models user intentions and not specific interactions with the system). It gathers a use case diagram ❷ and literal information about usage as the goal of the usage, the user, the hardware and the software description (this part is not represented in figure 3). Packages of uses cases in the diagram represent business operations already defined in the previous model. Conceptually, the use cases identified are considered as mediated business operations. This relation is graphically understandable through this modeling approach.
- The “diagram of interaction tasks and objects” ❸ describes abstract and concrete interaction tasks. The mapping with the previous model is created by the integration of the user intention at the higher level of granularity. Conceptually a user intention is composed of abstract tasks. “Interaction objects” are integrated, as it is the case both in Symphony and BIM approaches. Such objects are mediated business information (defined in the practices model). Mockups and quick prototyping can also complete this modeling phase❹.

Initially the common usage for sharing documents with CRTI-weB follows this iterative process: the user select one file to upload and the system upload it as one document with the related meta-data (name, author, date of upload, ect…). However, it has been required from users, to improve the service as they can select many files and upload them in a single process. Two usages have been differentiated.

- In the first one, each file selected is uploaded as one document.
- In the second one, all files are “clustered” in one document: this usage is particularly adapted for architects who want to share a cad file (e.g. a dwg file with all plans, sections, etc…) with the related pdf of each “view”. This second usage is the one that is described through models in figure 3.

4.3 The Service Model (i.e. Technical Perspective)

This last modeling phase is essential to define the behavior of the service to implement, by considering user tasks. This perspective is usually characterized by sequence diagrams ❺. These models are a transposition of previous models into a specific architecture. One can see that the system, previously seen as a “black box” is now detailed (fig.3).

In our example, the new “file upload” service implemented proposes to the user, according to his file selection, the opportunity to cluster files or not. This implementation respects both the expected usage specified in the precedent modeling phase and the architecture of CRTI-weB.

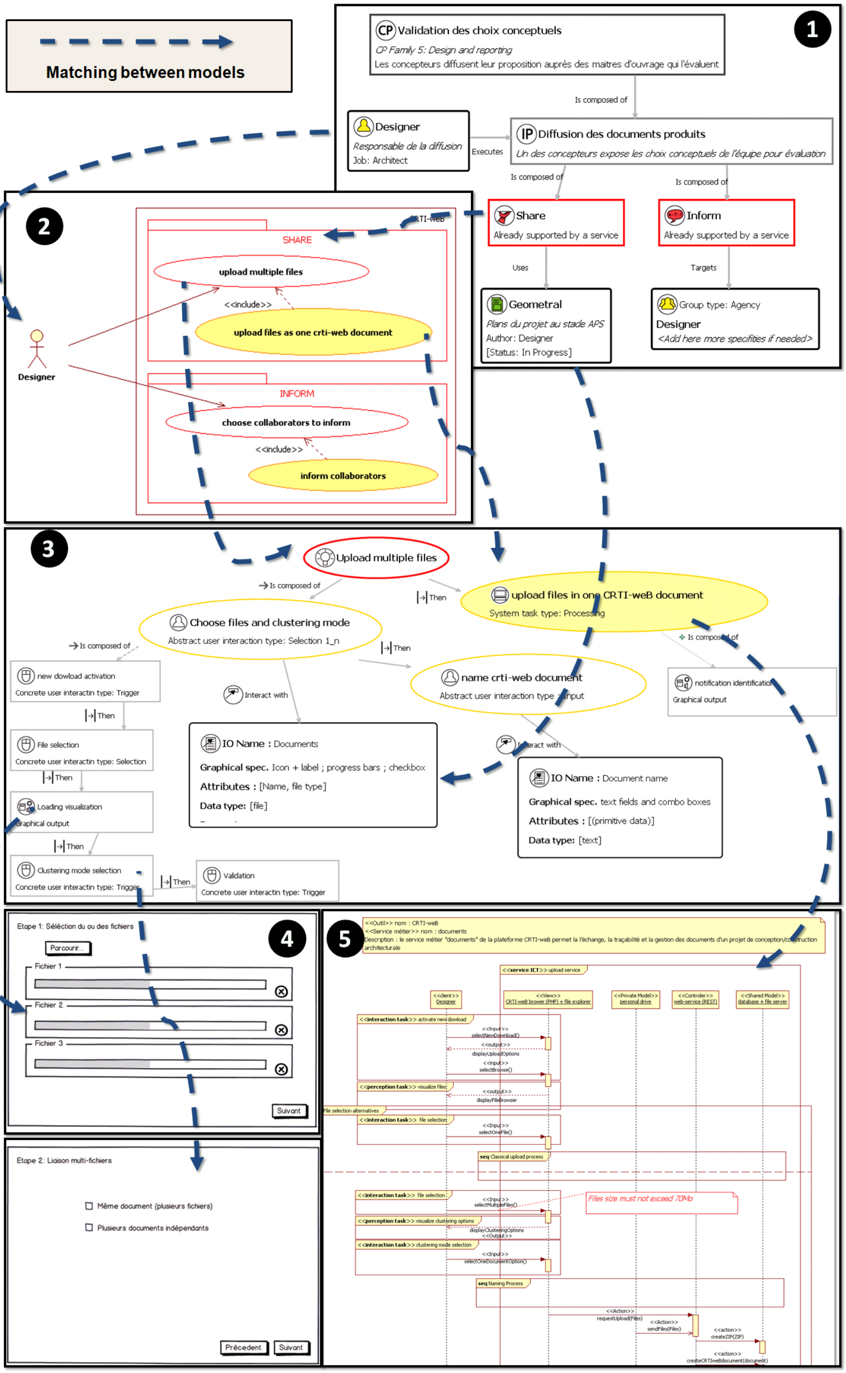

Fig. 3. The entire process of models mapping, from business analysis to service specification

5 Conclusion

The method introduced in this paper is inspired of studies in Software Service Design based on perspectives modeling. The particular approach relies in the modeling languages and perspectives mapping through dedicated or re-used models. These two issues address the management and the traceability of the design process with the aim to improve the collaboration between experts, designers and developers and, by extension, to improve the service quality.

The authors' interest is in the particular sector of AEC project, in which collaborative IT services are useful to manage such a complex context of work.

Practices and Usages modeling support innovation in Service design, whether it targets "business push" projects (by analyzing and improving business) or "technical push" innovations (by adopting and using efficiently new technical solutions).

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Service-Oriented Workflow System for Inter-enterprise Processes Collaboration

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Abstract. Forming networks through co-operation between different companies has become an important business strategy for SMEs. This brings about the prospect of ad hoc integration of processes across organisational boundaries to support collaborations. This paper aims at providing a breakthrough in the support of SME networks for building up and executing collaborative business processes in dynamic virtual organisations based on service-oriented workflow system.

Keywords: Inter-enterprise processes, collaborative product development, service-oriented workflow.

1 Introduction

The way of cooperation between different companies has become a strategic component, especially with regard to enable the cooperation of enterprises situated in different locations and having a different cultural background (e.g. Chinese and European companies). Not only the purchase or the supply of a product, but particularly the ability to find a matching supplier and its integration into the development process of a manufacturer during the whole product development process plays a more and more important role.

Every company usually follows its own proven strategy for the management of processes and information during product development. As soon as the boundaries of a company are crossed, the management of the processes and information of a common product development process concerning all involved partners is quite difficult. Having two companies in a collaboration (e.g. in two different locations), it is very difficult to ensure a consistent database while sharing information. However, process and information management between collaborative companies usually lack sufficient information exchange and sharing. In order to avoid sharing unprotected information representing a company's specific know-how, collaborating companies usually manage their product development processes and product data in a highly inconsistent and inefficient way. Besides these organizational and technical issues, there are additional topics, such as the assurance of intellectual property rights on used and shared information which is vital for companies in virtual market places.

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The overall goal of the paper is to realise a common workflow system between dislocated companies based on sharing processes.

2 The State-of-the-Art for Inter-enterprise Processes Collaboration

With the increasing heterogeneity and dynamics of the economy, more and more enterprises are challenged to adapt continuously to the rapid changes, to concentrate on their core competencies as well as to search for competitive advantages and innovations[1].

Rapid technological advances and altered customer demands create a new dynamic and complex business environment, whereas flexibility and mobility are implicitly required from enterprises. For these reasons different enterprises have to cooperate in order to meet effectively customer needs, to encounter the contemporary prevalent high competition and innovation pressure as well as to be permanently successful in largely saturated markets. The innovative moment consists in the cross-enterprise integration of data, functions and processes[2].

Tremendous developments in data storing, processing and communication over the last two decades have made unprecedented impact on how most enterprises operate, develop future business strategies and deal with day to day operations. At present, Businesses are increasingly moving towards extensive automation of their private and public processes. This automation takes the form of complex interactions between heterogeneous and autonomous systems within the enterprise and often cross multiple organizations. Controlling these complex interactions in order to effectively manage collaborative business processes is known to be a critical yet difficult problem using current technology solutions[3]. Process-oriented collaboration are becoming the most advanced inter-enterprise integration form.

Process collaboration provides a sophisticated management system that places an abstract business-oriented layer on top of traditional B2B communication mechanisms such as message brokers and message-oriented middleware (for example IBM MQSeries and Microsoft Message Queue).

The lifecycle of inter-enterprise processes collaboration includes business process modeling and model execution and collaboration.

There are some business process modelling languages being specified today, such as BPML, XPDL and BPEL4WS. BPEL4WS is an industry standard specification for defining the workflow between Web services[4]. It is intended to provide a workflow language to model complex and non-deterministic business processes. The most important feature of BPEL4WS is to support business process coordination among multiple parties. This enables the outcome (success or failure) of units of work at various levels of granularity of the business processes. BPEL4WS enables modeling of long-running interactions between business processes with nested units of work between them and each with its own data requirements.

For the execution and management of process models. Workflow has now been adopted as a way to implement the cross-organizational management needed to carry out businesses[5]. The interoperability is the essence of inter-enterprise workflow used for management of business processes. Considering the execution of workflow, services computing poses significant challenges as developers determine how to leverage emerging technologies to automate individual applications based on cross-organizational, heterogeneous software components. Nowadays, The Web has become the user interface of global business, and Web services now offer a strong foundation for software interoperability through the core open standards of XML, SOAP, WSDL, and UDDI. The interaction models that fully realize the potential agility of Web services computing are just beginning to emerge. At present, web service has become a hot topic in the research field of business process integration[6].

3 Design of Service-Oriented Workflow System

Because of the nature of service such as loosely coupling, coarse granularity, access transparency, platform independency and business orientation, workflow in Service-Oriented Computing also presents many new characteristics:

- Services are implemented by workflow. Workflow technology enables the resilient and dynamic composition of services.
- Workflow is just another kind of services. Business process itself may be distributed among dispersed partners, and the involved applications as well as the whole workflow are delivered as services.
- There are multiple processes running at the same time. They communicate with event/messages (No explicit control link among them) and share the resource or data. New processes/services are dynamically created or invoked.
- The processes change dynamically along with the changes of services. Because of the autonomy of services, it requires ensuring the usability of services and selecting service components in real time during the operation of processes, which also results in the difficulty in evaluating workflow performance.
- Based on the above characteristics, we proposed the definition of SOWF.

Service-oriented workflow (SOWF) is the business process partly or totally executed by the computers automatically in service-oriented environments, partial or entire activities in the business process are completed by services in Network. In other words, SOWF is a composition of web services for the purpose of special tasks.

As shown in Figure 1, the architecture of service-oriented workflow management system is put forward. It is a hierarchical structure which contains three layers, i.e., the user interface layer, the operation logic layer, and the persistent storage layer. The user interface layer includes interfaces for workflow model presentation, execution management and user interaction, while the persistent storage layer comprises databases (DB) for storing the workflow models and relevant data.

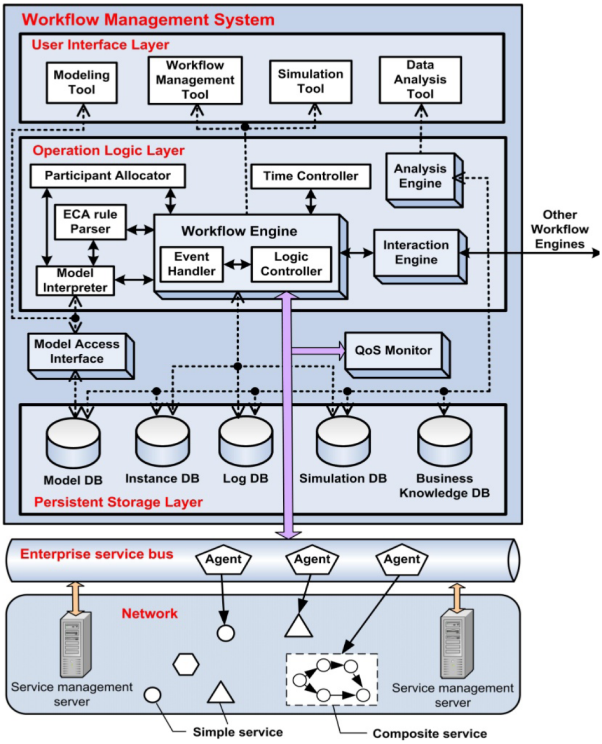

Fig. 1. The architecture of service-oriented workflow

The core element of the operation logic layer is the workflow engine, with the participant allocator, the model interpreter, the ECA (Event- Condition-Action) rule parser and the time controller as supportive components. The engine is basically composed of a logic controller and an event handler, with the former dealing with the navigation of control flows as well as data flows in a workflow model, and the latter handling particular events in service computing. The analysis engine deals with the data from persistent storage layer and supports the data analysis tools, the result of the analysis is fed back to business knowledge DB as rules or knowledge for future use. The interaction engine is a bridge between this workflow engine and other workflow engines by event communication and data correlation.

In service-oriented environments, there are two kinds of activities in business processes, one is normal task executed like traditional activity, and the other is service which needs special mechanism.

When the workflow engine encounters a service to handle, it turns to the enterprise service bus, in which the agent is responsible for the execution of the service through querying the service management server who stores the directory of all the service. Finally a simple service or composite service (constructed by composing several simple services according to certain regulation) in Network is selected to match the requirement of specific service. The quality of service is guaranteed by the QoS monitor modular.

4 Implementation and Application

Based on Service-oriented workflow, we developed a engineering collaborative portal, which can provide workflow management Functionality for collaborative product development.

The portal provides process-modelling services for collaboration partners to build a common product development process so as to integrate the local engineering process of each partner, as illustrated in the following picture (Figure 2). The basic functionalities include: create a process model, edit a process model, add an activity, edit an activity, save the process model, etc.

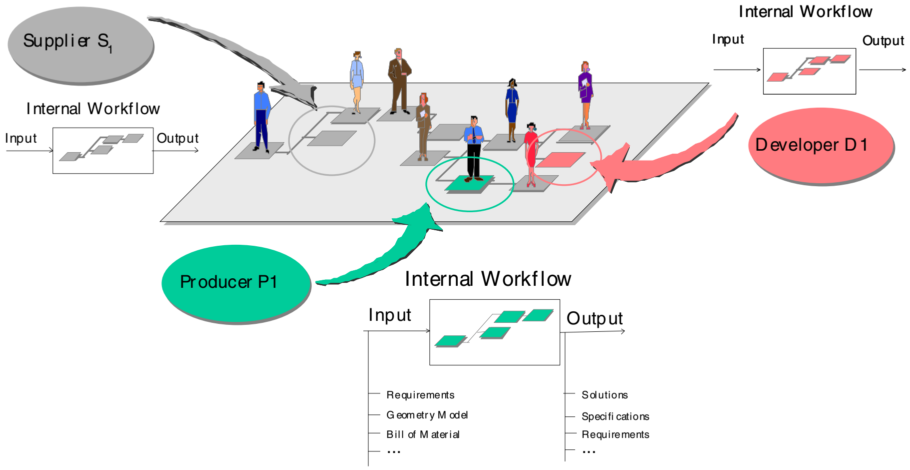

Fig. 2. Modeling for collaborative product development processes

Within the portal, the process-modelling services will have direct interaction with the workflow engine. Workflow engine executes the process model and manage the interaction between processes.

We built up a workflow scenario of electromechanical product design process on BPEL workflow engine (Shown in Figure 3).

In this workflow, we set one Receive-Reply Activity, six Invoke Activities and two Assign Activities. Different Partner Links were designed to meet different needs in operations. MechanicalDesign and MechanicalDetailedDesign share the same Partner Link Mechanic-alDesigner. So do ElectronicDesign and DetailedElectronicDesign. Mechanical(Detailed)Design and Electronic(Detailed)Design are put into Flow Containers so that the process could proceed until both of the Activities in Container are completed.

The detailed views of activities in this Process are listed from Tab. 1. to Tab. 3.

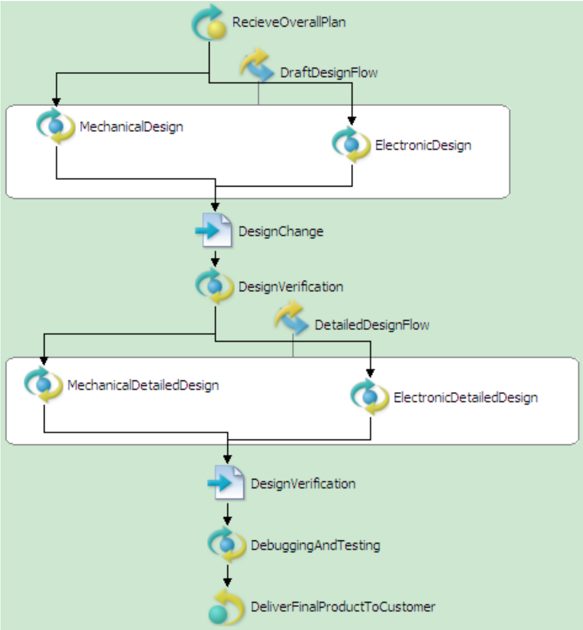

Fig. 3. Electromechanical Product Design Process

Table 1. Receive-Reply Activities

Activity Name	**ReceiveOve-rallPlan**	**DeliverFinalProductTo-Customer**
Activity Type	Receive	Reply
Operation	GetOverallPlan	GetOverallPlan
Partner Link	GetRequestLT	GetRequestLT
Port Type	OverallPlanPT	OverallPlanPT
Variable	OverallPlan	FinalDesign

Table 2. Assign Activity

Activity Name	DesignVerification
Copy Operations	Copy Variable(TwoDimCADDesign) Part(TwoDimDesign) TO Variable(FinalDesign) Part(TwoDimDesign); Copy Variable(ThreeDimCADDesign) Part(ThreeDimDesign) TO Variable(FinalDesign) Part(ThreeDimDesign);

Table 3. Invoke Activities

Activity Name	**Electron-ic(Detailed) Design**	**Mechani-cal(Detailed) Design**	**Design Verifica-tion**	**Debug-gingAnd Testing**
Input Variable	OverallPlan	OverallPlan	Modifi-cation	FinalDe-sign
Operation	Electronic-Design	Mechanical-Design	change-design	debugtest
Output Variable	TwoDim-CADDesign	ThreeDim-CADDesign		
Partner Link	Electronic-Designer	Mechanical-Designer	chagede-sign	tester
Port Type	Electronic-DesignerPT	Mechanical-DesignerPT	Change-De-signPT	Debug-TestPT

The Variables in process are defined by Message as shown in Tab. 4. These Variables help ThreeDimCADDesign and TwoDimCADDesign be changed throughout the process. By assigning value, the design are copied to the FinalDesign. Overall Plan is the Input of the workflow that guides the execution process. We need to write the initial value of OverallPlan Message to launch the process. FinalDesign is the output of this workflow, delivering final products to customers. Modification is used in DesignVerification Activity to record detailed changes in design.

Table 4. Variables Defined in BPEL Process

Variable Name	1		2	
	Part Name	Type	Part Name	Type
OverallPlan	Process Description	String	OverallPlan-Drawing	anyURI
FinalDesign	TwoDim Design	anyURI	ThreeDim Design	anyURI
TwoDim CADDesign	TwoDim Design	anyURI		
ThreeDim CADDesign	ThreeDim Design	anyURI		
Modification	Modifica-tionDoc	String		

5 Conclusions

This paper implements a service-oriented workflow system that could be deployed in cross-domain platforms. Currently, we have finished the definition and execution of collaborative product development processes on the system. Based on the system, internal business processes of an enterprise and external business processes between the enterprise and its partners can be integrated and coordinated.

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Object-Oriented Framework for Cooperative Testing of Control Algorithms for Experimental Pilot-Plants

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Abstract. In this paper a framework for cooperative testing, implementation and learning of control algorithms for the purpose of controlling experimental pilot-plants is presented. It is based on the principles stated in the IEC61499 standard. The proposed framework enables modification of the control algorithm structure without rewriting the main software component executed on the programmable automation controller (PAC). Functions realized by particular blocks may be changed dynamically during the runtime. The framework is implemented in LabVIEW enabling implementation of algorithms containing advanced analysis functions and complex control algorithms by multiple users, providing an effective practical group support system.

Keywords: collaborative learning, control algorithms, OOP, multiuser software.

1 Introduction

Classical control systems based on the notion of feedback are widespread in industrial automation. An architecture of software constituting such a system is the result of assumptions taken by system designers. Typically, the basic requirement is the long-term reliability of the system. As a result, a dedicated software solution is developed for a given control task. The software is developed with a dedicated development environment, usually based on a domain-specific programming language. After the verification of the control system, the software is deployed and executed. Any further modifications of the system require reediting and recompiling the source code, and temporary stopping the control system in order to update the software [1].

In the case of teaching, particularly focusing on control algorithms, the additional effort required for software deployment in a dedicated environment according to the procedure above is too large and unacceptable. It is often the case when industrial tools are improper for collaborative learning [2]. Therefore, computer science methods are sought, which allow for more flexible connection between algorithms and real objects (subject to control). An example of such a new method is employment of software agent technology to access industrial process data in real time [3]. However, because in the course of teaching a whole group of students work together, the IT environment should enable them to co-operate and divide the work. Moreover, in

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contrast to the industrial applications, the software platform should be open so that the providing modifications and executing algorithms do not require any complex operations, and ideally would be possible during the runtime.

In regard to the cooperation in teaching and learning, a typical scenario consists of a group of students developing a plant simulator and/or the control system according to a task given by an instructor. Students receive only the specification of the existing structure of hardware and software, and have to divide the work on their own, do the coding, start the developed system and verify it. Such a construction of the course follows the strong trend of project based learning, in which students work in real-world conditions under discrete teacher facilitation. To provide proper conditions for such cooperation, the structure of the system software should allow for creation of sub-modules and enforce their compatibility to some extent, to enable them to work together and interface with the real-world instrumentation, i.e. a synchronous Group Support System is required [4]. In addition, the teaching supervisor should have an insight into the structure and design of the cooperatively developed software to be able to manage the entire process and to assess the contribution of individual students. It will be particularly valuable if the conditions are met while supporting remote work with the system, so the remote students will be able to attend the course.

In the theory of dynamical systems, which is the basis for the control theory, the most common and widely used method of representation of complex dynamic systems is to picture them with block diagrams. In such a diagram, each of the blocks represents a more or less complex mathematical operation, and the structure of the connections between the blocks visualizes the data flow in the system [5]. To take advantage of this existing knowledge base, it was decided to develop a method of accessing the control system which uses dynamic allocation mechanism for each basic mathematical relation (i.e. a "block"), and allows to access and modify them remotely.

As the programming environment, the National Instruments LabVIEW was chosen because of its popularity in teaching and research, and the broad instrumentation base allowing connection of a developed software platform to the real-world objects at the disposal of the authors. The objects used in the teaching course are reduced variants of typical industrial automation systems and serve as a tool for teaching and research in Control Systems and Control Instrumentation group of the Institute of Automatic Control (Silesian University of Technology) [6]. Ability to connect reconfigurable cooperatively developed control algorithms to such real-world facilities significantly increases the functionality of the developed solution. It allows to verify the developed algorithms in an experimental way, taking into account all the factors impossible to model in the case of purely theoretical work (e.g. imperfect sensors and actuators).

2 Motivation

Development of computer programs that implement automatic control algorithms is a well-established area and has been standardized by the IEC61131 standard [7]. The standard introduces a software model, which defines notions of tasks, programs and resources. Therefore, tasks of a control algorithm are bound with the physical environment by means of the so-called resources - the tasks are implemented by programs, which in turn are executed within the resources. By a resource a standalone hardware component capable of executing a program is meant, e.g. an industrial PC, programmable logic controller or a single processor in a multiprocessor system.

The IEC61131 standard was the basis for the IEC61499 standard [8], which introduced an additional aspect of spatial dispersion within the memory model. The aspect has been modelled by adding mechanisms for communication between physically distributed resources connected by communication links.

The philosophy of executing and iterating the programs changed significantly, too. In the case of applications developed according to the IEC61131 standard, programs consist of an ordered sequence of actions to execute in a single clock cycle. The sequence is described, for example, by a sequence of IL (Instruction List) language constructs, or by a graphical diagram according to the LD (Ladder Diagram) specification. The task described in this way usually consists of one-time calculation of the desired state of the system's outputs, depending on the system's inputs. A resource (an industrial PC for example) then simply executes the sequence of instructions in loop, once per a clock cycle, to simulate the continuous behaviour. This design of the software architecture has been developed to exploit the knowledge and experience of engineers raised on analogue systems built using mechanical relays.

The IEC61499 standard introduces a completely new way of programming, involving the breakdown of the single monolithic program into separate function blocks (the program in each of the blocks still can be written in one of the traditional languages defined in the IEC61131 standard, but it can also be written in Java for example). The blocks' inputs and outputs are connected into a network transmitting numerical data representing the arguments and results of specific function blocks. Execution of the program requires the execution of the sub-blocks, and the order of their execution depends on an alternative network of connections between the blocks, which transfers the so called events. The events are flags which authorize a one-time execution of a single function block. Having this detailed control over the execution sequence of the blocks lets a programmer to ensure an adequate flow of data and eliminate situations in which parts of the application are executed in the wrong order.

The new ideas introduced by the IEC61499 standard are gaining popularity and are supported by automation equipment manufacturers. However, the ideas still do not provide any new methods to support multi-user work on a basis other than division of work on the source code of an application. As part of the study described in this paper, an idea is presented of selecting a subset of concepts propagated by both of the standards to provide the basis for a custom development environment. The students using the environment should on the one hand gain good habits which could be useful in their later professional work according to the standards, but, on the other hand, these ideas are combined in such a way that the dynamic multi-user reconfiguration of the connections between the function blocks became possible, enabling collaboration during a run time.

Thus, the presented environment is characterized by:

- Distribution of a single program into separate function blocks similar to those introduced by the IEC61499 standard. In the case of the standard, the distribution is intended to allow the execution of the distributed program in parallel, but in the case of the described environment the distribution is designed to allow multiple users to work simultaneously.

- Limitation of the program execution sequence according to IEC61131. The issue of controlling the execution order of blocks using additional event network connections is so complex, that the IEC61499 standard is still the subject of active research in the field of parallel systems and algorithms. Therefore, for the task of collaborative learning, the sequence is simplified and assumes that all blocks will be executed in a single clock cycle at a pre-defined order, as in the classic IEC61131 standard.
- Limitation to a single resource - parallel computing and physical distribution are superfluous when teaching control algorithms, so introducing additional complexity seems unnecessary. The proposed system focuses on multiuser access and cooperation rather than on parallel processing.

3 Execution Environment Description

The general architecture of the proposed framework is presented in Fig. 1. In the presented example of a pilot activated sludge process installation, the chosen Programmable Automation Controller (PAC) is a National Instruments Compact RIO (c-RIO-9074). PACs are the next generation of Programmable Logic Controllers (PLCs) widely used in industry. The controller has 8 slots for I/O modules, a real-time operating system (RTOS) and an Field-Programmable Gate Array (FPGA). It's real-time operating system is executing the main part of the proposed framework, namely the Iterator. It also enables various clients to connect to the Iterator in order to add, delete or modify blocks executed in the framework.

3.1 The Iterator

The Iterator is an application written in LabVIEW and executed using the RTOS of the cRIO PAC controller. The Iterator stores a data space that can be addressed either by simple indexing or by using aliases of data items. The data space is additionally divided into three regions. The first region contains values of measurement signals. An additional routine is therefore executed before every cycle of the Iterator that copies the I/O measurement values into the data space. Secondly, a region for writing controls is provided with an additional routine that copies those values to the appropriate I/O outputs after every cycle of the Iterator. Lastly, a data space region for additional variables is provided to enable the storage of values not assigned to inputs or outputs.

Commands from different users are received using a custom TCP based protocol, queued and executed in first-in-first-out order. Obviously it is assumed that the cooperating users are communicating with each other and are not changing the control algorithm at the same time with different intentions. To facilitate this cooperation, the Iterator publishes the current state of the process to all users.

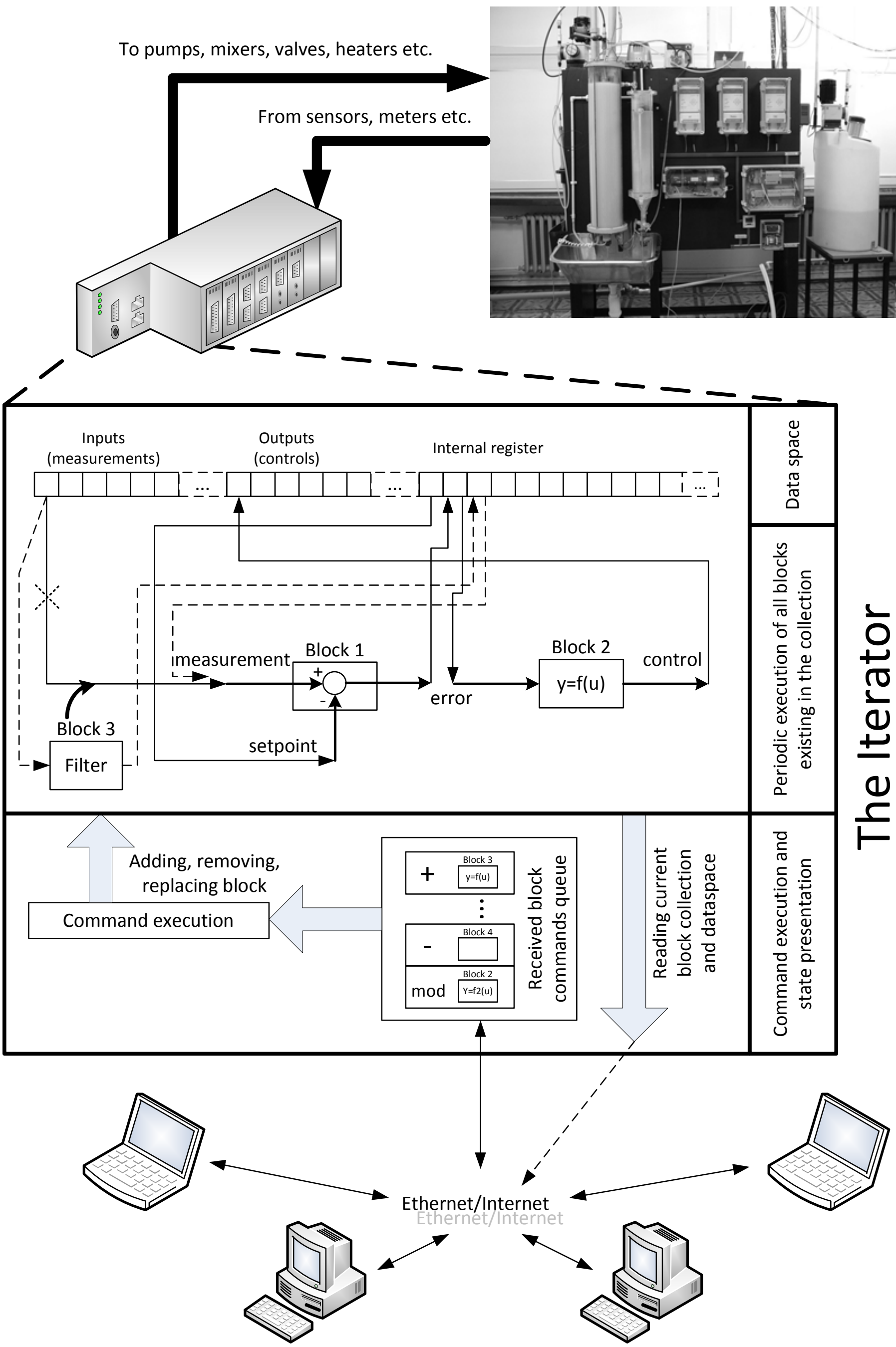

Fig. 1. Architecture of the proposed object-oriented framework for cooperative testing of control algorithms for experimental pilot-plants

3.2 Object-Oriented Realization of Blocks

The blocks are realized using an object-oriented paradigm as explained in [9]. The executed object is initialized by specifying input and output addresses. Blocks are stored in a container and are executed periodically. In the example presented in Fig. 1, two simple blocks are used. Block 1 receives two inputs, namely, the measured value from inputs and the set-point value from internal registers, and computes a simple difference between those values, namely the control error, which is written into internal registers. On the other hand, Block 2 realizes a control algorithm the purpose of which is to influence the process so that the control error is zeroed or minimized. It reads the control error from internal registers and writes the control value into output registers. Blocks can also be added dynamically (Block 3). Dashed lines in Fig. 1 indicate changes to the structure of the control algorithm.

In order to send an object from the client to the Iterator, the object is initialized, serialized and sent to the Iterator. Fig. 2 presents an example of a simple object written in LabVIEW with 3 private data items (Numeric, String and Boolean), the appropriate data access methods and other methods, and the static (or dynamic) creation of an object (`Example Class.lvclass`) and initialization of two data items (`Write Numeric.vi` and `Write String.vi`). An initialized object is than serialized using `Flatten To XML.vi` function and can be sent over the network. The obtained XML string is also shown in Fig. 2. Once the serialized object is received, the `Unflatten From XML.vi` function initializes a new object of the same type with the information contained in the XML string.

3.3 The General Block

To enable the cooperating clients to easily change the control algorithm controlling the process, a special type of block is provided. The purpose of this block is to execute any dynamical function the client wants. In order to do this, the block should accept the formula of the equation to be interpreted in each cycle of the Iterator. However, interpretation of equations in general is a difficult and time consuming process. To solve this problem, the formula interpretation process may be broken into two steps. In the first step, the string is parsed (`Parse Formula String.vi`). Then, the parsed formula is encoded in two arrays:

- 1-D array containing numbers representing addresses of detected and analysed numbers of the formula,
- 2-D array with three columns: one column with the code that stands for the operator and two columns containing codes that stand for operands.\

Once those two arrays are computed, the actual computation of the formula value based on input values and other constants is relatively easy as it only requires a one-time interpretation of consecutive operators and operands. This operation is performed using the `Eval Parsed Formula String.vi` function.

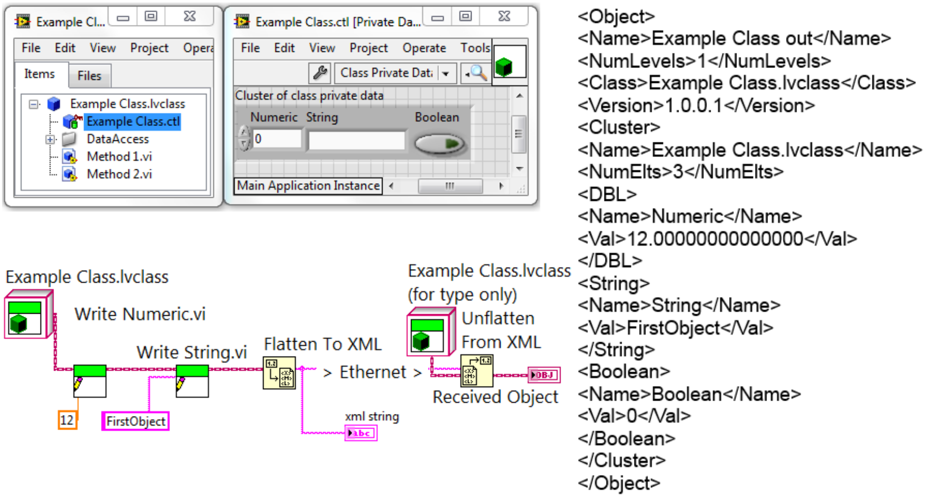

Fig. 2. An example of a simple LabVIEW object and object serialization

Therefore, the time consuming part of this operation is performed only once during object initialization and is performed on the client computer [10]. The initialized object is serialized and sent to the Iterator which adds the new object to the collection. In Fig. 1, Block 2 simply executes a given formula y=f(u). This formula can be changed during the runtime by replacing the old object using the "mod" command.

Realizing a dynamic block requires an iterative equation to be solved. Therefore, the General Block object stores as many previous values of inputs and outputs as required. For example, in order to implement a discretized form of a first order dynamical system, the following string representation is used: `x1+(u-x1)`, which implies, that the new "`x`" value (not specified explicitly in this string) will be computed based on the current input "`u`" and the previous value of "`x`", namely "`x1`".

The presented idea of the General Block may obviously be extended considerably to enable more complex computations, like multi-equation computations etc.; however, the principle remains the same.

4 Concluding remarks

The paper presented a proposed architecture of a framework enabling the cooperative design and implementation of control algorithms. This framework should be especially convenient for educational purposes. One particular example of application is the activated sludge wastewater treatment plant installation operated at the CSCI Group. In this biotechnological system, a number of different environmental conditions must be closely controlled, for example the concentration of dissolved oxygen, the pH value (including in-line feed [11]) or the Redox potential. The proposed framework enables the following operations to be effectively realized:

- Implementation of different control algorithm structures without reprogramming the controller. Therefore, specific basic level control algorithms are independently executed, thus maintaining an uninterrupted control of the critical parameters.
- On-the-fly modification of additional control and monitoring algorithms, enabling students and researchers access to a real-world process, thus providing them with the best chance of learning the real process and implementing control for those processes.

Further work consists of implementing a fully IEC61499 standard compliant multi-user framework. The work is currently at the stage of developing conflict solving methods, which are required to enable cooperative dynamical reconfiguration of complex inter-block event connections network. Preliminary work shows that a two-phase commit protocol will be required for the task.

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Building Information Modelling (BIM)-Supported Cooperative Design in Sustainable Renovation Projects

Benefits and Limitations

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Abstract. This paper presents and demonstrates the main benefits and limitations of the BIM technology in sustainable renovation projects. The built environment is acknowledged as a value both as material and cultural resource to be preserved. The set of buildings that constitutes the built environment represents a valuable deposit of meanings and knowledge. A proper conservation of the built environment is expressed by a sustainable use of materials and territories/lands that have to be preserved for the future generations. Furthermore, undertaking a sustainable way to renovate the buildings means to improve the quality of life and health of people/inhabitants. There are many differences between the design of new buildings from scratch and the renovation of existing buildings. In the latter case, the designer has to tackle the difficulties that arise from the real buildings, represented by a set of constraints (i.e.: walls, beams, spaces, etc.). Digital tools, and in particular Building Information Modeling (BIM), make manageable and improve the design, organization and construction of renovation projects. The benefits using BIM during cooperative design for sustainable renovation projects affect the three dimensions of sustainability (environmental, economical and social) but there are also limitations that delay its diffusion in this field within the AEC sector.

Keywords: BIM, sustainability, renovation, digital reconstruction, integrated design.

1 Introduction

This paper presents and demonstrates the main benefits and limitations of the BIM technology in sustainable renovation projects. The built environment is acknowledged as a value both as material and cultural resource to be preserved. The set of buildings that constitutes the built environment represents a valuable deposit of meanings and knowledge, considered also as used constructive techniques, energy and materials. A proper conservation of the built environment is expressed (beyond the cultural reasons) by a sustainable use of materials and territories/lands (it reduces the con-

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sumption) that have to be preserved for the future generations. Furthermore, undertaking a sustainable way to renovate the buildings means to improve the quality of life and health of people/inhabitants. Last, but not the least, in this time of global crisis, the renovation of existing buildings is also worth on the economic point of view. There are many differences between the design of new buildings from scratch and the renovation of existing buildings. In the latter case, the designer has to tackle the difficulties that arise from the real buildings, represented by a set of constraints (i.e.: walls, beams, spaces, etc.). We believe that digital tools, and in particular Building Information Modeling (BIM), make manageable and improve the design, organization and construction of renovation project.

2 Sustainable Renovation Projects

2.1 Renovation and Sustainability

With the expression to renovate, we do not want to simply specify the restoration of an existing condition, namely the original performances, but we want to improve it for the same use or for a new destination. During a renovation project, the designer has to find spatial and technical solutions to satisfy the user's needs using a creative way against the constraints that come from existing buildings. Current environmental issues require that any action will be also sustainable, namely all the choices carried out during the various phases of the life cycle of the building have to minimize and optimize the material consumption and the waste production. In synthesis, the renovation project can be defined sustainable when it minimizes the negative impact of the building on the built environment.
Among the actions to undertake during a renovation project there are the following:

- to take into account the natural and artificial characteristics of the site/context and the building orientation during the design phase;
- to prefer the use of renewable, recycled and recyclable materials;
- to choose dried connection systems, easy to assemble/disassemble/substitute;
- to integrate devices for energy saving: photovoltaic and/or wind system, etc.

In this paper, we decided to focus only on residential buildings with a concrete bearing structure inside.

2.2 Residential Buildings with a Concrete Bearing Structure

Among the residential buildings in reinforced concrete, we have paid attention to those who mainly use a structural grid defined by technical vertical linear elements (columns) with squared or rectangular section (rarely polygonal) and horizontal elements (beams and plates) that form a structural frame. Such a system usually presents one or more basic modules (i.e. the distance between two columns) repeated inside the building, in plan and elevation. In many places around the world in buildings with frame in reinforced concrete, the closings, that divide the inner and outer spaces, and the internal partitions are made with bricks, such as hollow brick or common brick.

During a renovation project the technological units of the building system that have to be analyzed, including the structure in reinforced concrete, could be synthesized using a classification scheme suggested by the Italian UNI Norms: s*tructures, closures, internal partitions, external partitions and plant delivery services* [1].
Is it possible to extend the life of these buildings, by preserving their main reinforced concrete structure and with the improvement of the functional, energy and aesthetic aspects?

2.3 Main Issue: Managing the Complexity

The high number of elements that constitute a building, its correlations, functional diversity, performance requirements and set of used materials make the analysis of an artifact a complex problem. All these aspects are more and more difficult to be managed with only traditional tools and methods; furthermore the best way to manage all these information as a potential solution is to apply an integrated approach - Building Information Modelling. The largest and worst limitation of the conventional aspect to the renovation project is the inadequate and ineffective collaboration and communication between the various stakeholders of the process. The contribution to the project are disconnected and this way of proceeding increases the risk of mistakes.

3 Cooperative Design

To manage all the variables/issues present in a sustainable renovation project in a proper way, also if we are working with residential buildings of small/medium size, it is necessary to collaborate with other professionals, each one experts of a particular subject: structures, materials, energy, etc. It is essential such a collaboration to achieve a common objective in an effective manner. In this context we prefer to refer to the word "cooperative", that in the Oxford Dictionaries online it is an adjective that means "involving mutual assistance in working towards a common goal" [2]. We prefer to use this word instead of "collaborative" because, according to Kvan [3] "*collaboration is a deeper, more personal synergistic process [...]. Perhaps we should refer to our field as "co-operative" design process itself is one of negotiation, agreement, compromise, satisfying in order to achieve success*".

The use of digital technologies inside architectural practices has contributed to considerably reduce the number of mistakes. New methods and tools such as CAD and 3d modeling software packages, spreadsheets, etc. have allowed to improve efficiency and productivity compared to traditional methods and tools [4]. A cooperative approach during the design phase of sustainable renovation projects imply a tight collaboration between all the stakeholders.

Furthermore, according with Rifkin [5], we believe that digital technologies, and in particular internet, together with renewable energies will change our society starting with the traditional hierarchy of the economical and political power. We will witness a new organizational system characterized by interconnected nodes, similarly to the one of the world wide web.

4 BIM: A General Introduction

The term BIM not only introduces new tools, but mainly new concepts and processes. The introduction of BIM in the AEC sector (Architecture, Engineering, Construction) is needed for several reasons, including the improvement of cross-disciplinary communication, collaboration and the production and management of the information of an artifact. Over the years, after following an evolutionary path, the two-dimensional objects, elaborated with the first CAD software, acquired the third dimension (with the introduction of 3D modeling), and they have been enriched (through BIM) in properties, data and information of various kind (that could be referred to any phase of the life cycle of the artifact). *"Traditional architectural drawings and CAD models abstract away from the supply chain, but Building Information Modeling databases make it explicit, designable, and manageable"* [6]. BIM technology is widely diffused in the design, construction and management of new buildings but barely in interventions focused on existing buildings. The use of the BIM in the documentation, analysis and renovation of the built environment is not very diffused yet, although there are examples in this regard [7] and [8]. In this latter publication there is an interesting case study about the transformation of the Toronto National Building in a Contemporary Hotel that use BIM (Autodesk Revit) in Remodeling and for LEED Certification. However, it is possible to assist to a gradual increase of interest among researchers and expertise in the application of BIM in this sector. This new trend was understood by the big software houses that started including in the new versions of their software functions that allow to import in the BIM environment also the point cloud [9].

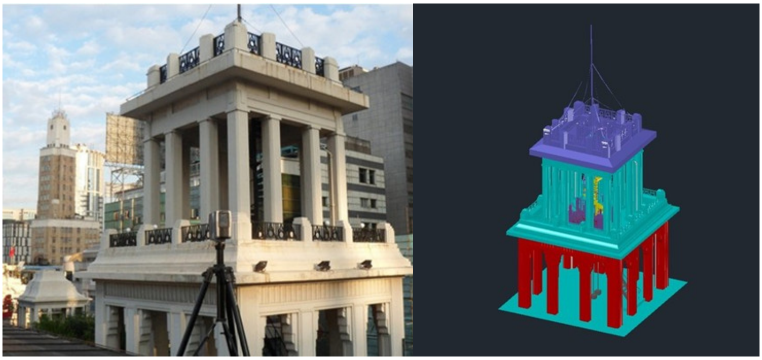
Beside the parametric objects, one of the most important features of BIM is to incentivize, support and improve the collaboration and communication between all the project team members, this means a reduction of the risk factors that create waste of resources.

5 Case Study

This section presents a case study of the application BIM technology in existing building renovation,

This BIM is based on a three-dimensional digital technology-based which integrated data model of information engineering construction projects. BIM is detailed expression of this project and an approach which supports the integrated management of the environment of the construction works, digitization methods in the design, construction, management. Construction work can significantly improve the efficiency and significantly reduce the risk of its entire process (see Figure below). There are also five major characteristics:

1. Visualization --- what you see is what you get;
2. Coordination --- professional collaborative design;
3. Analog --- energy-efficient analog, emergency evacuation simulation to simulate sunshine, heat conduction simulation, 4D, 5D;
4. Optimization --- design, construction and operational phase;
5. Easy for drawing --- architectural diagram, component diagram, integrated pipeline map, comprehensive structural drawing for left holes.



(a) (b)

Fig. 1. On-site scanning for BIM scene reconstruction; (b) BIM 3D model

Fig. 2. Point clouds data

6 BIM and Sustainable Renovation Projects: Benefits

The benefits using BIM during cooperative design for sustainable renovation projects affect the three dimensions of sustainability, namely: environmental, economical and social. We decided to classify these benefits in two main categories concerning the collaborative and the technical/constructive aspects. The main categories present also sub-categories. We will highlight the main benefits dividing them in two main categories, but we are aware that sometimes there are intersections and overlaps between them.

- Benefits concerning the collaborative aspects:
  - collaborative aspects within the design team:
    - *Integrated design:* the use of a central Building Information Model improves the collaboration of the stakeholders (architects, engineers, constructors, etc.) and reduce the chance of mistakes; this model represents the central element of the communication between all the stakeholders;

- collaborative aspects within the AEC sector:
  - the use of BIM processes and technologies could contribute in the creation of a network of relationships between the local producers of technical elements and materials, improving the collaboration and communication. The local producers could prepare a database with all their technical components (with dimensional, material, etc. characteristics) in BIM format, ready to be used and evaluate inside the digital model. For example we thought to technical elements built using materials according to the local context: wood essences, cork, coconut fiber, sheep wool, raw earth, straw bale, etc.
- within both situations the use of a shared model contributes to reduce the so called "island of automation".

- Benefits concerning the technical/constructive aspects (these aspects influence positively also the economical side):
  - *parametric design*: to adapt the same technical solution to different parts of the building changing few parameters; this will reduce the costs and the production of construction wastes;
  - *clash detection*: all the design solutions proposed by the stakeholders can be integrated and visually evaluated in the same 3d model, in this way it is possible to identify possible conflicts with the existing structure and/or with the design proposals elaborated by other specialists (i.e. structural and mechanical components);
  - the opportunity to simulate and hence study and evaluate also the constructability and the site management (evaluate the deployment of the technical elements and facilities inside the construction site);
  - a better definition of the project from the initial stages and the opportunity to investigate and evaluate various design alternatives using the same digital model permits to optimize and hence reduce the costs of the construction labor and the production of waste;
  - the chance to link the information and to make them interdependent, namely a parameter modified in the BIM will automatically occur in the other schedules/files and vice versa.

7 BIM and Sustainable Renovation Projects: Limitations

The limitations of the use of BIM in sustainable renovation projects rely on different factors that could be lead back to issues within the AEC sector and :

- Limitations connected to the existing building to renovate:
  - the lacking of quantity and quality in the documentation related to the most part the existing residential buildings;
  - to produce a proper documentation of the existing structure in a digital environment through a laser scanner followed by the creation of the surface model (in this regards please see again the); hence in that case, the dimensional and morphological accuracy of the 3d model in the BIM environment relies on this preliminary step.

- Limitations connected to the AEC sector:
  - the technological backwardness that characterizes the construction industry compared to other fields such as automotive and aerospace. The AEC sector is often hangs on to concepts, methods, processes and tools that didn't changed too much during the years [10].
- Limitations connected to the BIM:
  - the learning curve that characterizes a BIM could represent a difficulty for people that are accustomed to use the same CAD software for years;
  - the architectural practices and the other specialists should afford the training costs of their employees (architects, engineers, etc.), generally not all the practices agree to spend money in this way, even if it is an investment for their future;
  - not all the tools and processes inside the BIM environment are adequately streamlined; the software package should supports the design process making it easier (also for what concern the 3D modeling aspects), the main objective must be to produce a good project and to manage in a proper way all the information through the whole life cycle;
  - the specific ontology (classification of elements) used by a BIM could be a limitation compared to the wide number of technical elements that we can find in a real building;
  - *interoperability*: even if a lot of effort has been done on the interoperability side (i.e. with IFC), there is still a lot of work to improve the communication between the different software packages.

8 Final Remarks and Conclusions

In this paper we presented the main benefits and limitations of BIM as supportive tool and method in the cooperative design for sustainable renovation projects.

The BIM technology represents the ideal cooperative and communicative platform to promote and put in practice a cooperative approach to the renovation/reuse project of residential building pertaining to the built environment. The same technology could foster the definition of a network of relationships between the local producers of technical elements and materials.

With BIM it is possible to gain a better control of the project and so to minimize the use of resources and the production of waste along the whole lifecycle process.

Principles of sustainability together with BIM will re-shape the design process and the architectural/engineering practices throughout a redefinition/update of the roles. According with Cohen [11] we believe that it is necessary a new professional figure, a "project information architect" able to, as a movie director, coordinate and manage a new flexible, networked organization of professionals and businesses.

The reflections and concepts elaborated and presented in this paper could also be applied both to residential buildings that use a structural grid with columns and beams made by other materials (i.e. wood, steel, etc.) and to non residential buildings pertaining to any cultural context.

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Interactive Decision Making Environment for the Design Optimization of Climate Adaptive Building Shells

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Abstract. The purpose of this research is to propose an interactive decision making environment for design optimization of Climate Adaptive Building Shells (CABS). As the success of the CABS is highly dependent on the decision-making between design process and building performance simulation, we propose the effective design process and the method of information visualization. To reach the goal, first we optimize the motion state of kinetic facade using both the generative parametric design and building environmental performance simulation. Second we represent information for easy decision-making. This research can enhance the advantage of the CABS in terms of building life-cycle.

Keywords: Climate Adaptive Building Shell (CABS), Building environmental performance evaluation, Information visualization, Generative parametric design.

1 Background

It is significant to offer the new method of adaptation to emerging climate change in the field of building design although the human society has responded to it for a long time. There are many architectural research works which deal with the issue and several of them refer to the weakness of the "static building facade" (Kasinalis 2013, Loonen 2010). The reason is that static building façades are insufficient to protect buildings from being affected negatively by this external factor (WBCSD 2011). Therefore for the strategic adaptation to this change, the development of the flexible building envelope has been suggested. It is often agreed that the flexible building envelope is more effective than the static one when they are compared using the Benefit-Cost Ratio (BCR) (KMA 2007). This is because this flexible system can save enormous resources better than static ones which generally bring about more additional operation cost during building life cycle.

Several researches on the flexible envelope system which is referred to as Climate Adaptive Building Shells (CABS) have been tried in academia (Pan 2012, Rossi 2012, Loonen 2010, Rafael 2010). It is defined as the active building envelope system

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which is able to change the form and/or state in order to cope with not only climate change but also the contextual influences in a broad sense. The following paragraphs show key points of its experts in order to complete this system.

First, the success of the system is highly dependent on the integrated design process considering both motion state of kinetic system and building performance simulation. As such, CABS needs to be approached as a holistic system. When we consider operational mechanism of CABS, it is a sort of complex adaptive system (CAS) that is related to various physical domains, especially following two subsystems are critical to constitute the adaptive mechanism: 1) the kinetic system which controls the behavior of elements and 2) the smart material system which influences on the properties of the materials.

Second, the initial investment cost of the CABS tends to be more expensive than that of conventional building façade systems, which leads to difficulty in social, legal commercialization. So we need to convince the clients to understand the advantage of CABS in terms of building life-cycle from an early design stage. As the adaption of advanced technologies which makes the investment cost high is unavoidable, it is important to explain the quality of the CABS visually (Loonen 2010).

Hence, it is necessary to find a suitable design process for various alternatives generation, environmental performance evaluation and easy decision-making. However, there are two problems in attempting to integrate the design process: 1) lack of interoperability in collaboration work between designer and simulation experts (Kim 2003) and 2) lack of information visibility that makes the decision-making less complicated (Raftery 2011).

2 Design Process

The research objective is to propose a design process which aids rapid alternative appraisals based on results from the building performance analysis. Considering the holistic system, it is important for experts to generate alternatives, evaluate them rapidly, and communicate on their works with each other. Recently, there are many issues of 'Building Information Modeling (BIM)', which refers to the effective collaboration in heterogeneous fields. This issue emphasized the interoperability of data, which has most impacts on the building design quality (Flager 2009). If designers don't provide appropriate information to analysis experts, for example, decision-making would be delayed, which results in rising cost and uncertainty. In addition, in architectural process, clients of each project are often major decision-maker who affects the scope of works and the entire process (Cherry 2009). In this situation, communication with them becomes decisive in project management; therefore easy visualization of expert knowledge is needed for their clear understanding.

Therefore, it is essential for experts to exchange information rapidly and easily. When simulation experts require specific information for building performance evaluation, designers needs to recognize what are the essential elements. It is indispensable to make the integrated guidelines composed of the elements required for design and alternatives analysis.

There are several ways to structure the design process. In this study, as a case study, we plan the collaboration between designers and building performance simulation experts using Rhinoceros™ software.

① Software: Grasshopper™ is plug-in module in Rhinoceros based on generative parametric design. Using this, it is possible to generate complicate geometry and repetitive design modification.
② Predetermined factor: Referring to the design process model of European Commission (2003), we classify predetermined factor; in the strategic level, there are 4 elements such as structures, services, finishes and envelope. We predetermine mass, structure, services, finishes except envelope.
③ Design factor: Referring to the design process model of European Commission (2003), we operate variable factors; except mass, structure, services and finishes, we design unit type and optimize motion state of the kinetic envelope system.

The research composition is as shown in Table 1. As controlling design factors in Rhino Grasshopper™, we not only create several types of envelope and appraise them based on building performance.

Table 1. Key elements of the implementation

Element	Details
Software	①Rhinoceros Grasshopper™
Predetermined factor	②Mass, Structure, Services, Finishes
variable factor	③Unit type and motion state of envelope

Designers and simulation experts participate in progressing cooperative design process (Fig. 1).

① Design: Designers generate the kinetic unit of building envelope by controlling parameters, which is generative parametric design process.
② Building performance simulation: Simulation experts evaluate the design types with environmental performance and optimize motion states of the kinetic unit.
③ Data exchange: If designers and simulation experts discuss their works using same software, they are able to exchange data more conveniently.
④ Decision-making: If the generated types are not sufficient for evaluation criteria, they have to repeat the former process until generated products are appropriate for the design criteria.
⑤ Architecture design in software: Rhinoceros Grasshopper™ which is common software in architectural design, it is based on the generative parametric design.
⑥ Building performance simulation in software: In the Rhinoceros Grasshopper™, designs are evaluated for external environmental performance. Building envelopes are simulated with daylight using DIVA components, optimized using Galapagos components.

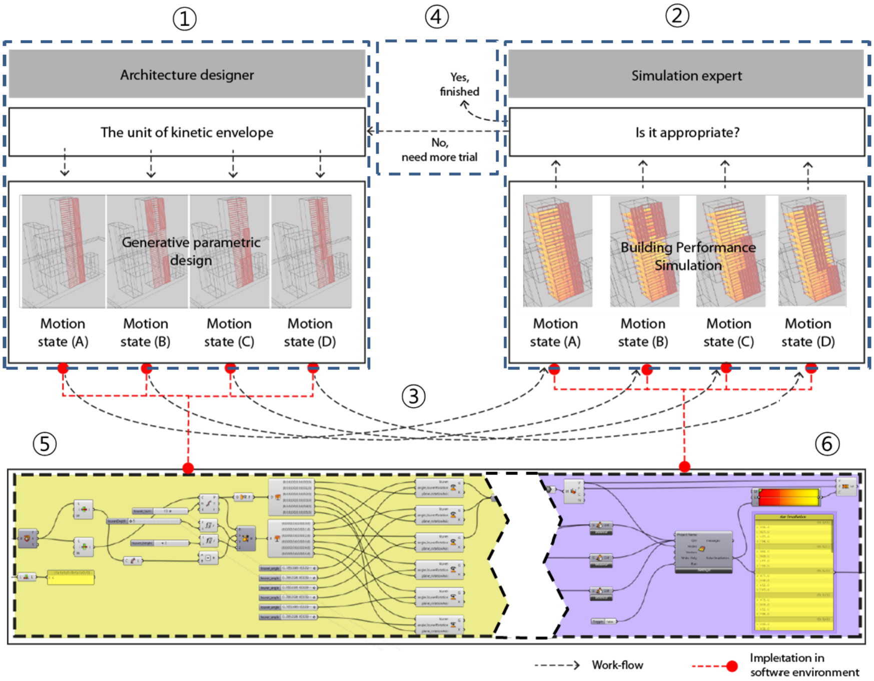

Fig. 1. Cooperation between designers &simulation experts

3 Information Visualization

To convince the client of the advantages of CABS, the information should be optimized for intuitive selection. However, it is difficult to distinguish which alternative is the best in terms of environmental performance, its information need to represent as a legible form (Simon 1996).

- Monetary cost: It is composed of initial investment cost, energy and water cost, operation, maintenance, repair cost, replacement cost, and so on. This category is not influenced directly on by building envelope.
- Non-monetary cost: It is critical factor in terms of building life-cycle cost. However, it is difficult to estimate value because its quality depends on decision-makers' opinion.
  - Solar radiation, daylight, thermal, glare: It is based on quantitative method using building performance simulation as DAYSIM^{TM}.
  - Prospect, aesthetic, security, safety: There is no software such as to analyze those aspects precisely. Then, it is excluded in this research.

First, to validate the CABS's long-term value, we refer to the WBCSD (2007); long-term values of buildings include the monetary cost, and the non-monetary cost.

Second, we divide the monetary cost into initial investment cost, energy and water cost, operation, maintenance and repair cost, replacement cost. And the non-monetary cost into the indispensable factors for making comfortable environment: daylight, solar, thermal, glare, prospect, aesthetic, security, and safety. Third, we define the sub-categories which are involved with qualitative and quantitative issues, and exclude the sub-categories based on experts' experience and real database (bold text). Forth, focusing on these 4 sub-categories, we simulate environmental performances of building envelope in Rhino Grasshopper as summarized in Table 2.

We adapt a radar graph representation method that contains simulation data, which helps clients choose preferred alternatives. By reflecting clients' opinion, the information is changed to convince clients to select a feasible design solution intuitively.

Table 2. Scope of application

	Category	**Relevance to building envelope**	**Calculation method**	**Scope of application**
Monetary cost	Initial investment	NO	-	-
	Energy and water	NO	-	-
	Operation, maintenance& repair	NO	-	-
	Replacement	NO	-	-
Non-monetary cost	Daylight	YES	DAYSIM™	**Included**
	Solar radiation	YES		**Included**
	Thermal	YES		**Included**
	Glare	YES		**Included**
	Prospect	YES	Flexible	Excluded
	Aesthetics	YES	Flexible	Excluded
	Security	YES	-	Excluded
	Safety	YES/NO	-	Excluded

4 Implementation

As a first step, each designer proposes a kinetic louver unit. They define parameters related to the movement of louver system and suppose the change of motion state. ① The 'Type A' of cylindrical shape has constraints of motion state as 'louver angle'. And the 'Type B' of bone shape has its constraints as 'lunge length'. ② Applied these motion state, they generate a digital model to be operated virtually. ③ They provide simulation experts with necessary information for the position of sensors and actuators as analysis nodes as shown in Fig. 2.

The second step is to simulate the environmental performance of the building such as the condition of daylight, solar radiation, thermal and glare. The simulation experts will optimize the motion state of each louver. After evaluating the environmental performances, analysis results are represented as specific scores. Those are visualized by textual representation that can give its scores. The analysis of the collection of radar graphs results are shown in Fig. 3.

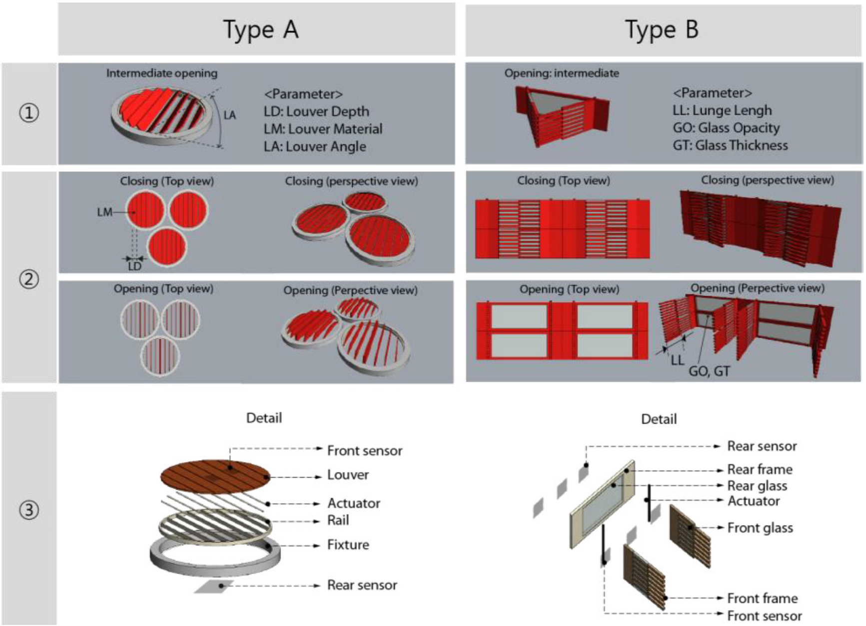

Fig. 2. Designing unit type of envelope

If the generated alternatives are not appropriate for the design criteria, designers will repeat the above workflow until they meet the criteria. During the simulation, the designers generated four similar species: For example, in the left of Fig. 3, Type A-1, Type A-2, Type A-3 and Type A-4 are same kinds originated from Type A. Type B in the right of Fig 3 follows the same process as Type A does.

The clients are able to choose the favorite type among the chosen alternatives through cooperative workflow. To evaluate quantitatively, the weight values of building performance elements are the same as ‘1’as in the left box of Fig 3. To evaluate qualitatively, weight values are set discriminately as in the right box. As we can see in Fig. 3, the best alternative is changed from Type A-4 to Type A-3. Contrasted with the case of the Type A, there is no change for the best alternative in the case of Type B. Therefore, the decision making tends to depend on the evaluator’s appraisal standard when s/he decides which element is the most important in this process. In this sense, additional researches on decision making strategies such as fuzzy theory and AHP(Analytic Hierarchic Process) are necessary not to reach the biased evaluation.

It is valuable to notice that the visualized information is helpful not only for experts to validate each design alternatives, but also for clients to choose preferred one intuitively.

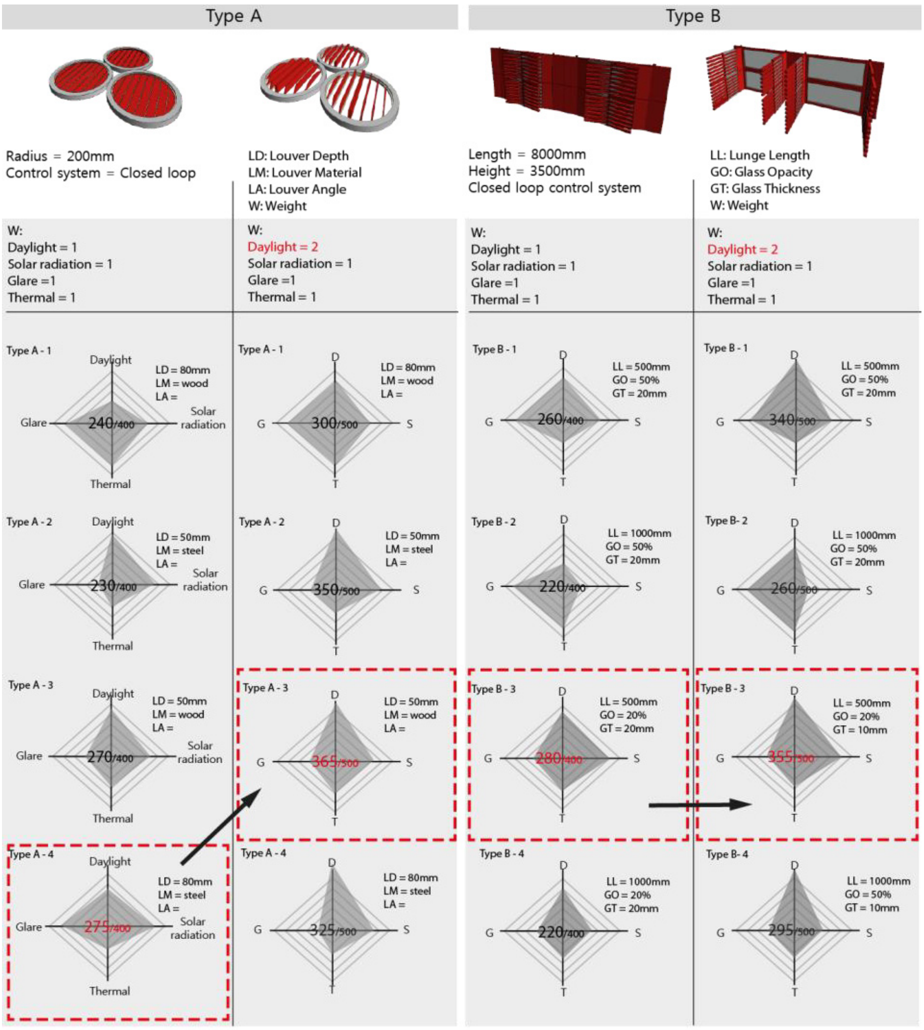

Fig. 3. Parametric design of the louver units & Visualized information of their performance

5 Conclusion

Our studies on the CABS have changed the shape of the envelope and its attributes actively to reduce the negative effects on the buildings. This is a complex system of heterogeneous knowledge-based design. The system integrated with heterogeneous fields needs to be approached as a holistic system to improve its quality. Therefore the quality is highly based on the effectiveness of the collaboration between experts in different fields in the project. Furthermore, it is necessary to inform the feasibility to the general clients. To provide the solution, we have carried out the analysis of the environmental performance and the information visualization method focused on the four important factors to justify the long-term cost of the building.

It is an effective approach to validate the quality of the CABS rapidly with a group of heterogeneous experts. It is also legible to provide the possibility for the clients to choose more qualitative alternatives according to their needs. However, it is still a challenge to make the process truly-integrated collaborative using the experience of the experts and the database in holistic system.

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Application of Collaborative Mobile System in AR-Based Visualization, Data Storage and Manipulation

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Abstract. Building Information Modeling (BIM) is a technology that can be applied in numerous fields, such as construction management, facility operation and structure and MEP design. BIM enables the representations of digital building information at any construction stages. However, very few instances have been investigated regarding how to apply BIM to effectively facilitate the collaborative work such as planning, design, and information sharing. This paper introduces a collaborative mobile system which integrates a context-aware Augmented Reality (AR) visualization with BIM. The BIM plus AR system visualizes the as-planned data onto the as-built environment. The applications based on this system give the possibility of using this system to address some of the real problems and issues from Australian Liquefied Natural Gas (LNG) construction industry, such as low productivity in retrieving information, tendency of committing error in assembly, low efficiency of communication and problem solving, etc.

Keywords: BIM, AR visualization, collaborative work, LNG.

1 Introduction

The concept and practicing of Building Information Modelling (BIM) originally started since 1970s [1-2]. However, the terms of BIM had not been popularly used until Autodesk released the white paper entitled "Building Information Modeling". Before BIM emerged, the design of construction projects was largely relied on the two dimensional (2D) representations such as planar drawings and isometrics. With the development of computer technology, processing three dimensional (3D) information has been enabled, which revolutionizes the representations of construction information. However, to support multi-disciplinary interaction regarding building information 3D representations was far from enough. BIM therefore emerges, covering more than just geometry and spatial relationships, but also all-level building information such as internal environment, geographic information, quantities and properties of building components, scheduling, cost planning and so on. BIM bridges the information loss associated with handing a project from design team, to

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construction team and to building owner/operator, by allowing each group to add to and reference back to all information they acquire from BIM models.

Augmented Reality (AR) is a technology where the additional information generated by a computer is inserted into the user's view of a real world scene. AR allows a user to work in a real world environment while visually receiving additional computer-generated information to collaboratively support the task at hand. The technological advancements of AR since the past decade have shown significant capabilities of applying AR in construction area. Apparently AR is a fantastic tool to display any chosen single view or an integrated view right into the real view of participants, and right in place to the proposed location where the component should be built in a real-scale and real-time manner. The execution of the *resulting plan* (e.g., initiating work tasks), and *re-planning* activities can all take place using AR. Although work tasks themselves remain essentially unchanged, the inter-relationships between work tasks can be better captured so that the causal links between actions could be better recognized and understood through visualization in AR. In addition, AR is a proactive approach through which the potential negative impacts of any action can be identified earlier and mitigated or avoided more easily.

2 Background

During the past decade, BIM concepts have been actively explored for expanding the usage into an nD environment [3]. It is encouraging that this expansion is moving away from merely 3D modelling, towards more engineering analyses and various construction business functions [4]. For example, engineering analyses in such areas as structure [5], energy [6], scheduling [7] and project control [8]. AR is envisaged to become the media to convey BIM effectively into the construction site [9]. Wearing a see-through head-mounted display (HMD) to overlay graphics and sounds over one's naturally occurring vision and hearing, the subject is able to see the location of augmented models in real space and detect the existing dimensions from already-positioned components as well as virtually to-be-assembled components attached [10]. Recent advances in computer interface design and hardware power have fostered a certain number of noted recent AR research prototypes or test platforms in the arena of construction [11-13]. More practical application domains of AR technology can be found in a thorough survey by Wang [14].

3 Why BIM + AR

The concept of AR + BIM can provide collaborative platform on sharing and managing all known project information, supported by the carrier such as iPhone, iPad, Android or Windows-based Tablet. BIM information can be intuitively visualized via AR to guide construction workers through the construction of actual buildings and improve the quality of their work. Some plans may be more effectively comprehended by registering virtual models with objects in the real scene. It may be easier to build quickly and precisely as planned, especially complex designs in constrained spaces. During construction, BIM information should drive the physical deliverables of the construction work. The discussion of the practical rationale and case illustrations for

BIM+AR use in construction site focus on a few key areas relevant to construction site activities. It is envisaged that AR, as a class of easy-access interface, has the potential to change how site manager, construction workers, etc. interact and access to digital technical information in BIM. Essentially the conventional role of AR is the visualization end. Any data fed into this end has to be pre-processed in a manner to help the data make sense to the end users. In the following section, the employment of BIM + AR integrated system for iPad-based collaborative work is illustrated, which improves the productivity of retrieving information and manipulating data substantially

4 Application of Collaborative BIM + AR System

Industrialization of the construction process requires a high level of automation and integration of information and physical resources [15]. Yet, the effective integration of information developed in data repository such as BIM during design with the physical construction site is a challenging proposition. All design and planning tasks work with information rather than physical resources. Designers, planners, and managers generally interact with a project through various information mediums and models. Software applications used to` support various work tasks, and documents (paper or electronic, including individual views presented by computer tools) provide a considerable amount of information from which participants can construct their mental models. This is the problem in as much as site work requires individuals to both work with information and transform physical resources to a constructed facility. In addressing this issue, AR should be ubiquitous and work together with accurate positioning technologies. This section shows that the AR-based visualization of information contained in database such as BIM can provide those onsite with a collaborative understanding of their work and thus increase productivity. The functionality is given in Table 1.

Table 1. Functionality and illustration of the system

Functionality	Illustration
Platform portability (it can be used in laptop, iPhone, iPad, Android or Windows-based tablet)	Figure 1a
Recognize barcode as an object (in this case a piece of pipe)	Figure 1a
Show label on the right (with the same properties as in 3D model)	Figure 1b
Show surrounding piping associated with this piece of pipe.	Figure 1c
Rotatable models (to understand the angles of installation, users can move the model in iPad with panning gesture and scaling or narrowing the model with pinch gesture)	
Menu on top.	Figure 1c

Table 1. (*Continued.*)

Changeable model texture and colour (if the quality of installation is unacceptable, the users can either hide or show the model in the screen with just a click)	Figure 1b, Figure 1c
Save the item as a bookmark for later retrieving.	Figure 1b (menu on top)
Freeze the object (For the convenience of viewing, users can also freeze the model and then move sight away from the model in order to avoid shaking of model).	Figure 1b (menu on top)
Show design of the object in PDF files	Figure 1b (menu on top)
Show isometric drawings in PDF files	Figure 1b (menu on top)
Show procurement (e.g, the purchase order No., vendor and QA report)	Figure 1b (menu on top)
Show maintenance (e.g, last inspection record, manual)	Figure 1b (menu on top)
Show operations, current pressure, temperature, throughput, isolation	Figure 1b (menu on top)
Safety management (show safety identification code)	Figure 1b (menu on top)
Add comment (to keep track of observations in the field)	Figure 1d
Take photo of object	Figure 5b (menu on top)
Report a problem (e.g. finding nearest upstream valve; organizing a meeting)	Figure 1e

Conventional AR environments are based on the ARToolkit where virtual objects are usually drawn using pure drawing functions of OpenGL (Open Graphics Language), a multi-platform high-level 3D graphics API (Application Programming Interface). However, if users want to build their own models, they must acquire the knowledge of OpenGL. For the purpose of facilitating layman users without OpenGL knowledge, some AR systems have realized the direct loading of varieties of model files, such as BuildAR and Layer. However, these systems cannot be transplanted or customized to fit the mobile devise such as iPad or other tablets. Thus, it was decided to re-develop a set of functionalities that can dynamically trigger the augmented models into our mobile devices by tracking the barcode and QR. Our system is prototyped using Objective C, an iOS programming language, and integrates various software development kits (SDK), e.g., mobile AR SDK, sensing/tracking SDK and real-time communication SDK. By scanning the barcode attached to each component, the system can demonstrate the menu on top, which can be customized by the users to encapsulate as much information as they want (Figure 5b shows that in our system, the menu encapsulates the information of component location, fabrication, design and so on). By scanning the QR attached to each component, the system can also generate the attribute list that corresponds to that component. By dragging the attribute list from the right side of the AR interface, users can view the attributes of any objects such as pipe, screw, connector, reducer and so on. At the same time, users can also see the AR components. By clicking these AR components, the conjoint components will pop up, so that users know what should be assembled then. Also, users can report a problem or organize a meeting to figure out the solutions if they detect any design or assembly errors using this system. Figure 1 depicts the flowchart of the process of how AR scene is triggered by barcode reading.

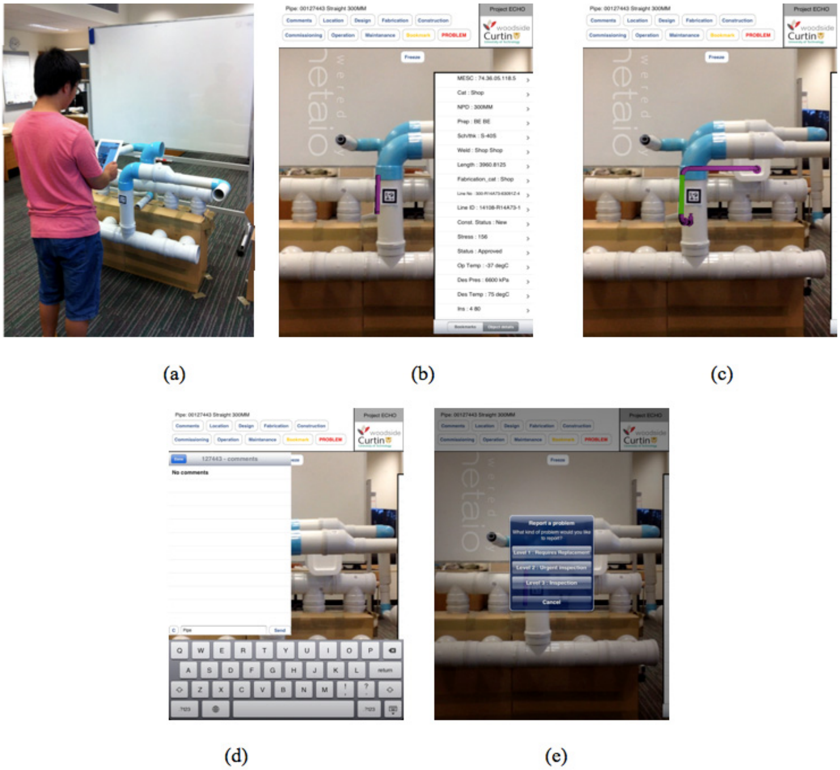

Fig. 1. The functionality and features implemented in AR on an iPad

5 Conclusion

Extended to the site via the "hand" of AR. BIM solution can address some of the real problems and issues from Australian Liquefied Natural Gas (LNG) construction industry, such as low productivity in retrieving information, tendency of committing error in assembly, low efficiency of communication and problem solving, etc. There are either BIM systems (for example, BIMSight is the software for viewing BIM models) or AR systems (for example, BuiltAR) in the state-of-the-art markets, however, the concept of BIM plus AR has not been materialized in construction industry and thus is more likely to help with addressing the real issues in particular LNG area.

Employing tablet with barcode/QR and AR to retrieve information in real-time, aid the virtual design, work out design problems, plan out scheduling and implement the commissioning of projects can effectively improve the way the information is accessed and therefore canimprovie. the productivity in the concerned aspects.

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Visualization of Unit and Selective Regression Software Tests

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Abstract. We present a visualization platform for managing software tests. First, the platform provides the developer with all useful information about code complexity, coverage and current test status. Second, the platform allows following the progress of the test, and in particular running selective tests and updating automatically the test information at every new versions of the software application under test or its specifications. The platform is designed to be incorporated in an Integrated Development Environment such as Eclipse.

Keywords: Software visualization; Selective testing; Integrated Development Environment.

1 Introduction

Development paradigms such as Agile development [1] and Test-driven development [2] mostly rely on incremental development. The development of a complex software application requires therefore multiple test procedures related to elementary tasks [3] and as a result loses sight of the application as a whole, making the meaning of the tests obscure and the testing process difficult to follow. Moreover, lasting partnership with automotive supplier industry on the test of software embedded in critical systems has evidenced the needs of intuitive and flexible testing infrastructure for improving code quality and reliability. We are therefore following-up this experience with an exploratory project that concentrates on test requirements and strategy to support actual trends in large applications, in order to ensure shorter time to market, decreased testing costs, and contributes towards improved code quality and reliability. The industrial context is characterized by these two constraints.

1. Whereas from a theoretical point of view, formal verification would be the only way to ensure correctness, in practice, software components are validated through experimental tests for a given set of well-chosen input data, optimized on the basis of their specification.

2. Due to the complexity of nowadays software, testing becomes more and more time consuming, so that is normally impossible to test all code of the system under test. Developer must decide when an algorithm has been sufficiently tested, which can be supported by software metrics. In particular, code coverage describes how much of

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the code is covered by a set of test cases; cyclomatic complexity identifies the complex code as, the most error-prone according to experience [4].

To be more specific and allow the approach to be validated in real-life setting, we concentrate on Unit testing in Java, most often used in context of test-driven development, and easy to handle for regression tests

2 Related Works

Some test assistant tools link code coverage and complexity. The relation helps identify code with high complexity and low code coverage which is then considered as fault-risky. This relation, in [5] can be converted to a numerical software metric. In Sonar [6], the relation is visualized as Treemaps where critical code can be identified easy by the size and color of the corresponding visualization. In Atlassian Clover [7] it is visualized as 2D-Matrix (e.g.): the critical code is easily identified by the location within the 2D-matrix (area of low coverage and high complexity).

Test functionalities are often available as features of an Integrated Development Environment (IDE), such as allowed by the plug-in based architecture of Eclipse [8]. CodePro AnalytiX [9] gives a set of Eclipse plug-in dedicated to a limited generation and edition, as well as code-coverage computation for JUnit tests [10].

Available tools are in general rather limited in the management of selective testing, which consist in running only a subset of the whole test suite [11] (e.g. test cases affected by code changes). CodePro Analytics misses a general survey of a software project and all analysis must be restarted manually after a code change. In addition, the detection of methods under test (MUT) is based on the name of test methods, which is error-prone and not convenient for most real-scale projects. Sonar [6] does not allow the MUT detection for test cases, and hence doesn't support selective tests. In Atlassian Clover, selective testing is limited to failed tests and tests cases that effectively test updated code.

On the whole, in the current setting where the complexity of software is increasingly exponential, the help provided by such utilities is rather limited. Developers lack an integrated and ergonomic view on all useful information related to the progress of the test during the life cycle of a software application.

3 Visual Testing

Our goal is an integrated tool to efficiently support the developer during the testing process by visualizing all relevant information: illustration of test results and software metrics, identification of code insufficiently tested. The tool must also support regression tests with code change detection, and an automatism to update test results and metrics.

The test utilities we provide are wrapped-up in an additional module for an IDE. For the first sketch, we consider the Eclipse environment, which allows the free development of extensions and is widely used in the Java world. This module must offer the possibility to edit, archive, and retrieve test material and also to compute the test coverage.

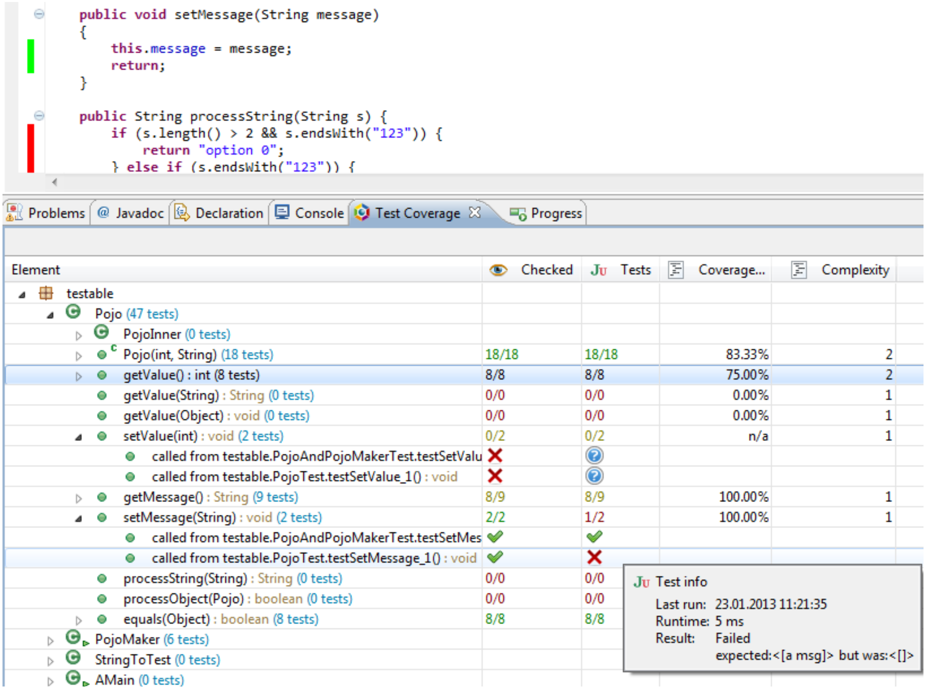

Fig. 1. Screenshot of the Crown plugin the Eclipse IDE

The current tool provides the automatic detection of JUnit 3 tests and the corresponding MUT. As a basic design requirement, the developer needs not to link the test cases to the MUT nor adapt the MUT for the inspection with our tool. This has been achieved by using referenced methods in the unit tests, and is the basis to offer a proper management of selective tests. As it well recognized, though this automatism brings valuable help, it can lead to false positives. We therefore offer the functionality to handle the manual removal of false positives. Optionally, the developer can choose to recheck test methods after MUT has changed. In this case no further inspection is possible till the corresponding test cases have been marked as checked.

For the execution of the test cases the JUnit API of the JUnit eclipse plug-in is utilized. The collection of code coverage data (line, instruction, branch coverage) is realised via the JaCoCo Java Code Coverage Library [12]. The execution of selective tests and the recalculation of the metrics can be triggered automatically when changes of the corresponding MUT are recognized. Alternatively the developer has the possibility to force the execution of all linked tests to one or more selected methods, classes or packages under test. All the information is integrated in a tabular tree view.

4 Conclusion and Perspectives

A visualization platform for code analysis, test editing and execution has been presented. In a future step, we will concentrate on improved visualization to identify methods that need more testing. Our idea is to involve runtime method invocation data which is collected by a profiler, under the assumption that the code more often executed in the average runtime of the system under test should be tested more intensively. Our ultimate goal is to design a clear visualization that combines coverage, complexity and method invocation data.

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Knowledge Management Based Cooperation for Energy Cost Optimization

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Abstract. The paper presents studies on the improvement and development of cooperation methods for cost optimization in power supply systems using polygeneration technology. A support for cooperating operators, which are responsible for maintenance and supervision of the power supply system, is realized by means of appropriately chosen mathematical models and ontology based knowledge sharing and management idea. Ontology based approach enables various pieces of the integrated system to cooperate more autonomously by optimizing and reducing their need for communication. In effect, the system operators are provided with strictly necessary information on: the functioning of devices, the number of operating states, available control strategies and the actual and expected prices of electricity. Based on this information, the system operators are able to take appropriate decisions leading to cost reduction and to maintain reliability of the power supply system at the desired level for various operating conditions.

Keywords: knowledge management based cooperation, MAS, energy cost optimization.

1 Introduction

In times of increasing demand for electricity, polygeneration technology attracts more and more researches' attention due to its advantages in comparison to the classical methods of generating electricity, including heating and cooling [1]. This is due to the obvious fact that during production of electricity most of the generated energy (e.g. waste heat) is dispersed into the environment. The existing literature provides many examples of the use of waste heat generated during the production of electricity from various power supply sources (e.g. biogas cogeneration units) [1].

However, the systems involving various sources of energy require more complex control systems and energy management mechanisms [2]; without them, the maintenance costs are higher. A good example is a micro-grid, which can function autonomously,

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owing to the possibility of generation of electricity from independent sources of energy [2]. For the proper energy management of the micro-grid, the following additional factors should be taken into account: the amount of electricity (including heat and cooling energy from the polygeneration system) that can be produced at the moment and the current costs of electricity production, e.g., in biotechnological plants under unstable operational conditions, but especially, in collocation centers (Data Centers). On the one hand, the users of Data Center services require the best data protection and sufficient computing power, but on the other hand, the higher protection from the power interruptions results in higher cost borne by the customer (the user of system). Hence, an essential problem for cooperating system operators, which are responsible for maintaining and supervising such objects like the Data Centers, is the cost optimization, while maintaining sufficient protection against power outages. Diversification in power supply sources makes the problem of energy management more difficult. The latest studies in this field are mainly based on multiagent systems (MASs) [2], which can manage the micro-grid by itself or provide a support for system operators. However, little stress has been put on the ontology based MASs integration methodology. Hence, the purpose of presented paper is to provide a solution for reducing energy costs and increasing the robustness of power supply system in collocation center with emphasis on the description and role of ontology and MASs.

2 A Hybrid Model of System for Designing Ontology

The synthesis of the MAS supporting cooperating operators requires the construction and improvement of ontology. The preliminary data on the structure of the agentified system, allows us to describe it as a hybrid system, i.e. a finite state machine with guard conditions for state transitions and actions (Fig.1). Moreover, the list of states is complemented by the dynamical models of power supply devices.

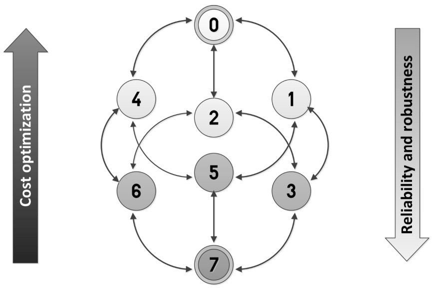

Fig. 1. The feasible state transitions in the cooperation problem. The numbers correspond to the states described in Table 1

Such hybrid model, including continuous dynamics, discrete events and interactions between them, will be the basis for the design of supervisory control layer, which is responsible for solving supervisory control tasks. Table 1 presents the possible discrete states of the controlled system (collocation center) supplied by two power lines and one gas line. The preliminary analysis on the feasibility of individual states allowed for estimation of their occurrence probabilities. The individual states can be achieved depending on the operating conditions of the power supply subsystems and the possible transitions are triggered by the cooperating operators to make the power supply system robust and reliable, while at the same time, optimizing the generated costs.

Table 1. Decomposition of the power supply system into discrete states

State	Gas supply	Electric supply 1	Electric supply 2	Probability
0	malfunction	malfunction	malfunction	negligible
1	malfunction	malfunction	working	unlikely
2	malfunction	working	malfunction	unlikely
3	malfunction	working	working	low
4	working	malfunction	malfunction	unlikely
5	working	malfunction	working	low
6	working	working	malfunction	low
7	working	working	working	likely

3 Cooperation Mechanism Supported by Ontology

Ontology based solutions, for some time, presents area of interest and source of various diverse researches addressing problems of cooperation, standardization, transparency, unification, incompatibility, inconsistency and reusability of various different programming components interfaces. This is because ontology is considered as a fundamental base for both human actors and program components serving as a formal reference and explicit integrated system knowledge being additionally reused as a communication protocol between various different integrated systems and elements.

Ontology is considered as a communication protocol for the wide variety information exchange processes. It is used to integrate and establish inter-operability between various different, incompatible software systems and applications formalizing domain for the software control at runtime. It shapes obtained integration solution's architecture and model, improves implementation and maintenance processes. Established architecture and model provide intelligent software infrastructure at runtime for the cooperation purposes and serves as a reference for the implementation, maintenance and integration processes formalizing obtained solution components. This is true because ontology focuses only on significant and important concepts by capturing their semantics, disregarding the irrelevant ones and defining explicitly both integrated system states and transition conditions between those states [3,4]. Additionally, it is used to support knowledge management and sharing processes, which is a distributed process that allows gathering and binding various different pieces of information during runtime from ongoing processes [3,4]. Such inference capability can provide the information on actual state of the power supply system, which is then used by the MAS to support the system operators. Ontology based knowledge sharing and management idea enables various pieces of the integrated system to cooperate more autonomously by optimizing, and in effect, reducing their need for communication [3,4]. Such mechanism is a factor that can actively guard both system's data integrity and quality at runtime optimizing communication processes by minimization of computation workload and processing time reduction. However the difficulty of this concept lies in managing the problem of knowledge propagation and synchronization between hierarchically chained ontology based system elements, but it is out of the scope of this paper.

4 Concluding Remarks

MASs, for some time, are the source of many intensive studies covering plenty of completely new real life software architectures, models and solutions providing currently the most suitable i.e.: agile, flexible and self-coordinated infrastructure enabled to cover the most demanding needs and requirements of modern integration systems engineering. It is by far the only technology capable to fully support integration of completely distributed environment resources and various corresponding pieces of information since both are equally important and vital for the wide variety of different businesses and their production processes. MASs clearly exposes the notions of cooperation, openness and scalability providing the most advanced and sophisticated toolset needed to fully exploit ontology mechanisms which enables to design, build and deploy completely distributed, fully functional and flexible, thus easy to be maintained, AI based systems.

The presented AI based system allows for effective management and costs optimization in the polygeneration system through cooperation. It should be emphasized that one of the greatest advantages of the proposed solution is the possibility of continuous cost optimization by the system supporting operators. In the absence of such intelligent system, the operators supervising and maintaining the power supply system would have to perform many tasks themselves. As a result, the management and cost optimization would not be very effective. This applies mainly to large and complex polygeneration systems using various forms and sources of energy, for example, renewable energy resources. For such systems, the problem of management and cost optimization can be more difficult, because the operation of power supply systems using renewable energy sources is affected by weather conditions.

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