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Preface

The 6th International Conference on Cooperative Design, Visualization and Engineering CDVE 2009 was held in central Europe - Luxembourg. Participants from five continents came together to celebrate this annual event.

The papers published in the conference in this volume reflect the new progress in the following aspect.

Research in developing cooperative applications is currently focusing on two directions. One is the cooperation in the software development process and the other is the variety of the targeted cooperative software products. Many papers address how to facilitate cooperation in the software engineering process particularly global software engineering. The importance of sharing information in cooperation is emphasized by the authors. For example, papers that addressed the development of sharing mental models, tools for easily shared projects, sharing links for cross-media information spaces, sharing resources and transfer of knowledge among team members etc. have attracted special attention. Many papers presented in this volume are the research results of tackling problems in developing a great variety of cooperative software products. The targeted systems are cooperative support for music creation, cooperative process management systems, cooperative visualization systems for geographic information, cooperative cultural information sharing platforms, cooperative reasoning systems, cooperative sensor networks for environment monitoring, remote cooperative video vehicle monitoring systems etc. Another aspect of the papers in this volume is dealing with the problems in finer phases in the cooperative product production life cycle. The topics addressed range from partner selection for cooperation at the beginning, requirement gathering, requirement negotiation, to cooperative design, production to cooperative testing, and finally to cooperative system operation.

All these papers show that research and development in cooperative design, visualization, engineering and other cooperative applications has reached a finer stage. New focus points and new objectives for better cooperation are growing continuously.

The success of CDVE 2009 is the result of an international cooperative effort. I would like to express my thanks to our Program Committee, all the volunteer experts all over the world for reviewing our papers and providing generous help to assure the quality of the conference. I would also like to thank all the authors for their submission of high-quality papers to the conference.

I would like to express my special thanks to the Centre de Recherche Public - Gabriel Lippmann in Luxembourg and all the members of the organization team for their excellent job in organizing this conference. Our conference Organization Chairs Benoît Otjacques and Fernand Feltz have shown their high professionalism and responsibility in the organization work. Without their work and their

seamless cooperation with the UIB team in Spain, the success of CDVE 2009 would not have been possible.

Finally, this publication is a result of the main financial support of the Fonds National de la Recherche Luxembourg which we gratefully acknowledge.

September 2009 Yuhua Luo

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Collaboration in Global Software Engineering Based on Process Description Integration

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Abstract. Globalization is one of the big trends in software development. Development projects need a variety of different resources with appropriate expert knowledge to be successful. More and more of these resources are nowadays obtained from specialized organizations and countries all over the world, varying in development approaches, processes, and culture. As seen with early outsourcing attempts, collaboration may fail due to these differences. Hence, the major challenge in global software engineering is to streamline collaborating organizations towards a successful conjoint development. Based on typical collaboration scenarios, this paper presents a structured approach to integrate processes in a comprehensible way.

Keywords: Collaboration, Interoperability, Mediator, Workflow, Graph.

1 Introduction

Globalization is one of the key success factors for business in general and software development in particular. The portion of (globally) distributed development projects across different locations, countries, and continents has increased significantly in the last decades [8], [9]. One of the underlying reasons is the need of complementary knowledge and complementary skills for developing various products. As most organizations have specialization as one of their company strategy goals, they are coerced to collaborate. That is, buying all work which someone else could make cheaper, including, but not limited to outsourcing development to low cost countries.

Project managers rather focus on time, budget, resource availability, and requirements than considering different cultures and development approaches they find in their projects, too. Streamlining different processes can be effectively done by integrating different approaches, supporting specific and important aspects of each development processes. This increases the acceptance of the included workforce of setting up collaboration projects which in turn reduces development time (bottlenecks), budget, and increases quality of the intended product to be developed. Therefore, the research question is: “How does a methodical and formalized approach look like that

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allows for process-based integration of two or more development organizations for collaboration?" Additionally, formalization of this approach is necessary for tool-support and higher efficiency of the methodology.

Valuable work has already been done in this field of research by A. Avritzer et. al in a Global Studio Project (GSP) [1]. This project describes an experimental research project and comes up with a special process for distributed development. Knicho Law addresses the functionality and communication of engineering service in one of his recent research projects. Thereby network behavior within a defined IT architecture is analyzed [4]. Amar Gupta is doing lots research within distributed development and "developing with the sun" in the "24-hrs knowledge factory". His work especially concerns information technology and knowledge-based systems [2]. R. Prikladnicki addressing different business strategies and models regarding distributed software development on (project) management level [7].

This paper addresses the definition of process-based collaboration-types in a distributed global development. A mechanism is provided that allows for combination of semantically different processes by describing scenarios typically occurring in globally distributed collaborations. This results in incorporated and integrated process descriptions which consequently can be directly used by tools based on V-model XT® or SPEM. V-model XT® is a standard development model of the Federal Republic of Germany and guideline for planning and conducting development projects [3]. The higher the rate of team distribution in development the more important is the definition and institutionalization of development processes. In globally distributed teams processes are valuable towards transparency, project control, and quality of the final product.

The goal of this approach is the construction of syntactical correct processes and workflows that allow for bridging the semantic gap between processes. The decision whether or not the resulting workflow makes sense from a business or development point of view is to be decided by responsible process managers and composers.

Since this paper focuses on process only, we will not explicitly consider e.g. lack of personnel, hand off failures, or communication media. In contrast the following approach should even help to successfully solve these problems by not overloading the project contributors.

Section 2 introduces an example that concurrently illustrates the described theory. In section 3 typical collaborative scenarios are introduced that addresses different challenges of distributed and global development. A summary and outlook is provided in section 4.

2 Illustrating Example

An illustrating example is provided in this paper in order to give a better understanding of the theory. In this example two organizations A and B exist, which act globally. For simplicity it shows only two organizations A and B with an appropriate initial workflow that collaborate with each other. However, this approach is fully scalable and therefore the number of workflows and organizations can be adapted to the real needs in collaborations. All scenarios have been discussed and review with experts and practitioners from industry, however an empirical validation has not been done yet. This is the main part of future work. The development practice shows us that in most of the cases one organization functions as “Master”, i.e. that organization identifies a need for additional, special competence, e.g. implementation, hardware development, or testing towards a higher overall effectiveness and efficiency. The “Master” is also responsible for initialization and organization of collaborations. “Master” does not mean that the complete workflow of organization A is mandatory for all organizations to follow. The other collaborating organizations are “suppliers”. The master and each supplier only know their own specific development process and approach from their point of view. The challenge is now to incorporate different processes and workflows before project start, which typically means uncoordinated and unstructured manual work, e.g. adaption workflows, definition of new milestones and quality gates, re-design of templates etc. This is especially in a global context prone to errors which in turn make the use of a structured approach necessary.

3 Collaboration Scenarios

Generally, four collaborating scenarios are identified, which are introduced in this section. The given workflows of organization A and B for describing the first and second scenario are depicted in Figure 1 (left). These workflows are modeled using UML activity diagrams [6]. Every modeled workflow uses parts from a software development lifecycle and considers “System Design”, “System Implementation”, and “System Test”. A system might either be a software system (“System of systems”) or a system consisting of software and hardware.

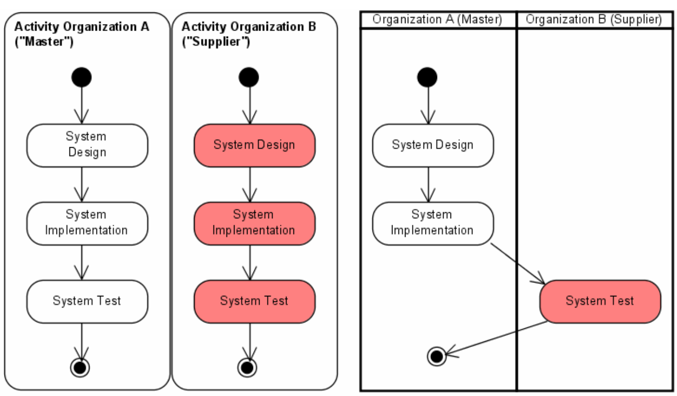

Fig. 1. Workflows of organization A and B (left and middle activity) and collaboration process having semantically the same processes (swim lane diagram)

The following sections introduce the collaboration scenarios. Thereby, a basic structure is used that considers the

1. initial situation of the participating organizations
2. the defined mediator pattern that is applied to the given workflows
3. the final situation, which provides the “collaborative” process.

The usage of this mechanism is as follows. Any development organization that wants to collaborate with another one identifies which collaboration scenario fits best for the desired cooperation. The selected scenario shows on a development process basis how to connect two or more processes together, e.g. inclusion “hand-over” activities. As a next step those scenarios need to be formalized to source process to that support and automated the definition of collaboration processes for development. However, the formal descriptions are not show here.

3.1 Collaboration with Semantically Equal Processes

The first scenario defines the collaboration process of organization A and B having semantically the same processes on each side implemented. This means for the two basic workflows in Figure 1 (left) that not only the action names are same; moreover, they mean exactly the same. This scenario is similar to a typically sub-order relationship like in V-Model XT®. However, this approach even extends a sub-order relationship due to the fact that indeed the process models are semantically equivalent, but the decision of task allocation is not modeled in the process like in V-Model XT® upfront. Figure 1 (swim lane diagram) shows the final collaboration process. Let's assume that organization A wants to hand over e.g. the “System Test” to another organization due to more independence or cost reduction. Since the processes are semantically equal, organization B is able to just take over and to execute the “System Test”.

3.2 Collaboration with Semantically Different Processes

Now, collaboration is not anymore restricted to having semantically the same processes defined in each organization. Referring again to V-Model XT® this means that in contrast to “Horizontal Integration” (section 3.1) the collaborating organizations even have different processes defined and moreover the task allocation is again not defined in these initial processes. The latter problem is addressed by adapting the appropriate workflows. For this case there are three more scenarios identified, which are explained in the following. When the implemented processes are semantically not equal, one cannot just exchange single actions or activities. For example, the activity “System Implementation” may exist in both organizations, but organization A associates other actions and activities with it than organization B (e.g. different coding guidelines, configuration management, templates for documentation etc.). At this point we need some sort of interface, which is defined as a “mediator pattern”. A mediator pattern is a kind of function that brings together two or more actions that need to be combined. These mediators are also modeled with UML activity diagram terminology, but do not necessarily follow the UML modeling rules, since they have only an auxiliary character [5]. They serve the purpose to illustrate the mechanism of how to connect processes and workflows before collaboration starts. With the help of these auxiliary functions it is possible to exchange either single actions/activities from any workflow or even whole action chains.

3.2.1 Horizontal Integration

Within the scenario “Horizontal Integration” it is possible to exchange single actions or activities from a defined workflow. It is named “horizontal”, because the action to be integrated is "moved horizontally" into the workflow of organization A. Since the processes and workflows are semantically different we use the mediator pattern shown in Figure 2. A mediator looks different depending on the scenario applied. The mediator for "Horizontal Integration" basically consists of two "hand-over" actions and one action in between which should to be integrated. The action to be integrated comes from the "supplier", whereas <action X> and <action Y> are the existing connection points of the master's workflow (organization A). The hand-over actions are new and have to be added to the target (collaborative) workflow. These actions function as a converter to streamline the existing different semantics of actions or activities.

Additionally, the hand-over actions have to be connected with those actions that lay above and below that action to be integrated from any other workflow. From a practical point of view all organizations have to be included in the hand-over. The first hand-over clarifies the basic issues, e.g. clarification and allocation of roles, the usage of templates, etc. The second hand-over addresses e.g. the check of completeness, the mapping of used formats, inclusion of help files, etc.

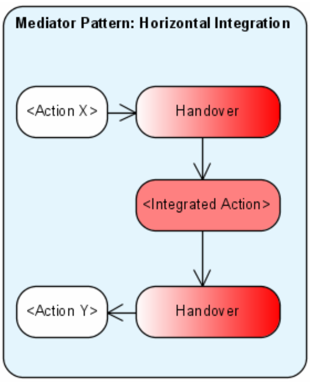

Fig. 2. Mediator Pattern for Horizontal Integration

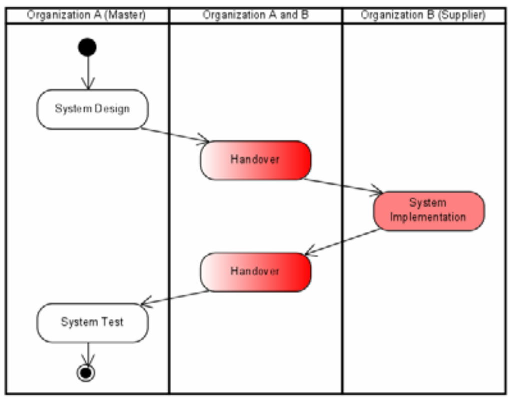

Fig. 3. Collaborative workflow after Horizontal Integration

When the mediator pattern in Figure 2 is applied to our concurrent example above, it is now assumed that organization A wants to outsource "System implementation". Firstly, organization A has to identify the action to be assigned to organization B. Using the mediator two hand-over actions have to be added, one right before "System Implementation" and one right after.

"System Implementation" itself is now not done anymore by the "Master", but as identified before by the "Supplier". For this reason "System Implementation" can be deleted from organization A. Figure 3 illustrates the horizontal integration appropriately.

3.2.2 Additive Vertical Integration

The scenario "Additive Vertical Integration" allows for adding whole workflows or action-chains and is generally defined more coarse-grained. The basic difference to "Horizontal Integration" is the parallelization of activities and workflows and the definition of activities executed together, i.e. decomposition and integration. The decomposition splits the overall product into several sub-products to be implemented and allocates appropriate responsibilities. Integration consolidates the outputs of different parallelized workflows. In contrast to the used "Synchronization" actions in 3.2.1 "decomposition" and "integration" rather focus on sub-products or domains than focusing on single actions/activities on micro process level, e.g. roles, artifacts, or usage of templates.

The mediator pattern used for the collaboration scenario "Additive Vertical Integration" looks different compared to the one used before. Instead of having hand-over actions there are "Decomposition", as an entry-action and an exit-action called "Integration" added to the workflow. Again, these two actions must be performed by both organizations. Both <action X> and <action Y> are existing connection points of the master (organization A). In between these actions two sub-workflows are running simultaneously, i.e. this scenario is used when collaboration activities need to be executed in parallel. This is also symbolized by a fork-node after decomposition and a join-node right before integration. Figure 4 (left) depicts the definition of this mediator.

For better illustration in the concurrent example the basic workflow from organization A ("master") is now marginally modified so that the "System Implementation" is modeled as a sub workflow consisting of "Software Design", "Software Implementation", and "Software Test" as shown in Figure 5.

Considering again our example it is assumed that organization A now wants to include hardware to the system, which is e.g. needed in conjunction with a new product. For this reason decomposition in software and hardware makes sense. The hardware part is taken over by a supplier, which might be specialized on that. Figure 5 also provides the workflow of the hardware vendor (organization B).

Figure 6 shows the collaborative process as additive vertical integration of a whole workflow. After "Decomposition" (this action comes from the mediator) of the system, which is done by both organizations, each of them simultaneously executes its

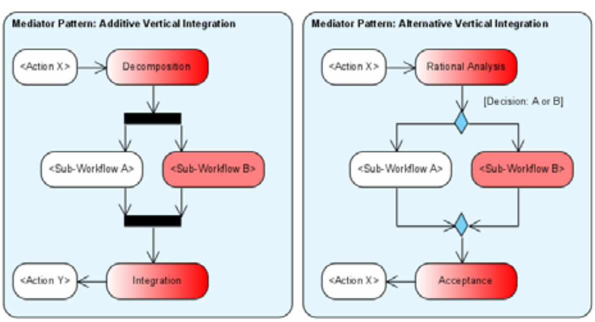

Fig. 4. Mediator Pattern for Additive Vertical Integration (left) and Alternative Vertical Integration (right)

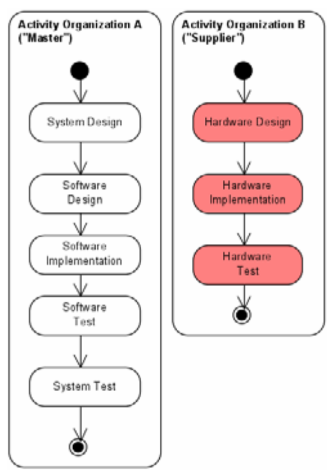

Fig. 5. Workflow Organizations A and B

own workflow or domain. After finishing the sub-domain workflow the “Integration” (this action comes also from the mediator) takes place (again by both organizations A and B) right before the control moves over to organization A executing the “System Test”.

3.2.3 Alternative Vertical Integration

The last scenario “Alternative Vertical Integration” also considers the integration of a whole action chain or sub-workflow. The difference to “additive vertical integration” is that the sub-workflows are executed alternatively, not additionally. The defined mediator in Figure 4 (right) is similar to the one in the scenario before. Due to the fact that the sub-workflows run alternatively there is a need for a “Rational Analysis” that serves as input for the decision which organization should implement a defined sub-product. At the end there is an “Acceptance” activity included that proofs quality aspects of the sub-product against defined requirements, e.g. performance. This pattern is very interesting, if first, the allocation of sub-products can only be done just before implementation, e.g. in new innovative projects and, second, the number of sub-products cannot be specified upfront, which makes more iteration necessary. Our example again refers to the workflow of organization A as defined in Figure 5. It is now assumed that organization B serves as a supplier of any sub-product if the requirements to be implemented are safety-critical, if not the sub-product is done by organization A itself. Figure 7 illustrates the collaborative process using the defined mediator as basis.

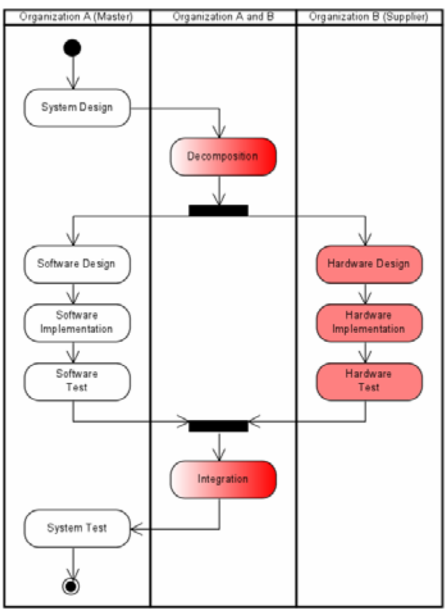

Fig. 6. Collaborative workflow after additive vertical integration

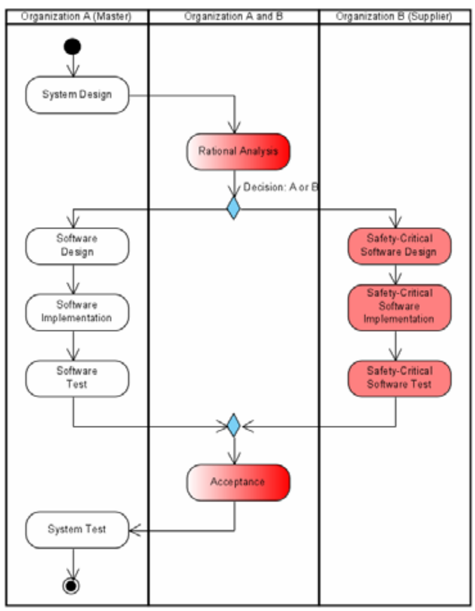

Fig. 7. Collaborative workflow after alternative vertical integration

4 Summary and Outlook

This paper showed a structured approach for defining collaboration processes based on different scenarios and requirements. A key element of this approach is the usage of mediators, which are differently defined depending on the scenario selected. With this mechanism it is possible to build complex collaboration processes of any size. As shown in various scenarios this allows for a controllable and structured way of collaboration, which is absolutely necessary when it comes to projects across organizations all over the world.

A major aspect for future work concerns semantic checks of the organization's processes towards collaboration. Thereby the conformity checks from V-Model XT® might be very useful. The results of those conformity check help to define syntactic correct collaborative process based on the collaboration scenarios above. The semantic definition itself is also done very roughly. This also needs to be done in future, especially towards automation it is absolutely necessary that an exact definition of the activities' semantic is provided.

Additionally, this approach shall be piloted in a real software development project, in order to verify and validate the defined theory towards practicability. This is important for development because many organizations work under cost pressure and have neither time nor money to invest in impracticable and inefficient process.

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Design Concept Development of a Cooperative Online Support Platform for Music Creation

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Abstract. To work online cooperatively with other music creators can stimulate the music creation ideas. To have an online cooperative support platform for music creation atmosphere is a dream for many music professionals that are spread geographically. The objective of the work presented in this paper is to develop system design concepts for a cooperation online music creation support platform. Necessary concepts in existing systems are identified. Missing new design concepts for the platform are developed and presented in the paper.

Keywords: Cooperative applications, cooperative music creation support.

1 Introduction

Internet has been used for music distribution and helping clients to find and purchase music online. Music authors also use Internet for marketing and presenting their projects. Using computers as instruments for music creation has become very common. The work presented in this paper is aiming at finding new ways to support and stimulate music creation cooperation online.

Following the software development life cycle, our objectives can be described as follows. The ultimate objective of our work is to develop a software application to provide online support for cooperative music creation, a Cooperative Online Support Platform (COSP). Our target users are music creative professionals who compose music and are usually spread geographically. The major purpose of the application is to provide support to the cooperative music cooperation process, but not a tool for creating music itself. There are many computer tools available for music composition that the music professionals are already applying. This clearly defines the boundary and scope of our system.

The next step in the software development is the user requirement gathering. We would like to find out what kinds of support the music creators really need which are missing in existing systems. For this purpose, a qualitative approach is used to discover the needs of the users including their innovative ideas for such support [4].

After a period of extensive qualitative interviews with a group of users, an analysis of the user requirements is performed, and - as a result of an aggregation process - requirements are consolidated in a summary. During the user requirement analysis, we identified a group of design concepts that can satisfy the user requirements and may provide effective support to the process of cooperative music creation. In order

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to re-use possible existing system concepts in other system, first we check both, general and specific existing concepts, to see if they satisfy our user requirements. By "general concepts" we address the concepts in a wide range of cooperative applications irrelevant to which area they apply, whereas "specific concepts" are referred to the design concepts for music creation or cooperation in music creation. By the analysis and comparison of existing concepts and the concepts required, we are able to identify those new concepts that should be developed. The last stage of our work presented in this paper is the development of selected new concepts.

We have identified two important cooperative concepts that are not supported by existing systems: (1) an online virtual music creation environment which allows users to generate and transmit creative atmosphere, support the music creators to communicate about their work in progress and exchange ideas, and (2) protecting and securing the core value of their music creative work, i.e., the copyrights.

The second section describes the data collection process, i.e. the user requirement gathering, and the qualitative approach to determine the requirements from this specific user group. The third section discusses a group of candidate general concepts for cooperative systems that could be integrated into our platform. The fourth section examines music creation specific concepts. Section five develops new concepts for our platform.

2 Requirement Gathering by Qualitative Interviews

A very common problem of failed software is that the software does not meet the users' requirement. Often this is because the method of getting the requirements from the user is not adequate in the first place. Actually how you ask a question affects the answer to the question. To find out what the users really need, it is necessary not to influence the user or at least to influence them as less as possible when you ask questions. A requirement engineer should always be aware that the user him/herself has the knowledge of what he/she needs. "Fundamentally, technology is an extension of the stick when the arm cannot reach "[5], and just the user can tell what exactly this stick supposed to be.

To find innovative ideas from the music creative users, we used a qualitative method of narrative interviews. At the beginning of the interview one very open question is asked that allows the user to answer very broadly. Later in the interview some more concrete questions follow. By doing this, more detailed answers can be obtained for the already identified requirements.

The interviewed persons came from different background. Depending on their experience, their way of creating music and their professionalism, the weight of the found requirements can vary. The first answers given to the opening question have more weight than the answers later on. The following major requirements were found in the first answers:

- The need of communication between the cooperation partners
- The importance of an atmosphere (mood, feeling) in music creation
- The security and the copyright of their music creative work

Further in the interviews, more detailed requirements are found, such as:

- The need of some mechanism for searching cooperation partners
- The need of tracking and versioning of the creative work in progress
- The need of reuse of material
- The necessity of non-standard notations and user defined notations
- The possibility to vote on music quality
- Music formats such as MIDI, MML, MEI may not be so useful for professional music creation, but should be available

3 General Concepts for Cooperative Systems

There is a big amount of general concepts for computer supported cooperative work (CSCW). The CSCW Matrix in Figure 1 [1] shows the different standard applications depending on the context the system is used.

Our platform is meant for geographically spread music creators to cooperate either at the same time or at different time. Therefore, the platform is located in the regions of “different place” in the CSCW matrix, in Figure 1 Standard applications like video conferencing and shared screen have to be extended to meet the needs of the COSP requirement. Other applications such as bulletin boards and group calendars can be integrated as standard components.

Existing concepts for the platform and the use of actual state knowledge can be found in the 3C model (Figure 2) [2]. In this categorization framework, the OCSP is on the line connecting the cooperation and the communication.

Besides these two approaches for defining standard concepts, existing systems can be analyzed for their suitability to the requirements of the COSP. The implemented cooperative working concepts such as in Aulanet, TelEduc, WebCT, Moodle, BSCW etc. can therefore be useful for the conceptualization of a comprehensive COSP system [3].

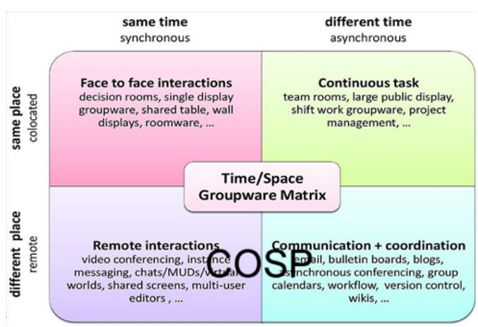

Fig. 1. COSP in the CSCW Matrix[1]

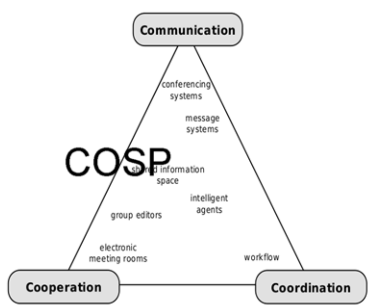

Fig. 2. The 3C collaboration model [2]

4 Specific Design Concepts for Cooperative Music Creation Platforms

Several publications describe cooperative music creation platforms. In [6] the related work “Cooperative Visual Manipulation of Music Notation” (MOODS) is described, which enables a cooperative visual manipulation of music notation. Some of our music notation requirements are covered by MOODS. MOODS is bound to music creation in orchestras where composition and notation of music is in a very centric location. It does not support musician that are in different locations nor people who want to cooperate at different times. It is not applicable for other kinds of music creation and therefore is not suitable as a solution for other target group of users.

The concept of notation and distribution in this system can be used and integrated into our COSP. From the requirements gathered in our qualitative interviews there is a demand for more flexibility in notation because not all musicians are able to read and write the standard notation. For some application cases, it may only need to write down music chords. Another requirement derived from the interviews is the possibility to use the users own notation for the music or notations defined by themselves.

Another related work “Beyond open source music software: extending open source philosophy to the music with CODES” [7,8] attacks the problem from a very different point than MOODS.

CODES provides tools for music creation. Their target user group is the music creation novices. The objective is to allow music creation novices being able to cooperate without knowing the music technical terms. CODES uses the computer and its devices as musical instrument [8]. This is a very big difference from the objective of COSP because we leave the technical music creation to the musician. The COSP is not targeting the absolute novices. Its aim is to support the music creative professionals. How the users produce their audio tracks is left to the users. An integration of CODES in the COSP as additional feature would surely be a good possibility to gain the target group of novices into the community.

Similar to the CODES authors, we are also convinced that the technology offers great contributions to social ways of music making. [8] Our approach has another target group of users who are professionals. The COSP is not going to force the users to do anything but rather to support their way of music creation.

One of our main requirements – communication between the cooperation partners – is addressed in CODES by group awareness: “... mechanisms to manage understanding of actions and decisions of group members cooperating and sharing music prototypes ...” [8].

CODES uses different formats (MIDI, MML, MEI) [8] for music recording but not real audio recording from a microphone. The COSP builds in the first place on real analog audio recordings. The outcome from our interviews shows that the quality of computer generated music is not acceptable for most professional users and hinders the creative process. Of course, the quality of the microphone recorded analog audio signal is not sufficient for a final music production. When the creative process is finished it is necessary to use a studio for the final recording.

The music formats in CODES will be available even not useful for most of the interviewed persons. For this reason the COSP will give the possibility for creating music and using such formats but will not rely on them.

The product itself created by CODES is a kind of “free music” or “open music” which will prevent most professional musicians from using it. The requirement for alternative licensing is addressed in CODES but not solved [8]. With a target user group of music professionals in our platform, this is a high priority necessity and a main requirement when it comes to professional music creation.

CODES covers some of our found requirements such as music notation, group awareness, tracking of modifications… However, CODES lacks two main requirements: protection of security and copyright of the created music product and the need for atmosphere in music creative process.

The related work “A System for Collaborative Music Composition over the Web” covers some of our requirements. For example, they described the database structure as a “... compositions table, which has a recursive relationship to itself, allowing by a tree like representation of the pieces” [9]. This covers our requirement for tracking and versioning of the work in progress and also the reuse of material.

The requirement for licensing is addressed but not solved as well in [9]. A right tracking option was implemented in their first version which used a registration to an authority for copyright reasons. Because COSP has a main requirement for copyright protection, such a concept will be adopted and further developed to support the music creative professional in this aspect.

Our requirement for voting is addressed in CODES. It is possible to “... vote on the quality of any composition.” [9] It is also pointed out that this and other information can be used to shape a user profile for finding cooperation partners. This concept will also be developed in the COSP but with a broader application through a combined searching concept.

A concept for real-time user interaction was addressed in CODES which is also necessary in the COSP. The technological problems such as the “net-jamming” problem caused by this real time interaction are also addressed in CODES.

This work has some concepts that can be adopted or further developed for our found requirements. However, a major requirement for transmitting creative atmosphere is not addressed. Another difference in their approach is the focus on electronic music. The computer is used as an instrument to generate music. Our platform tries to support the audio creative professional at their work and not to bring the users to use the computer as a music instrument.

5 New Concept Development for the Cooperative Online Support Platform

The result of the qualitative interviewing shows what users require. However, the method does not directly reveal the requirements; rather it is necessary to derive them from the formulated needs of the interviewed users. This section derives and develops some major new concepts to satisfy these requirements.

Subsection 5.1 to 5.3 try to develop some new design concepts to satisfy the major requirement for the communication between cooperation partners. Subsection 5.4 will develop the design concepts for the requirement of music creation atmosphere and subsection 5.5 is for the requirement of security and copyright.

5.1 Synchronous Cooperative Player

Just as every website or platform that handles multimedia contents, there is a need for a contents player. The COSP player has to meet the special demands to cover the requirement for communication among the cooperation partners. Both synchronous and asynchronous communications are necessary.

For synchronous communication it is necessary that the player allows the cooperation partners to listen to the work in progress simultaneously. This should be possible through a waiting mechanism that does not start the playback until every cooperation partner has clicked on their own play button. The pause function should work likewise. If one partner clicks the pause button, the playback should stop for everyone and just go on if everybody clicks the play button again. This functionality is combined with the possibility for voice over IP or video conferencing. If the playback starts the audio of the communication channel has to adapt or stop to avoid acoustic feedback. As soon as the playback pauses or stops, the audio channel should adapt or start again.

For asynchronous communication there is the need of a mechanism to mark parts of the work in progress. This could be a mark for just one track or a set of combination of tracks. Such a mark, a track or a set can be annotated text, audio or video. A link to this annotation can be sent to the necessary cooperation partners. If a partner is assigned for the project he gets a change alert message automatically. The partner can listen to the marking with just one click and read, listen or view the annotation etc.

These conceptual functionalities should cover the need for a simple way of communication among the partners.

5.2 Detailed Progress Indication

To facilitate the communication among cooperating partners, there has to be a possibility for the user to mark parts of tracks or sets easily. It is very tedious to search for a particular millisecond that a mark starts or ends. For this reason the player should offer a Detailed Progress Bar under the standard progress bar that has the same size.

This bar represents a detailed part of the standard progress bar. The speed of the operation can be adjusted through different scaling. Figure 3 shows a scaling of 5 seconds. The green vertical indicator of the progress bar shows the position of the playback in the whole audio track. The horizontal orange compartment marks which part is shown in the Detailed Progress Bar. The indicator of the Detailed Progress Bar shows the position of the playback within the zoomed compartment.

By using the "+" button on the right end of the progress bar the scale can be changed by an interval of 0.5 seconds. Figure 4 shows the change to 6 seconds scaling.

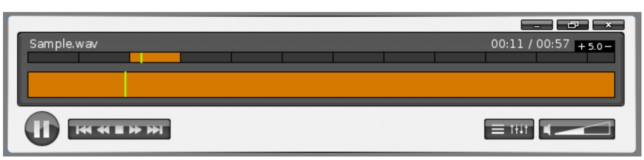

Fig. 3. The Detailed Progress Bar - Scale: 5 Seconds

Fig. 4. Detailed Progress Bar – with a scale of 6 Seconds

The number of compartments of the progress bar changes from 12 to 10 and the size of each compartment increases. The Detailed Progress Bar does not change in size but in the speed of the operation. This allows the user to toggle the speed so it is comfortable to put a mark on the detailed progress bar. This makes it very convenient to set some marks and add an annotation to any of them. The first mark is the starting mark and the last mark is the ending one. By using this, a user can send a cutout of the work in progress with comments to a cooperative partner.

5.3 Categories and Searching Mechanism

As a cooperation platform, COSP should give the possibility to the users to find the right cooperation partner. To implement this, there has to be a search mechanism that allows the user to specify values of categories as search parameters. A category can be, for example, the genre or a country. In addition to standard categories, functionality for adding new categories and subcategories by users should be provided. To avoid uncontrolled growth of numbers of categories, a self regulation mechanism has to be implemented. The reason for using categories is to let the user to be found in other users´ search process. If a user defines some categories and values that nobody or too many people are using, the chances to be found is very low. If this happens, the user has to find a category and a value that is detailed enough and abstract enough to be found. To force this behavior, the searching mechanism has to be designed accordingly. For example, the platform can force the categories that are too small or too big to go backwards.

To search in the COSP for possible cooperation partners, categories and values can be chosen to form part of the information of the profiles of users, projects or even single songs or music pieces. To ease the search, three different levels of searching should be possible.

An automatic search without explicit search parameters uses the information in the user´s own profile, which can be projects and songs created by the user to find possible cooperation partners.

A simple search offers just selected categories and values to ease the input for the user. Criteria for offering a category or value could be the amount of users that are in a category or have assigned a value. This search is designed to support a self regulation mechanism.

An extended search offers all the possible categories and values. Amounts of values in a category and amounts of users using a category or values etc. should be shown.

5.4 The Virtual Project Room

A Project can be a single song, a complete album or all the work of one band depending on the shared atmosphere. Therefore the non classical project concept goes further than just music creation. Especially in this case the transmission of the atmosphere becomes more important.

The virtual project room concept deals with a major requirement found in our interviews: the need for an atmosphere in the music creation process. Due to the nature of this requirement and the technological environment constraints, it is impossible to make up a real world situation. To transmit the creative atmosphere is sure a bold venture and a great idea due to the heavy weight the interviewed professional laid onto this requirement. The virtual project room is an attempt to transmit this environment as much as possible over distance and time shifted cooperation.

This concept of virtual project room will allow the user to place different types of media onto the screen. It can be visual, audio, audio-visual, textual or simple links. Upon the start of a project, the virtual project room and its walls are empty. Each assigned project member can pin media onto the walls; change colors and add or delete audio files to the virtual room radio. This radio can be configured to start automatically when entering the room.

One of the major purposes of the virtual project room is to give the project an audio-visual space to overcome temporal and spatial distance in the cooperative work. The use of this virtual project room can also be optional.

Another major purpose is to use the virtual project room to organize the project related material. A general computer supported cooperative work tool like a forum or other social networking tools can be integrated into this virtual project room. One possible application can be for informing the project partner about changes in the project since his last login. The virtual project room is a central organization point in the COSP platform. See figure 5 for more details.

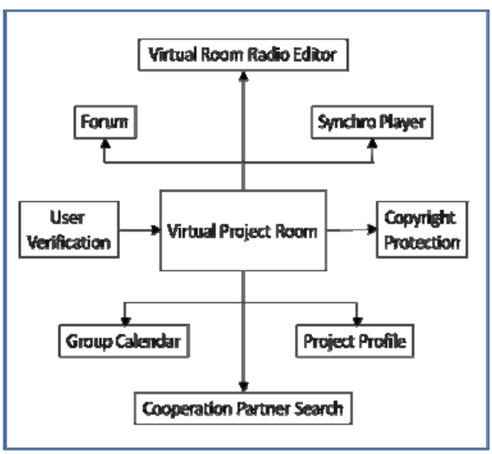

Fig. 5. The Virtual Project Room as the central organization point in COSP

5.5 User Identity Verification

An important design concept in COSP is the verification of the user´s identity. As an option, a user can verify his identity by using his passport. One advantage of this is a higher trustworthy to other users or cooperation partners. Other ways to raise the trustworthy is a reference and a recommendation mechanism. The verification is also the realization of a major system requirement: the security and copyright protection.

The countries handle the copyright issues over some international organizations such as the International Confederation of Societies of Authors and Composers (CISAC) [10]. In order to secure copyrights, the COSP should be monitored by such an organization and the verification process should be enforced.

Security can be raised through the monitoring of the platform by the CISAC. This is an independent control mechanism and therefore the users of the platform can be sure that their uploaded files get tagged with the actual date and will not be deleted nor manipulated. This process is immediate which has an obvious advantage than other methods.

The verification process itself allows the proof of copyright together with date tagged files and therefore it will allow the user to enforce a legal claim action when necessary.

6 Conclusions

The ultimate goal of the work presented in this paper is to develop a Cooperative Online Support Platform (COSP) for cooperative music creation. The target users are music creative professionals who compose and perform music, and who are usually spread geographically in different locations. The major purpose of the proposed application is to support music creative professionals in their cooperative effort to create and perform music and the accompanied processes on a collaborative basis.

By our qualitative approach of user requirement gathering, we identified some important design concepts that can effectively support the remote users to work cooperatively together. Among these concepts, the transmission of music creative atmosphere is identified as a key element for the cooperation. Since our platform is meant to support professional musicians another key requirement of security and copyright protection comes to the fore.

The work in this paper is the result of a software development phase during its development life cycle. The requirement gathering and the deriving of concepts are the first steps in the agenda. Further work includes the development of a concept for community building and a business concept to achieve a sustainable operation of such a cooperative platform.

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Implementation of a Web-Based Collaborative Process Planning System

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Abstract. Under the networked manufacturing environment, all phases of product manufacturing involving design, process planning, machining and assembling may be accomplished collaboratively by different enterprises, even different manufacturing stages of the same part may be finished collaboratively by different enterprises. Based on the self-developed networked manufacturing platform eCWS(e-Cooperative Work System), a multi-agent-based system framework for collaborative process planning is proposed. In accordance with requirements of collaborative process planning, share resources provided by cooperative enterprises in the course of collaboration are classified into seven classes. Then a reconfigurable and extendable resource object model is built. Decision-making strategy is also studied in this paper. Finally a collaborative process planning system e-CAPP is developed and applied. It provides strong support for distributed designers to collaboratively plan and optimize product process though network.

Keywords: networked manufacturing; collaborative process planning; resource model; hierarchical decision making.

1 Introduction

Now with increasingly intense competition of global market, the production paradigm has changed from few-type and large-batch production to various-type and limited production. The process of product design and manufacturing has also been transformed into collaborative development involving various enterprises. With the rapid development of computer, communication and network, geographical location is no longer a barrier for manufacturing and selling product in the worldwide. Networked manufacturing and virtual enterprise will become main production paradigms in future[1, 2].

Process planning is a function that establishes the machining processes, machines and tooling capable of performing these processes, and machining parameters to be used to convert a piece part from its initial form to a predetermined shape, as per the engineering drawing. Under the networked manufacturing environment, each phase of

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product development including design, process planning, part machining, assembling and final assembly may be accomplished cooperatively by different enterprises. Even different working procedure of the same part may be finished in various enterprises. Because of the difference of resources supplies, processing capability and technical levels among enterprises, many factors must be considered during process planning. So collaborative process planning has become hot spot of academic research and industrial application and been widely researched at home and abroad.

Many scholars studied key technologies of the CAPP system supporting networked manufacturing. Tu[3] proposed the CAPP framework including a reference architecture for structuring a CAPP system in virtual OKP(One Kind of Production), a new CAPP method which is named the 'incremental process planning (IPP)', and an optimal/rational cost analysis model. Yang[4, 5] presented the structure of the group process planning system for the virtual enterprise (GPPS-VE) and developed a process planning task model with a maximum-first heuristic algorithm to realize the process planning task allocation. Ni and Yi[6, 7] studied a CAPP prototype system suited for rapid reconfigurable manufacturing system in agile manufacturing mode and CAPP in Networked Manufacturing Environment. Zhang[8] proposed the architecture of a web-based distributed network CAPP system and studied a web-based process data query method. However existing research mostly focused on architecture or some key technologies. Chen[9] developed a CAPP system for networked manufacturing named NET-CAPP built on CORBA architecture. Huang[10] presented a CAPP framework based on B/S architecture and studied some key technologies of CAPP supporting Internet-based manufacturing. But most of the prototype system is limited to verification and has been uncommon well applications, because a variety of factors that may occur in actual product development can not be roundly considered in the study.

In this paper, the framework of a web-based collaborative process planning system e-CAPP is presented, and some key realization techniques in the e-CAPP such as classification and modeling methods of shared resource provided by cooperative enterprise, and hierarchical decision-making strategy are discussed. Finally based on the self-developed networked manufacturing platform eCWS, e-CAPP is developed and provides strong support for distributed designers to collaboratively plan and optimize product process though network.

2 Web-Based Collaborative Process Planning System Framework

2.1 Requirement Analysis

Traditional product development is usually completed by an independent enterprise. Feedback between its various stages can be brought under control and gradually decrease when designers fully know processing capacity, equipment and personnel in enterprise and information is shared efficiently in enterprise.

Under the networked manufacturing environment, collaborative process planning is accomplished by process designers from various enterprises in a shared environment. These designers can not be well aware of the production capacity of other enterprises. The traditional approach of process planning is no longer satisfied to the requirements.

Especially when special circumstance such as equipment failure or personnel changes is appeared, product quality and overall progress will be affected. Therefore, collaborative process planning system must meet the following requirements:

(1) Distribution: System should have the ability to support distributed staff to design process collaboratively and ensure consistency.

(2) Real time: System should support various synergistic manner, in particular, real-time distributed collaborative design.

(3) Dynamic: System should dynamically update information, including cooperative enterprise, personnel and shared resource information.

(4) Openness: System should adapt to the new hardware and software environment and the change of customer demands.

(5) Intelligent: System should have some intelligent decision-making capacity to assistant process designer so as to improve efficiency.

(6) Security: System should ensure enterprise information security and consistency.

2.2 System Framework

According to characteristics and requirements of network Collaborative Process planning and based on self-built network collaborative working platform eCWS[11], a web-based collaborative process planning system is proposed and its system framework is shown in Fig. 1. It includes three layers: client layer, server layer and data layer. The function of each layer is as follows:

(1) Client layer, which is used for conversation between user and system, provides a consistent Web interface for process designer. The user can download collaborative process planning components and collaborative tools components provided by the server layer, and achieve corresponding mission based on role.

(2) Server layer, which mainly includes application function kits and system environment, is core of system application. Application function kits accomplish all kinds of application in system environment, which include process search, task grouping, scheme selection, process sequencing, detailed design, process document management and maintenance of enterprise resource information. Information maintenance mainly completes resource classification, resource modeling, resource management, resource search, and so on. System environment mainly provides collaborative tool kits such as collaborative remark, group evaluation, group voting, shared whiteboard, file transfer and so on. So multidisciplinary groups distributed in different places can collaboratively plan and optimize process planning.

(3) Data layer, which includes product data, shared resource information of cooperative enterprise, knowledge / methods and system information such as user, security, conference and so on, is used for saving, making, maintaining and managing related data. Product data is the foundation of process planning. It describes product configuration, organizational structure, part geometric information and process requirements. Shared resource information of cooperative enterprise is the key to organize and guide process planning. It describes share resource information provided by cooperative enterprises.

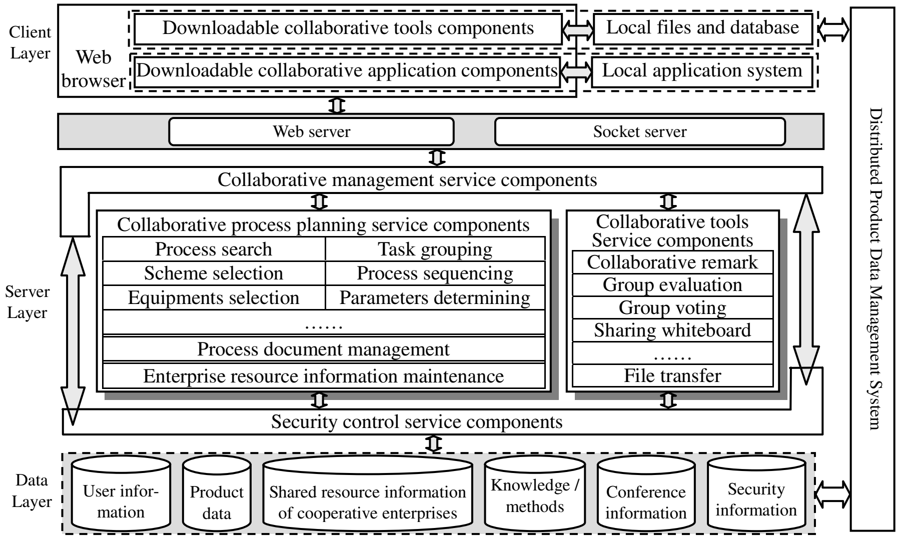

Fig. 1. Network Collaborative Process planning System Framework

3 Key Techniques of e-CAPP System

3.1 Classification and Modeling of Shared Resources

In order to manage shared resources provided by cooperative enterprises efficiently, we classify shared resources into seven categories. The specific breakdown is as follows:

(1) Product, which refers to various types of products provided by cooperative enterprise, includes standard parts, universal parts, special products, custom products, etc., can be part or component.

(2) Personnel, which refer to personnel form cooperative enterprises who can participate in collaborative process planning, include managers, experts, product designers, process designers, operators, etc.

(3) Equipment, which refers to a great variety of processing equipments provided by cooperative enterprises, includes machining, testing, heat treatment, assembly and other auxiliary equipment, etc.

(4) Auxiliary tool, which refers to various types of auxiliary tools provided by cooperative enterprises, includes cutting tools, fixtures, measuring, tooling and other special tools.

(5) Design tool, which refers to design methods and software used by collaborative designers from cooperative enterprises, includes design methods, processing methods, assembly methods and all sorts of software such as design, analysis, simulation, programming, management and others.

(6) Design knowledge, which refers to all sorts of design knowledge used in collaborative process planning, includes design standards, design manuals, design rules, the typical technology, etc.

(7) Others, which refers to a collection of all resources that are provided by cooperative enterprises and do not belong to the above types, includes materials, blank, information. It can be expanded in accordance with the actual situation.

Based on the above classification, a multi-level resource object classification model is set up [12, 13]. Using the object model of shared resources, users from cooperative enterprises can query or maintenance shared resources through several classes in model, design database tables under the rules of transformation, and guide the development of data management system. During the running course of e-CAPP system, the user can use resource definition module to expand the classification in accordance with requirements. So it can provide strong support for collaborative product design and manufacture.

3.2 Hierarchical Decision-Making Strategy

During the whole course of product process design, cooperation is not required at every moment or every stage, and at different stages of process design personnel participated in cooperation are different. So we divide collaborative product process design into three levels:

(1) The first level is to design process scheme. Usually product is designed by top-down design methodology. In this level, collaborative process design focuses on assembly process scheme of product or component. Designers collaboratively complete design and analysis including design and optimization of assembly sequence, assembly path planning, assembling dimension chain analysis, assembly tolerances assignment so as to provide a basis for product or component assembling and parts machining process planning. This cooperation is realized by the experience and simulation-based method. Participants usually are product R & D personnel and assembly designers. If necessary, process designers may be invited to take part in. Cooperative enterprises only need to provide resources information about product development and assembly capacity, etc.

(2) The second level is to design process schedule. In this level, collaborative process design focuses on a part process schedule. Designers collaboratively form a number of optional part process schedules after design, analysis and optimization, so as to provide a basis for working procedure design, process changing and task dispatching during the actual production process. This cooperation is realized by the case and reasoning-based method. Participants usually are part designers, process designers and machining personnel. Cooperative enterprises need to provide its typical parts machining technology and related resources information.

(3) The third level is to design working procedures. In this level, collaborative process design is finished usually by different departments and occasionally by different enterprises, and focuses on detail design of a part working procedure. Designers collaboratively determine machine tools, assistant tools, machining parameters, operators and so on, and program NC codes if possible, so as to guide the actual production process. This cooperation is realized by the data and knowledge-based method. Participants usually are part designers and process designers. If necessary, production managers may be invited to take part in. Cooperative enterprises need to provide detailed machining resources information.

In e-CAPP system, the process decision-making is implemented by human-computer interaction with the assistance of inference engine. Inference engine determines how to call the corresponding module or function according to process design requirements in current level, as well as how to select appropriate data or knowledge from database or knowledge base for process planning.

In order to be able to search usable rules in short time and simplify course of process design and knowledge base management, hierarchical decision-making strategy is used in e-CAPP system. Complex decision-making processes are separately finished by three inference engines[12]: engine 1 finishes feature-based assembling process decision-making; engine 2 finishes feature-based machining process decision-making; engine 3 finishes knowledge-based process decision-making and procedure optimizing decision-making. As shown in Fig. 3, each engine is also divided into several sub-tasks which can also be subdivided into a number of sub-mission.

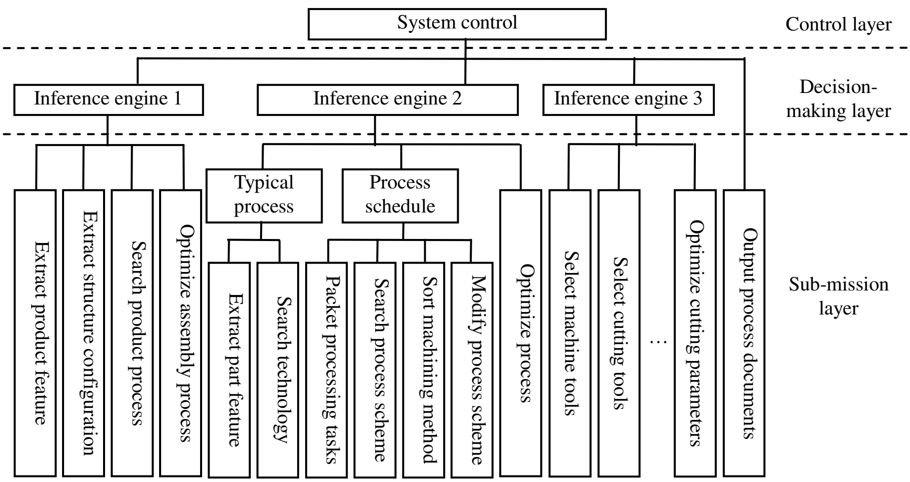

Fig. 2. Hierarchical Decision-making Strategy

In the course of cooperative process design, the system call the corresponding sub-engine based on the current design object information, and implement the various sub-mission under the control of inference engine and the guidance of navigation system, until the entire mission is completed. Results of reasoning, design or calculation of various sub-tasks are in turn recorded and filled in process schedule, and then process document is formed[13].

4 Implementation

e-CAPP system is developed based on eCWS under the development toolkit Visual Studio. In order to meet the needs of real-time collaboration and improve the efficiency of collaborative process planning, a platform for real-time communication is set up and the necessary support tools[14], such as cooperation meetings, collaborative remark tools, group decision-making tools and so on, are provided for personnel during the process of cooperation.

With e-CAPP system, process designers can achieve independently process design in accordance with requirements of mission. If necessary, process designers also can request cooperation, study out a list of persons to participate in cooperative meetings and issue the meeting notice after being approved.

After starting cooperation meetings, designers can collaboratively accomplish the process planning, also can collaboratively evaluate and remark the process schedule (Fig. 3) so as to analyze and optimize it.

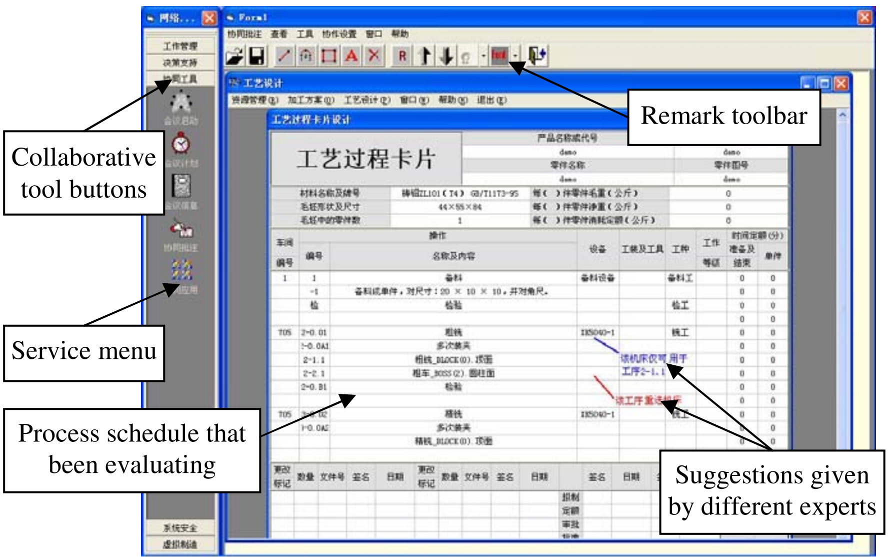

Fig. 3. Evaluate and remark a process schedule collaboratively

In accordance with the above approach, designers can collaboratively accomplish product process planning including design, analysis and optimization through the network.

5 Conclusion

Based on networked manufacturing platform eCWS, a network collaborative process planning system e-CAPP is built. Compared with existing works, the main contribution of our e-CAPP is as follows: (1) sharing resources can be updated, managed and searched efficiently; (2) process decision-making can be accomplished with relevant inference engine in three levels; (3) several collaborative tools are integrated to make collaborative process planning smoothly. This system is believed to be of significant importance to the process planning of complicated parts.

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Cooperative Analysis of Production Systems with Simulation Techniques

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Abstract. In this work we present an analysis of simulation tools and modelling technologies for production systems. The use of these tools within a collaborative environment will be a mainstay for distributed manufacturing companies which require the integration of design, manufacturing resources and processes across the product lifecycle.

Keywords: Collaborative Engineering, Concurrent Design of Product and Production Processes, Process Modelling, Discrete Event Simulation.

1 Introduction

The new globalized environment drives companies to adopt new strategies while they distribute their activities around the world. In this scenario Information and Communication Technologies must provide the right information at the right moment in order for the right decision to be made.

Companies must have full control of their production systems and shop floor activities must be continuously improved. In the case of supply chains, inter-company cooperation has been converted in the task force but for the special purpose of flexible manufacturing systems or adaptive manufacturing, collaboration is needed with the selected supplier in order to optimize the production system. Process modelling and simulation techniques can aid collaborative design and manufacturing engineering activities.

2 Simulation Levels and Modelling Techniques

The current competitive and ever-changing market leads manufacturing companies to increase productivity while offering high-quality low-cost products; thereby they are forced to implement a number of engineering changes in production systems. Thus,

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new and emerging information systems are required to plan and control methods and tools that will define processes for production systems analysis.

Two methods for systems analysis are: analytic methods, focused on machines or equipment variations; and simulation methods, used to model complex systems.

Simulation methods provide approximate and dynamic information about a system's behaviour [6]. Their application in problem solving and decision-making can result in tremendous cost savings [6], due to their ability to create, simulate and evaluate alternative process scenarios without the need for physical implementation.

Computer-based simulation is the most popular method due to its low cost and high availability. One of the main tools in this method is discrete-event systems simulation, which is the modelling of systems where the variables change only at a discrete set of points in time [1]. This characteristic and the availability of resources make discrete-event systems simulation the most used tool.

Proposed simulation levels in this paper are based on the level of detail of the study and the system component to be analyzed: operation (manufacturing processes), machine (set of operations in a single machine), workcell (interaction between workcell elements: workers, machines, material handling equipment, operating speeds), and production system (facility layout, process flow, staff schedules, and machine arrangement integration at three levels) (Fig. 1).

SIMULATION LEVELS	SIMULATION TOOLS	ProCAST®	Flow3D®	DEFORM®	Workspace5®	Autodesk® Moldflow®	CAD/CAE/CAM TOOLS	VERICUT®	Tecnomatix Robcad®	DELMIA Automation®	Tecnomatix®	DELMIA®	ProcessModel®	iTHINK®	ARENA®	ProModel®	SIMUL8®	WITNESS®
OPERATION	CASTING METAL	X	X															
	MOULDING PLASTICS					X	X											
	FORMING / SHAPING			X														
	MACHINING			X	X		X											
	ASSEMBLY				X													
	OTHERS		X		X													
MACHINE	CNC MACHINES							X			X							
	ROBOTS				X				X	X								
	OTHERS																	
WORKCELL	MANUAL ASSEMBLY										X	X						
	AUTOMATIC & ROBOTIC ASSEMBLY										X	X						
PRODUCTION SYSTEM	PROCESS PLANNING / WORKFLOW										X	X	X	X	X	X	X	X
	PLANT DESIGN										X	X			X	X	X	X
	ENTERPRISE PLANT SET																	

Fig. 1. Simulation levels and Computer Aided Tools

The construction of a system model is one of the steps in carrying out a simulation study [1]. The development of a process model prior to the development of a simulation model is required to aid in systems information collection and to reduce the effort and time consumed in developing a simulation model [3] (Fig. 2).

A process model describes the elements and components of a system and the interaction between them. One example of a process modelling method is the Integrated Definition (IDEF). The IDEF modelling method was developed as a set of notational formalisms for representing and modelling process and data structures in an integrated fashion [2]. It is comprised of IDEF0 (functional), IDEF1 (information), IDEF1X (data), IDEF3 (process flow and object state description capture), IDEF4 (object-oriented design) and IDEF5 (ontology description capture) [3]. IDEF0 and IDEF3 serve as the basis for describing processes [5]. IDEF0 is a method designed to model the decisions, actions, and activities of an organization or system, while IDEF3 captures precedence and causality relations between situations and events of an organization or system [4]. IDEF and other modelling techniques (Petri Nets, UML, BPMN, etc.) in simulation modelling enhance the quality of simulation models.

SIMULATION LEVELS	SIMULATION TOOLS	ProCAST®	Flow3D®	DEFORM®	Workspace5®	Autodesk® Moldflow®	CAD/CAE/CAM TOOLS	VERICUT®	Tecnomatix Robcad®	DELMIA Automation®	Tecnomatix®	DELMIA®	ProcessModel®	iTHINK®	ARENA®	ProModel®	SIMUL8®	WITNESS®	MODELLING TOOLS USED
OPERATION	CASTING METAL	1	1																
	MOULDING PLASTICS					2													
	FORMING / SHAPING			1															
	MACHINING						4												
	ASSEMBLY																		
	OTHERS																		
MACHINE	CNC MACHINES							1											
	ROBOTS									1									
	OTHERS																		
WORKCELL	MANUAL ASSEMBLY																		
	AUTOMATIC & ROBOTIC ASSEMBLY								1										Flowchart & other
										1									*
PRODUCTION SYSTEM	PROCESS PLANNING / WORKFLOW													1					DFD & other
																	1		*
													1						Modular Manufacturing Simulator
											1								Flowchart
											1							1	Metaheuristics
																		1	Activity Based Costing model
	PLANT DESIGN											1							*
															1				Analytical model
																1			Flowchart
															1				IDEF0
															1				Petri nets & other
	ENTERPRISE PLANT SET																		

* No modelling tool description available.

Fig. 2. Simulation levels, modelling technologies and number of research works

3 Proposal for Collaborative Manufacturing Simulation

The research approach includes the latest developments explained above and a framework for the collaborative simulation. This collaboration is based on previous works done in collaborative process planning and aims to complete the activities to be done during the integrated product and related processes development. The proposal includes the workflow for the collaboration and the selection of the modelling technique that is most suitable for the simulation level analysis, mapping the tool as described in the previous figures (Fig. 3).

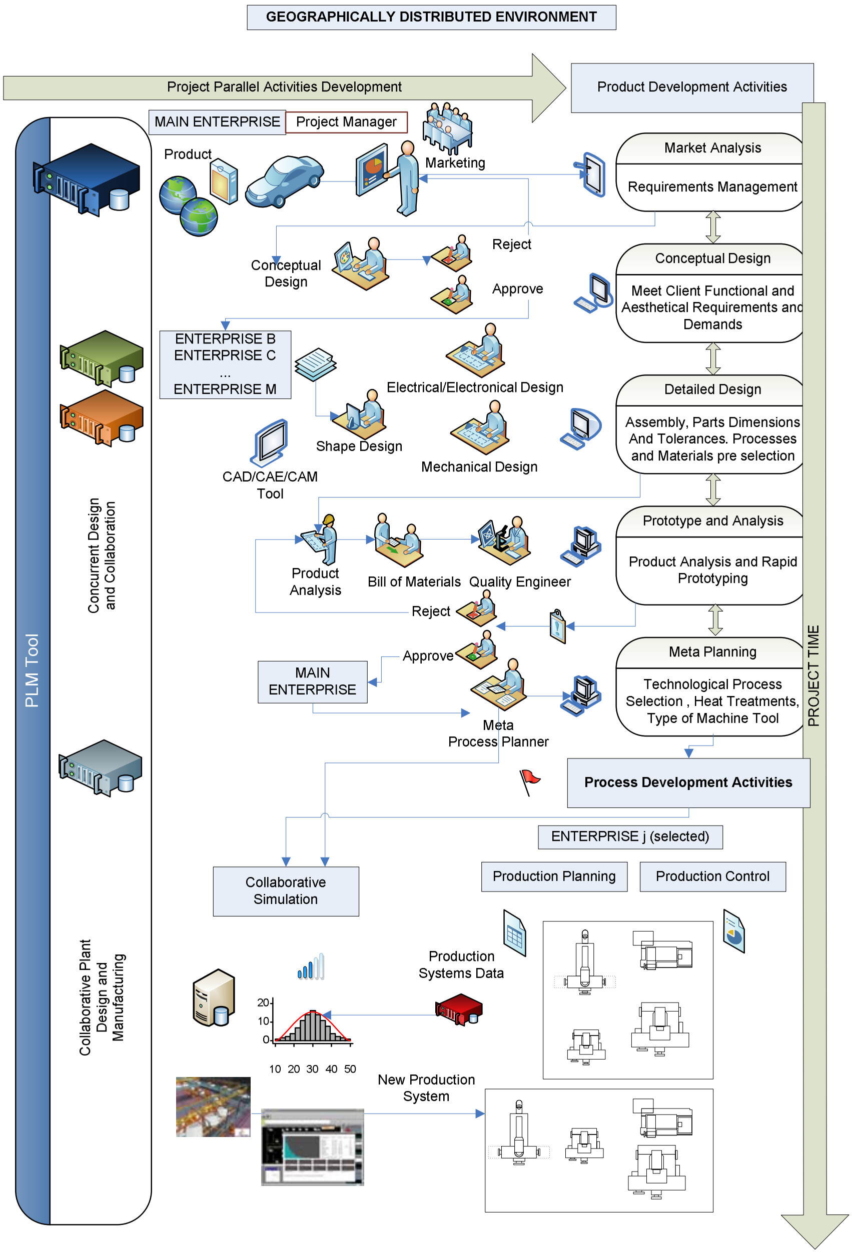

Fig. 3. Collaboration across the product lifecycle

The collaborative simulation involves the collection of data from the production systems selected by the main contractor. Once the metaplan (production technologies and resources) has been approved, there is a close collaboration between both companies. Here a simulation analysis is needed prior to the production launch and also during production in order to assist operations management. The proposal has two main objectives: to help select the correct modelling technique and simulation tool and to establish the data exchange in order to implement collaboration in this stage.

5 Conclusions

The Collaborative Product Development Processes in an extended enterprise environment requires the use of modelling methodologies to facilitate the implementation of automated workflows to enable the required collaboration across the supply chains. Although collaboration is really needed in the early stages little work has been done in collaborative engineering during the production planning and control stages. Modelling of shop floors and production systems is crucial for knowing how the systems act but simulation can be a helpful tool for the future in adaptive manufacturing.

Frameworks are needed for the use of these techniques and tools in order to continue the collaboration begun during the design phases and future work should be in this direction.

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Collaborative Web-Enabled GeoAnalytics Applied to OECD Regional Data

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Abstract. Recent advances in web-enabled graphics technologies have the potential to make a dramatic impact on developing collaborative geovisual analytics (GeoAnalytics). In this paper, tools are introduced that help establish progress initiatives at international and sub-national levels aimed at measuring and collaborating, through statistical indicators, economic, social and environmental developments and to engage both statisticians and the public in such activities. Given this global dimension of such a task, the "dream" of building a repository of progress indicators, where experts and public users can use GeoAnalytics collaborative tools to compare situations for two or more countries, regions or local communities, could be accomplished. While the benefits of GeoAnalytics tools are many, it remains a challenge to adapt these dynamic visual tools to the Internet. For example, dynamic web-enabled animation that enables statisticians to explore temporal, spatial and multivariate demographics data from multiple perspectives, discover interesting relationships, share their incremental discoveries with colleagues and finally communicate selected relevant knowledge to the public. These discoveries often emerge through the diverse backgrounds and experiences of expert domains and are precious in a creative analytics reasoning process. In this context, we introduce a demonstrator "OECD eXplorer", a customized tool for interactively analyzing, and collaborating gained insights and discoveries based on a novel story mechanism that capture, re-use and share task-related explorative events.

Keywords: Collaborative web-enabled geovisualization, Geovisual Analytics, collaborative time animation, storytelling, OECD regional statistics.

1 Introduction

The major tenets of Web 2.0 are collaboration and sharing, be it of content or technology. The term 'Web 2.0' has become undisputed linked with developments such as blogs, wikis, social networking and collaborative software development. Web 2.0 can make dramatic impact on developing interactive and collaborative geovisual analytics (GeoAnalytics) tools for the Internet. Tools are needed that advances humans ability to exchange gained knowledge and develop a shared understanding with other people [1]. Stimulate brainstorming and problem-solving through creative and incremental discovery and develop a contextual collaborative understanding - commonly referred to as geospatial "analytics reasoning" are important tasks to solve.

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While the benefits of GeoAnalytics tools are many, it remains a challenge to adapt these tools to the Internet and reach a broad user community through sharable knowledge. In this context, we introduce a novel web-enabled toolkit GeoAnalytics Visualization (GAV) and associate demonstrator OECD eXplorer composed of GAV components facilitating a broad collection of dynamic visualization methods integrated with the Adobe© Flash© and Flex© development platform. OECD eXplorer focuses on the analytics reasoning aspects enabling statisticians to explore spatial, temporal and multivariate data from multiple perspectives simultaneously using dynamically linked views, discover interesting relationships, share their incremental discoveries with colleagues and finally communicate selected relevant knowledge to the public. These discoveries often emerge through the collaboration between expert domains with diverse backgrounds and are precious in a creative analytics reasoning process. We demonstrate the GAV Flash toolkit in the course of an emerging application domain facilitating visualization of socio-economic information at detailed territorial level that enable the analysis of regional differences and performance within a country and comparison of different areas across countries (figure 1).

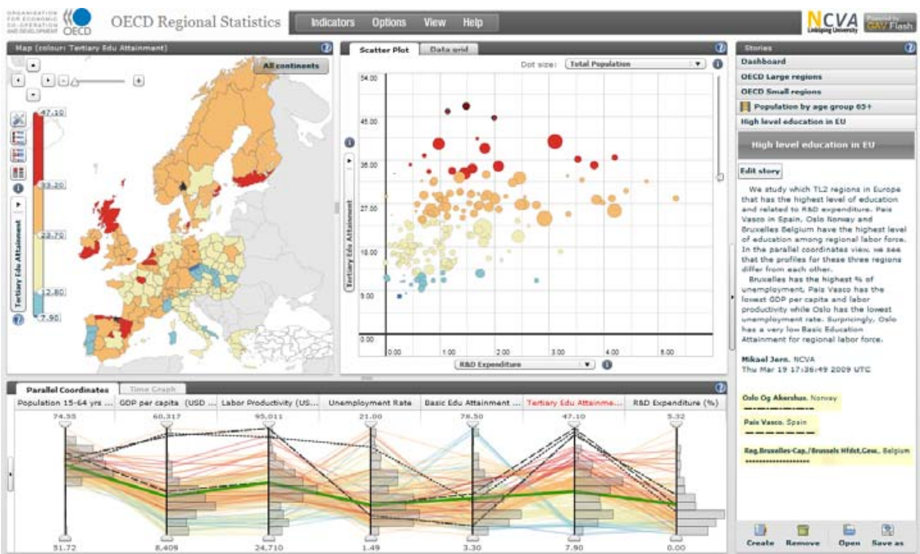

Fig. 1. Example of a geovisual analytics discovery that was captured on March 19th and saved as a story called “High level education in EU”. This story is once more opened and explained. The colour indicator represents “Percentage of labour force with completed tertiary education". Three regions, Pais Vasco Spain, Brussels Belgium and Oslo Norway have the highest education level among the labour force and are highlighted in all views. Their profiles (different line types) can be compared in the Parallel Coordinates view. Brussels has highest unemployment rate, while Oslo surprisingly has low basic education rate. Pais Vasco has lower GDP per capita than the others. The scatter plot shows a correlation between “R&D expenditure" and “Labour force with tertiary education". The Story (right panel) shows the metatext for current story and a list of associated stories. http://www.oecd.org/gov/regional/statisticsindicators/explorer

The main contributions of this paper can be summarized:

- Interactions, dynamic time animation and state-changes in an analytical reasoning process, such as visual inquiries or highlighted outliers but also linked views, can be saved during an explorative process through "memorized interactive views".
- A story records the status (attributes) of an explorative discovery including tasks, events, conditioning, dynamic linked views, region highlights, colour legend scale, results from filter or cluster operations and even novel time animation;
- Combination of a descriptive and conceptual text with an interactive and guided discovery process could improve not only the educational aspect but also the credibility of the sharable understanding of analytical results;
- A GeoAnalytics framework and class library for web developers with integrated service for communicating and collaborating analytical assessments to remote team members and public;

2 Related Work

The importance of a capacity to snapshot explorative sessions and then reuse them for presentation and evaluation within the same environment was early demonstrated by MacEachren [2] and Jern [3] in geovisualization and incorporated features to capture and reuse interactions and integrate them into electronic documents. CCMaps [4] presents a conditioned choropleth mapping tool that allows users to save snapshot events and reuse them for presentation purpose. More recent effort was made by Visual Inquiry Toolkit [5] that allows users to place pertinent clusters into a "pattern-basket" to be reused in the visualization process. [6] describes a method they call "Re-Visualization" and a related tool ReVise that captures and re-uses analysis sessions Keel [7] describes a visual analytics system of computational agents that support the exchange of task-relevant information and incremental discoveries of relationships and knowledge among team members commonly referred to as sense-making. Wohlfart [8] describes a storytelling approach combined with interactive volume visualization and an annotated animation.

Many capture and reuse approaches are limited to be used within the same application environment that may well require a software license and are not always easily accessible to team members without installing external software [9]. Increased computer security practice for statisticians could limit this possibility. In this context, we introduce a web compliant layered component toolkit facilitating a snapshot mechanism that captures, re-uses and shares active properties for individual functional components. We envision and demonstrate [10] that such an implementation could provide a more open and collaborative GeoAnalytics framework for public use.

3 The OECD User Perspective

OECD countries have experienced a growing interest in regional development in recent years [11]. The performance of regional economies and the effectiveness of regional policy help determine a nation's growth and shape the measure of well-being across countries. For the past years the OECD has been studying regional disparities and development patterns in its member countries in order to evaluate innovative strategies and spread successful policies.

This interest has generated new demand for sound statistical information at the sub-national level on factors that are important to regional competitiveness. The *OECD Regional database* [12] is a unique source of statistical information at sub-national level for all the OECD Countries. It contains yearly time-series for around 50 indicators on demographic, economic, social and labour market for more than 1,700 smaller regions of the OECD countries. OECD has since long felt the need to make regional data much more easily available on the web in an interactive and user-participative way. In particular, to make a more extensive use of dynamic web-enabled maps which can, more effectively than a graph, convey the four dimensions included in the regional database: statistical indicator, time variable, country value and regional value. In addition, timely information on the progress of a local community requires crossing different sources of information and new ways to generate and share information for decision-making.

Finally, many analysts and citizens want to create content and express themselves through "user-created knowledge" and a more pro-active, collaborative role in content creation, distribution and shared use. More active users and user-centred innovation could have increasing social impact and importance.

Target groups for such a knowledge-generating collaborative GeoAnalytics tool are quite diverse. A primary target group is policy-makers in charge of regional development policy, who can make use of this tool in their decision process. As well as statisticians and analysts involved in policy analysis and evaluations. Citizens and the media would also be able to get informed and at the same time participate in increasing the knowledge on how life is lived – and can be improved – from region to region. Because of the different expertise and needs of the target-groups, the tool should be flexible and adaptable to different audiences.

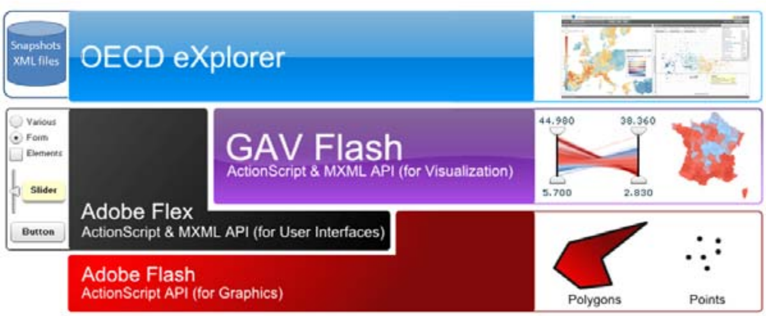

Fig. 2. OECD eXplorer is developed with the GAV Flash framework and class libraries

4 System Implementation

First developed for Microsoft's .Net and DirectX [13], [14], [15] our geovisual analytics methods have now been adapted for the Web 2.0 using Adobe's Flash basic graphics and Flex for user interfaces. Programmed in Adobe's object-oriented language ActionScript, GAV Flash (figure 2) facilitates 100% deployment to the Internet through Adobe Flash Player V10 - a requirement from OECD and its associated global statistics community.

GAV Flash includes a collection of common geo-visualization and information visualization components, data analysis algorithms, tools that connect the components to each other and data providers that can load data from various sources. Interactive features that support a spatial and temporal [16] analytical reasoning process are exposed such as tooltips, brushing, highlight, visual inquiry, conditioned statistics filter mechanisms (figure 1 and 4) that can discover outliers and methods supporting dynamically linked multiple views.

As GAV Flash is built upon Adobe Flex, a developer has access to all Flex user interface functionalities. By combining buttons, panels and sliders with GAV data providers, managers and visual representations, applications can easily be customized. The open architecture, allows new or existing tools to be incorporated with the already existing components, e.g. statistical analysis tools or visual representations. By

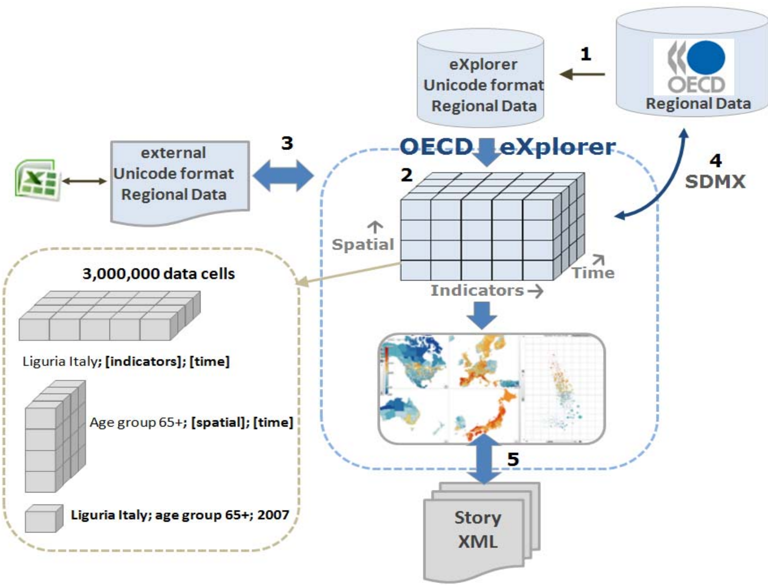

Fig. 3. 1) OECD regional data are transferred into a standard Unicode cell-structured data format; 2) Upon eXplorer start-up, space-time-indicator data are loaded into the GAV data cube for fast dynamic access by the dynamic linked views; 3) External indicator data for selected regions can be read providing an open data interface alternative; 4) a standard web SDMX database interface can load data direct from the OECD regional database or other database with SDMX support; 5) Stories are captured and saved as XML files with external data; The space-time-attribute data cube is used to conceptually explain the methodology in eXplorer's data handling. The data cube has three dimensions: geography (OECD regions), time (years), and attributes (indicators such as age groups, education etc). Each cell in the cube is defined by a specific spatial object (Liguria Italy), a specific time (year 1999), and a selected indicator (age group 65+). The value at that cell is the indicator value (Liguria, 1999, age 65+). Each of the around 2,000 regions is represented by a horizontal slice in the data cube.

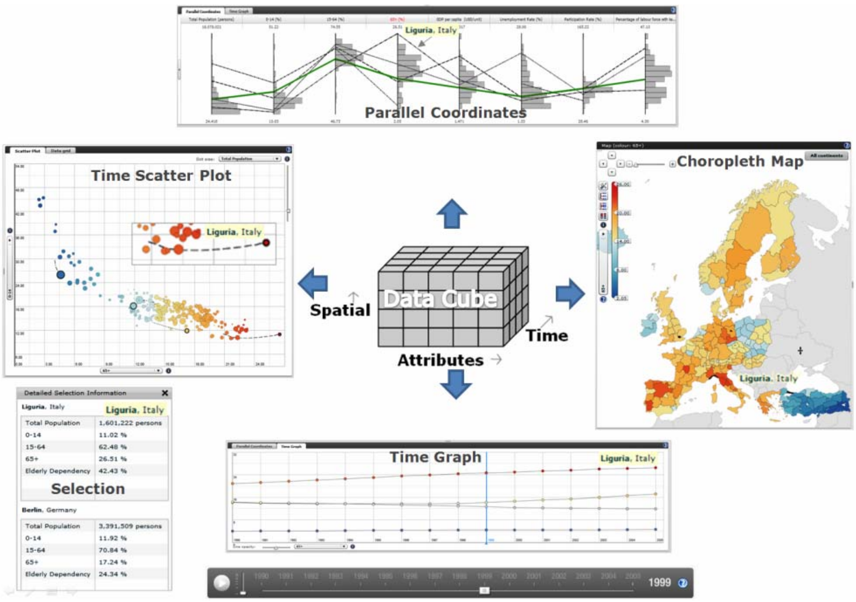

Fig. 4. OECD eXplorer helps the analyst collaborate patterns of events, relationships, and interactions over time within a geospatial context [16]. Selected regions are represented as "time profiles" in the Time Graph above for a given indicator. All five views are dynamically time-linked and updated with immediate smooth results. In the figure above, a region in Italy with high elderly population (65+) Liguria are highlighted in all views.

separating the data structure from the visual representations, applications are created that work regardless of input, so that data can be supplied from the outside and linked into the system with minimal programming skills (figure 3).

5 Collaborative Space-Time-Attribute Animation for Storytelling

Complex and collaborative geovisual analytics sense-making tasks require the external representation and visual organization of information. These methods could help sense-makers compare, organize, comprehend and reflect on what they know, to quickly access specific information when needed, to remember relevant thoughts and ideas, as well as to exchange knowledge and develop a shared understanding with other people. Computer generated information visualizations usually explicitly state relationships among information items thus allowing for quick and non-ambiguous explorations of an information space. Human generated information arrangements are often vague in regards to relationships thus inviting more creative interpretations of an information space. The GAV Flash Framework integrates tools for both collaborative interactive visualization and sense-making. A story indicates a successful suggestion and subsequently fosters additional suggestions based on similar considerations.

This learning mechanism allows our storytelling system to improve the accuracy of its suggestions as well as to dynamically adapt to particular users, tasks and circumstances. Colleagues can review a story arrangement and respond with suggestions and comments and subsequently fosters additional suggestions based on similar considerations.

OECD eXplorer facilitates the architecture to support means of capture, add descriptive text, save, packaging and sharing the discovery and results of a geovisual analytics process in a series of snapshots "Story" (figure 5). When the button "Capture" in the *Story Editor* is pressed, the state of each GAV Flash view (figure 1 and 4) in OECD eXplorer is saved together with user-defined metatext. Before closing the application, the user exports the story into a XML formatted file. Team members can through descriptive text combined with interactive visualization follow the analyst's way of logical reasoning by loading selected stories. At any time a team member can access stories and apply them in OECD eXplorer or any other GAV Flash application assembled from the same component. A comprehensive story in the context of a remote collaborative sense-making activity can thus be created by the analyst through a set of linked snapshots (chapters). Users will discuss relevant issues through storytelling based on solid evidence, thus raising awareness and increasing the common knowledge on a certain phenomenon.

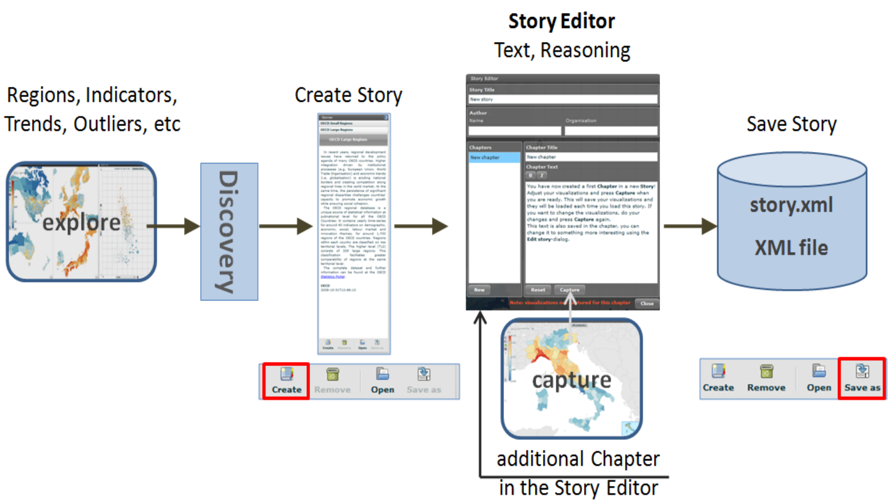

Fig. 5. During an eXplorer session, the analyst first selects regions to be analysed and associate indicators. Then a search for trends, outliers, discovers important observations, highlights regions to be compared etc. - a discovery is made! Secondly, open the Story Panel (right view), use button Create a Story, a Story Editor panel comes up, fill in the required information and associate reasoning text and finally press Capture , the entire current eXplorer scenario (all views and attributes) are saved together with selected indicators. The user can now start a second Chapter (New) and create a new scenario and repeat the process or Close and then use the button Save as , give the Story a name "my story nr 2".xml. The Story is now saved locally on your computer and can be reused Open or sent to a colleague for review in eXplorer.

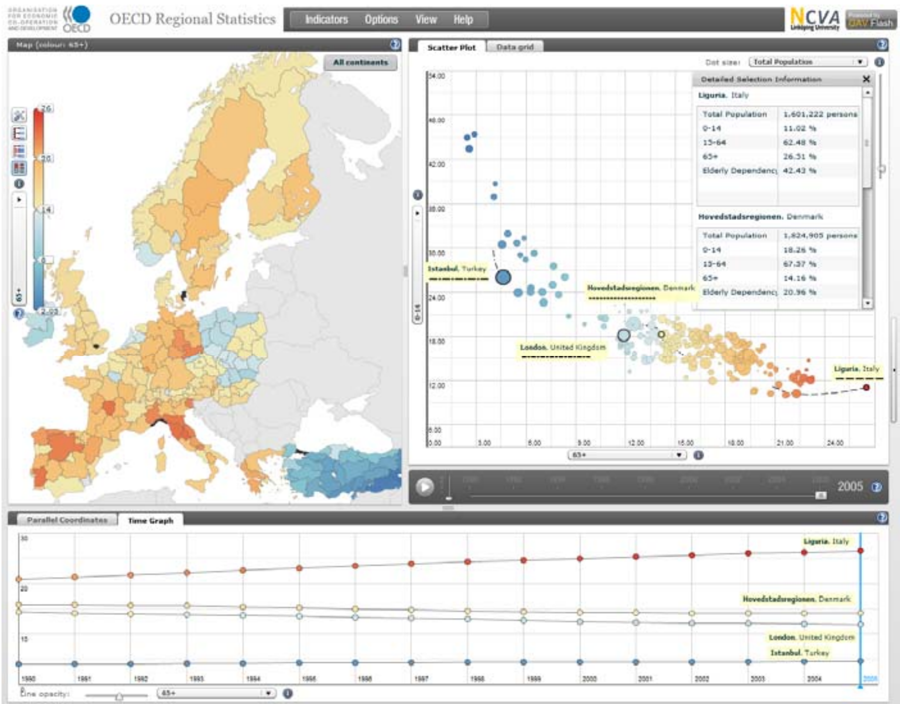

Fig. 6. Example of an explorative time animation discovery process that is captured and saved as a single story. Colour indicator represents "Percentage of age group 65+". The scatter plot shows a correlation between "age group 0-14" and "age group 65+" where dot size represents “Total Population”. Four regions are highlighted Liguria Italy (highest rate elderly people in Europe), Berlin, London and Istanbul and compared in the Time Graph.

5.1 Space-Time-Variable Time Step Animation for Collaborative Visualization

When a loading a time varying data set, eXplorer automatically changes into animation mode. This affects the views and settings in different ways. All five views (figure 4) are dynamically time-linked and updated with immediate smooth results.

The **Choropleth Map** shows smooth animated coloured regions for time steps. You can select one or several (ctrl and region) regions to be highlighted in all views. The **Time Scatter Plot** shows a coloured dot (selected colour indicator) and the correlation between 2 indicators along the X- and Y-axis and an optional 4th indicator that sets the dot size. The graph is dynamically updated for each time step. During an animation a tail is displayed showing the movements of the region related to the two axes indicators. The **Parallel Coordinates** animates the profiles for selected regions and time steps. Also the horizontal frequency histograms are animated. The **Time Graph** shows time lines for selected regions that can be compared over time. A small coloured dot for selected region and current indicator is displayed for every time step. The blue line can be moved to change time steps in all views. The **Detailed Selection View** shows the actual indicator values variations of time steps.

5.2 Collaborative Activity Levels

We envision four possible collaborative activity scenarios:

- OECD domain experts organize and explore task-relevant indicators to be communicated to team members and mixed expertise for comments. This group is responsible for selecting interesting story telling to the public;
- Mixed expertise organizes and explores task-relevant indicators relevant to their expertise; discovers important trends and relationships and communicate these discoveries to OECD team members;
- Same as above but these statisticians now want to share discoveries among team members and converge their individual contributions;
- Public users access OECD eXplorer and a repository of selected interesting stories to be viewed interactively. Public users can also create their own snapshots and share with colleagues or friends;

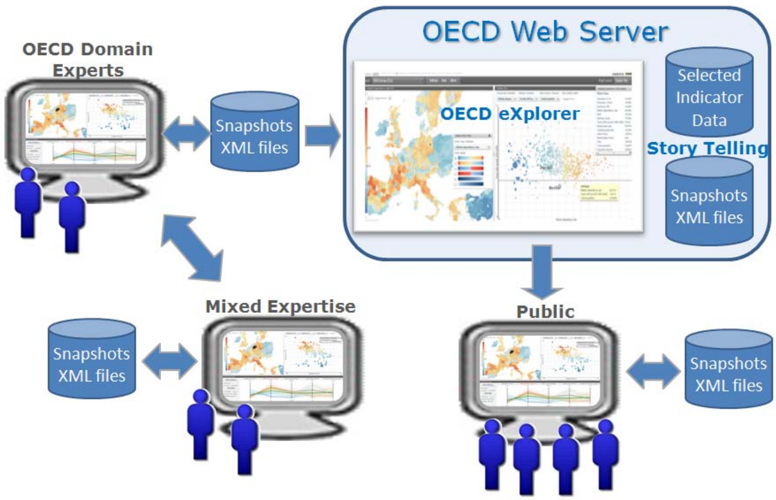

Fig. 7. Stories can be captured, saved and shared between domain experts and loaded by the public

6 Evaluation

The OECD eXplorer development followed a user-centric design approach [17]. A combination of domain experts from OECD, statistical managers and selected users of OECD statistics outside the organisation have been involved in the various stages of the prototype design and implementation, providing user feedback about usability and utility evaluation. The user-centric design process involved public access to beta versions of the web-based tool, allowing focus group discussions. The overall involvement and reactions have been very positive. Many useful suggestions for improving the functionality were made and have been incorporated in successive implementation iterations.

A number of characteristics of the current version of OECD eXplorer were derived from comments received during the evaluation phase. First, it became clear that there was a need of having help functions and tutorial features for dynamic web-enabled GeoAnalytics tools targeted to audiences whose expertise is not in geo- or information visualization technologies. Second, users asked to keep the entire structure sufficiently simple, while maintaining some functions to analyze data and not only visualize them. In this context, for example, the PCP was considered not to be self-evident to traditional users of statistics, as this is a technique that has not previously been employed in the statistics community and is not described in the methodological literature on statistics, and therefore it was decided to keep it hidden in the start-up phase; at the same time it was regarded as a valuable addition to the statistical toolbox, especially the possibility of dynamically filtering to discover outliers and use profiles to make comparisons between highlighted regions. The coordination between views (map, scatter plot, PCP and table grid) was evaluated as very important. Finally, the novel dynamic time-linked views and integrated storytelling were the most extraordinary appreciated tools.

7 Conclusions and Future Development

We expect that the web-enabled and collaborative nature of the OECD eXplorer [19] will enhance the use and understanding of OECD regional statistics, thus adding to sound, evidence-based policy decisions and transformed into shared knowledge. At the same time, it will encourage the practical use of advanced, collaborative GeoAnalytics science technologies because of its easy accessibility on the Internet. It will enable the analyst to take a more active role in the discovery process of exploring regional indicators, for example, to identify those regional areas that outperform other regions of their country or OECD mean values. The tool will increase the interest in and knowledge of regional structures and development patterns among specialist as well as non-specialist users. The patterns of development may differ widely in urban and rural areas and regions may lag behind even when the national economy is performing well. Feed-back from domain experts and statisticians who have started using the tool shows:

- A sense of analytical reasoning and speed-of-thought interaction is achieved through the ability to dynamically link views and thus see the multi-dimensionality of regional development;
- Importance of dynamic time linked views for interactive animation;
- Possibility to capture and save discoveries (including time animation) with attached analytics reasoning text;

NCVA has become an associated partner to in the OECD Global Project on “Measuring the Progress of Societies”. This “Wiki4progress” [18] project should represent the catalyst of initiatives existing around the world on the measurement of progress, as well as their use for raising awareness amongst stakeholders, informing them through statistical indicators describing economic, social and environmental trends and allowing them to discuss relevant issues through storytelling based on solid evidence. GAV Flash will provide geovisual analytics tools that can answer questions like:

- Who is developing initiatives on measuring progress (well-being, quality of life, etc.)?
- What type of classification do these initiatives use?
- Which indicators are being used to measure the different dimensions of progress?
- How is my country/region/community achieving over time and in comparison to other similar territories?

Wiki4Progress should represent **the** place where both experts and public could share their analysis practices on indicators, about the data that underlies our knowledge and hence our action. OECD eXplorer has indicated that GeoAnalytics could represent a fundamental tool in developing knowledge, thus making better evidence based decisions possible. Major achievements that can be summarized:

- GeoAnalytics framework and layered component architecture developed in the O-O language ActionScript with 100% deployment to Internet users;
- A proof-of-concept application OECD eXplorer developed and evaluated in close collaboration with domain experts from OECD and exposed to global statisticians;
- An O-O architecture facilitating the statisticians to explore data and simultaneously save important snapshots of discoveries or create a continuous story of snapshots to be communicated and shared with team or public;
- An ambition to develop a generic collaborative "eXplorer" platform that can be the foundation for easy customization of similar dynamic web applications using different geographical boundaries and indicators and be publicly available;
- Possibility to explore and collaborate trends over time (yearly time series) for the indicators in the regional database;
- Snapshot mechanism for presenting stories about the statistics embedded with interactive visualization and integrated into, for example, a HTML document structure;

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Visualizing Cooperative Activities with Ellimaps: The Case of Wikipedia

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Abstract. Cooperation has become a key word in the emerging Web 2.0 paradigm. The nature and motivations of the various behaviours related to this type of cooperative activities remain however incompletely understood. The information visualization tools can play a crucial role from this perspective to analyse the collected data. This paper presents a prototype allowing visualizing some data about the Wikipedia history with a technique called ellimaps. In this context the recent CGD algorithm is used in order to increase the scalability of the ellimaps approach.

Keywords: Information Visualization, Visualization of Cooperation, Ellimaps, Hierarchies Visualization, Wikipedia.

1 Introduction

Cooperative production of content exists for centuries (e.g. French Encyclopaedists of the 18th century) but it is only in the last decade that the availability of free and easy-to-use technologies has transformed it into a worldwide phenomenon. Wikipedia is probably one of the most impressive undertakings of this kind. Thousands of people collectively writing articles about thousands of topics without any financial reward would have probably been incredible some decades ago. Moreover, the quality of the content is amazingly of good quality [1]. However, this new model of diffusion of knowledge is challenging. Among others it raises the risk to diffuse inaccurate information in an apparently trustworthy form. Due to the high level of mean quality of the articles many people liken Wikipedia to a reference book by renowned experts, which it is not. Nevertheless, Wikipedia offers some advantages of a new type. Mistakes are rapidly corrected and the information is kept more up to date than on a printed support. Moreover, the history of its writing is made public, which offers the reader a way to assess the level of trust he/she can put in. Wikipedia will probably gain in the future more educational power than most of the books but it requires from the reader to have a critical judgment based on new forms of quality control. Considering these elements, it is of prime importance to undertake some research to better understand

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the fundamentals of Wikipedia, not only from the technical view point but also from the social perspective. This paper aims to contribute to this trend by providing a tool to visualize some Wikipedia data available on the Internet.

2 Visualization of Cooperative Activities on Wikipedia

2.1 Analysis Data and User Behaviour in Wikipedia

Considering that it represents one of the largest systems to create content in a cooperative way the online encyclopaedia Wikipedia has been studied from various view points since its emergence some years ago. Kittur et al. [2] investigated the concept of trust in Wikipedia. They carried out some experiments showing that "*the distrust of wikis and other mutable social collaborative systems may be reduced by providing users with transparency into the stability of content and the history of contributors*". Information visualization has started to be applied in this context. Viégas et al.'s "*History Flow*" tool [3] allows identifying various patterns of collaboration and negotiation among the contributors during the life of the articles. Suh et al. [4] proposed "*WikiDashboard*": a visual add-on to Wikipedia that shows the weekly edit activity of an article and the related discussion page. The activity of the most active contributors to the article is also visualized in this system.

Visualizing of some aspects of Wikipedia may support other elements than trust. For instance, Yang et al. [5] designed a tool that help visualizing the dynamics of graphs and took the example of Wikipedia to illustrate it.

2.2 Visualization of Hierarchies

Like most of the web sites Wikipedia is basically organized as a graph. Unfortunately representing large graphs is a challenging task that raises several issues, especially concerning the clutter reduction. A common strategy to visualize the structure of a web site is therefore to transform the graph into a tree by crawling into the pages from the root to the deepest leaves. It offers at least two advantages. First, a tree is easier to visualize than a graph. Second, the usual concept of web site depth is made clearly visible. Nevertheless, the weakness of this approach is that a single node in the graph can appear several times in the tree. We have, however, decided to adopt this strategy.

Representing large hierarchical structures has been well studied in the literature and several techniques have been used to visualize web sitemap (see [6] for a list of examples). Most of the available techniques to visualize hierarchical datasets basically rely on two perceptual paradigms: the nodes-links paradigm and the closure paradigm. In the former some punctual objects (points, icons…) are used to represent the hierarchy nodes and links visualize the relationships among them. In the *Gestalt* theory of perception it relies on the "*connectivity*" law (also referred to as "*connectedness*") saying that drawing lines among the items of a set is a powerful mean to show that some relationships exist among them [7]. The techniques relying on this paradigm are efficient to make visible the dataset structure. They are also very intuitive and easy to understand. Their major weakness concerns their relatively poor scalability. As they use the display space quite inefficiently (points and lines used few of the available pixels), they are not very adequate to visualize large datasets.

Nevertheless, numerous researchers have explored how to improve the weaknesses of node-links graphics (e.g. [8]).

The second paradigm relies on the "*common region*" and the "*closure*" laws. Briefly presented, these results of cognitive psychology [9] show that wherever a closed contour is seen, there is a very strong perceptual tendency to divide regions of space into *inside* and *outside* the contour. Venn and Euler diagrams perfectly illustrate the expressive power of these laws in a general context. The treemaps [10] and their numerous improvements (e.g. [11], [12]) also rely on this paradigm for the specific case of hierarchy visualization. The treemaps use nested rectangles but other techniques have explored how to use more complex primitive shapes (e.g. ellipses [13]; Voronoi diagrams [11]). Another strategy has been investigated by Vliegen et al. [14] who apply geometrical distortions to treemaps in order to make them similar to more common business graphics.

Beside those techniques that clearly belong to one of the two paradigms, we can also find some hybrid approaches. For instance, the Space-Optimized Tree [15] uses an enclosure-based rule to divide the display space but uses nodes and links to show the items and their relationships.

We have chosen to explore the use of ellimaps to visualize data related to Wikipedia. This decision is based on four arguments. First, the ellimaps are able to represent the weight of nodes. Second, an experimental study [13] has shown that they are efficient to make visible the hierarchical structure of the dataset. Third, a recent algorithm [16] has improved the space occupation, which was one of the major weaknesses of the initial version. Fourth, they have not been used so far in this context and their potential has still to be studied.

3 Prototype

3.1 Generic Features

In former projects we have developed and iteratively enhanced a Java-based prototype to visualize hierarchies (e.g. case of virtual platform monitoring [17], the improvements of the prototype can easily be noticed by comparing the figures of this paper to those presented in [17]). XML files are used as input. They can be retrieved from a file manager or from a relational database. A specific module allows mapping the data attributes to the appropriate visual variables. For instance, the node weight can be represented by the ellipses size in an ellimap and the node growth can be mapped to a monochromatic scale in a treemap.

This tool implements several visualization techniques. Some of them are very usual (e.g. tree, treemap, pie chart) and others are more original (e.g. various versions of ellimaps). The views are coupled in the main user interface (cf. Figure 1), which allows the user to navigate the dataset with his/her preferred one. The classic interaction features are also present, such as filtering, dynamic queries, tooltips or sorting. An unusual sorting function has also been implemented. It allows positioning the nodes (i.e. ellipses) with the largest weight in the middle of the view. This feature is intended to locate the most important nodes in the central zone of attention of the user (cf. Figure 1).

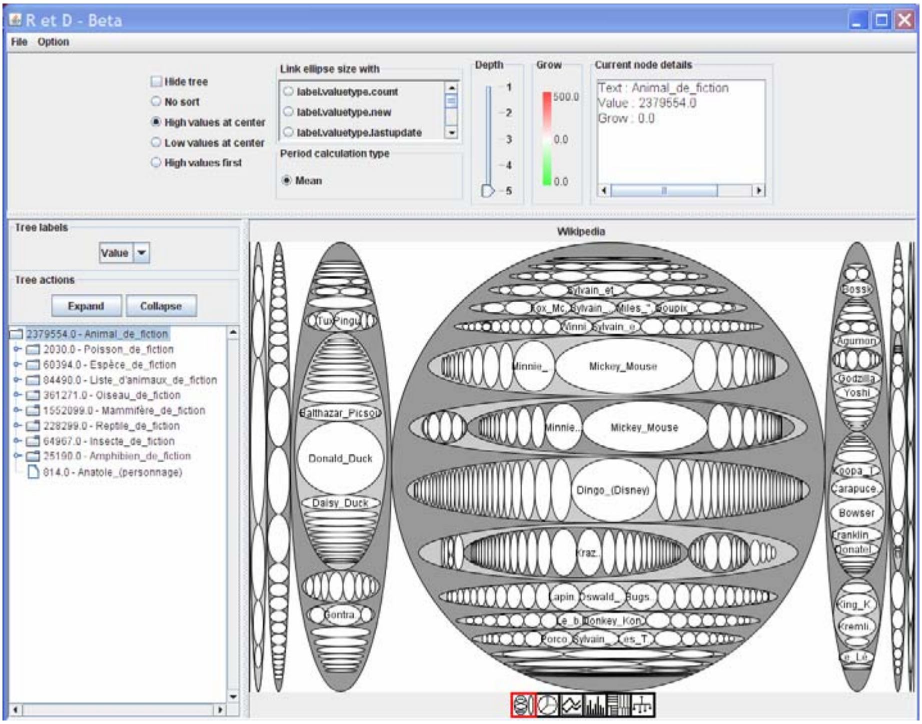

Fig. 1. Main user interface of the visualization tool

The tool also includes a reporting module to export the views in a picture format (used to produce Figure 2 to 5) and to generate detailed reports as *pdf* files.

3.2 Wikipedia Data Visualization

We have used the visualization tool (and especially the ellimaps view) to support the exploration of Wikipedia datasets. We identified several questions having a potential interest for analyzing the dynamics of the content production and the social behaviours of Wikipedia authors (see non-exhausting list below).

- *Q1: What is the relationship between the size and the age of an article?*
- *Q2: Which old articles have never been revised?*
- *Q3: What is the relationship between the size and the number of revisions of an article?*
- *Q4: When do anonymous users start contributing to the articles?*
- *Q5: How are distributed the references to the articles?*

Note that the social analysis itself is beyond the scope of this paper that rather aims to present the analysis tool. Nevertheless, we comment some of the pictures in order to illustrate how our tool can be used in practice.

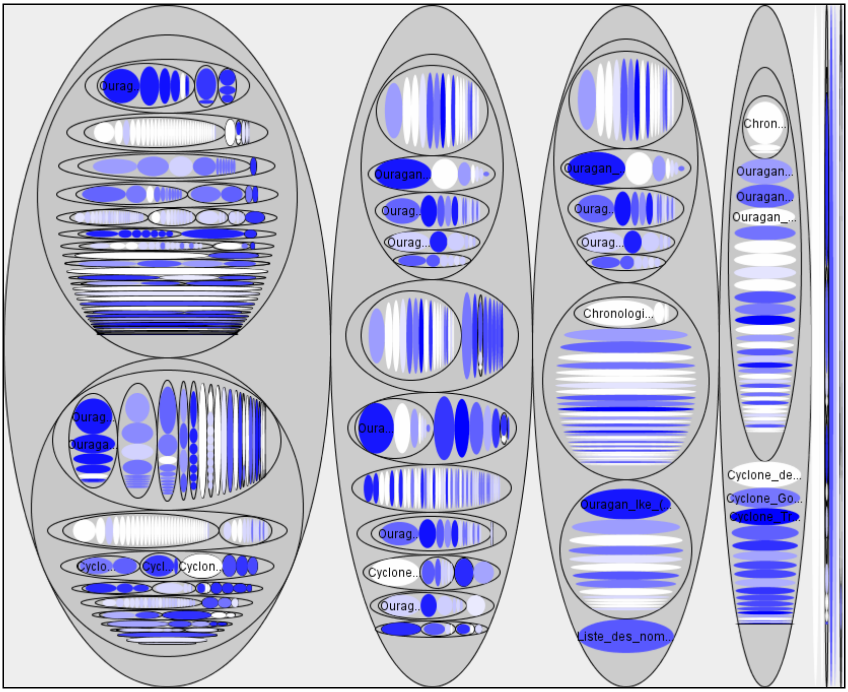

Fig. 2. Size vs. age of articles

First of all, we remind that the hierarchy leaves are the Wikipedia articles. In the ellimap view, they are visualized by ellipses. To explore the first question (Q1), the ellipse size is mapped to the article size (cf. Figure 2). A monochromatic scale (blue) is used to represent the temporal distance between the current day and the creation date of the article (dark blue = recent creation date).

In the case of Figure 2, there is no clear relationship between the age and the size of an article. We can observe the whole range of possible configurations. In order to analyze more thoroughly this issue, we can hypothesize that the articles that are simultaneously old and small might be abandoned items. This aspect can be analyzed by mapping the colour scale to the last modification date of the articles, which highlights the most recent updates.

We can also apply a filter to select only the articles that have never been modified (i.e. creation date = last modification date). If we apply a monochromatic scale (red) to the temporal distance between the current day and the creation date of the article (dark red = articles created for more than 500 days), we obtain the Figure 3. The old articles that have never been modified can be easily identified (cf. Q2).

It may also be interesting to study whether the long articles have been modified more often than the small ones (cf. Q3). The following configuration is appropriate in this case (cf. Figure 4). The ellipse size represents the article size and the monochromatic scale is mapped to the number of revisions (dark blue = many revisions). Note that the sorting option in decreasing order is activated in this figure.

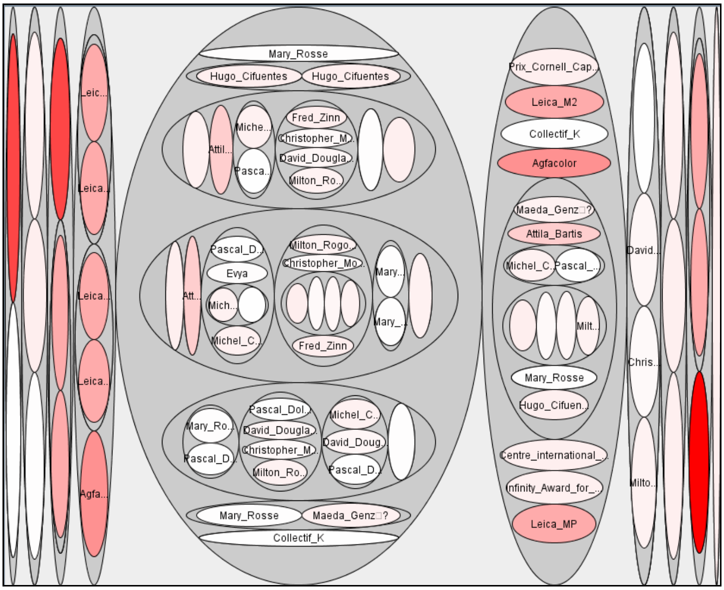

Fig. 3. Articles never modified

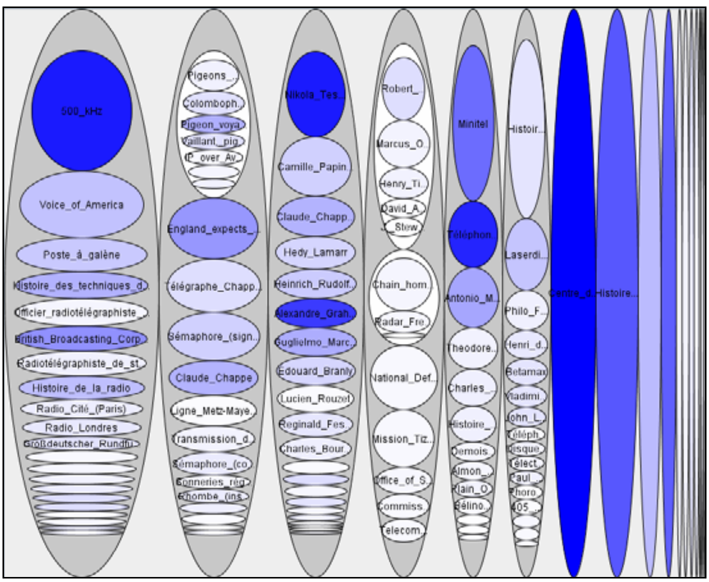

Fig. 4. Article size vs. number of revisions

The issue of anonymity (cf. Q4) is also important to analyze the Wikipedia articles. In this case (cf. Figure 5) the ellipses size is mapped to the number of revisions of the article and the ellipse colour is set to orange when the article is only written by identified users. When a least one author is anonymous the ellipses are painted in white. In the example illustrated by Figure 5, many articles (painted in orange) are revised only by identified users. However, all nodes of one specific branch of the hierarchy are always updated by at least one anonymous user (see the ellipse including only white smaller ellipses). Studying such special cases can raise interesting questions concerning the role of anonymity in Wikipedia.

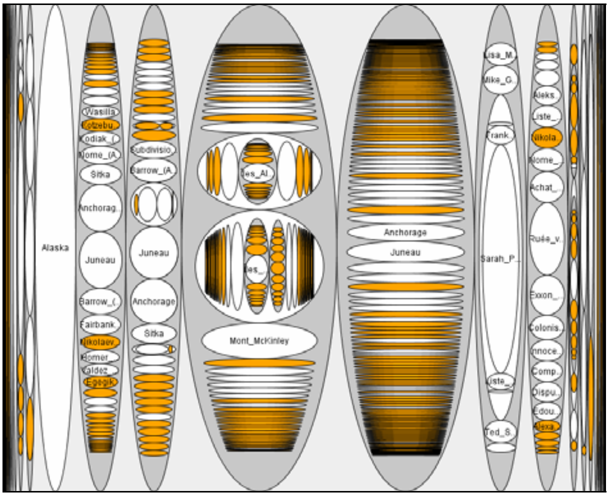

Fig. 5. Number of revisions vs. anonymity of users

It may also be useful to visualize the number of categories referencing the articles (cf. Q5). This aspect can be investigated with the following configuration. The ellipses size corresponds to the article size and a monochromatic scale is mapped to the number of categories referencing the article.

4 Conclusion

The dynamics of content creation and the social behavior of Wikipedia contributors have just started to be studied. Many aspects must still be investigated from a scientific perspective. In order to support such research works new tools are needed to get insight from the databases and history files available on the Internet.

Exploration with interactive visualization software is nowadays acknowledged as a powerful means to understand the relationships among the items of a dataset. This paper explores the potential of ellimaps in this context. Several examples are presented to show how our prototype can help answer to relevant questions about the cooperative authoring activities carried out on Wikipedia. However, our application is only a tool and the final purpose remains the understanding of the cooperative activities. The next step of our research will further analyze this element. For the future, we also aim to improve the features of our tool to tackle pending visualization issues, like highlighting cycles in the graph of articles.

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Exploring Context Semantics for Proactive Cooperative Visualization

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Abstract. Context-awareness offers opportunities in proactive adaptation of visualization services. The acquisition and representation of the user situation can better support the cooperative tasks, adapting the interactive services at run-time. This paper proposes a formal context model, based on Semantic Web languages, and providing interoperation between heterogeneous services and mechanisms for a dynamic definition of user interfaces.

Keywords: Semantic Web, Cooperative Visualization, Context-Awareness.

1 Introduction

Information Visualization provides a powerful mechanism to support user's activities carried out into intelligent environments. Context-aware systems respond to the situation changes, in a proactive way, and support the automatic adaptation of the user interfaces. The visualization in smart environments is studied from different perspectives. For example, the public displays have concerned considerable interest in recent years. There are increasing demands for ubiquitous and continuous access to information and for interactive and embedded devices. Typically, public displays can enhance the user collaboration and provide mechanism to coordinate multi-user and multi-location activities. The displayed information may offer an overview of the flow of work, revealing its status, enabling communication between users and the management of contingencies or unexpected situations [1].

The transition from the collaborative desktop computers to public displays brings up a wide range of research questions in user interfaces and information visualization areas. An attempt to make use of applications designed for desktop computers in public displays may lead to problems. An important difference is the spontaneous and the sporadic use of public displays, but the main question is the necessary adaptation to a variety of situations, multiple users and a wide range of required services.

Consequently, it is necessary to reconsider the design process and to provide proactive mechanisms in order to achieve a run-time generation of user interfaces. By enabling the representation of context information, the environment will be able to react to situation changes and determinate the services to be displayed. In this paper

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we introduce an infrastructure to generate visualization services at run-time through context-awareness based on the Semantic Web. The context-awareness is provided by a formal and ontological representation of the user's surrounding, as well as, the information visualization concepts and properties.

2 Information Visualization Model Based on the Semantic Web

The main challenges to generate context-driven visualization services at run-time are: (a) to determinate the relevant changes in the context elements and the correlation between these changes and the reconfiguration of the displayed user interfaces, (b) how make the heterogeneous visualization services interoperable in order to work together in a uniform way; several services should share information and complement one another, and (c) how integrate the set of services in order to be displayed into a homogeneous view.

By modeling the world around the applications and users, in a simplified way, through Semantic Web Languages (i.e. OWL, RDF and SQRL) is possible to deal with the above-mentioned problems.

The context model has been defined from two perspectives: Information Visualization and Ambient Intelligence issues. The first one is specially focused on general aspects concerned to perceptive and cognitive issues, graphic attributes, and data properties. The second one is about the recognition of environment characteristics to improve the information visualization. On the one hand, the environment issues are described through three OWL ontologies: (a) User Ontology, describing the user profile, his/her situation (including location, activities, roles, goals, etc.) and his/her social relationships, (b) Device Ontology, that is the formal description of the relevant devices and their characteristics, associations and dependencies, and (c) Physical Environment Ontology, defining the spaces distribution. On the other hand, an ontological definition of information visualization concepts and properties is also proposed. We have organized the ontology elements as follows: relationship between the visualization and the relevant elements of the context, metaphors and patterns, visualization pipeline issues, interaction paradigms and methods, view structure and characteristics, users' social organization, data properties and scalability aspects. The ontologies details can be look up at [2]. The correlation between these changes and the reconfiguration of the displayed user interfaces is defined by the Semantic Web Rule Language (SWRL).

3 Ontology-Driven Visualization Services

The run-time generation of views follows a component-driven process. The displayed views are called ViMos (Visualization Mosaics) [2] because they are formed by independent and related pieces of information compounding a two dimensional user interface. Initially, we have a whole set of information pieces. Analyzing users' situations (described in the context model) the best pieces are selected. Each one has several associated characteristics that have been described in the visualization information ontology and make the final generation of mosaics possible. The generation process is carried out by adapting the user interface according to the situation. Consequently, it is plausible to improve the dynamism, the adaptability and the content quality. The generation has six main steps: obtaining the current context situation, selection of required data, choice of the design pattern, determination of the appropriate pieces of information, design of the mosaic, and, finally, insertion of the interaction elements. This process is based on the contributions of Jesse J. Garret [3] that identifies the significant elements in the user experience at the time to develop web sites and multimedia applications. It is important to mention that Garret identifies the properties of user experience focusing on design-time development and we obtain these properties from our context-aware engine, at run-time.

3.1 Synchronous Collaborative Activities

Public displays placed in a context-aware environment support to a group of users working together at the same time and place, as well as, in different places. The context model acquires, analyzes and provides relevant information in order to improve the visualization of information. When several users begin the interaction with the display, the environment recognizes them, analyzes their situation and infers their information needs and their current tasks. Figure 1(a) shows two users reviewing documents in a public display. The relevant documents for both users are selected. Moreover, the ontological description allows us infer additional information through SWRL. Listing 1 shows an example of inference rules. The first rule establishes that a document topic can be assigned as a user topic of the document author. We also assume that several users, viewing the same displays, should receive a list of documents whose topics are interest for both users. This behavior is represented by the second rule.

Listing 1. SWRL Rules using context and visualization ontology concepts

```
/*Rule1:*/ Paper(?x) & paperTopic(?x,?y) & Topic(?y) &
author(?z,?x) => userTopic(?z,?y)
/*Rule2:*/ Document(?d) & workingIn(?u1, ?d) &
workingIn(?u2, ?d) & docTopic(?d,?t) & offered(?d2,
?u1) & docTopic(?d2,?t) => offered(?d2, ?u2)
/*Rule3:*/  Mosaic (?m1) & Mosaic (?m2) & interacting
(?u1, ?m1) & interacting (?u2, ?m2) & Agenda (?ua) &
define (?e,?ua) & consistOf (?ua, ?s) & Schedule(?s) &
Event(?e) & involve (?u1, ?e) & involve (?u2,?e) =>
synchronize (?m1, ?m2)
```

Additionally, it is possible to support synchronous problem solving by people in different locations. For example, the last rule determinates that the visualization have to be synchronize whenever two users, in different places, are interacting with public displays and the agenda contains a common activity (e.g. a virtual meeting).

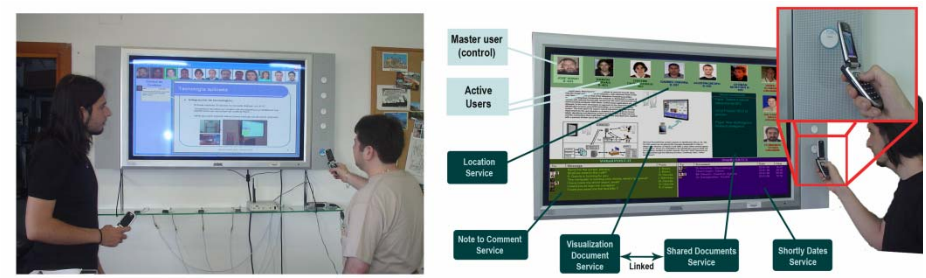

Fig. 1. Examples of synchronous (a) and asynchronous (b) information visualization services using public displays

3.2 Asynchronous Collaborative Activities

In a similar way, context-driven visualization improves asynchronous groupware applications. Users can define, embody, and manage workflow in the organization, they also can leave messages and document to other people using public displays, etc. Figure 1(b) shows a user viewing a document previously inserted by another one (using this display or other in any place)

4 Conclusions

This paper shows how context-awareness models and visualization techniques can be applied together in order to improve the proactive capabilities of cooperative applications at run-time. We are focusing on visualization services in public displays by applying formal knowledge representation techniques. In our case, by using description logics like OWL, users obtain relevant information at the right time, in an appropriate mode and through the most suitable device for each situation. The system's use peculiarities can be acquired at run-time and the visualization service be adapted to cooperative activities co-located or geographically distributed, and whether synchronously or asynchronously.

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DooSo6: Easy Collaboration over Shared Projects

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Abstract. Existing tools for supporting parallel work feature some disadvantages that prevent them to be widely used. Very often they require a complex installation and creation of accounts for all group members. Users need to learn and deal with complex commands for efficiently using these collaborative tools. Some tools require users to abandon their favourite editors and impose them to use a certain co-authorship application. In this paper, we propose the DooSo6 collaboration tool that offers support for parallel work, requires no installation, no creation of accounts and that is easy to use, users being able to continue working with their favourite editors. User authentication is achieved by means of a capability-based mechanism.

Keywords: collaborative systems, version control, capability-based security.

1 Introduction

Collaboration is a key requirement of teams of individuals working together towards some common goal and hence of importance to any organisation - be it business, science, education, administration or social. A great deal of information central to the operation of an organisation is held in documents and therefore support for sharing and collaboration over documents has to be offered.

In spite of the existence of specialised collaborative writing tools, very often when people want to collaboratively author a document they edit locally the document and then they send emails to the other members of the group transmitting them their version of the document as an attachment [12]. Users have then to manually integrate the changes done in parallel, which might become a difficult task.

Studies have shown that the most desired features users need for supporting their group work are control over document versions and concurrent access to the shared documents [12]. Concurrent access means that while a user is editing a document, the other users have the possibility to consult the document or edit it. However, existing tools that offer support for collaborative parallel work feature some complexities of use. The software must be correctly installed at the site of all users that collaborate independently of users operating system, users need to accept this software and it must be usable by all users. As shown in [8],

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installing and using software can pose several problems. Installation of software might be a difficult task for certain users. Moreover, very often learning how to use a tool requires a great deal of effort and users might easily abandon that tool. Furthermore, for certain users it might be a problem renouncing at their favourite word processors in order to use a co-authorship application. Moreover, existing tools for parallel work require that either each client opens an account or the project administrator creates accounts for each client and assigns clients to the collaboration group.

In this paper, we propose a collaboration tool over shared projects that offers the basic functionalities of a version control system for supporting parallel work and overcomes the problems mentioned above. Each user locally maintains a copy of the shared project. Users can perform modifications on their local copy and publish their changes at a later time on the repository containing the shared project at a later time. The collaboration tool requires no installation and no accounts for users. Using the tool is very easy and users do not need learning complex commands necessary for tool functionality. Moreover, users can edit their local copy of the project with their favourite editor and are not obliged to use an imposed editor. Furthermore, as group awareness is a very important feature of a collaborative system [5], we integrate some basic aspects that provide information about group members activity.

Concerning the aspect of easiness of use of our tool we were inspired by the shared agenda called Doodle [4] that helps finding suitable dates and times for group events such as an appointment, a conference call or a family reunion. Doodle is an online tool that does not require any software installation and no account creation for using a shared agenda. However, Doodle is limited to the use of a shared agenda and cannot be used for collaboration over shared projects.

For dealing with authentication issues we use a capability-based security [9] for restricting actions of updating the local workspace and publishing changes to the shared repository only to the members of the group that possess these rights.

The paper is structured as follows. In section 2 we start by presenting by means of an example the limitations of existing systems that offer support for sharing and collaboration over a project. In section 3 we present our DooSo6 collaborative system for supporting parallel work and we show that it is very easy to use. In section 4 we give some details about our synchronisation mechanism. Concluding remarks and directions for future work are presented in section 5.

2 Motivating Example and Related Work

Consider the example of two researchers of two different universities that wish to collaborate on a paper. They have several approaches for sharing the source documents of the paper. A first solution would be to ask the system administrators of their universities to create accounts for the remote user. However, this solution imposes an administrative burden that does not scale with a large number of users and projects and needs a careful analysis of the rights given to the external user. Often, the latency for opening an account is large and users cannot accept it. Moreover, sometimes institutions do not allow opening guest user accounts for people that do not work for that institution.

The two users could use individual word processors for editing the document and then sending each other emails containing as attachment versions of the document that integrate their changes. This work mode requires a good planning of activities. Integration raises no difficulties if people work sequentially. Manual integration in the case of parallel work can be easily performed by a coordinator if the document is well segmented and the different document segments are assigned to different authors. However, if the document decomposition is not possible and the number of collaborators is large, manual integration of parallel changes becomes complex. The number of exchanged document versions grows proportionally with the number of collaborators and therefore user changes in the exchanged versions are more difficult to be tracked.

Another solution would be that users put their documents on the web which is unacceptable as documents are often confidential. There exist some online document sharing services that offer solutions for a secured space which can be used as a virtual drive. Unfortunately, these solutions do not deal with concurrent modifications of the same document. Therefore, users have to manually perform versioning and merging of their shared documents.

Another option for the two users is to use real-time collaborative editors such as SubEthaEdit [14] to edit shared documents. These editors offer an awareness mechanism about the activity of the other group members as it shows the users that are editing a document at the same time. However, this solution requires that the two users install these tools and use these editors that they are not familiar with. Very often projects contain documents other than textual ones for which real-time editors might not offer support such as latex, code source or XML documents. These documents need to be compiled with special tools and they need to be kept in a stable state that prevents continuous integration of concurrent changes. Therefore, users need to make a copy of the shared documents each time they need to compile them. If, for resolving issues at compilation time, the users modify the local documents, they have to manually re-integrate their changes into the real-time editor. Manual integration is necessary as real-time editors do not offer support for work in isolation, i.e. users cannot work in their private workspaces and synchronise their changes with a shared repository. Moreover, these editors synchronise in real-time changes done on the same document, but do not synchronise changes targeting shared directories.

The burden of tool installation is eliminated in the case of web-based collaborative editors such as GoogleDocs [7] and ZohoWriter [16] at the price of necessity of creation of user accounts. All the other disadvantages previously mentioned for real-time editors hold for web-based collaborative editors.

Version control systems are popular systems for supporting parallel work. Centralised version control systems such as CVS [1] and Subversion [2] require that a server is installed by an administrator which has to create also user accounts for all project collaborators. Users have then to install the client applications.

Distributed version control systems such as Git [6], Darcs [3] and Mercurial [10] eliminate the need of a server, but require that users install locally the client applications. In distributed version control systems users maintain locally their data and their changes and can push their changes to different channels. Other users that have granted rights may pull these changes from these channels. These channels may be hosted on users' hardware. However, for maintaining channels permanently available for allowing authorized users to pull changes from those channels and for avoiding firewall problems, users of distributed version control systems often push their changes on dedicated servers that have to be installed for hosting their projects. Therefore, all version control systems require an installation process that might be difficult to be achieved by certain people. Moreover, these tools are quite difficult to be used by non developers as they require an understanding of how the system functions and a good knowledge of the set of commands.

This section proved the need of a collaborative system that offers support for parallel work, requires no installation and no burden for users to create accounts and log on for using the system. Moreover, the collaborative system should be easy to use. Users should be able to use their favourite editors for editing changes on the project and do not be obliged to use an imposed editor. Furthermore, group awareness mechanism about the activity of the other members of the group should be offered. In the next sections we present our approach that offers all these features.

3 DooSo6: Easy Collaborative System

The basic methods that have to be supplied by a collaborative system that supports the parallel work of a set of users are checkout, commit and update. A checkout operation creates a local working copy of the project from the repository. A commit operation creates in the repository a new version of the project based on the local copy, assuming that the repository does not contain a more recent version of the project than the local copy. An update operation performs merging of the local copy of the project with the last version of that project stored in the repository. In what follows we describe all the phases necessary for setting up and using the DooSo6 framework.

3.1 Project Setup

For setting up a project, the initiator of the collaboration has to create first a repository as shown in Figure 1. The project initiator is then required to fill in a title of the project together with a short description. As shown in Figure 2, the user is then provided with a link for the administration of the project such as deletion of the project, a link for committing changes to the repository and a link for updating changes from the repository.

These links represent system capabilities. A capability is defined to be a protected object reference which, by virtue of its possession by a user, grants that

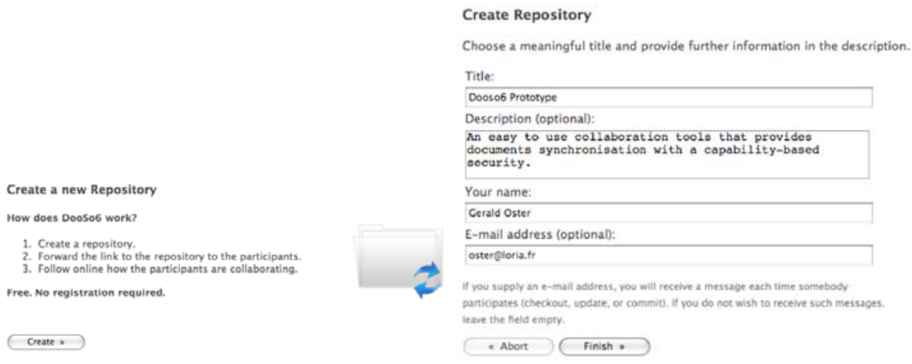

Fig. 1. Creation of a repository

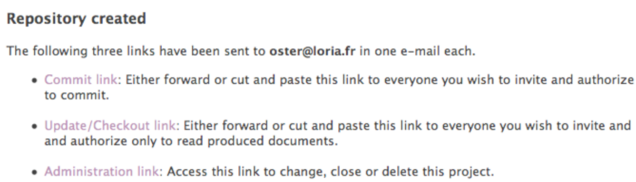

Fig. 2. Links that represent system capabilities

user the capability to interact with the object in certain ways. For instance, the `Administration link` in Figure 2 is a key that gives the initiator the right of administration of the project. The initiator is supposed to do not distribute the key to other users. On the contrary, the initiator should forward the key for committing to the repository and updating changes from the repository to the other members involved in the project. The commit and update keys offer users that are in their possession the capabilities of updating and committing respectively to the repository. It is possible that the key for updating is distributed to some users and these users do not receive the key for committing. It means that these members of the group have only the right to update changes from the repository and do not have the right of committing changes to the repository.

3.2 Check-Out/Update of the Project in the Local Workspace

For performing a check-out or an update a user has to follow the update link, being provided with the interface shown in Figure 3.

The user can see the list of the other members of the group that already checked out the project and started working on it. Each member is associated with his up-to-date status, i.e. the percentage of the number of commits in the repository that he integrated in his local workspace. If the user has not yet performed a checkout, his name does not appear among the members of the group. If, however, the user previously performed a checkout, the name that he

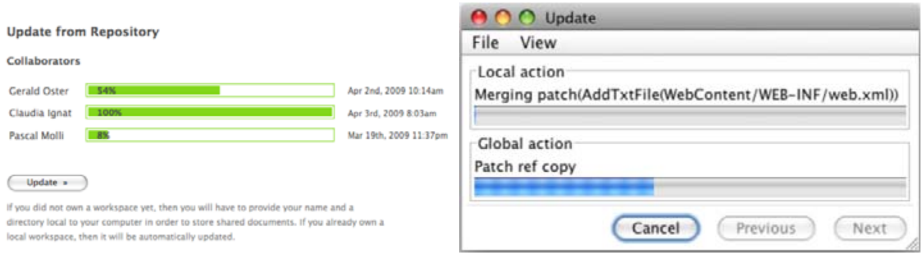

Fig. 3. Updating from the repository

provided appears in the list of names together with his up-to-date status. Note that user names are used only for awareness purposes and not for authentication.

When the `Update` button is clicked, the client application is downloaded and launched. This is achieved by using the Java web start technology. Server sends the update capability to the client application. If `Update` button is clicked for the first time, i.e. a checkout is performed, user is asked to provide a name and a path to a local directory where his copy of the project will be stored. This path is stored by the local file system and will be used for next updates. Afterwards, the local workspace is synchronised with the latest version of the project from the repository.

3.3 Committing Changes to the Repository

If the user wants to commit changes that he performed locally he is presented with almost the same interface as the one shown in Figure 3 with an additional `Commit` button. If `Commit` button is pressed and the user is not up-to-date, he is advised to perform first an update. If, however, the user is up-to-date, he can commit the changes he performed locally. Afterwards, the client application is started and commit procedure executed. The system automatically detects the patch of operations performed locally since the last update and sends this patch to the repository.

3.4 Why Collaboration Is Easy with DooSo6?

As we use a capability-based security mechanism according to which users that own a key have the right of updating or committing to the repository, we do not need to authenticate users by means of logins and passwords. Therefore, users do not need to create accounts and logins for using the system.

The facility of non-installation of software is achieved by means of technology. The system is written in Java which is a platform independent language and therefore we do not have problems of incompatibility between operating systems. By using the Java Web Start technology, our Java software application can be started by clients directly from the Internet simply by using a web browser.

Our collaborative system is easy to be used as users do not need to learn and type commands for publishing and synchronising their changes. Users have basically two buttons for activating the actions of updating their local version of the project and for publishing the changes to the repository.

Changes on the local copies of the shared project can be edited using any editor. At the moment when synchronisation is performed between the local project and the shared one in the repository, directories and files belonging to the project are synchronised according to their content (textual, XML or binary).

An awareness mechanism is offered for tracking group activity – users can see their up-to-date status of the project and the delay with which users follow the project. From our first experimentation we observed that, due to this awareness visualisation, users try to provide a good impression to the group by contributing and keeping their local copies of the shared projects up-to-date.

4 The DooSo6 Synchronisation Mechanism

In this section we present a short overview of the DooSo6 synchronisation mechanism. The DooSo6 system contains two main components: the DooSo6 repository and several DooSo6 workspaces associated to different clients. The DooSo6 repository hosts a timestamper and a sequence of patches of operations. A patch of operations contains a list of operations representing changes performed by a certain user. When a user executes a commit, the list of all operations locally performed is sent as a single patch to the repository. The list of operations is obtained by executing a diff [11] algorithm between the last updated and the current local version of the project.

A DooSo6 workspace stores all documents shared by a user. Operations locally performed by that user are saved in a log of operations. The DooSo6 workspace also keeps the timestamp of the last delivered/received patch to/from the repository. Initially the local timestamp is set to 0. When a user wants to publish his changes into the DooSo6 repository, he needs first to request a timestamp. According to this received timestamp the user is allowed or not to save his changes. If the timestamp received equals to the value of the local timestamp, the user is allowed to save his changes. A patch of operations containing the operations locally generated since the last time the user committed is sent to the DooSo6 repository. If, however, the timestamp received from the DooSo6 repository is greater than the value of the local timestamp, the user needs first to update his local workspace. The DooSo6 repository sends the workspace the list of unconsumed patches. The client then merges the list of operations representing the unconsumed patches with the local operations and applies them to the workspace.

The merge algorithm used by DooSo6 is adapted from SOCT4 [15]. The algorithmic description of the checkout, update and commit procedures is similar to the one of the same procedures presented in the So6 system [13]. The main difference between the DooSo6 merge mechanism and the So6 merge mechanism is that DooSo6 works with patches of operations while So6 works with operations.

5 Conclusion

In this paper we presented a very easy to use system for the collaboration over a shared project. Users do not need to open accounts for having access to the shared projects and do not need to learn any commands for using the system. Moreover, they can use their favourite editor for performing changes to the project. We use a capability-based security for restricting actions of updating and committing changes to the shared repository only to members of the group.

Currently, our system uses a centralised repository. Besides issues of limited scalability, lack of shared administration costs and limited fault tolerance, data centralisation is an inherent threat to privacy. In order to overcome these issues, we investigate to store repositories containing patches of operations on a distributed hash table.

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Scientific Literature Metadata Extraction Based on HMM

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Abstract. Metadata serves as an important role in the archiving, management and sharing of the scientific literatures. It consists of title, authors, affiliation, address, email, abstract, keywords, etc. However, the metadata is usually easy-to-read for human and difficult-to-recognize for computers. In this paper, we propose to improve Viterbi algorithm based on text blocks instead of words, increase the precision and recall based on unique characteristics of metadata items.

Keywords: Hidden Markov Model; Metadata Extraction; Viterbi Algorithm; Resource Sharing.

1 Introduction

In order to extract specific metadata from literatures, three types of information extraction models have been proposed, i.e., extraction models based on dictionaries [1] based on rules [2] and based on HMM (Hidden Markov Model) [3]. The use of HMM for information extraction is a machine learning based method. HMM is easy to establish, which need not large-scale dictionaries or rules sets. Because HMM has better adaptability, higher extraction accuracy, it has attracted the concern of researchers.

Most HMM information extraction models in the literatures used the word as the basic unit [3]. This will not only increase the algorithm's execution time, but reduce the precision of the algorithm. In order to meet the needs of literature layout, one metadata item may be divided into several text blocks and in turn each text block only corresponds to one metadata item. In this paper, we proposed a new algorithm to improve Viterbi algorithm based on blocks and unique characteristics of metadata items.

2 The Improved Metadata Extraction Based on HMM and Rules

2.1 A Typical Literature Header

In the following paragraph, the first and the second line denote the title; the third line denotes the authors; the fourth and the fifth line denote the affiliation; the sixth line denotes the address.

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Web Mining: Information and Pattern Discovery
on the World Wide Web
R. Cooley, B. Mobasher, and J. Srivastva
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Minneapolis, MN 55455, USA

2.2 HMM Parameters Determination

A HMM can be regarded as a five-tuple: $\lambda = (S, V, \pi, A, B)$. Hereinto, S is the state set; V is the vocabulary set; π is the initial state probability vector; A is the N*N state transition matrix; B is the N*M emission probability matrix. Detailed explanation can refer to literature [4]. The HMM can also be abbreviated as: $\lambda = (\pi, A, B)$.

Based on the cora dataset [5], we defined 10 states for HMM. Moreover, we added a final state. If one state is the last state in the header, we define that its next state is the final state. Therefore, we modify the matrix A into N * (N +1)-dimensional. We use machine learning algorithm to draw the parameters of HMM, by the following three formulas to calculateπ, A and B respectively.

$$\pi_i = \frac{Init(i)}{\sum_{j=1}^{N} Init(j)}, \quad 1 \le i \le N \tag{1}$$

Init(i) denotes the sequence number with the initial state i in all the training sequences that use text block as the basic unit.

$$\mathrm{a}_{ij} = \frac{C_{ij}}{\sum_{k=1}^{N} C_{ik}}, \quad 1 \le i \le N, \quad 1 \le \mathrm{j} \le N+1 \tag{2}$$

C_{ij} denotes the transfer number from state i to state j in all the training sequences that use text block as the basic unit. If state i is the last state in the sequence, then $C_{i(final)}$ += 1.

$$\mathrm{b}_{jk} = \frac{\mathrm{E_j}(V_k)}{\sum_{i=1}^{M} \mathrm{E_j}(V_i)}, \quad 1 \le j \le N, \quad 1 \le \mathrm{k} \le M \tag{3}$$

$E_j(V_k)$ denotes the number that state i emits word V_k in all the training sequences that use word as the basic unit.

2.3 Literature Metadata Extraction Process

The literature metadata extraction process can be divided into two steps:

Step 1 Text pre-processing: divide the text into blocks, and compute the emission probability of each block. Based on the layout format information, we can transform the literature header into text block [6] sequence. The emission probability of each text block is the sum of that of the words in the text block. Assume that the block sequence is: $O = O_1O_2 \ldots O_T$, and the length of the t^{th} block is K (i.e., it contains K words), $O_t = O_{t1} O_{t2} \ldots O_{tK}$. The probability that state j emits the t^{th} block is:

$$b_{jO_t} = \sum_{k=1}^{K} b_{jO_k} \tag{4}$$

Step 2 Input a text block sequence $O = O_1O_2 \ldots O_T$, and output the most likely state sequence using the Viterbi algorithm.

2.4 Improve the Viterbi Algorithm Based on Unique Characteristics of Metadata Items

The text block-based Viterbi algorithm has better performance. However, some metadata items can't strike a balance between the precision and the recall. One of the reasons for this phenomenon is that some characteristics of the metadata items have not been fully utilized. For example, an email must contain an @ symbol, a web address must begin with http or ftp, etc. If we use these characteristics to revise the text block emission probability b_{jOt}, the precision and recall of the extracted metadata items should both be increased.

These metadata extraction rules are as follows:

Rule 1. If a text block O_t contains "@"or "email", then it must be emitted from state "email" (B[state("email"), O_t] = 1 ^ B[!state("email"), O_t] = 0.00001); else, it must not be emitted from state "email" (B[state("email"), O_t] = 0.00001).

Rule 2. If a text block O_t starts with "http" or "ftp", then it must be emitted from state "web".

Rule 3. If a text block O_t starts with "keywords" or "index items", then it must be emitted from state "keyword".

Rule 4. If a text block O_t contains a substring that satisfy a phone regular expression, e.g., "\([0-9]{2,3}\)[0-9]{2,4}-[0-9]{4}", then it must be emitted from state "phone".

3 Experiment and Result Analysis

We use the dataset provided by CMU University CORA search engine group for testing[7]. The dataset provided 935 literature headers with HTML tags. We evaluate the algorithm performance using the precision and recall, which are defined as follows:

Precision for each state is defined as the number of text blocks with the correct tag for the state divided by the total number of text blocks with the machine tag for the state.

Recall is defined as the number of text blocks with the correct tag for the state divided by the total number of text blocks with the manual tag for the state.

Table 1. Metadata Extraction Precision and Recall Comparison for Special Items

Metadata Items	Word Based		Block Based		Characteristic Based		Total Blocks
	Precision	Recall	Precision	Recall	Precision	Recall	
title	0.929515	0.490128	0.868421	0.920930	0.886463	0.944186	215
author	0.694268	0.699839	0.881657	0.861272	0.916168	0.884393	173
affiliation	0.839806	0.814118	0.846154	0.923664	0.873646	0.923664	262
address	0.618875	0.802353	0.902703	0.907609	0.939227	0.923913	184
email	0.860544	0.630923	0.854167	0.872340	0.921569	1.000000	94
web	1.000000	0.261905	1.000000	1.000000	1.000000	1.000000	9
phone	0.942857	0.407407	1.000000	0.647059	1.000000	0.882353	17
date	0.636364	0.954545	0.846154	0.970588	0.868421	0.970588	34
abstract	0.815534	1.000000	0.966171	0.976077	0.977642	0.986329	1463
keyword	0.824561	0.887395	0.878049	0.765957	0.877551	0.914894	47

We use 800 headers as training data, and use the rest 135 headers as test data. Test results are as shown in table 1. Hereinto, the second and the third column data are taken from reference [8].

From table 1 we can see that, the recall for metadata items “title”, “author”, “affiliation”, “address”, “email”, “web”, “phone”, “date” of the block-based is much larger than that of the word-based. The recall for metadata item “abstract” of block-based is slightly less than that of the word-based, but its precision is much larger than the latter. The reason is as follows: in a text block, some words belong to characteristic words, such as “department” and “university” in an affiliation; other words belong to non-characteristic words, such as the specific institution names. When a word is taken as the basic unit, these non-characteristic words extraction can only rely on the transition probability. However, if a text block is taken as the basic unit, so long as the block contains at least one characteristic word, the block as a whole is easy to achieve correct extraction, so it improves the precision and recall.

In table 1, the precision and recall of the characteristic-based for all metadata items is much larger or equal to that of the block-based, especially the items “email”, “phone” and “keyword”. The reason is that the unique characteristic is more than one common characteristic, which has a decisive impact on the status of a text block. In other words, if a unique characteristic appears, then we can determine which state emits the text block. By revise the block emission probability to 1, the precision and recall of these items will be improved.

4 Conclusions

In this paper, we described an approach to extract metadata item from the scientific literature. The text block is used as the basic extraction unit. Block-based approach can reduce the impact of the state sequence caused by single word. In order to improve the precision and recall of the metadata extraction, we summarize four rules to revise the text block emission probability for the Viterbi algorithm. The experiment results show that the precision and recall have been greatly increased.

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An Ontology-Based Collaborative Design System

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Abstract. A collaborative design system architecture based on ontology is proposed. In the architecture, OWL is used to construct global shared ontology and local ontology; both of them are machine-interpretable. The former provides a semantic basis for the communication among designers so as to make the designers share the common understanding of knowledge. The latter which describes knowledge of designer's own is the basis of design by reasoning. SWRL rule base comprising rules defined based on local ontology is constructed to enhance the reasoning capability of local knowledge base. The designers can complete collaborative design at a higher level based on the local knowledge base and the global shared ontology, which enhances the intelligence of design. Finally, a collaborative design case is presented and analyzed.

Keywords: Collaborative design, Ontology, Semantic, Intelligence.

1 Introduction

Collaborative design means that many experts complete a design together with the support of computer technology. Abundant knowledge will be involved in the design process, so the description and utilization of knowledge is the key for collaborative design. Firstly, different designers have different comprehension of knowledge. If there is a uniform knowledge representation model to provide a semantic basis for the communication among them, it will disambiguate knowledge comprehension. Secondly, knowledge engineering has been applied in collaborative design such as [1] and [2], which makes the intelligence of design somewhat enhanced. However, because the knowledge is not machine-interpretable, the design can't proceed at a higher level. Ontology is applied into collaborative design to describe domain knowledge in this paper. It does not only provide a semantic basis for the communication among designers, but implements collaborative design based on machine-interpretable knowledge as well which enhances the intelligence of design.

The rest of this paper is organized as follows: Section 2 presents the modeling primitives and the description language of ontology; Section 3 presents the architecture and key techniques of collaborative design system based on ontology; Section 4 presents a case and the analysis; Section 5 concludes the paper and discusses future considerations.

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2 Ontology and OWL

2.1 Summary of Ontology

Ontology is a formal specification of a shared conceptualization [3]. It can be used to capture knowledge about the domain of interest and makes people share common understanding of the structure of information.

Ontology can explicitly describe domain knowledge through its basic modeling primitives: classes, properties, restrictions and individuals. Domain knowledge comprises abundant concepts and classes can be defined by extracting some of these basic concepts which constitute the framework of domain knowledge. Properties can describe the features of classes and relations among classes. To describe some constraint information, ontology provides the definition of restrictions. Individuals represent objects from the perspective of semantics. Ontology provides a representation of a shared conceptualization of a particular domain that can be communicated between people and applications [4]. So as a formal declarative knowledge representation model, ontology provides a foundation for machine understandable knowledge, which in turn makes machine intelligence possible [5].

2.2 OWL and Its Logical Basis

Ontology provides a model for knowledge expression and it should be represented by some special language so as to make domain knowledge machine-interpretable. OWL[6], namely web ontology language, which has the capacity of both knowledge expression and reasoning supported can be used to construct ontology. It is based on description logic which describes domain knowledge through concepts corresponding to one predicate and roles corresponding to binary predicate. A knowledge base based on description logic comprises two components, TBox and ABox. TBox which is the sets of concepts and roles assertion can be defined as follows.

$$\text{TBox}=\{Ci \subseteq Di | 1 \leq i \leq n1\} \cup \{Cj \equiv Dj | 1 \leq j \leq n2\} \cup \{Rk \subseteq Sk | 1 \leq k \leq m1\} \cup \{Rl \equiv Sl | 1 \leq l \leq m2\} . \quad (1)$$

Where, C and D are concepts, R and S are roles. ABox which is the sets of individual assertion can be defined as follows:

$$\text{ABox} =\{ C_j(a_i) | i , j \in I \} \cup \{ R_k (a_i , a_j) | i, j, k \in I \} . \quad (2)$$

An inference based on description logic includes subsumption test, equivalence test, satisfiability test in TBox and instance test in ABox. All of them can come down to satisfiability test as follows:

(i) $C \cap \neg D$ is unsatisfiable $\Rightarrow$ $C \subseteq D$;

(ii) $(C \cap \neg D) \cap (D \cap \neg C)$ is unsatisfiable $\Rightarrow$ $C \equiv D$;

(iii) $A \cup \neg C(a)$ is unsatisfiable $\Rightarrow$ $A=C(a)$;

Based on the analysis above, description logic has strong knowledge representation ability. It provides the basis for OWL to describe knowledge at semantic level.

OWL provides three increasingly expressive sublanguages OWL Lite, OWL DL and OWL Full. OWL DL is based on description logic SHIQ[7]. It is more expressive than OWL Lite and decidable, nevertheless, OWL Full is just opposite, so we employ OWL DL in our work.

3 Architecture and Construction of Ontology-Based Collaborative Design System

The architecture of ontology-based collaborative design system is shown in Fig. 1. Ontology can be constructed through extracting domain knowledge by protégé, etc. There is a global shared ontology and local knowledge base comprising local ontology and SWRL rule base in the system. The local ontology mainly describes domain knowledge of designer's own, which is the basis of knowledge-based reasoning. SWRL rule base complements the rule definition based on local ontology, which enhances the reasoning capability of local knowledge base. Some structured data can be stored in the database which complements the local knowledge base. It has a mapping relationship between global shared ontology and local ontology. Different designers can share the common understanding of knowledge by ontology translation between them. They can communicate with each other by communication platform on the base of global shared ontology. The inference engine pellet, racer, etc. can be used to maintain ontology especially for large-scale ontology through satisfiability test and implement rule-based reasoning.

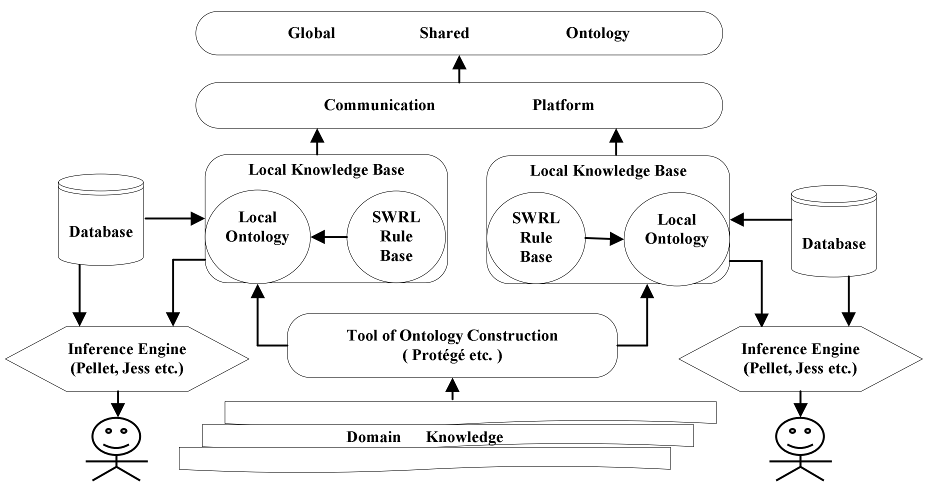


Fig. 1. Architecture of collaborative design system based on ontology

3.1 OWL Ontology Construction

Classes constitute the framework of domain knowledge. They are defined by extracting some domain concepts and have a good hierarchical structure which can be seen in the form of Fig.2, a die ontology constructed in protégé. Among these classes, the lower grade is the subclass of the upper grade which reflects an inheritance relationship. However, not all classes have inheritance relationships. For example, die carrier comprises four parts: lower bolster, upper bolster, guide bushing and guide tube. It is unsuitable if lower bolster is defined as the subclass of die carrier because there is a whole and part relationship between them. So they are defined as the subclass of "universalParts" and "assiatantStructureParts" respectively in this paper.

To represent the characteristics of classes and relationship among classes, ontology provides the definition of property. It comprises ObjectProperty and DatatypeProperty. Fig.2 shows parts Properties of the die ontology. For example, punching workpiece is processed by die and punch. "isProcessedBy" can be defined as the ObjectProperty of punching workpiece, with which the die and punch can be associated. Thus it can be seen that ontology is not only the accumulation of domain concepts, but also making the concepts associate with each other which forms machine-interpretable "sentence". This allows ontology represent knowledge at semantic level.

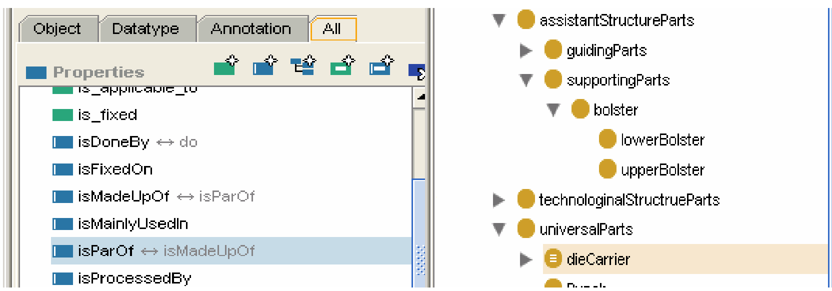


Fig. 2. Classes (right) are defined by OWLClassesTab and properties (left) are defined by PropertiesTab in the die ontology

The hierarchical division of classes embodies the vertical relationship among classes. However, there are also lots of horizontal relationships among classes such as dependency relationship, etc. Properties can be used to determine such relationships, but they cannot restrict these relationships. Restrictions can further clarify the relationships among classes through its constrained attributes. The constraint type of restriction mainly include: AllValuesFrom corresponding to universal quantifier of DL, someValuesFrom corresponding to existential quantifier of DL and hasValuesFrom. The assembly relations among the parts of die can be represented through restrictions. For example, the restrictions added to die are as follows:

Restriction 1 : isFixedOn allValuesFrom (fasteningPlateOfDie or bolster)
Restriction 2 : isFixedOn someValuesFrom (fasteningPlateOfDie or bolster)

The two restrictions above represent die must be fixed on fastening plate of die or bolster, determining the horizontal relationship among them through restricting the fixture of die.

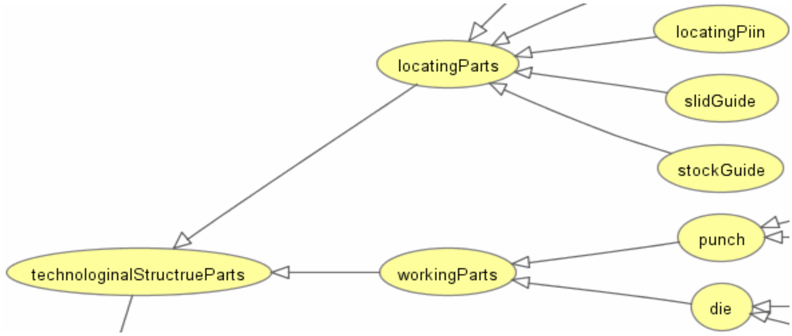


Fig. 3. It shows parts class diagram of technological structure components using OWLVizTab, a plug-in in protégé. In this figure, the ellipses represent classes. The arrows represent the lower grade is the subclass of the upper grade. They have "is-a", namely inheritance relationships.

Based on above research, we can find that ontology can completely describe knowledge at semantic level through its basic modeling primitives. Fig. 3 shows parts of technological structure Components defined in the die ontology.

3.2 SWRL Rule Base Construction

OWL has a strong ability of knowledge representation but not possess the function of defining rules. SWRL, namely Semantic Web Rule Language, can make up this limitation. It is a language that based on a combination of the OWL DL and OWL Lite language with the Unary/Binary Datalog RuleML sublanguages of the Rule Markup Language [8]. It complements the definition of rule based on OWL so as to improve the reasoning ability of ontology.

SWRL comprises two parts: antecedent and consequent. The conditions specified in the consequent must hold whenever the conditions specified in the antecedent are satisfied. Both the antecedent and consequent consist of a series of atoms. The form of these atoms mainly include C(x), P(x, y), etc. where C and P is the class, property which has been defined in OWL respectively. x and y are the individuals have been defined in OWL or Variables added external. To enhance the expression capacity of SWRL, the built-ins are introduced, such as swrlb:lessThan(?x, ?y), swrlb:add(?z, ?x, ?y), etc. Some SWRL rules are added to local knowledge base. We take the design of punch and die as an example. The calculation formulas for the dimension in the working portion of punch and die are as follows:

$$dp = d + x \times \triangle \ . \tag{3}$$

$$dd = dp + Zmin \ . \tag{4}$$

where, dd, dp are the nominal dimensions of the punch and die respectively ; d is the nominal dimensions of the punching workpiece; △is the tolerance of blanking working; Zmin is the minimum clearance between the punch and die; x is a coefficient, relevant to the tolerance grade of the workpiece: when the tolerance grade is over IT10, x=1; when the tolerance grade varies form IT11 to IT13, x=0.75; when the tolerance grade is below IT14, x = 0.5.

(i) the value taking of x:

cuttingWorkpiece(?x) ∧ gradeOfTolerance(?x,?y) ∧ swrlb:lessThan(?y,11)→ modulusX(?x, 1) (1)

Rule (1) defines the value taking of x when tolerance is 10 or higher.

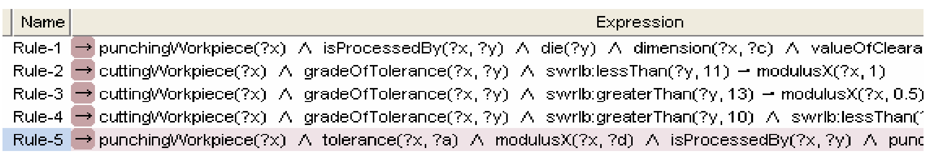
(ii) the inference of dimension of die and punch:

punchingWorkpiece(?x)∧tolerance(?x,?a)∧modulusX(?x,?d)∧isProcessedBy(?x,?y) ∧ punch(?y) ∧ dimension(?x,?c) ∧ swrlb:subtract(?e,?a,?d) ∧ swrlb:add(?b,?c,?e)→ dimension(?y,?b) (2)

punchingWorkpiece(?x) ∧ isProcessedBy(?x,?y) ∧ die(?y) ∧ dimension(?x,?c) ∧ valueOfClearance(?y,?d)∧swrlb:add(?e,?c,?d)→dimension(?y,?e) (3)

The valueOfClearance in rule (3) depends on both the material and the thickness of working piece. It can be stored in database.

From the description above, we can see that SWRL represents rule information through the classes and properties have been defined in OWL, which enhances the reasoning ability of ontology. SWRL can be edited by SWRLTab (shown in Fig.4).



Name	Expression
Rule-1	→ punchingWorkpiece(?x) ∧ isProcessedBy(?x, ?y) ∧ die(?y) ∧ dimension(?x, ?c) ∧ valueOfCleara
Rule-2	→ cuttingWorkpiece(?x) ∧ gradeOfTolerance(?x, ?y) ∧ swrlb:lessThan(?y, 11) → modulusX(?x, 1)
Rule-3	→ cuttingWorkpiece(?x) ∧ gradeOfTolerance(?x, ?y) ∧ swrlb:greaterThan(?y, 13) → modulusX(?x, 0.5)
Rule-4	→ cuttingWorkpiece(?x) ∧ gradeOfTolerance(?x, ?y) ∧ swrlb:greaterThan(?y, 10) ∧ swrlb:lessThan(
Rule-5	→ punchingWorkpiece(?x) ∧ tolerance(?x, ?a) ∧ modulusX(?x, ?d) ∧ isProcessedBy(?x, ?y) ∧ punc

Fig. 4. SWRL edited by SWRLTab (a Plug-in in protégé)

4 Implementation of the Collaborative Design System

4.1 A Case about the Design of Die and Punch

It is assumed that there are two designers A and B, both of them choose Jess as the inference engine. They call Jess by java application program. Now A should accomplish a task, designing the dimension of die and punch. The design parameters are respectively: process: punching; material:brass; the dimension of punching workpie: 36mm; thickness: 0.5mm; grade oftolerance: IT14; tolerance:0.62.

A accomplish the design of punch through its own knowledge base in local. The reasoning process and result are shown in Fig. 5.

```
    input the tolerance of the workingpiece
0.62
INFO: Loading triples
INFO: Start processing ontology: file:/D:/program/Die/punching2.owl Time:
INFO: [ProtegeOWLParser] Importing http://www.w3.org/2003/11/swrl (from ht
INFO: [ProtegeOWLParser] Importing http://www.w3.org/2003/11/swrlb (from h
INFO: [ProtegeOWLParser] Importing http://swrl.stanford.edu/ontologies/3.3
INFO: [ProtegeOWLParser] Importing http://swrl.stanford.edu/ontologies/bui
INFO: [ProtegeOWLParser] Importing http://swrl.stanford.edu/ontologies/bui
INFO: [ProtegeOWLParser] Importing http://swrl.stanford.edu/ontologies/bui
INFO: [ProtegeOWLParser] Importing http://swrl.stanford.edu/ontologies/bui
INFO: [ProtegeOWLParser] Importing http://swrl.stanford.edu/ontologies/bui
INFO: [ProtegeOWLParser] Completed triple loading after 15360 ms
INFO: [TripleChangePostProcessor] Completed lists after 10 ms
INFO: [TripleChangePostProcessor] Completed anonymous classes after 151 ms
INFO: [TripleChangePostProcessor] Completed deprecated classes after 50 ms
INFO: [TripleChangePostProcessor] Completed properties after 110 ms
INFO: [TripleChangePostProcessor] Completed named classes after 140 ms
INFO: ... Loading completed after 22363 ms
Rule engine 'SWRLJessBridge' registered with the SWRLTab bridge.
the modulusX of punchingWorkpiece is 0.5
the dimension of Punch is 36.31
```

Fig. 5. Reasoning process and result of punch

But A doesn't know how to design "die" which works with punch. A send a message that who can design the dimension of die when punching through the commutation platform in a broadcast way. B received this message, but he doesn't know the meaning of "die" in the message. This time B can inquire global sharing ontology. After inquiring B knew the meaning of "die" is the same as "die block" in its own knowledge base. Then B informs A to transfer the design parameters and accomplish the design of "die block" through its own knowledge base based on punch whose design has been accomplished by A. The collaborative design result of "die" and "die block" are shown in Fig. 6.

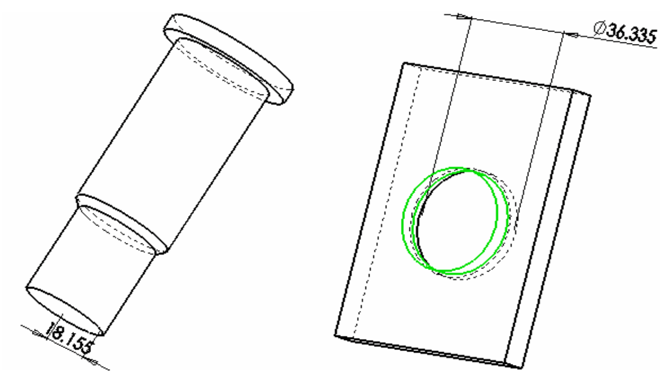


Fig. 6. Result of punch designed by A and die block designed by B

4.2 Case Study

Based on the case above, we can see that the global shared ontology provide a semantic basis for the communication between designers A and B which makes them understand each other, so B can know the meaning of the message send by A. Then they accomplish the task through their local knowledge base respectively. A and B stored the knowledge about punch and die block in their respective ontology-based knowledge base which has both good knowledge representation and reasoning ability supported. Computer can take advantage of this knowledge to design at a higher level, realizing knowledge driven collaborative design so as to improve the intelligence of design.

5 Conclusion

Aiming at the different understanding of domain knowledge for different designers and the intelligence in collective design, the architecture of ontology-based collaborative design system is proposed in this paper. Due to the machine-interpretable of ontology, the knowledge described through ontology not only enabling commutation among designers at semantic level as global shared ontology, but also providing the basis of reasoning as local ontology. Besides, SWRL rule base is constructed to enhance reasoning ability of local knowledge base. Above all, the intelligence of collaborative design is enhanced by the application of ontology. But ontology can only describe explicit knowledge. fuzzy knowledge representation needs further study to refine our system in future.

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Parallelizing the Design and Development of a Monitoring System

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Abstract. We describe a software framework to shorten the design and development time of complex monitoring systems. The use of a message exchange format allows the division of a monitoring system into two simpler ones that can be solved concurrently: an ad-hoc expert system and a sensor framework. Hence a shorter development time is required. The expert system's usability is improved to facilitate the real-time visualization of the reasoning process. The communication between the expert system and the sensor framework makes use of the Intrusion Detection Message Exchange Format (IDMEF), which allows higher level cooperation between the software design and security experts.

Keywords: visualization, cooperative engineering, collaborative design.

1 Introduction

The activities of the software development process have typically been: requirements; design; implementation; verification; and maintenance. These activities are needed and used in some way in all the Software Development Life Cycle (SDLC) models [8]. To build application domain knowledge, it takes an enormous effort from the development teams until the project finishes. And the domain application experts have few things to do to collaborate except teaching development teams about problem domains and how to validate their work.

What we propose to solve this problem is a message format to communicate domain-specific experts and a rule-based engine in order to allow experts to create reasoning rules from the content of the message. The purpose of the message format is to contain all the information needed to describe a security or dependability event. More specifically, the message format that we use is IDMEF [1] (Intrusion Detection Message Exchange Format). Furthermore, the message exchange format will allow domain experts to collect and create complex detection and decision-making logic, isolating the software development team from this task. At the same time, development teams can use any type of tool, protocol or language to gather the needed information as long as it is finally translated to the proper format.

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We have an event-driven architecture, depicted in Fig. 1, in which the software development team is in charge of the architecture development, including: event probes (also called sensors); parsers to extract the information from different application logs; or the communication between components. At the same time, experts will be able to create the rules inside the *Detection* and *Decision* components. The *Detection* component correlates the events so that it can detect attacks against the system and the *Decision* component can advise possible solutions to the problem. The difference between these two components is the rules they contain. Both components may be used by the domain experts just adding rules and redirecting the incoming and outgoing events. In order to reduce the design and development even more, we propose the use of a Message-Oriented Middleware (MOM) to increase the interoperability and flexibility of the system. We have used this MOM following a publish/subscribe paradigm.

Finally, although understanding the logical reasoning followed by the rule-based system may be suitable for the expert who created the rules, it may be a bit difficult for other experts or system administrators who will use this tool. They may have or use other rules to get the same conclusion. Users need to know the process followed by the system in order to achieve their final conclusion. For this reason, we have also developed two visualization tools that will help system administrators to understand the reasoning process followed by the experts. Furthermore, these tools are web based so that multiple users can visualize the current status of the system and its progress concurrently and in real time.

The remainder of the paper is organized as follows. Section 2 presents a detailed description of the proposed architecture. The visualization interface is explained in section 3. Section 4 compares the Engineering and Development Model proposed with a traditional Spiral Model. To demonstrate the feasibility of the proposed framework, an illustrative example is explained in section 5. Section 6 addresses related work. Finally, conclusions are drawn in section 7.

2 Description of the Proposed Architecture

This section describes all the components of the final architecture, depicted in Fig. 1b), and their pros and cons. This architecture is the evolution of the

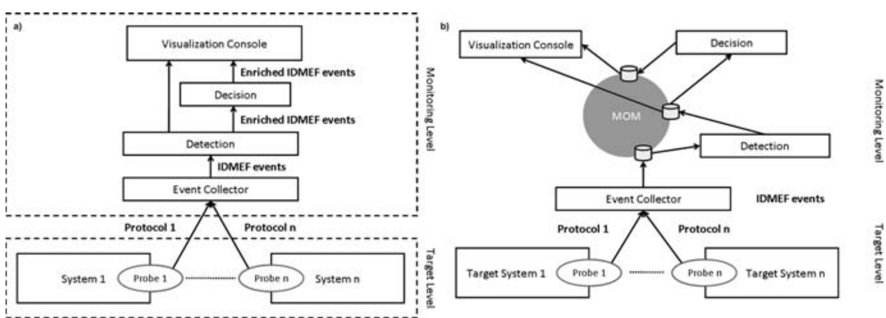

Fig. 1. Detailed System Architecture using a publish/subscribe MOM

architecture proposed in Fig. 1, which is made using the proposed Message-Oriented Middleware (MOM) in a subset of the communications between components.

2.1 Reasons to Use the xmlBlaster MOM

The first reason to use a publish/subscribe approach is that it is an asynchronous messaging paradigm. We need to receive events from applications that do not wait for an ACK. These applications cannot be slowed down by the monitoring system. The second reason is that publishers of messages are not programmed to send their messages to specific subscribers. Instead, messages are published into topics, without knowledge of what subscribers there may be. Subscribers express interest in one or more topics, and only receive messages from those topics.

We have chosen xmlBlaster from the available MOM products because we want to be open to as many languages as possible and we also want an open source product. The xmlBlaster server is pure Java under LGPL license.

2.2 Detail Description of the Components

In this section we describe all the components of the architecture depicted in Fig. 1. We can distinguish the *Target Level*, which comprises all the elements our system will monitor, and the *Monitoring Level* that comprises the components created by us and not deployed in the target system.

The target level may contain any application that can be under attack or that can give us information about possible attacks. This includes application servers, firewalls, intrusion detection systems, other monitoring systems, etc. It also contains the probes that will send information to our monitoring system.

There are different types of probes that can be divided into two big subsets taking into account the work they do: passive probes, that only send the logs produced by the applications; and the active and more intelligent probes that can make calculations and send higher level information. The passive ones may typically be Syslog and Syslog-ng. Examples of the active ones are PreludeIDS (`http://www.prelude-ids.com`); Snort (`http://www.snort.org`); or Nagios (`http://www.nagios.org`). These systems can provide very detailed information that allows taking the role of a security expert that has used all those systems. Between the passive and active ones there is a set of probes that calculates more specific measurements. Passive probes are very useful to check the behavior of target systems in a non-intrusive manner. Active probes are usually installed in target networks and their purpose is to detect intrusion incidents.

The monitoring level comprises only our components in order to create the monitoring system. These components are:

- The *Event Collector* receives events in different formats, through different protocols, and parses them producing IDMEF events. In this component we can filter the events before parsing them with the aim of discarding

the unnecessary ones. Only the useful IDMEF events are published in an xmlBlaster topic, which will be received by the *Detection* component.
- The *Detection* component receives the IDMEF events and puts them in the working memory of its rule engine. It will produce enriched events that will assess the monitored system.
- The *Decision* component receives the events published by the *Detection* component. As the *Detection*, the *Decision* component runs the rule engine but containing the output events of the decision logic. The final output is a set of enriched events with possible reactions to fix or mitigate the detected attack.
- The *Visualization Console* component allows users, system administrators or domain experts, to both monitor the current status of the system and assess the reactions proposed by the system.

2.3 Advantages of the Component Breakdown

The *Detection* and *Decision* components contain exactly the same code. Particularly, they contain the same rule engine and the same interfaces. What makes them different is the set of rules the expert can insert in them. In other words, this component can be used by domain experts to set up the rules and redirect the input and output to the desired topic. Both components receive IDMEF events and send also IDMEF events to the next components.

The visualization console uses the IDMEF events to show experts the current status of the system and its evolution. For this reason the user of the console just needs to know how to read IDMEF events. The use of IDMEF and Drools allows that changes in the expert logic will not affect the visualization tools.

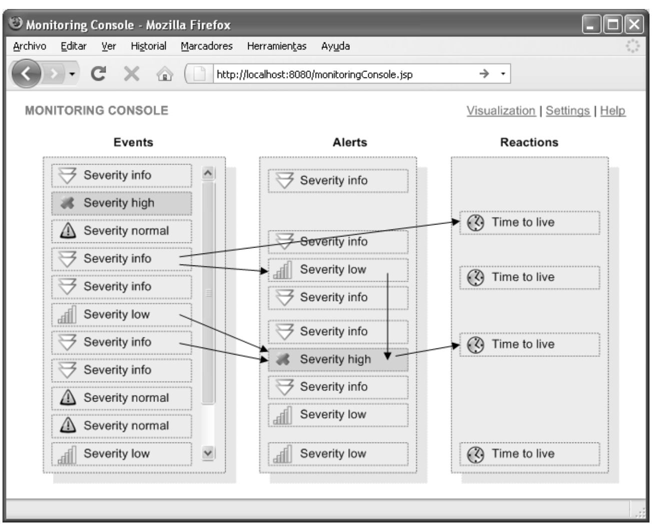

Fig. 2. Real Time Monitoring

3 Visualization Interface

Our visual interface is divided in two screens. The former provides real time information about the status of the system. The latter helps during the reasoning process applied in the system. Both screens have been implemented with web technology so that they provide concurrent visualization by different users. The real-time visualization screen, shown in Fig. 2, is composed by three columns that represent three different FIFO structures. The incoming events are inserted at the bottom and they go up as time goes by.

In the first column the user can see the events (different content fields of the IDMEF) received by the rule engine. We have only set the severity to make it more readable. The events produced by the Rete [2] rule engine are shown in the second column. When there is an arrow it means that the tip of the arrow points out to an event produced by a rule, and the back part of the arrow is an event that belongs to the condition part of the rule. The third column contains the possible reactions advised by the system to tackle the detected problems.

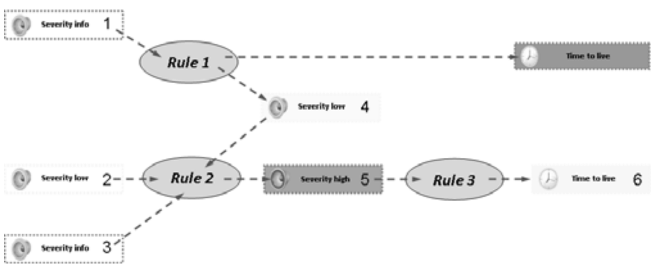

Fig. 3. Reasoning Console

The reasoning console, depicted in Fig. 3, has been created to follow the reasoning of the system in a user-friendly way. This console increases the readability of the system's reasoning. In processes where many rules and events are linked, it is possible to have a whole picture of the reasoning that takes place.

4 Proposed Engineering and Development Model vs. a Spiral Model

We compare our Software Development Life Cycle (SDLC) with a Spiral Model because in today's business environment the Spiral Model [9] [10] (or its other iterative model building methods) is one of the most used SDLC model.

What we are really doing is to split the Spiral Development Model into two smaller ones that can be applied concurrently, as can be seen in Fig. 4. The complexity of the problem is reduced by the software development team because they do not have to understand the application domain as much as it would be if they had to code the rules in a general-purpose development language. They will not have to recompile the whole code when new rules are released.

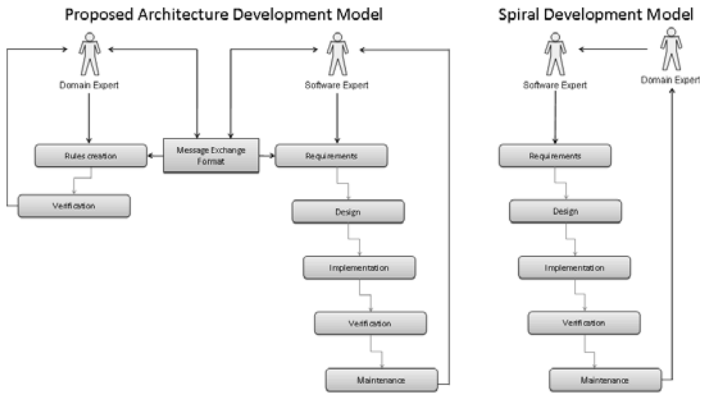

Fig. 4. Models Comparison

The experts will have a tool to collect complex decision-making logic and work with data sets too large for humans to effectively use. This tool uses declarative programming which allows expressing "What to do", and not "How to do it"; in contrast with imperative programming used in general purpose languages. Declarative languages are nearer from human being's thinking than imperative ones. This makes the creation of the rules much easier than developing them.

We have provided a software architecture that allows a collaborative and parallel design by domain experts and software experts. The problem has been divided into two smaller ones taking into account the knowledge needed to solve them. We have used a message format which is easier to create than a domain-specific language, and use it in something similar to an event-driven architecture. It is not exactly an event-driven architecture because we do not follow the definition of event: "a significant change in state" [4] [5]. For us an event does not necessarily imply a change in state. An event can also be an indication that the system is still working right or that there is the possibility of an attack. And of course, it can also mean a change in the state.

5 Illustrative Example

This section shows two IDMEF messages received by the network-based detection engine during a port scan. The former, depicted on the left hand side in Fig. 5, shows the detection by a single analyzer that will be sent to the correlation engine. The correlation engine receives alerts from different analyzers and will create a new enriched alert by adding information to it. This information is the result of applying the expert knowledge.

The correlated alerts will provide higher level information such as different proposed actions contained within the assessment, as the one extension depicted on the right hand side in Fig. 5. This information is very helpful for the decision engine to offer different possibilities to the administrator. Other information that can be very useful for the administration process is the set of alerts that are correlated.

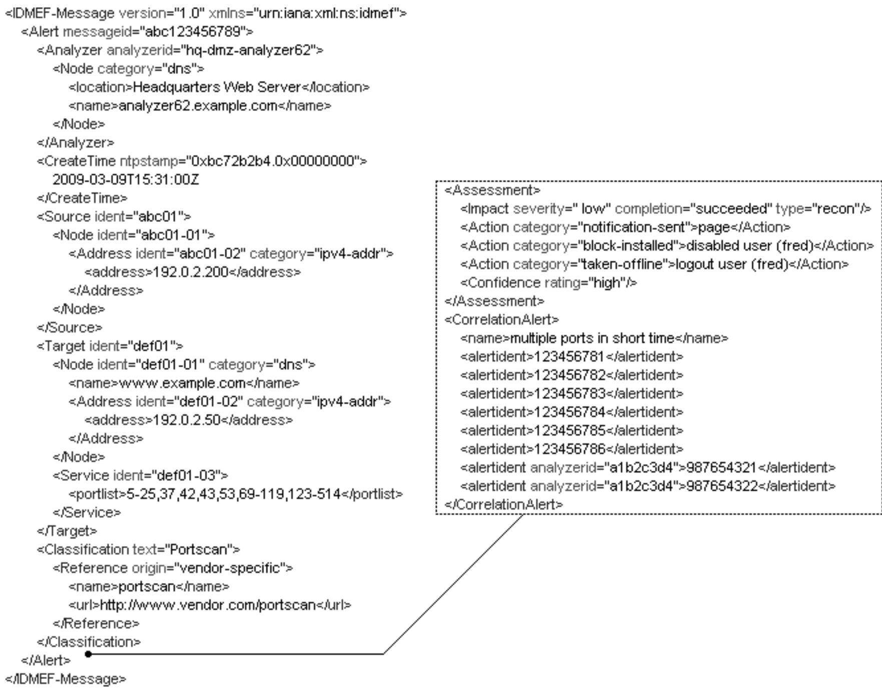

Fig. 5. Samples of IDMEF messages

6 Related Work

The appearance in the last few years of the intrusion detection systems has provoked the increasing of many related works, which focused initially their effort on the event management and subsequently on the detection process of security attacks. In both [7] and [3], authors presented two approaches to manage security events from different sources in real time. The former describes a rule-based system to normalize raw events into meta-events, or higher level events that follow a common schema. After aggregating and correlating these events, the system is able to trace suspicious network activities. The latter presents a correlation methodology based on rules able to extract QoS parameters from large complex systems with the aim of measuring the availability of the underlying services.

The systems commented above are complemented by the current ones through the addition of decision-making logic to enforce specific actions, for example by executing a set of commands, in order to fix o mitigate the problems caused in the target system. In [6] the authors analyzed this kind of systems and provided an alert-based decision support system, in which aggregated alerts are classified into rule classes and thereby detecting intrusion behavior patterns.

All these systems move now their attentions to the design and development of visual tools that allows system administrators to manage the reasoning process of the system they are controlling, as the ones presented in the present work.

7 Conclusions

We have reduced the complexity of the monitoring problem for CIS so that we can create ad-hoc solutions for different customers' networks. We have found a set of tools and developed a method that allow applying the same architecture to different domains, thereby reusing a big part of the design and code. We have facilitated the parallel and collaborative design between domain experts and software engineers.

We have added visual tools to help experts and users to follow the reasoning of the system. This will be very useful for debugging, knowledge transfer and to give the user confidence in the system. These tools may also be used in complex forensic analysis.

Acknowledgment

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Model-Based Collaborative Design in Engineering

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Abstract. This paper is about understanding and analysis of ways of model-based collaborative design in engineering. Models help engineers in overcoming complexities and to create a common understanding about processes and products. Organizational, commercial, technical and process-based circumstances have impact on models and modeling practices. Based on ethnographic studies in a distributed real work environment, several modeling practices are identified and described: 1) modeling to visualize several important issues, 2) modeling to support collaboration and coordination, 3) modeling to support system engineering, and 4) models triggering automated actions. Before concluding the paper, we discuss some interesting points we found in our investigations and try to provide a base for a collaborative engineering approach.

Keywords: Collaborative design, visualization of cooperative work, cooperative engineering.

1 Introduction

System engineering is a collaborative process with several interdependencies between tasks and participants. It is embedded in organizational, economic, technical and collaborative context. How to deal with the complexity of interdependent tasks can be supported by several mechanisms. Such support for core engineering activities can either be provided by integrated development environments or by isolated tools like editors, compilers, linkers, test scripts, messaging and modeling tools, or common information spaces. Additionally, certain standards, conventions, notations or rules can be established to unify design practices and help to communicate design principles and values within and across teams. The impact of organizational settings like the size of the design team, the size of the project, structures for decision making in an enterprise, agreements with and distribution of work among partners, etc., are important issues to consider in introducing modeling into engineering.

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In a European STREP project called MAPPER[1] (Model-based Adaptive Product and Process Engineering) (IST-016527) we[2] investigated technological and methodological possibilities to support designers in collaborative engineering, which involved participative engineering methodologies to enable joint product and process design, interdisciplinary and inter-organizational collaboration throughout multiple product life cycles.

We carried out an ethnographic study [6] in one of the industrial partners, we call in this paper *Beta*. We visited *Beta* three times to observe participatory the workplaces, meetings and design sessions, what we recorded as video and audio files. We interviewed in-depth some the key actors. Additionally, we gathered and analyzed *Beta*'s artifacts like documents, source code, test reports, simulation results, project plans, charts, organization diagrams, and models of different kinds. This qualitative study resulted among others in field visit and validation reports [5].

Beta provides IP (Intellectual Property) cores since 1997, VHDL and Verilog model development services as well as hardware and software development for microcontroller-based systems. In our ethnographic study at *Beta*, we identified the problem of missing of a radically new collaborative engineering approach that engineers need to face challenges in design and manufacturing of modern electronic systems in respect to their complexity and constraints in time-to-market. In this paper we suggest a solution space for *Beta* by showing the role of models and modeling to develop a different approach to collaborative engineering.

In the next section we will describe modeling in collaborative design by illustrating four different types of models used at *Beta*: 1) models to visualize several important issues, 2) models to support collaboration and coordination, 3) models to support system engineering, and 4) models triggering automated actions. Before concluding the paper, we discuss some interesting points we identified in our analysis.

2 Models in Collaborative Design

By definition, a model is a representation of reality that helps to better focus on specific aspects of the considered reality. Models are both descriptive and generative in the sense that they describe what is observed by the model creator and that they support the construction or modification of a construct in the reality. When engineering processes are model driven, models are used as primary artifacts throughout the whole life cycle.

Besides the research on enterprise modeling [4], some research has been done about the different levels of models created in manufacturing [9]. They distinguished between paper-based, table-based, non-executable and executable models. They showed that it is possible to integrate product models with process models, however due their complexity it is not always easy to deal with them

[1] http://mapper.eu.org/

[2] The project group consisted of Hilda Tellioğlu, Ina Wagner, Gianni Jacucci and Gian Marco Campagnolo.

during daily work. Sometime it is not enough to have only visualizations of objects-in-design. So, a mechanism of interaction must be established around common models to facilitate collaborative design and engineering. *Active knowledge models* (AKM) try to implement this requirement.[3] They are based on user knowledge about business realities, which is not always the case in other conventional model-driven architectures. In this paper, we do not focus on knowledge management features of AKM, but rather on their active use by collaborating actors. Active models can be actively used during the operation of the system. The representation of the model is available to users at runtime. They are dynamic and reconfigurable, so tailorable for their users, and influence the behavior of the underlying computerized system [2]. AKM can also be used as executable formal models to manage design workflows. This supports (semi-)automation of design processes when executed.

In collaborative engineering processes at *Beta* we could identify and study the following types of models:

- *Models to visualize several issues* that are relevant for collaboration, like the organizational and temporal structure of a project, the collaborating partners and their suppliers, roles and responsibilities in these collaborations.
- *Models to support collaboration and coordination* between actors involved in the engineering process: These formal or informal executable models mainly created by *Beta*'s employees build the base of workflow systems established between distributed groups.
- *Models to support system engineering* which are created during the engineering process: These are formal, non-executable models, supported by a range of computer systems. They have been established in design, development and manufacturing for a long time.
- *Models triggering automated actions* during the engineering process, like simulation and testing: These formal executable models help to reduce errors in engineering, enable consistent reproduction of tests and simulations by avoiding human error. By enabling remote access to collaborators, articulation and coordination of work are supported.

In the following sections we would like to show some ethnographic evidence to these different types of models.

2.1 Models to Visualize Several Issues

Before *Beta* and its partners could start modeling their cooperation in USB design, they needed to think about several other issues. First of all, they tried to model their own company with human and non-human resources to achieve a common understanding of their organizational structure. The main tool the product manager at *Beta* was using to model the organization was a *mind*

[3] AKM is based on a visual externalization of knowledge model of enterprise aspects and views that can be operated on, viewed, analyzed, simulated, and executed by authorized users.

mapper. Some organizational charts were connected to mind maps to create an overview of issues related to organizational structure like relevant information about products, people, customers or decisions made.

With an organizational design game, we[4] managed to move the employees from marketing and engineering departments *Beta* to think about their organization and about its improvement. We setup a workshop for two days where two groups had the opportunity to model the company in several steps. For the workshop we had chosen three important questions (as results of our analysis of ethnographic study earlier at *Beta* [5]: How to acquire a business management culture and construct a community of practice? How to change from being sophisticated contractors to a profitable brand? How to transfer knowledge and design to the market?

By using an organizational game kit, *Beta*'s employees tried to build their organization out of *building blocks* of different colors and shapes. Additionally they used figurines, stickers, and pencils to enhance and modify the shared representation of the company. Two groups delivered completely different models (Figure 1).

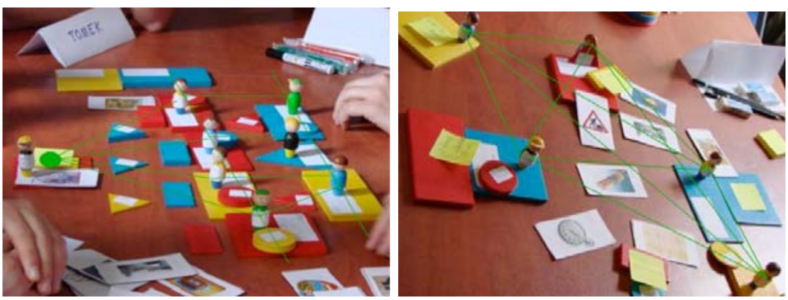

Fig. 1. Differing organizational models created by using organizational game kit: On the left much more hierarchical with the CEO on top (created by engineers), on the right much more networked, flat but with more difficulties and gaps in communication (created by marketing people)

2.2 Models to Support Collaboration and Coordination

After an initial, informal specification of the USB IP component design that was agreed upon by cooperating companies and their customers, each participant firm defined its design workflows as *AKM* with IDEF[5] notation. Besides showing the interfaces to other workflows, these AKM-based workflow spanned over specification, development, verification, and product preparatory phases. Next, actors responsible for particular design phases in the design flow were identified, technologies for components manufacturing and tools to be used were decided.

[4] The group was composed of Gianni Jacucci, Hilda Tellioğlu and Ina Wagner.
[5] ICAM Definition Language.

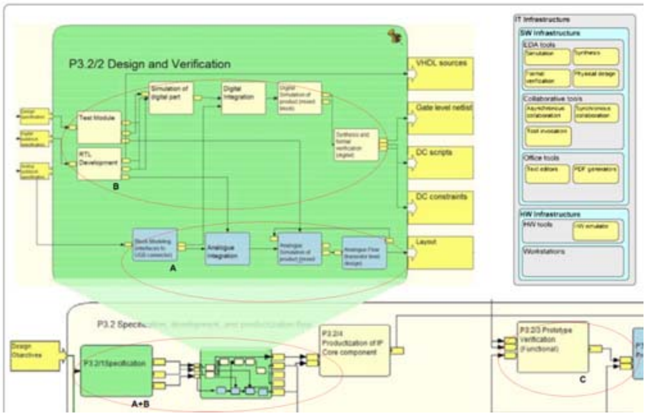

Fig. 2. A view of a part of the design processes distributed into three locations (A, B, C): AKM in IDEF notation of "Design and Verification" process

The design flow represented as a visual model (Figure 2) comprises sets of design tasks performed at three geographical locations, at A, B, C. The design object is a mixed-mode component. Design processes are split among the team members, taking the engineering competences into account, in such way that an analog design takes place at A, a digital design at B, and a board-level testing at C. The model shows also a wide spectrum of information related to the current shared product, namely information on: the internal organization of involved companies (e.g., company structure, locations, human resources, staff competence skills), the available IT infrastructure (e.g., design automation, administration, and office tools), the current project organization (e.g., project responsibilities), the detailed structure of the common product, and the project plan (e.g., management and design workflows). These details are not illustrated in the figure.

2.3 Models to Support System Engineering

System engineers use several models to design their products by showing their components, interfaces and data flows, to communicate open issues and important properties of product components, to discuss uncertain points of product definition, to visualize the simulation results, and to show dependencies between products or product parts. Engineering practices and tools used regularly shape these models. Engineers at *Beta* used almost for everything *mind mappers* (Figure 3). Sometimes the product manager inserted AKM models to the mind maps. This enabled easy access to model images within the project context.

In case of misunderstandings or uncertainties, engineers were used to draw a *model of the object-in-attention on a flip chart or a pin wall*. These ad-hoc created models were temporal and not persistent. On the other hand, simulation results were communicated within and across the teams. The results needed to be

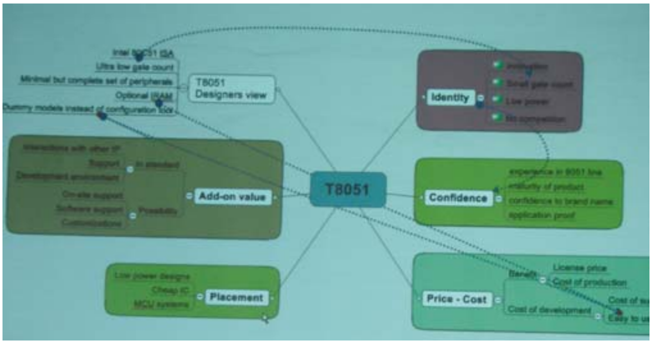

Fig. 3. Mind maps created to model products by showing their main properties explicitly

very detailed and complete. They were analyzed, interpreted and then compared with previous results, and used to improve the product design.

2.4 Models Triggering Automated Actions

There were several workflow-based systems established at *Beta*. Firstly, they used a platform called *TRMS (Tool Registration and Management Services)* to support remote invocation of tasks embedded in sequential workflows [2]. We found 18 workflows with five to six tasks each. The aim was to support distributed design between A, B, and C. Figure 4 shows an example flow with TRMS. By selecting the buttons, processes could be started and repeated. Completed tasks were visualized as such, so that engineers were aware of the status of the workflow execution.

Based on the process and organization models of collaborating partners A and C, cooperation models were created. These were mainly *AKM views* showing links between the tasks carried out at different sites.

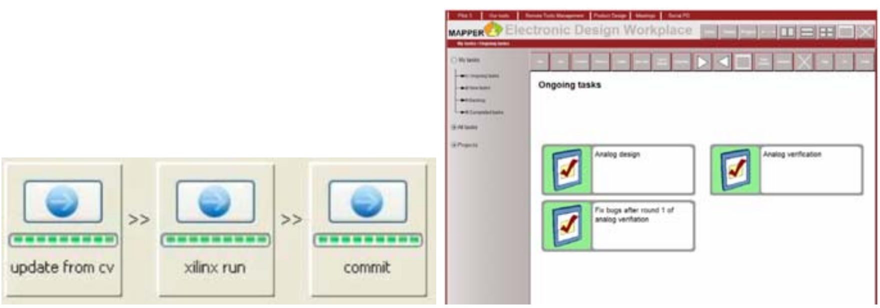

Fig. 4. An example workflow with TRMS (left) and configurable virtual workplace (CVW) as desktop for a user (right)

Finally, they created *configurable virtual workplaces (CVW)* as model-based work environments generated for specific users by considering their role and cooperation paths to others in the project. Each user could access his or her current tasks by using the CVW as an entry point (Figure 4, right).

3 Discussion

It is obvious that models can help engineers in design and production [3] [7] [8]. They *visualize* several issues like problems, misunderstandings, points of attention, responsibilities or task dependencies locally or globally in the network. They help engineers to *overcome complexities*, deal with complex processes and artifacts. This involves structuring and re-structuring, composing and decomposing, creating overview and detailing, establishing stability (of concepts, structures, processes, methods, approaches, features of products) and exploring new things (like methods, tools, approaches, etc., otherwise no further development or innovation are possible).

Beta's engineers started with modeling their own company to *create a common understanding*, then continued to link their tasks with processes of partners. They have established workflows to support their collaboration, added detailed product models to their workflows and based on that created automatically configurable virtual workplaces. All these models span from *organizational*, to *commercial, technical, workflow-* or *coordination-related levels*. By means of models, *Beta*'s engineers tried to handle the complexity at these different levels.

These different types of models are *complementing each other*. They are applied at different points of time, they serve for different purposes, they do not need to be deterministic, complete, or integrated. As system designers of modeling environments, we first have to understand when and why modeling is applied by engineers. Ethnographic studies give us insights. Not everything in a work environment can benefit from modeling and models. If we want to introduce modeling into an engineering team, we have to answer the important *question of what to model* in the first place.

In modeling, *organizational principles and strategies* guide the abstraction of organizational entities (systems being modeled by abstraction, like products, organization of human resources, processes and interactions between units). *Beta*'s engineers and marketing people were very much influenced by the current status of the company at the market and in relation to its cooperating partners. This could be observed in the organizational models created by using organizational game kit.

Another influence on modeling is *the way of thinking*. Applying the object-oriented approach determines the way how objects and system actions are identified by modelers: For each of the identified objects computational objects can be created. For each system action a symbolic operation can be defined. Organizational strategies can be concentrated on objects "viewing a large system as a collection of distinct objects whose behaviors may change over time" or on "the stream of information that flow in the system, much as an electrical engineer views a signal-processing system" [1][p.218]. This shapes the structure of task dependencies or work flows.

4 Conclusions

Design objects as we have seen in engineering of IP cores are complex, their parameters are multifold, dependencies between parameters are temporal, sometimes they must be modified because of changes in some parameters or in features of products. It is a dynamic process. A model is the right semantic (re)presentational artifact for this type of complex relations.

Models used at *Beta* are of different types: executable or non-executable AKM models, product models for simulation and testing, workflow models to support collaboration between distributed design and production teams, mind map models to support the re-organization of the enterprise, etc. They are all necessary and needed for different purposes. Models help to capture organizational (organizational game kit, mind maps, organizational charts, AKMs), economic (product and process models with simulation support), technical (UML or AKM product models, simulation models) and collaborative (workflows, CVWs, TRMS workflows) context and to create a common understanding in and across organizations. Identifying the sinful use of models at *Beta* and understanding its impact on design processes brings us further in developing a new collaborative engineering method, which is based on models. Further work is needed to create, document, and evaluate the collaborative methodology in engineering environments.

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A Cooperative Application to Improve the Educational Software Design Using Re-usable Processes

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Abstract. In the last few years, Educational Software has developed enormously, but a large part of this has been badly organized and poorly documented. Recent advances in the software technology can promote the cooperative learning that is a teaching strategy in which small teams, each composed by students of different levels of ability, use different learning activities to improve their understanding of a subject. How can we design Educational Software if we never learnt how to do it? This paper describes how the Technological University of the Mixtec Region is using a cooperative application to improve the quality of education offered to its students in the Educational Software design.

Keywords: Software reuse, educational software, cooperative learning, process reuse, process notation, process tailoring.

1 Introduction

As education and technology combine, the opportunities for teaching and learning are ever growing. However, the very rapid rate of change in the field of technology poses special problems for academic institutions, specifically for the engineering disciplines. Nowadays, the software engineering and modern theories of learning converge in the construction of Educational Software (ES) to develop tools that define and implement educational objectives while preserving quality patterns. However, there are still gaps in our ability to assess whether a component or process meets the specified requirements or expectations and needs of students or groups of students. It is wrong to think that ES is less complex than commercial software, which has definitely received more attention from the field of software engineering.

ES covers a range of sub domains, types of systems, requirements and diverse idiosyncrasies which have been covered by the application of principles, specific methods and tools of software engineering in a specialized field. According to Van Schaik, *"clear and unambiguous emphasis on human learning and knowledge acquisition, differ from the educational software with other types of software"* [3]. Thus, ES is evidence of the technological impact on educational processes that has taken place in recent years, providing a valid alternative to students through an environment of generation (and regeneration) of knowledge. From our perspective, ES development should incorporate a practical mechanism for designing and establishing effective

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activities for Instructional Design. The major objective is to facilitate and ensure the accomplishment of educational needs to a target audience, not forgetting to take into account its profile to edit the actual contents. However, a basic problem faced by the learning community is to determine how to develop and deliver quality content for learning experiences, while being able to compose, revise and update this content in an efficient way. This brings up the issue of reusability (content developed in one context being transferable to another context). The profit of a high level of process reusability in software development is a sign of maturity in any discipline of engineering. Software engineering is no exception; in recent years reuse-based paradigms have contributed to the reduction of costs and schedules in the software industry. It is clear that in software engineering the compositional paradigm or component-based paradigm has dominated [17] [10] [15] [6] [9], but in the concrete case of ES, this situation is the opposite; and traditionally, the generative paradigm has been preserved [1][12].

2 Cooperative Learning for Defining Reusable ES Processes

One method cited for accelerating process improvement in ES development is to replicate a standard, reusable process within other projects. However, the creation of a process that is usable on diverse projects is a difficult task. What is needed is an effective method to capture the common and variant elements of project-specific processes and create process definitions that can be applied in a variety of situations, i.e. that are reusable. But what is a reusable process? Feiler and Humphrey defined a process as *"a set of partially ordered steps intended to reach a goal"* [5]. A few years later, Hollenbach and Frakes defined process reuse as *"the usage of one process description in the creation of another process description. It is not multiple executions of the same process on a given project"* [8].

These definitions could be applied to the educational systems context to create a type of graphical repository to produce and refine reusable processes and improve the quality of the final product at the same time. A literature search shows that groundwork for SE process reuse exists. Research by Sheremetov et. al. [16] proposed a Web-based learning composed of knowledge, collaboration, consulting and experimentation spaces and conventional software components working over the knowledge domains. The research work of [18] conceptually describes modularity (granularity) of learning sequences, learning activities and actions, reusable learning objects and atoms, and reusable information atoms. Research by [13] relates a special type of labeled material called Intelligent Reusable Learning Components Object Oriented (IRLCOO), producing learning materials with interface and functionality standardized rich in multimedia, interactivity and feedback. Research by [2] concerns the development of a Web-based Education Systems architecture that considers a diversity of requirements and provides the needed functionalities based on creating reusable components for content and evaluation tasks to reduce the complexity, change management, and reuse of learning. We can observe that the creation of reusable processes is dependent on domain analysis. In spite of existing studies, not many domain analysis methods/tools for creating re-usable ES trough experiences of cooperative learning have been developed. The ES process life cycle contains the following steps:

- *Define reusable ES process from repository.* Even if a previous ES process does not exist, the student must start from here. The output is of one or more process descriptions, along with tailoring guidance and output products. The process descriptions are also integrated into the repository if they have been tested to ensure they are fit to (re)use.
- *Select process to adopt in new project.*_Once the re-usable ES process is complete, the Process Manager is ready to deploy it in a real environment.
- *Tailor the ES reusable process on a project.* The re-usable ES process is tailored to meet the specific technical and instructional requirements and environment of an educational project.
- *Enact the process on the project.* The process is put into practice on the educational project. An assessment function evaluates the educational project to ensure that the new process is faithfully enacted.
- *Refine the process.* Based on the previous evaluation the process definition is then refined and inserted in the repository as a "good" process.

3 Building an Alternative Repository of ES Processes

A learning approach to ES development captures project-related information during the creation of individual ES artifacts which is then disseminated to subsequent educational projects to provide experience-based knowledge of development issues encountered at a repository of effective processes. These principles have been successfully applied in software engineering in [7] and [8], and we are trying to apply them in the ES context through an exploratory prototype, named ESPLib (Educational Software Process Library). The initial ESPLib research focused on developing a tool to support the creation of domain repositories. In particular, we focused on defining precise processes to accomplish the instructional design. ESPLib is composed of domains which are independent knowledge realms consisting of a set of activities and rules (reusable process) that define the context in which an ES process is applicable to a learning objective. Our approach combines a rule-based system to match project characteristics to ESPLib processes and a deviation process to continuously update and improve new practices. At key points in a cooperative development procedure, students are taken through a set of questions designed to elicit educational project characteristics and match them to specific process elements in our schemas (or lifecycle models). This creates a customized process that goes through a review procedure validating the path taken through the rule-based system and assessing whether the processes assigned to the ES project are necessary and consistent, or are in need of further refinement or correction. The result is a modified process which should be followed. Thus it is clear that ESPLib implements the constructive theory of Jean Piaget: *you can learn if you can do it* [14]. The five elements in [4] define the ESPLib' cooperative learning: positive interdependence, individual accountability, face-to-face primitive interaction, appropriate use of collaborative skills, and group processing.

3.1 The ESPLib Tool

The main interfaces for ESPLib are shown in Figure 1. The *Project Manager* displays a hierarchical arrangement of educational project activities. In the figure, a project named “English Lab System” has been chosen from the list of current projects. Each activity contains project-specific information which was obtained by double-clicking on the activity named “Prepare for Educational Design” in the project hierarchy. Processes are used in a rules-based decision support approach, and describe specific guides to establish development activities in ES projects. Guides consist of a description of a specific activity, the related activities, a description of input and output, and specific information about process notation.

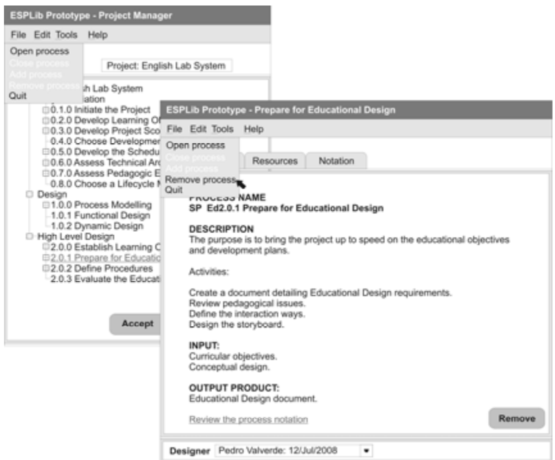

Fig. 1. ESPLib Project Manager

3.1.1 Creating Domains

As we said previously, ESPLib is composed of domains. Domains are independent knowledge realms that consist of a set of domain diagrams defining activities and domain conditions that define the context in which a process is applicable to a specific learning objective. Currently, educational projects belong to a single domain, which is chosen when a project is created in ESPLib. All subsequent project activities will use the activities and notations defined for that domain. A domain defines the area of possible activities for educational projects within a given field (e.g. computer science, mathematics courses, electronic practices, learning a foreign language, etc.), structured in a work breakdown plan. They define standard activities that have proved useful for situations encountered by educational projects within that specific domain. The diagrams describe some of the problems or necessary steps that must be taken to ensure that the procedure is correctly followed, and can be updated by a project to reflect specific activities that this project follows. The obtained descriptions are used to tailor the ES development process to the specific needs of different projects. Internally, ESPLib uses a simple forward chaining production mechanism implemented using an SQL database to represent alternative processes (see Figure 2).

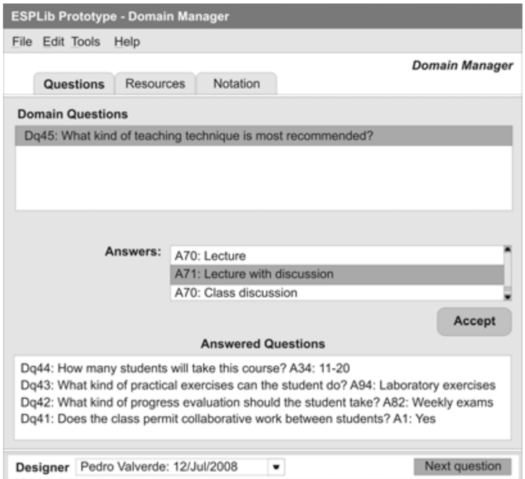

Fig. 2. The Domain Manager

Questions are chosen by students to tailor the ESPLib's standard process to individual educational needs. For example, Figure 2 shows a session in which four questions have already been answered and a fifth has been chosen, revealing the possible answers. These options address high-level project requirements which may influence which educational activities are chosen for the project. When all preconditions of a domain evaluate to true, the Domain Manager "fires", causing a set of defined actions to be executed. The core actions in ESPLib can remove questions from the question stack, add a question to the question stack, or add a domain to a project.

3.1.2 Using a Process Notation

Process definitions are specified using the process definition component of the *Process Manager* and are based on a defined framework using notation. Nowadays, in the context of ES, the research lines are focused on working with the specific components of systems, like content. There is an initiative that inculcates globalization of materials for its use in different learning programs and sessions through the use of "metadata". In this category, the proposal that most stands out is the Learning-Object Model (LOM) developed by IEEE-LTSC. This model is composed of nine different records that identify general characteristics, lifecycles, metadata, technical and educational issues, relations with objects, and classification of resources [11]. ESPLib combines the LOM approach with the notation from Object Modeling Technique (OMT). ESPLib's GUI consists of a main window containing a process display area, various pop-up dialogue windows which can be dismissed when no longer required, and a toolbox that can be displayed or hidden as required by selecting the Tool option (see Figure 3).

3.2 Creating and Modifying ESPLib's Processes

To define an ES process for use on a project, ESPLib allows an existing process model to be modified.

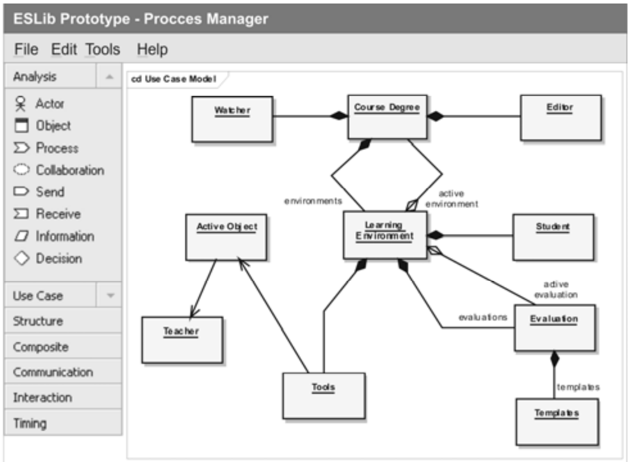

Fig. 3. An Example of ES process in ESPLib

Alternatively, the process can be defined starting with an empty process. Only one student of ESPLib is permitted to modify a software process at any one time, thus removing the possibility of multiple concurrent updates to the ES process definitions. Process elements can be added to a process by selecting the required component in the toolbox and then drawing it into the process display using the mouse. When any modifications are made to a process the student is required to justify why the change was made. This is designed to provide some reasoning for the ES process that is to be followed for a particular project. ESPLib supports the dynamic modification of collaborative process definitions. This allows process instance to evolve throughout the lifetime of the educational project. This is especially important for projects of long duration. When a process definition is modified whilst it is being executed, the changes made to the process must still conform to the defined process framework.

4 Evaluation and Future Work

Traditional education is based upon a paradigm normally called the “knowledge reproduction model”. This model is based on verbal lecture, drill and practice sessions, printed handouts, structured classroom activities, and office hours. In its pure form this model is grounded in the belief that knowledge is objective and the purpose of the teaching process is to transfer this static body of knowledge from its source to the student. The general goal of ESPLib is to create educational knowledge management tools that are more proactive in delivering information to students than typical repositories. One way this can be accomplished is to create a collaborative process that provides domain-sensitive information to ES development efforts. The ESPLib tool and framework is flexible enough to bridge the gap between overly-restrictive ES development methodologies and ad-hoc practices to fit the needs of ES as they evolve. The small number of process elements available for use in a process definition assists students understanding. Although only a small number of process elements exist, it is still possible to construct a process definition, such as the English Lab process (see Figure 3), without the definition becoming overly cluttered. It is possible in ESPLib to add additional attributes to a process element or to customize process elements. This is a valuable feature in a process modeling tool, allowing process definitions to be customized to the style used by any student. Another positive feature of ESPLib's process definitions is that they are easy to understand by all students due to the diagram notations. The process framework is not currently customizable making it impossible for any student to specialize the process rules to incorporate their specific policies. Storing the process definitions allows past process models to be examined and evaluated. This can be valuable when a process model is being chosen for use on an educational project because a successful process can be chosen.

It was clear from our brief study that the domain interface of ESPLib (Domain Manager) needs some improvements. In particular, there needs to be a method of finding answers to some behaviors (such as a case being added to a project) or other attributes. Currently, students need to page through the questions one-by-one to find an answer with the desired precondition or action. Another improvement is related to the addition of a "content editor" module, the main idea being to relate each phase to a topic from the normal course and include (or modify) it according to the students needs.

5 Conclusions

Knowledge management for educational software development is more than just repositories and models. Recent advances in the Internet technologies can promote the cooperative learning that is a teaching strategy in which small teams, each composed by students of different levels of ability, use different learning activities to improve their understanding of a subject. The reviewed approaches have shown that the reuse process provides relevant useful and up-to-date information to improve the quality of ES. This mandates a strong tie between technologies and pedagogy in which using the technology must become part of routine work activities. The contribution of this research pretends to define and implement a single tool to improve the analysis and design of ES using the cooperative learning approach, with the intention of successfully merging pedagogical and technical aspects equitably. As the repository of ESPLib grows through the principled evolution of the knowledge domain, it also becomes able to handle a wider range of domains, while evolving towards answers to problems that fit the student's technical and pedagogical context. The real question is not whether the repository of ESPLib is "correct" in some objective sense, but rather whether less mistakes are repeated and better ES solutions adopted when using the repository.

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Undo-Based Access Control for Distributed Collaborative Editors

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Abstract. When adding access control layer to a replication based Distributed Collaborative Editor (DCE), ensuring convergence to the same copy of the shared document becomes a challenging problem. We consider here an optimistic access control in the sense that temporarily access right violation is tolerated [3]. This leads to data divergence. To maintain convergence, updates violating access rights must be undone. However, undo approach may itself lead to divergence cases called undo *puzzles* [6]. In this paper, we address undo as the main feature in an optimistic access-control-based DCE. We also show how we can avoid several known undo puzzles and present additional ones. We propose a new generic solution for these puzzles and provide performance measurements of our undo command.

Keywords: Access Control, Collaborative Editors, Selective Undo, Operational Transformation.

1 Introduction

Motivation. Access control in a Distributed Collaborative Editor (DCE) is very important since several shared documents need restriction of rights to certain users according to the application nature. For example, consider a DCE dedicated to collaborative programming in a software company. Some parts of the source code may be confidential and must not be accessed by all programmers. In addition to that, programming tasks may change dynamically according to the project nature. In this paper, we are interested in the collaborative editor model presented in [2]. This model offers a new coordination framework for real-time collaborative editors which is characterized by the following aspects:

1. Use of an optimistic replication scheme providing simultaneous access to shared documents.
2. Causality preservation thanks to a novel and simple technique instead of state vectors which is called semantic dependency. This technique is minimal because only direct dependency information between document updates is used. It is independent of the users number and provides high concurrency in comparison with vector timestamps.
3. Reconciliation of divergent copies automatically in a decentralized fashion based on the Operational Transformation (OT) approach [1,7].
4. Scalability thanks to the semantic dependency.

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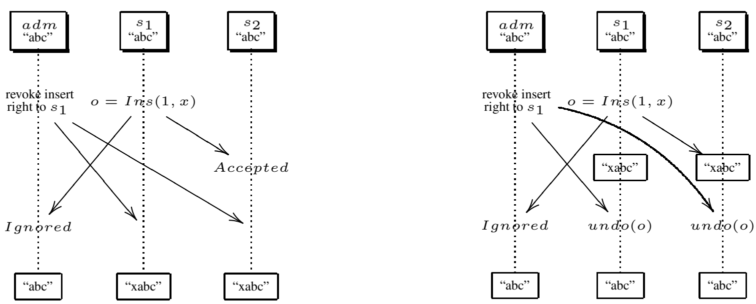
We have built an access control layer on the top of this framework [3]. This layer is also replicated in order to avoid network latency problem. The policy object is replicated at all sites and two kinds of operation are considered:

– *cooperative operations*: these operations change the document state and are the following:
  1. $Ins(p, e)$ where p is the insertion position and e the element[1] to be added at position p;
  2. $Del(p, e)$ which deletes the element e at position p;
  3. $Up(p, e, e')$ which replaces the element e at position p by the new element e'.
– *administrative operations*: an administrative operation allows to add/delete an authorization to/from the authorization list which represents the policy object.

Note that this model is characterized by the use of canonical logs to maintain insertions before deletions.

In the resultant access control based DCE, a user can violate the policy temporarily when performing a document update concurrently to a policy update. This flexibility may lead to divergence cases as it is illustrated in the following scenario.

Necessity of Undo Command. To motivate the necessity of undo in the considered model, we underline the impact of the interaction between the two different kinds of operation cited before on the copy convergence. Indeed, cooperative and administrative operations may be executed in different orders at every site. This may inevitably lead to data divergence.



(a) Divergence case (b) Convergence thanks to undo mechanism

Fig. 1. Selective Undo Motivation

To illustrate this issue, let us consider the scenario of the Figure 1 where we have a group composed of an administrator adm and two standard users s_1 and s_2.

Initially, the three sites have the same shared document "abc" and the same policy object where s_1 is authorized to insert characters. Suppose that adm revokes the insertion right to s_1. Concurrently s_1 executes a cooperative operation $Ins(1, x)$ to derive

[1] The type of the list elements is a parameter that can be instantiated by each needed type. For instance, an element may be a character, a line, a paragraph, a page, an XML node, etc.

the state “xabc”. When adm receives the s_1’s operation, it will be ignored and then the final state still remain “abc”. However, s_2 receives the s_1’s insert operation before its revocation, he reaches the state “xabc”. We are in presence of data divergence (see Figure 1.(a)).

To solve this problem, we propose to use *selective* undo approach to undo only illegal operations. For instance in Figure 1, $Ins(1, x)$ should be undone in s_1 and s_2 after the execution of the revocation (see Figure 1.(b)).

Related works. Various group undo solutions have been proposed. The first selective undo was proposed in [4]. It consists on placing the selected operation in the end of the history by swapping then executing its inverse. Since swapping is not always possible, authors add the conflict notion in which case undo is aborted. Hence, the proposed solution does not allow to undo any operation.

Another solution is to undo all the operations in the inverse chronological order, $i.e$ from the last to the wanted operation as it is proposed in [5]. This approach avoids the conflict but is expensive and does not allow undo in all cases.

The ANYUNDO-X proposed in [6] is the first solution allowing the undo of any operation and solving the known undo problematics. However it has a non linear complexity and may not be performant for access control based DCE.

Contributions. We propose an undo command appropriate to an optimistic access-control-based DCE. We also show how it is possible to avoid some puzzles and present additional ones. Finally, we present our solution to resolve these puzzles and measure the performance of our approach.

The rest of the paper is organized as follows. Section 2 presents the undo approach in general and its puzzles. Section 3 illustrates our adopted solution for puzzles. Section 4 shows implementation and experimental results. Finally, section 5 concludes.

2 Undo Approach

A non linear group undo solution was presented in [6]. It proceeds in 5 steps: to undo an operation o in HB, we should first find it in the log then generate its inverse noted $\overline{o}$. After this, we calculate the form of $\overline{o}$ to be executed on the current copy by integrating the effect of all the following operations in HB with IT[2] function. A copy of all the forms token by $\overline{o}$ during the transformation mechanism is stored in a temporary buffer. Finally, the resulting form of $\overline{o}$ is executed then coupled with o in HB. The last step produces a new form of HB as if o was not executed.

2.1 Undo Correctness

Undo puzzles results from the violation of two properties called $IP2$ and $IP3$ (see Definitions 1 and 2) by the transformation function IT.

Definition 1 (Inverse Property 2 (IP2)). *Given any operation o_x and a couple of operations $[o, \overline{o}]$, we have $IT(IT(o_x, o), \overline{o}) = o_x$.*

[2] This function is used in the Operational Transformation (OT) approach to allow the integration of remote operations.

Definition 2 (Inverse Property 3 (IP3)). *Given two operations* o_1 *and* o_2. *If* $o'_1 = IT(o_1, o_2)$, $o'_2 = IT(o_2, o_1)$ *and* $\overline{o_1}' = IT(\overline{o_1}, o_2)$ *then we ensure that* $\overline{o_1}' = \overline{o'_1}$.

Inverse Properties preservation. In the ANYUNDO-X, IP2 and IP3 are preserved by the extension of transformation functions (IT and ET) to IT-X and ET-X. To achieve convergence, several information have to be stored such as original forms of operations and resultant transformation forms.

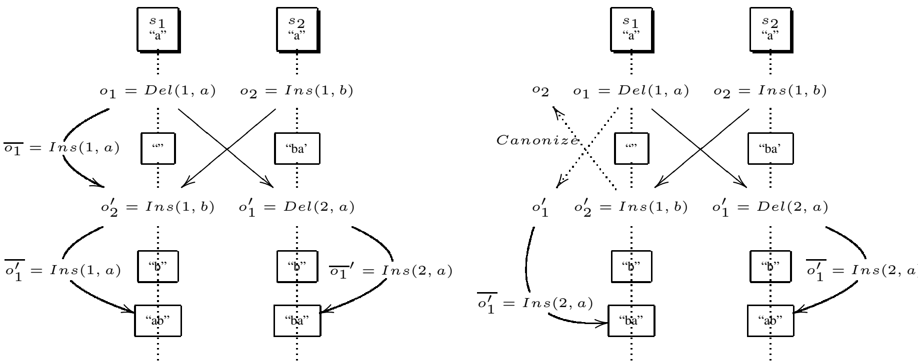
In the following, we discuss undo puzzles and show how we can avoid three between them. We also present two additional puzzles introduced by the update operation. Finally, we present our solution which is linear, generic and matches with any collaboration model based on OT approach independently of the operation set used.

3 Undo Puzzles

Four puzzles were identified in [6] and classified according to the violated property.

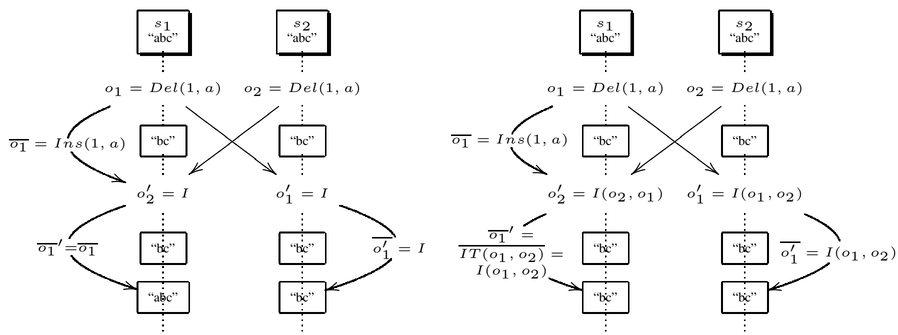
1. IP2 violation puzzle:
   (a) coupled do-undo-pair trap: occurs when transforming an operation through a coupled do-undo-pair. The solution for this puzzle is to skip the couple do-undo pair as if it was an idle operation.
   (b) uncoupled do-undo-pair trap: results when transforming an operation o against another operation and its inverse during the couple do-undo pair procedure. The problem occurs only when we integrate two insertions at the same position since the position is changed arbitrarily according to site identities. Consider the two operations $o_1 = Del(p, e_1)$ and $o_2 = Ins(p, e_2)$. Suppose that o_2 is concurrent to o_1 in which case we have to determin $o'_2 = IT(o_2, o_1) = o_2$. Now if we undo o_1, we have to determin $IT(o'_2, \overline{o_1}) = IT(IT(o_2, o_1), \overline{o_1})$ during couple do-undo pair procedure. According to site identities, we can find a result different from o_2 which means that $IT(IT(o_2, o_1), \overline{o_1}) \neq o_2$. Hence IP2 is not conserved.
2. IP3 violation puzzle:
   (a) Insert-Insert puzzle: occurs when transforming two insertions during undo procedure where the first is an inverse (see Figure 2.(a)). This puzzle is eliminated in our model by the use of canonical logs as shown in Figure 2.(b).
   (b) Delete-Delete puzzle: in the scenario of the Figure 3.(a), two deletions at the same position are performed concurrently by s_1 and s_2. These operations ares transformed into two idle operations I in both sites. Now, if we undo $o_1 = Del(1, a)$ at site s_1, we generate $\overline{o_1} = Ins(1, a)$. Then, we integrate o'_2's effect to obtain $\overline{o_1}' = \overline{o_1}$ whom execution recovers the state “abc”. However at s_2, the state remains “bc” since $\overline{o'_1} = \overline{I} = I$. It is obvious that IT fails to preserve IP3 as we have $\overline{o_1}' \neq \overline{o'_1}$.

   We add the two following puzzles caused by the update operation:
   (c) Update-Update puzzle: in Figure 4.(a), the two sites execute concurrently two updates o_1 and o_2 at the same position, then we undo o_2 in the two sites. At site s_2, $\overline{o_2}' = IT(\overline{o_2}, I) = \overline{o_2} = Up(1, y, a)$. This results in the state “abc”. However, in site s_1, $\overline{o'_2} = Up(1, y, x) \neq \overline{o_2}'$ whom execution gives “xbc”.



(a) Undoing o_1 produces a divergence (b) Avoiding divergence thanks to canonization

Fig. 2. Insert-Insert puzzle



(a) Undoing o_1 produces a divergence (b) Delete-Delete puzzle resolution

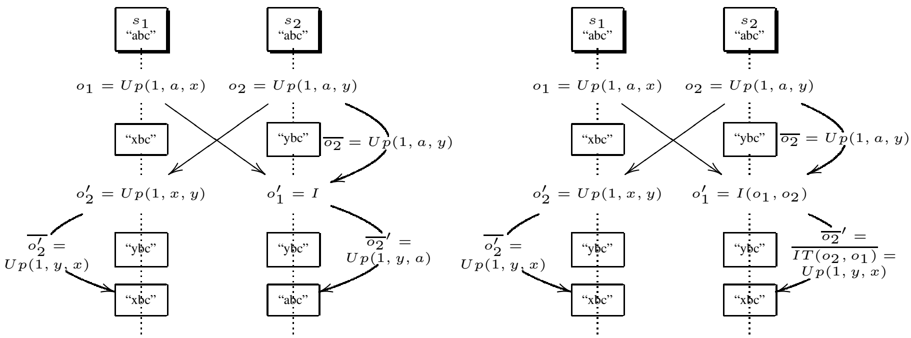
Fig. 3. Delete-Delete puzzle

(d) Delete-Update puzzle: in Figure 5, the site s_1 executes $Del(1, a)$ concurrently to s_2 that executes $Up(1, a, x)$. We obtain $o'_2 = I$ at s_1 and $o'_1 = Del(1, x)$ at s_2. Now undoing o_1 in s_1 consists of generating $\overline{o_1} = Ins(1, a)$ which is then transformed against $o'_2 = I$ and executed to produce the state "abc". In the site s_2, $\overline{o'_1} = Ins(1, x)$ since $o'_1 = Del(1, x)$ so we obtain the state "xbc".

3.1 Undo Puzzles Solution

To solve puzzles, we must ensure IP2 during couple do-undo pair procedure and IP3 when undoing and transforming against idle operations. The first kind of puzzles is avoided thanks to canonical logs as insertions are placed before deletions is history. Consequently, we only have to ensure IP3.

The key of our solution is to redefine the idle operation so that we do not loose any information. In fact, when an operation is turned to an idle one, we loose information about the original operation. We propose to present an idle operation by $I(o_1, o_2)$ where o_1 is the transformed operation against o_2 instead of the notation $I()$. We have defined



(a) Undoing o_2 produces a divergence (b) Update-Update puzzle resolution

Fig. 4. Update-Update puzzle

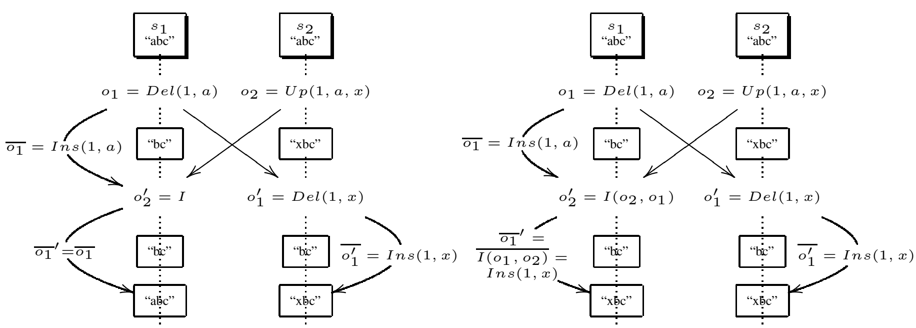
a new transformation property to underline the behavior of IT when transforming idle and inverse operations (see Definition 3).

Definition 3 (Idle operation transformation property). *Given two operations* o_1*,* o_2*,we have:*

$$IT(\overline{o_1}, I(o_2, o_1)) = \overline{IT(o_1, o_2)}.$$

Thanks to this property, IP3 is always preserved.We illustrate it by its application to the precedent scenarios as follows:

1. Delete-Delete puzzle: when undoing o_1 in site s_1 we will first generate $\overline{o_1}$ then calculate $\overline{o_1}' = IT(\overline{o_1}, o_2') = \overline{IT(o_1, o_2)}$ by respect to the proposed IT property which results in $I(o_1, o_2)$. In the other site we will simply generate $\overline{I(o_1, o_2)} = I(o_1, o_2)$. The puzzle is resolved since $IP3$ is preserved.



(a) Undoing o_1 produces divergence (b) Delete-Update puzzle resolution

Fig. 5. Delete-Update puzzle

2. Update-Update puzzle: in Figure 4.(b), to undo o_2 in site s_1, we calculate $\overline{o_2'} = Up(1, y, x)$ whom execution produces "xbc". In site s_2, we generate $\overline{o_2} = Up(1, y, a)$ then determine $\overline{o_2}' = IT(\overline{o_2}, I(o_1, o_2)) = \overline{IT(o_2, o_1)} = \overline{o_2'}$ whom execution leads to the same state as site s_1.
3. Delete-Update puzzle: Figure 5.(b) illustrates the solution of this puzzle. In fact, to undo o_1 in the first site we execute $\overline{o_1}' = IT(\overline{o_1}, I(o_2, o_1)) = \overline{I(o_1, o_2)} = Ins(1, x)$. The same result is obtained in the other site as we execute simply $\overline{IT(o_1, o_2)}$.

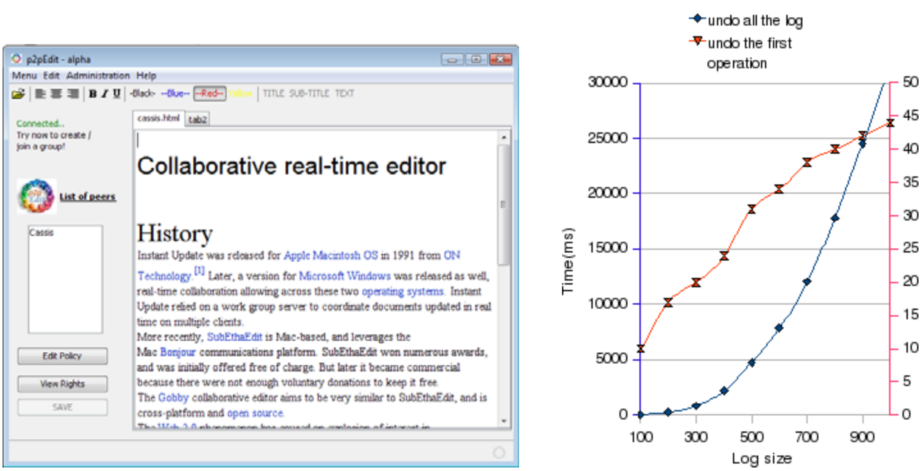
4 Implementation and Performance Analysis

To undo an operation o_i, our undo command proceeds as follows:

1. Find o_i in HB;
2. mark o_i as an undone operation,
3. generate $\overline{o_i}$,
4. For all operation o_j $(i + 1 \leq j < |HB|)$
   (a) calculate $\overline{o_i}' = IT(\overline{o_i}, HB[j])$ (integrate the effect of $HB[j]$ into $\overline{o_i}$;
   (b) replace $HB[j]$ by $IT(HB[j], \overline{o_i}')$ (exclude the effect of o_i from the log),
5. execute $\overline{o_i}'$.

Note that we need neither to store transformed forms of $\overline{o_i}$ nor original forms of any operation as it is required in [6] since puzzles are solved by IT construction.

The worst case of the algorithm is to undo the first operation of the log which results in $O(|HB|)$. To see the impact of our *undo* solution on our DCE, we also calculate the complexity of undoing all the log as the worst case faced during policy violation which gives a quadratic result ($O(|HB|^2)$).



(a) Main screen of p2pEdit (b)Time required by the undo function

Fig. 6. Implementation and experimental results

To see the asymptotic behavior of our solution we implement it in the collaborative editor p2pEdit implemented in JAVA, compiled by GNU/Linux, and executed on a computer running Ubunto Linux kernel 2.6.24-19 with an Intel Pentium-4 2.60 GHz CPU and 768 Mo RAM (see Figure 6.(a)).

We have realized experimental tests for different values of the log presented in Figure 6.(b) where the right Y axis plots the worst case when undoing the first operation and the left one plots the undo of the entire log. Note that in reality there is no need to undo all the log mainly if we consider that communication time is negligible.

5 Conclusion

The presented work motivates the necessity of undo in an access-control-based DCE. We have largely inspired from previous works on group undo solutions [6] and propose a new simple solution to solve undo problematics that is easy to implement and does not affect the complexity of the undo algorithm since it is based on the semantic of idle operation.

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Personalized Context-Aware Collaborative Filtering Based on Neural Network and Slope One*

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Abstract. Currently, context has been identified as an important factor in recommender systems. Lots of researches have been done for context-aware collaborative filtering (*CF*) recommendation, but the contextual parameters in current approaches have same weights for all users. In this paper we propose an approach to learn the weights of contextual parameters for every user based on back-propagation (*BP*) neural network (*NN*). Then we present how to predict ratings based on well-known Slope One *CF* to achieve personalized context-aware (PC-aware) recommendation. Finally, we experimentally evaluate our approach and compare it to Slope One and context-aware *CF*. The experiment shows that our approach provide better recommendation results than them.

Keywords: Recommendation, Context, Neural Network, Collaborative Filtering, Personalization.

1 Introduction

Recent years, personalized recommendation approaches have gained great momentum both in the commercial and research areas [1]. *CF* is the most successful technique for recommendation [2,3]. Most *CF* approaches have not taken context into consideration. However context has been recognized as an important factor for recommendation [4-6]. Based on *CF*, several context-aware approaches have been proposed, but the contextual parameters in the approaches have the same weights. However, the weights may be different for users [6]. For example, in a movie website, time and place are important parameters, but they may have different weights for different users, e.g. for users working at open plan office or working at *SOHO*.

In this paper we first review the state of the art in *CF* (Section 2). Then propose approaches for context-aware item difference analysis, *BP*-based personalized weight training, and Slope One based rating estimation in Section 3. And at last we experimentally evaluate our results in Section 4.

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2 Background and Problem of Item-Based and Context-Aware *CF*

In a typical *CF* scenario, there is a rating matrix which includes a set of m users and a set of n items (products) and lots of ratings $r_{u,i}$. A rating $r_{u,i}$ means how user *u* likes item *i*. The key step of *CF* is to extrapolate unknown ratings. The basic idea of traditional user-based *CF* is to predict the rating based on the opinions of similar users. It was very successful in past, but suffering from scalability problem [3]. The scalability problem means the computation complexity grows rapidly with the users and items increasing. It has been proved that item-based *CF* can solve the problems.

2.1 Item-Based Collaborative Filtering

Item-based *CF* is proposed to compute the similarity between items and then to select the most similar items for prediction. It recommends items quickly because a pre-computed model is used. There are several methods to compute the similarity, such as cosine (1) and Pearson correlation similarity (2). *U(i)* includes all users who have rated on item *i*. $\overline{r_u}$ is the average of user *u's* ratings.

$$Sim(i,j) = \frac{\sum_{u \in U(i) \cap U(j)} (r_{u,i} * r_{u,j})}{\sqrt{\sum_{u \in U(i) \cap U(j)} r_{u,i}^2} \sqrt{\sum_{u \in U(i) \cap U(j)} r_{u,j}^2}} \quad (1)$$

$$Sim(i,j) = \frac{\sum_{u \in U(i) \cap U(j)} (r_{u,i} - \overline{r_u})(r_{u,j} - \overline{r_u})}{\sqrt{\sum_{u \in U(i) \cap U(j)} (r_{u,i} - \overline{r_u})^2} \sqrt{\sum_{u \in U(i) \cap U(j)} (r_{u,j} - \overline{r_u})^2}} \quad (2)$$

There also are lots of methods for prediction, such as weighted sum (3) and regression. Here *S(i)* includes all similar items of item *i*.

$$p_{u,i} = (\sum_{j \in S(i)} (sim(i,j) * r_{u,j})) / (\sum_{j \in S(i)} |sim(i,j)|) \quad (3)$$

$$d_{i,j} = \sum_{u \in U(i) \cap U(j)} (r_{u,i} - r_{u,j}) / (|U(i) \cap U(j)|) \quad (4)$$

Slope One is a typical item-based *CF*. It works on comparing the intuitive principle of a popular differential between items [2] rather than similarity between items. The differential $d_{i,j}$ is computed by the average difference between item arrays of *i* and *j* (4). |•| denotes the cardinality of a set.

In turn, the deviation of items will be used to predict an unknown item, given their ratings of the other. The prediction is based on a linear regression model (5). Here $r_{u,j}$ is a unknown rating; $\overline{r_u}$ is the average of all known rating $r_{u,i}$ of user *u*; and $\overline{d}$ is the average of differential $d_{i,j}$. $r_{u,i} - d_{i,j}$ is a prediction for $r_{u,j}$ according to $r_{u,i}$.

$$r_{u,j} = (\sum_{i \in r_u} (r_{u,i} - d_{i,j})) / | r_u | = \overline{r_u} + \overline{d} \tag{5}$$

It has been proved that the Slope One scheme achieves accuracy comparable to that of the adjusted cosine and Pearson scheme [2]. The Slope One has won the wide attention of researchers and companies because it is simple and efficient.

2.2 Context-Aware Collaborative Filtering

Context is “any information that can be used to characterize the situation of an entity” [7, 8]. It is important for recommendation [4-6]. The idea of the context-aware *CF* is similar users in similar context like similar items. Chedrawy etc. [4] divided context into multiple perspectives, then calculated the similarities in perspectives and combined them. Let W_p be the weight assigned to perspective p; $sim_p(i,j)$ be the similarity between items i and j to p, the similarity $sim_c(i,j)$ is as in (6). Adomavicius and Tuzhilin [9] proposed a multidimensional space (include contextual information) and a method for prediction in the space. They divided dataset to dimensions for different contexts. Then the recommendation was defined by selecting “what” $D_{i1},\ldots,D_{ik}$ and “for whom” $D_{j1},\ldots,D_{jm}$.

$$sim_c(i, j) = (\sum_{p=1}^{N} W_p \times sim_p(i, j)) / (\sum_{t=1}^{N} W_p) \tag{6}$$

The weights of contextual parameters in current approaches are same for every user. However, they should be different [6]. On one hand a user usually has different preferences in different context; and on the other hand some contextual parameters are more important than others. *{(Contextual parameter, Weight)}* pairs form the personalized context. The weights indicate how the user is sensitive to the parameters. In the paper we present a *BP*-based approach to learn the weights of the parameters, and then incorporate them into Slope One.

3 Personalized Context-Aware Collaborative Filtering

Our vision of the personalized context-aware *CF* is based on *BP* and Slope One. In this section we propose approaches for context-aware item differences analysis, personalized context learning, and rating estimation. Given training and test dataset *S* and *T*, we divide *S* into a training set *D* and a test set *TT* for the *BP*-based training.

3.1 Context-Aware Item Difference Matrix

Item difference matrix (*DM*) includes all deviations between items. Context-based item difference $d_{i,j,ck}$ is the deviations between item i and j in context c_k. The *DMs* in different contexts are the basis of PC-aware prediction. It takes two steps to get them.

Step1. Given a training dataset *D*, we extract subset $\{Dc_1, Dc_2,\ldots, Dc_n\}$ from *D* according to different context. Every subset Dc_k includes the data belongs to c_k.

Step2. For every two items i and j of Dc_k, calculate average deviation $d_{i,j,ck}$ of them by (7) (extension of (4)). $Uc_k(i)$ includes users who have rated i in Dc_k. All the $d_{i,j,ck}$ forms the context-aware DMc_k for c_k.

$$d_{i,j,c_k} = \sum_{u \in Uc_k(i) \bigcap Uc_k(j)} \frac{(r_{u,i} - r_{u,j})}{|Uc_k(i) \bigcap Uc_k(j)|} \tag{7}$$

3.2 *BP*-Based Personalized Context Analysis

First of all, according to DMc_k, we predict all ratings in *TT* (8) (extension of (5)). $p_{u,j,ck}$ is the prediction for j rated by user u in context c_k. The predictions are input instances.

$$p_{u,j,ck} = \frac{\sum_{i \in R_u} (r_{u,i} - d_{i,j,ck}) * |U(i) \bigcap U(j)|}{\sum_{i \in R_u} |U(i) \bigcap U(j)|} \tag{8}$$

The weight training procedure includes three main parts: network structure of the *BP* algorithm (a), active function selection (b), and weight adjustment function selection (c). At last an algorithm for the procedure is given (d).

(a) Network Structure of the BP Algorithm
According to Kolmogorov theorem [10], three-layer *BP* with sigmoid function can represent any linear or non-linear relationship between the input and output. So in our research, a three-layer network and sigmoid is used. It consists of an *input layer (IO)*, a *hidden layer (HL)*, and an *output layer (OL)* (See Fig.1).

- The number of neural nodes n in the *IO* is the number of contextual parameters. The inputs of them are prediction $p_{u,i,ck}$.
- The number of the *HL* is $2n+1$ according to Kolmogorov theorem.
- There is only one node in the *OL*. The output value of this node represented the last prediction for $p_{u,i}$.

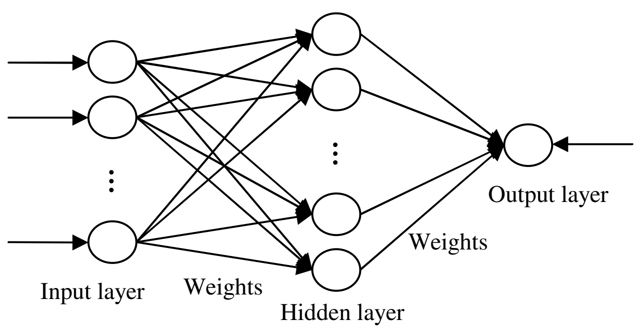

Fig. 1. The Network for the weights of contextual parameters

(b) Active Function

In the *NN*, the activation function is used to express the relationship process between the input and output. There are many links to a neural node. We regard the weighted sum of this links as the input of the node. We use the most commonly used sigmoid function [10] $f(x)=1/(1+e^{-x})$ as the active function for the weight training. Here x is the input of the node, and $f(x)$ is the output.

(c) Weight Adjustment

During training, the adjustment of the weights uses error back-propagation. The weight connected with two nodes is adjusted according to the amount proportional to the strength of the signal and the error. The error at the *OL* is reallocated backwards through the *HL* until the *IL* is reached. This process is repeated until the error for all data is sufficiently small.

For the node in the *OL*, we compute error Err_i using formula 9. Here the O_i is the computed output at node i. T_i is the real output instance value (in *TT*), and $(T_i - O_i)$ is the actual output error.

$$Err_i = O_i(1-O_i)(T_i - O_i) \tag{9}$$

For the nodes in the *HL*, we reallocate the errors Err_i using formula 10. Here j means that there are j outputs of node i, Err_j denotes the error of node j, and $w_{i,j}$ is the weight of the link from node i to node j.

$$Err_i = O_i(1-O_i)\sum_j Err_j w_{ij} \tag{10}$$

After getting all errors, we adjust the weights $w_{i,j}$ using formula 11. Hereη is the learning rate parameter. It is 0.8 at the beginning. And it will differ with the deviation of the computed output and the real value.

$$w_{ij} = w_{ij} + \eta * Err_j * O_i \tag{11}$$

(d) BP-Based Personalized Weights Learning Algorithm

Input: Dc_k, DMc_k

Output: The weights of contextual parameters for every user

Procedure:

Step1. Prepare instances for inputs and outputs for *BP*-based weight learning

All predictions $p_{u,i,ck}$ form input instance datasets and all true ratings $r_{u,i}$ form output instance dataset.

Step2. Initialization, activation, weight computation

1) Initialize the input and output instances. Use random values between 0 and 1 as the weights of contextual parameters.

2) While not (terminal condition)

{

a) For a set of input instances

{ Compute the weighted sum of the inputs as x

Compute the outputs of *hidden layer* using sigmoid function

Regarding the outputs of *hidden layer* as the inputs of *output layer*, compute the weighted sum of them

Compute the outputs of *output layer* using sigmoid function

}

b) For the output instances
{ Compute the error of the node in *output layer* by formula 9
Compute the error of the node in *hidden layer* by formula 10
Update weights of the links by formula 11
}
}

At last, we get the weights $w_{ck,u}$ of the contextual parameters for every user. The weights form a personalized context matrix (*PCM*) which includes users (rows) and contextual parameters (columns).

3.3 Personalized Context-Based Prediction

This procedure predicts all ratings in *T* through 3 steps.

Step1. Given the target user *u*, we get the weights $w_{ck,u}$ from *PCM* for him/her.
Step2. Calculate prediction $p_{u,j,ck}$ for $r_{u,j}$ by (8) (Section 3.2).
Step3. Calculate the prediction $p_{u,i}$ for $r_{u,j}$ (12). Here c_k is a contextual parameter, *C* includes all contextual parameters, and $w_{ck,u}$ is the personalized weight of the contextual parameter c_k for user *u*.

$$p_{u,j} = (\sum_{c_k \in C} p_{u,j,c_k} * w_{c_k,u}) / (\sum_{c_k \in C} w_{c_k,u}) \tag{12}$$

4 Experimental Evaluation

4.1 Data Set and Evaluation Metric

We used dataset from the well-known Movielens project (http://movielens.umn.edu). The dataset consists of 100,000 ratings (1-5). It was divided into training and test set (80% and 20% of the data) five times. These training and test sets are named U1base to U5base, and U1test to U5test. Without loss of generality, we used U2base and U2test to evaluate our approach. Then divided U2base into U2basec and U2testc (70% and 30% of U2base) for personalized context analysis. The contextual parameters include age, gender, occupation, zip, and time (work time and rest time).

We used widely used metric MAE (Mean Absolute Error) [5] to measure the deviation between predictions and ratings. The lower the MAE, the more accurately the predictions are, and the better the recommendation approach is.

4.2 Experimental Procedure and Results

***(a)** Context-aware Item Deviation Matrix Computing*
If the context were not considered, the *DM* (13) is calculated on training set U2basec. If we regard sex as the first contextual parameter, we got DMc_1 from subset Dc_1 of U2basec where the user's sex was male or female. So did DMc_k.

$$DM = \begin{pmatrix} 0 & 0.702 & 0.957 & \dots \\ -0.702 & 0 & 0.286 & \dots \\ -0.957 & -0.286 & 0 & \dots \\ \dots & \dots & \dots & \dots \end{pmatrix} \quad DMc_1 = \begin{pmatrix} 0 & 0.793 & 0.9 & \dots \\ \text{-}0.793 & 0 & 0.352 & \dots \\ -0.9 & -0.352 & 0 & \dots \\ \dots & \dots & \dots & \dots \end{pmatrix} \tag{13}$$

(b) BP-based Personalized Context Analysis

The *BP* network includes 5 nodes in the *input layer*, 11 nodes in the *hidden layer* and 1 node in the *output layer*. According to the steps in Section 3.2, we first predicted $p_{u,i,c}$ for the ratings in U2testc. Then regarding the predictions as input instances and the true ratings as output instances, we trained the weights for every user. At last we got *PCM* (14).

$$PCM = \begin{array}{c} \\ U_1 \\ U_2 \\ U_3 \\ \dots \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & C_3 & \dots \end{array} \\ \begin{pmatrix} 0.203 & 0.112 & 0.385 & \dots \\ 0.151 & 0.315 & 0.159 & \dots \\ 0.179 & 0.236 & 0.165 & \dots \\ \dots & \dots & \dots & \dots \end{pmatrix} \end{array} \tag{14}$$

(c) To predict all ratings in the test set U2test using formula 8 and 13.

(d) Comparison of Prediction Results

To validate our approach and determine the sensitivity of the Size of Item, we performed the experiment where we computed MAE for different size of item for the algorithms. Size of Item means how many users have rated the item. The results are shown in Fig.2. The blue line is for Slope One algorithm, the pink one is for context-aware algorithm, and the yellow one is for our PC-aware algorithm. It can be observed that our algorithm out performs Slope One and context-aware algorithm at most values of item size. For example, at item size of 40-80, Slope One, context-aware, and our *PC*-aware algorithm show MAE of 0.771, 0.759, and 0.752 respectively. At item size of 150-250, our algorithm get optimum value. But at item size of above 250 all algorithms perform worse. We believe this happens as the model suffers from data over fitting at high density levels. These data represent that personalized context is helpful to improve the recommendation results.

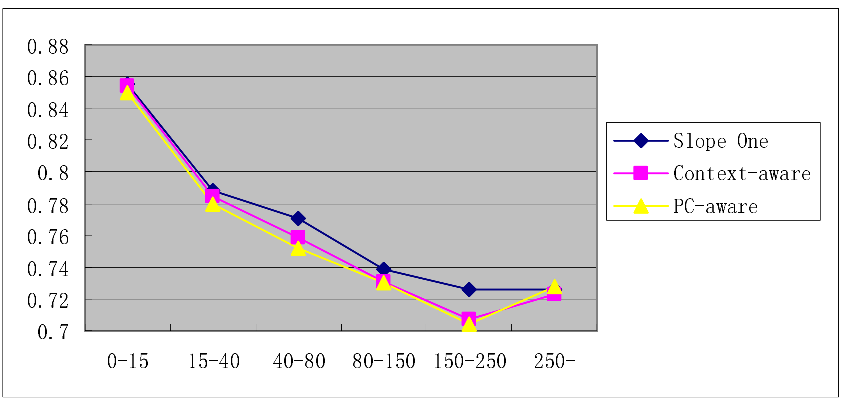

Fig. 2. Performance results on the item size

5 Conclusion

Recommender systems help users find items they would be interested in. *CF* is the most popular approach for recommendation. Based on *CF*, some context-aware approaches have been proposed. However in these approaches, the weights of contextual information are the same for users. To achieve personalized context-aware recommendation, in this paper we analyzed how to compute context-aware item difference, to learn personalized contextual weights, and to predict ratings based on *BP* and Slope One. Experimental results showed that personalized contextual information is helpful to improve the prediction results of *CF* algorithms.

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User Studies of a Sketch-Based Collaborative Distant Design Solution in Industrial Context

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Abstract: This study evaluates the opportunities and constraints linked to the technological transfer of a sketch-based distant collaborative environment, from academy to industry. The paper relates the concepts of the sketch-based collaboration, describes the Distant Collaborative Design Studio and proposes a methodology to assess the utility and usability of the system in two different companies. The results and conclusions show the issues linked to the implementation of such sketch-based collaborative environment in professional contexts.

Keywords: Sketch, creative design, collaborative design, virtual desktop.

1 Introduction

Since several years, the LUCID-ULg (Lab for User Cognition and Innovative Design) develops advanced CAD tools, in research and educational scopes. Among its most advanced prototypes, the DCDS (Distributed Collaborative Design Studio) is a sketch-based distant collaborative environment to support creative stages of design. This environment has already been tested and validated by the laboratory in an educational context. The objective of this study is to go beyond the walls of the university: the aim is to evaluate the opportunities of the technological transfer of this device in industrial domain, which is quite different from academic and research contexts, and to evaluate the core issues linked to the sketch-based collaboration in professional practices.

This paper describes the INNOVATIC project, a validation study of the DCDS technological transfer from university to industry. From field studies, anchored in real professional contexts, we drive conclusions about the utility of the DCDS, and show how our prototype should be enhanced to respond to true demands of industrial contexts. This study is grounded in a more general context of a user-centered methodology, which has prevailed from the very beginning of the DCDS development.

At first, we briefly describe the context of the project, i.e. the usefulness of sketch-based collaboration in the early steps of design. We then give a description of the DCDS environment. The methodology frame of our technological transfer study and its results are given in the next two sections. We then conclude on perspectives about the utility of such an approach and the issues linked with sketch-based collaborative design in industrial context.

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2 Context

In a wide range of activity sectors, collaboration has been intensified, notably in the design domains. Collective work is increasingly organized simultaneously (rather than sequentially as it used to be in the past). Moreover, design teams are often geographically distributed, and the need for distant real-time interaction is consequently emerging. A lot of effective systems are available for sharing information, but most of them are asynchronous (e.g. database server, email…) or allow only partial interaction (e.g. phone or visioconference).

Virtual reality is a promising way to respond to challenges in organizations and processes. The LUCID-ULg proposes a system for sketch-based multimodal interaction, which is based on the *invisible computer* paradigm [1]. Instead of requiring designers to change their way of conceiving, we propose to support one of the most usual way of collaborating: the free-hand sketching, which plays an crucial role, especially during initial stages of design. Even in domains where design constitutes only a part of the whole process (as for instance building or naval engineering, architecture, industrial design or town planning), there are great ideas that emerge from quick drawings made on a napkin! Many authors grant to the upstream sketching phase the biggest magnitude: it reduces the cognitive charge, makes designers explore more solutions, enhances creativity, and eases the artifact communication [2].

3 DCDS

Our prototype, named Distributed Collaborative Design Studio (DCDS) is composed of a hardware part – the Design Virtual Desktop – and a software part – SketSha (for sketch sharing), completed by external modules.

The Design Virtual Desktop (fig 1) consists of an electronic A0 table with a suspended ceiling equipped with a projection system offering a large working surface (approximately 150x60 cm^2). An electronic stylus allows the drawing of virtual sketches onto this surface. The central unit is located in the ceiling. This leaves the stylus as the only interaction tool, so that the computer can disappears from designers' mind.

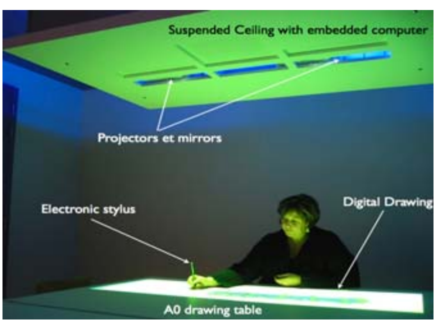

Fig. 1. Virtual Desktop

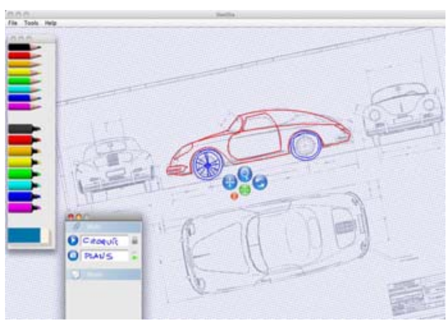

Fig. 2. SketSha Interface

The SkeSha software (fig. 2) is a shared drawing environment allowing several virtual desktops to be connected to the same drawing space. Various functionalities, such as a panel of colored pens (and an eraser) and a navigation widget (zoom, translate, rotate), are proposed through intuitive graphical widgets. This software captures the strokes that compose the sketch, share them between the different distant locations (through a classic internet connection) and transmits the whole information in real-time on the active boards through video-data projectors.

Some layout facilities have also been included in the prototype, such as the possibility to draw and to manage different sheets of virtual paper, to delete or duplicate them, and to manage their transparency. The software also allows to import CAD plans and bitmap images.

Pointing, annotating and drawing are possible thanks to the electronic pen that activates the virtual desktop drawing recognition. Social exchanges are transmitted through external modules (videoconference commercial solutions) in order to support the vocal, the visual and the gestural aspects of the collaboration. The system is thus completed by a 24 inches display with an integrated camera, that allow the participants to see and talk to each others, in an almost 1/1 scale, during a real-time conference. This integrated camera is in fact a very simple way to avoid the gaze deviation when talking to interlocutor(s) (see fig 3 for the whole environment).

Fig. 3. Distributed Collaboration Design Studio

Initially thought specifically for architecture, our system revealed itself to be useful for many other design domains.

Following the user-centered framework underlying the DCDS development, the system has been first tested in different sessions : individual uses [3,4], distant collaborative sessions [5,6] and pedagogical long duration collaborative work settings [7,8,9].

All testing sessions have been videotaped (fig 4) and analyzed by ergonomists. They have demonstrated the simplicity of the system, which is quickly mastered by all participants. They have also shown the richness of interactions in our environment, and the system ability to support collaboration close to co-present situations. The long-term sessions have also shown its utility as an efficient cooperation tool for concrete projects.

Fig. 4. Screenshot of collaborative session recording (front view and top view)

Furthermore, industrial partners (mechanical engineering office and an architectural office) have shown to be very interested by this environment for their professional practice and foresee many real advantages by adopting our technological solution.

4 Methodology

In order to deepen the user-centered approach, we needed to assess the opportunity of the DCDS technological transfer to industrial context. With this objective we designed a three steps methodology for involving users in the reflection.

1. On-site interviews to understand the collaborative habits of companies: the idea is to identify the opportunities of the introduction of the DCDS, as well as challenges and issues it raises, from an organizational point of view.
2. Demonstration of the prototype, composed of three steps: a formal demonstration leaded by the researchers; an artificial situation designed to let people try the system; and a structured brainstorming, aiming at identifying the opportunity of using such a system
3. Real work session: one half-day work session has been planned to become a part of a real project of the users. It consisted in a real meeting with different actors of a same design project but, instead of taking place around a table in the office, it took place on two connected DCDS, which were located in two different rooms of the University of Liège.

The first two steps were targeting company directors and managers, who are aware of the organizational challenges linked to the introduction of such a system. The last step was targeting the main designers, who are potential end users of the device. Therefore, the first two steps aimed at identifying *utility* issues, while the last one was more linked to the system's *usability*.

This three steps methodology has been implemented with two sets of users: in a large international architecture office (about 120 collaborators in 3 countries) and a mechanical engineering office of about 60 people. These two kinds of company have different types of organization, different habits, different legal steps in design process, and above all different uses of free-hand sketches. The first step gathered 4 users in architecture office and 4 in industrial design office, the second step 3 and 2, and the real work sessions involved each time 4 users, distributed on two DCDS.

All the steps have been recorded and/or videotaped for analysis purpose. The figure 4 shows a screenshot of the recording of the third phase work sessions.

5 Results

This study has led to two sets of results. The first one is related to current collaboration practices and the way they could be enhanced or, at least, modified by the DCDS. They refer to the utility of the system. The second set of results is complementary: it gives insights for identification of usability problems and missing functions, through the analysis of activities. The following sections summarize the main observations and conclusions.

5.1 Envisioned Utility of the System and Organizational Changes

In the mechanical engineering office, every project goes through systematical steps, being always the same. 1) At first, there is an encounter with the client in a copresent meeting (in the company or in the client's place) where all initial information is exchanged. Then the first working stage is leaded inside the company. Several workers are already involved, and share numerous documents. Using the DCDS in a copresent situation should be interesting for their project meetings, because it can keep track of the annotations and modification, and share them among every actors. 2) Afterwards the collaboration with the client intensifies. Many documents, plans etc. are exchanged and annotated. For this purpose, the DCDS could be a beneficial tool to save time, especially when the client is far from the company. 3) Then loops of "internal work/work with the client" continue until the final presentation. All these exchanges are usually asynchronous, which may lead to losses of time and misunderstandings. The real-time capacity of the DCDS is therefore highlighted by the interviewees. Furthermore, they emphasis reduction of paper and travels, and limitation of the ecological footprint.

In the observed architecture office, the workflow is well structured: a project starts by a design phase for a few weeks or a few months, before going in a development phase. These two stages are clearly distinct in the organizational structure of the company. The design cell uses its own tools and standards. It is composed by people with different qualification than those of the development team and is mainly leaded by time constraints: the work organization has to be very flexible. Pen and paper sketches are core tools for the preliminary design, as well as some computer graphics tools. The main issue of the development cell is related to the harmonization of representations. Due to the length of projects (generally several years, up to seven), the production has to be standardized, to manage regular turnover of workers. CAD tools are mostly used by this development cell.

For the architects, the DCDS offers several advantages. It is considered as a "*quite obvious necessity*", as it allows reducing displacements in every project step.

- For the design stage, it allows to communicate between different designers, in real-time and using a simple manner. This will lead to an interesting change in the power structure of the company. For the moment, the head office leads the design process and the distant partners feel sometimes disempowered from the core design. They are just involved in a few meetings. Having the possibility to make day-to-day distant meetings should enhance the investment of distant partners in the design, with a better balance of teams responsibilities.
- For the development phase, the DCDS allows a quick communication between the architects and the contractors on the building site, enabling quick problem solving, mainly based on plans annotations.
- It also facilitates communication with the client, who is often far from the head office. For this last utility, however, 3D representations could still enhance the DCDS offer.

For the two situations, the main problem is linked to the “heaviness” of the hardware infrastructure. The system is still costly and bulky, especially to be installed in small branch offices, or at the client’s office. Furthermore, for the design phase, the architects fear that the introduction of such a system lead to the multiplication of short meetings, which are perhaps not always necessary. Without a strong organizational regulation, this may globally lead to a loss of time.

5.2 Usability Issues and Needed Functions

The testing in the two situations (with the mechanical engineering office and the architecture office) was qualified as a success. Real meetings took place and the results were very satisfying for both teams. This testing has led to several conclusions.

At first, it has to be noted that some usability issues need improvement: difficulties with layers management, calibration problems and lack of the undo function are highlighted. Nevertheless, these adjustments are qualified as minor by the development team.

The major strength of the DCDS is linked to the “natural” interaction modalities and the completeness of collaborative interactions between distant users. Multimodality of interaction (sketches, annotations, voice, images, gestures) is appreciated and several suggestions are linked to an enhancement of the offered simplicity: facilitating the pointing, word and gesture recognition, gestural interface are proposed. On a global pointy of view, it has been noted that the real-time collaboration allowed by the system leads to an enhancement of participation and a time profit for generating and validating ideas.

Other suggestions are linked to the management of collaboration inside the system: users would like to clearly identify who is drawing at each time and which strokes are drawn by which user. In the same idea, they would like to implement a digital signature. Indeed, until now sketches are drawn on the DCDS with no legal value. Electronic signatures should allow real legal collaboration. The system should also allow the management of different project versions that may be numerous. Finally, some users proposed to use the system to keep track of the collaborative process, by audio recordings for instance: the drawing could then be doubled by verbal annotations.

One of the major propositions, already evoked in the previous section, is linked to the availability of a mobile version of the device. More generally, the users claim for a more flexible working surface: some users want the drawing surface larger, other ones consider the virtual desktop as already too large for their use. This flexibility implies obviously reflections about software compatibility between different devices, and especially management of several drawing surfaces of different sizes into the real-time collaboration space.

The import-export modules should be enhanced. For the moment they lack to support heavy files, which are numerous in the large projects usually involving distant collaboration. Moreover, designers of the mechanical engineering office (who are less used to free-hand drawing than the architects) would really benefit to using vectorial drawings.

The issue of transfer security is also an important point, because many information exchanged in the design are confidential by nature. DCDS should be enhanced to avoid security failures.

Compatibility with "classical" CAD tools is also highlighted. The system should support different file formats and should allow a direct link with the other tools used by companies.

Finally, the Internet stability seems satisfying. SketSha is quite stable for long-term sessions. The main problem of Internet transfer are linked to the common visioconference module.

6 Perspectives

The results have led to several conclusions. At first it is interesting to notice that the DCDS seems to be appropriate in two quite different contexts, namely in architectural design and in mechanical engineering design. If these two contexts imply different issues and development propositions, they support quite similar activities. They can be classified into 4 categories: (1) naturalness of interaction, (2) collaborative process and legal and organizational issues, (3) compatibility with other tools and (4) flexibility of hardware component and mobility. From this point specific modules should be differentiated, according to the different contexts. For instance, the use of vectorial drawing is a core issue for the mechanical engineering office, but not for the architecture company.

The study and its methodology, which are proposed here to validate the technological transfer, are simple but seems efficient: thanks to a few working sessions, it allows to identify a lot of issues and potential developments. We argue this is only possible throughout user studies in real settings. This study also reinforces our industrial partnerships, by demonstrating to our partners and potential clients the effective utility of our technological proposition.

Finally we have to highlight that collaboration is not just a matter of collaborating. It raises several issues linked to organization, management, legal aspects, transfers security, etc. All these issues have to be taken in account when designing appropriate technologies for collaboration. The simple technological capabilities and the "smart aspects" of a new tool are not sufficient: collaboration is rooted in organizations and habits that need to be taken into account. Our next steps will be to test the DCDS in long-term settings inside the companies. This will show us deeply the issues linked to organizational constraints and advantages of its usage. This will also be the opportunity to gather a lot of complementary information about the usability and the potentialities of our DCDS system.

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A Conceptual Model for Analysing Collaborative Work and Products in Groupware Systems

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Abstract. Collaborative work using groupware systems is a dynamic process in which many tasks, in different application domains, are carried out. Currently, one of the biggest challenges in the field of CSCW (Computer-Supported Cooperative Work) research is to establish conceptual models which allow for the analysis of collaborative activities and their resulting products. In this article, we propose an ontology that conceptualizes the required elements which enable an analysis to infer a set of analysis indicators, thus evaluating both the individual and group work and the artefacts which are produced.

Keywords: Groupware, CSCW, Collaboration and Interaction Analysis.

1 Introduction

Groupware systems were conceived with the aim of providing software to support the work of a group in solving a problem and achieving a common goal. In these collaborative activities, the work carried out by the group is based on a very diverse range of communication and interaction methods [10]. In this context, one current challenge is to build models and methods which can facilitate the analysis of the collaborative work [6] and also to evaluate the resulting product of that process. An analysis process can identify problems in the collaborative process, and these problems can be solved by means of mechanisms that automatically intervene to aid the users. The conceptual model proposed in this article aims not only to provide a global analysis of the collaboration and of the built product, but also to analyse the contributions of each group member and their influences on the resulting product.

A number of previous studies in the field of CSCL (Computer-Supported Collaborative Learning) research have focused on carrying out an analysis of collaborative work by evaluating students' collaboration whilst they make use of these learning environments [11]. These proposals are based on the concept of analysis indicator [5]. An analysis indicator is a variable that assesses certain properties (e.g. quality) of the collaborative work process or the resulting products.

The next section reviews some other studies which have analysed aspects related to collaborative work using groupware systems. After that, our conceptual analysis model is described by means of an ontology. Finally, the conclusions drawn from this work are given and some future lines of investigation are considered.

Y. Luo (Ed.): CDVE 2009, LNCS 5738, pp. 125–132, 2009.

2 Related Work

In the field of CSCW, several studies have proposed frameworks and conceptual models to classify the activities that take place during the collaborative process, as well as the resulting products. In some cases, these frameworks do not carry out any actual analysis, limiting themselves to detecting the changes made by each group member in the shared workspaces [13]. Although these frameworks do not allow for the inference of analysis indicators, they use descriptors that fully characterize the actions carried out by each user. Therefore, these descriptors can be used to analyse the users' actions.

A second set of studies set out to analyse the collaboration between the members of a work group. Kleef et al. [8] propose a social context model, which is used to evaluate communication between the members of virtual communities. However, there are other aspects, besides communication, involved in the collaborative work process [9]. Some of these aspects, such as task distribution, the contributions made by each user, or the use of shared workspaces, are conceptualized by means of an ontology in the proposal by Barros et al. [3].

On the other hand, the OCAF framework [1] establishes models containing the objects that make up the artefacts produced by the group work. As such, Babič et al. [2] define an ontological model referring to the process in which learners are collaboratively developing shared objects.

3 A Conceptual Model for Process-Product Analysis

An ontology enables the conceptualization of the analysis process of the completed collective activities and the products obtained by the users of a groupware system. In our case, the process of building this ontology began with the identification of the elements that should be conceptualized in an analysis process. Once the elements to be conceptualized had been identified, they were defined and the relations between them were established. These relevant concepts and relations were organized into two ontologies: the first ontology conceptualizes the elements involved in the collaborative problem-solving process, and the second ontology specifies the elements required for an analysis of the collaborative process. These ontologies are expressed by means of UML diagrams [7] and tied together by a natural language description of all the concepts.

3.1 Ontology of the Collaborative Problem-Solving Process

This ontology includes three subontologies. The first defines the elements which are necessary to formalize the application domain supported by the groupware system. The main objective of the second subontology is to establish the characteristics of the products that the users must build by manipulating the elements defined in the subontology of the application domain. Finally, the collaborative work subontology defines and classifies the actions that users can carry out.

3.1.1 Subontology of the Application Domain

In order that the analysis can be carried out independently of the application domain of the system, it is necessary to create a generic conceptual model that supports the definition of any domain. The application domain is made up of all those elements that can be manipulated by the users to build artefacts. This subontology conceptualizes the following elements:

- *Entity*: This is the central concept of the domain. Once instantiated, these elements can be related to other entities. An entity can also be made up of other entities.
- *Relationship*: These are conceptual links which allow for communication between the entity instances. Each relation must define what kinds of entities can communicate and the number of objects that can be related.
- *Attribute*: Each entity contains attributes. They define the state of the entity.

An example that illustrates this approach is the specification of the UML Use Case Diagrams application domain. This application domain can be specified as a set of *entities* (actors and use cases) which can be linked via different *relationships* (e.g. association, include, extend). This approach to conceptualizing the *application domain* enables the use of XML-based meta-meta-modelling standards to formalize the application domain (meta-model).

3.1.2 Subontology of the Problem-Goal

This subontology presents the concepts required to specify the tasks that must be accomplished by the group. The *problem-goal* is an abstraction of the problem to be solved by the work group, i.e. the main goal that must be achieved through the successful completion of the work. Some proposals in the field of CSCL specify the tasks via an instructional design [12] wherein the students must reach the final goal by carrying out previously specified intermediate activities.

In our proposal, we adopt a greater degree of abstraction, thus allowing our ontology to be applied within more generic collaborative systems, and not only within the academic sphere. For this reason, in our proposal each *problem-goal* is formalized by means of a set of *laws*. These *laws* can be expressed as a set of specific properties that should be met by the collaborative work and the built artefacts. This subontology classifies each law into one of the following two groups:

- *Constraint*: A limitation or prohibition that must be respected in the problem solving process. For example, a time limit for using the system.
- *Requirement*: This specifies an obligation, defining how the product to solve the proposed task must be built and how the collaborative process must be carried out. The requirements characterize the properties of the instances of the application domain elements which must make up the final product. For example, in UML Use Case Diagrams each use case and actor should contain an attribute specifying its name.

The users must have a set of competences, known as *skills,* in order to correctly fulfil each proposed *law*. An example of a *skill* is the ability to implement recursive methods, which is necessary for solving certain structured programming problems in the domain of Computer Programming. Finally, this subontology can include an *ideal-solution*, which is a solution that fulfils the *problem-goal* proposed in the task in accordance with all the constraint and requirement formalizations. An *ideal-solution* consists of a product made up of diverse instances of elements of the application domain (see subsection 3.1.1).

3.1.3 Subontology of the Collaborative Work

This subontology conceptualizes the *collaborative-process* as an abstraction of all the work carried out by the *users* of a *groupware* system in order to solve a *problem-goal* (see subsection 3.1.2). The *users* are organized into *groups,* which collaborate in *work sessions*. A *work-session* defines the date and time when the work should start and the amount of time that the *users* can spend on it.

The *users* usually organize the collaborative work by dividing up the work to be done. As such, the collaborative work is divided into smaller units of work known as *tasks*. Each user has a *role,* defining the task that they must carry out. An action is the smallest unit of work. The *users* use the *tools* included in the *groupware* system to perform *actions*. From an analysis point of view, this subontology classifies a collaborative action as:

- *Instrumental*: When an instantiated element of the application domain concepts is manipulated in the shared workspace where the model is created.
- *Communicative*: This is an action oriented towards obtaining a common understanding among the members of the group by means of the exchanging of ideas. For example, sending a comment via a chat or e-mail tool.
- *Formal*: An action that allows for the development of the collaborative process in an ordered, synchronized and systematic way, in accordance with the collaboration policies established in the task.
- *Cognitive*: An action that permits some type of knowledge to be extracted from the performed work, or which allows this knowledge to be put to use. For example, simulating a model that is being designed or storing the final product so that it can be accessed by people outside of the group.

The main goal of the *collaborative process* is to build a *solution-result*, which consists of a combination of instantiated elements defined in the *application domain*. The final built product is the result of all of the *instrumental* and *cognitive* actions carried out by the group.

3.2 Ontology of the Analysis Process

This ontology conceptualizes the analysis process by means of three subontologies. The first subontology models the process which gathers information about the collaborative work. The second ontology conceptualizes the process of inference of indicators to represent the collaborative work. The third subontology presents an intervention procedure that uses the analysis indicators to improve the collaborative work. This conceptualization is derived from the methodological proposal of Bravo et al. [4] for analysis processes in CSCL environments and their application in a case study.

3.2.1 Subontology of the Observation Process

The observation process captures, models and stores the information required to infer analysis indicators (Fig. 1). For this purpose, an *observer* module takes as its input the actions carried out in the collaborative process and produces models of each action.

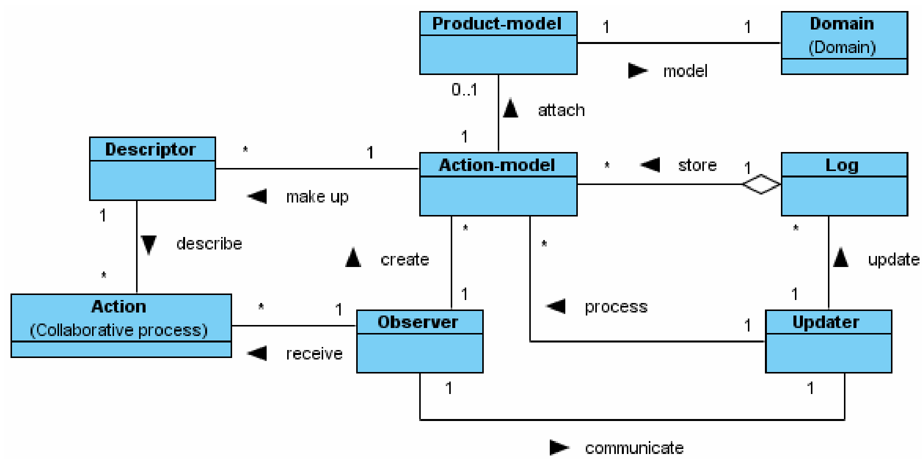

Fig. 1. Subontology of the observation process

These models, known as *action-models*, represent the actions using a set of *descriptors*. A descriptor is a property that describes an aspect of an action (e.g. user who performed the action, name of the groupware system or tool that supported the action, etc.). When the action modifies the product being built (e.g. introduces a new use case in a model), the *action-model* attaches a *product-model* which represents the effects of the performed action using a representation of an entity instance of the *domain*. The *updater* module stores every *action-model* in a *log* document, so that the *log* can be processed later to infer analysis indicators.

3.2.2 Subontology of the Abstraction Process

This subontology (Fig. 2) specifies an *abstraction* process which infers a set of analysis *indicators* from the users' actions. An analysis *indicator* is specified entirely by means of the set of *values* that it can take and its *purpose*. For instance, an indicator *Cost* assesses the use of spatial and temporal resources in the building of a product (this is the purpose) and can take three different discrete values (Low, Intermediate or High).

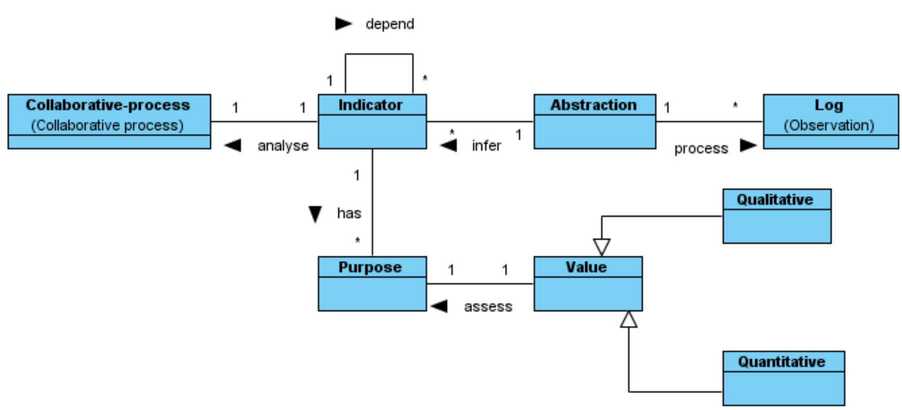

Fig. 2. Subontology of the abstraction process

A set of indicators can be used to infer a new indicator. This newly inferred indicator is a high-level indicator because it is dependent upon other indicators. Low-level indicators are calculated simply by processing information stored in a log document and they do not depend upon other indicators. For example, in a collaborative process where a group design a use case diagram, a low-level indicator may quantify the number of use cases. Another low-level indicator quantifies the time spent by the group building actors. A high-level indicator can infer, with a qualitative variable, the balance between the two ratios (number of actors and number of use cases in the solution).

3.2.3 Subontology of the Intervention Process

This subontology (Fig. 3) models the *intervention* as the process that triggers a set of *mechanisms*, using the inferred analysis indicators, to improve the collaborative work process. To this end, the *intervention* process should check the *conditions,* which define those situations in which an intervention *mechanism* should be launched. The *elapsed-time* specifies when a condition should be checked. Each intervention *mechanism* is made up of the following elements:

- *Form*: The intervention usually consists in providing feedback in the form of advice or suggestions. However, other forms of intervention can also be specified.
- *User-target*: This defines the user (or the group) that is the target of the intervention mechanism.
- *Information*: The data to be used (e.g. displayed) in the intervention.
- *Place*: A groupware system tool or an analysis workspace.

An example *mechanism* intervention is could be sending messages (*form*) to those users (*user-target*) who insert an actor or use case without using an attribute which specifies the name of these new objects. Therefore, the intervention *mechanism* must use *information* about the insertions and intervene within the shared editor (*place*) where the diagram is created.

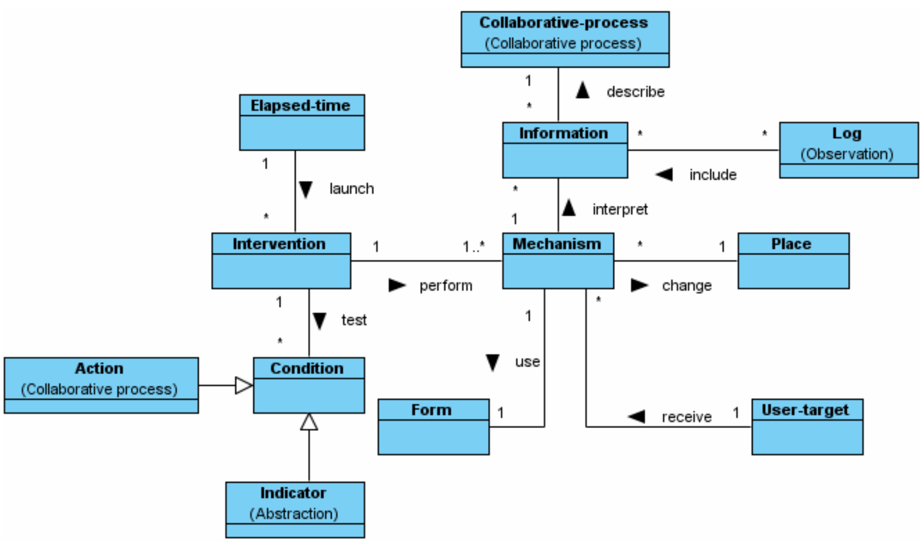

Fig. 3. Subontology of the intervention process

4 Conclusions

Groupware systems are tools that allow a group of users to work collaboratively in order to achieve a shared goal. Once the group work process has finished, it is difficult to carry out an analysis of the individual (or collaborative) work since everybody was working with the same resources and common artefacts. Therefore, it is necessary to establish a conceptual model that allows for the analysis of individual work as well as collective work and the built products.

In our study, this challenge has been approached by means of an ontology that conceptualizes the elements which are needed in order to define: (i) the problem-goal that must be solved/achieved by the group, (ii) the collaborative work process, (iii) the application domain underlying the system, and (iv) the analysis process that infers indicators to characterize the work actions and produced products in order to improve the collaborative work process.

In the near future, meta-modelling tools will be used to represent the different meta-models of our conceptual model. In addition, the conceptual model will be extended to consider the application of inference mechanisms that work in real time. This will allow incorrect actions or product building processes to be detected and users to be informed immediately, thus allowing them to change their behaviour.

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Semantic Web Technology Applied for Description of Product Data in Ship Collaborative Design

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Abstract. During ship collaborative design, it is difficult to describe product data explicitly and formally because of the complexity, diversity and heterogeneity of product data as well as existing description methods of product data lack enough semantic. To effectively achieve sharing, exchange, reuse the ship product data, semantic web technology is employed to represent the ship product data. In this paper, the ontology and OWL are used to describe product data of ship preliminary design.

Keywords: Ship Product Data, Semantic Web, Ship Collaborative Design, Ontology, OWL.

1 Introduction

For larger ship product, design process is very complicated, involving many designers of geographically distributed. These designers need share design data, the design data may be generated by different systems of CAD, CAE or PDM, theses systems may be geographically distributed too. These design data usually are complexity, diversity and heterogeneity. In order to manage these data, it is necessary for designers with different people to cooperate during the development process [1-4].

Recently, with the deep research of semantic web technology[5,6], which becomes possible to solve the semantic problem of information sharing. Ontology has been realized as the key technology to shaping and exploiting information for the effective management of knowledge and for the evolution of the semantic web and its applications[7-9]. The Web Ontology Language (OWL) is a new ontology language for the semantic web. OWL is being designed by the W3C Web Ontology Working Group in order to provide a language that can be used for applications that need to understand the content of information instead of just understanding the human-readable presentation of content. OWL facilitates greater machine readability of web content than XML, RDF, and RDFS support by providing an additional vocabulary for term descriptions [10, 11].

In this paper, in order to achieve ship product data sharing, exchange, reuse, and collaboration based on Internet, the ontology is used to describe ship product data and OWL is used to express ship product data instance during ship collaborative design.

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2 Data Processing in Ship Collaborative Design

For ship product, design process is very complicated, involving many designers of geographically distributed. These designers need share design data, the data may be generated by different design tools. The process of ship design usually is divided four main phases, conceptual design, preliminary design, detail design and production design. Every phase produces much new data, in this paper, in order to deal with these data, we adopt the process as shown in Fig. 1.

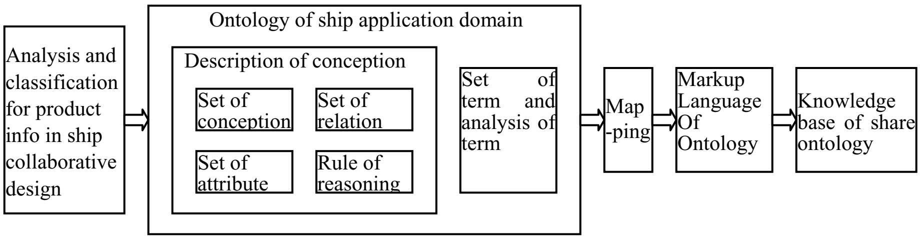

Fig. 1. Processing of Ship Product Data

As show in Fig. 1, the data processing of in ship collaborative design is: (1) analysis the product data and classification it by the rules; (2) extracting ontology of ship application domain, including description of conception, set of tern analysis of term, for description of conception, including set of conception, set of relation, set of attribute and rule of reasoning; (3) mapping ontology of the ship application domain to the generic ontology; (4) using markup language to describe the generic ontology; (5) saving the generic ontology described to database of ship share ontology.

3 Ontology Description of Ship Product Data

The ship design data can be represented by ontology, for example, in stage of ship preliminary design, need achieve a lot of tasks, including ship dimension, type of ship, general layout graph, molded line graph, static Hydraulic computing of ship, estimate of resistance performance, design of screw propeller, design of typical structure and design of typical cross-section etc. In table 1, it is part information of ship preliminary design, these information can be described by ontology as follows:

Ship preliminary design set can be express by “cs”, cs=<ship information, ship dimension, type of ship, eneral layout graph, molded line graph, …>.

Attribute set of ship information can be express by “as1”, as1=< Ship name, Shipowner, Design agent, Shipyard, Classification society, Shipbroker>

Attribute set of ship dimension can be express by “as2”, as2=<Ship length, Molded breadth, Molded depth, Waterline length, Waterline breath, Molded draft>.

Attribute set of ship tonnage can be express by “as3”, as3=< Displacement, Ship speed, Deadweight, Host power>.

Table 1. The Part Information of Ship Preliminary Design

Ship information	Ship name	3000T	Shipyard	shipyard1
	Shipowner	shipower1	Classification society	CS
	Design agent	agent1	Shipbroker	broker1
molded dimension	Ship length	92m	Waterline length	95m
	Molded breadth	13.5m	Waterline breath	13.5m
	Molded depth	7.5m	Molded draft	5.5m
Ship tonnage	Displacement	5000	Deadweight	3000
	Speed of ship	12.5kn	Host power	1300

In order to deal with these data by Internet, and make these data save to database of ship share ontology, the OWL is used to describe as following.

```
 <owl:Class rdf:ID=”Ship” >
  <owl:ObjectProperty rdf:ID=”Ship_name”>
       <rdfs:range rdf:resource=”&xsd;String”/>
  </owl:ObjectProperty>
  <owl:ObjectProperty rdf:ID=”Shipowner”>
       <rdfs:range rdf:resource=”&xsd;String”/>
  </owl:ObjectProperty>
  <owl:ObjectProperty rdf:ID=”Design_agent”>
       <rdfs:range rdf:resource=”&xsd;String”/>
  </owl:ObjectProperty>
  <owl:ObjectProperty rdf:ID=”Shipyard”>
       <rdfs:range rdf:resource=”&xsd;String”/>
  </owl:ObjectProperty>
  <owl:ObjectProperty rdf:ID=”Classfication_society”>
       <rdfs:range rdf:resource=”&xsd;String”/>
  </owl:ObjectProperty>
  <owl:ObjectProperty rdf:ID=”Ship_broker”>
       <rdfs:range rdf:resource=”&xsd;String”/>
  </owl:ObjectProperty>
</owl:Class>
<owl:Class rdf:ID=”molded_dimension”>
  <rdfs:subclassof rdf:resource=”#Ship”/>
  <owl:ObjectProperty rdf:ID=”Dimension_unit”>
       <rdfs:range rdf:resource=”&xsd;String”/>
  </owl:ObjectProperty>
  <owl:DatatypeProperty rdf:ID=”Ship_Length”>
      <rdfs:range
rdf:resource=”&xsd;positiveInteger”/>
  </owl:DatatypeProperty>
  <owl:DatatypeProperty rdf:ID=”Molded_breadth”>
      <rdfs:range
rdf:resource=”&xsd;positiveInteger”/>
  </owl:DatatypeProperty>
  <owl:DatatypeProperty rdf:ID=”Molded_depth”>
      <rdfs:range
rdf:resource=”&xsd;positiveInteger”/>
    </owl:DatatypeProperty>
    <owl:DatatypeProperty rdf:ID=”Waterline_length”>
      <rdfs:range
rdf:resource=”&xsd;positiveInteger”/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID=”Waterline_Breath”>
    <rdfs:range rdf:resource=”&xsd;positiveInteger”/>
</owl:DatatypeProperty>
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    <rdfs:range rdf:resource=”&xsd;positiveInteger”/>
      </owl:DatatypeProperty>
</owl:Class>
<owl:Class rdf:ID=”Ship_Tonnage”/>
    <rdfs:subclassof rdf:resource=”#Ship”/>
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         <rdfs:range rdf:resource=
                              ”&xsd;positiveInteger”/>
      </owl:DatatypeProperty>
      <owl:DatatypeProperty rdf:ID=”Ship_Speed”>
         <rdfs:range
rdf:resource=”&xsd;positiveInteger”/>
      </owl:DatatypeProperty>
      <owl:DatatypeProperty rdf:ID=”Deadweight”>
         <rdfs:range
rdf:resource=”&xsd;positiveInteger”/>
      </owl:DatatypeProperty>
      <owl:DatatypeProperty rdf:ID=”Host_power”>
         <rdfs:range
rdf:resource=”&xsd;positiveInteger”/>
      </owl:DatatypeProperty>
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  <Ship_name rdf:resource=”3000T”/>
  <Shipower rdf:resource=”shipower1”/>
  <Design_agent rdf:resource=”agent1”/>
  <Shipyard rdf:resource=”shipyard1”/>
  <Classification_society rdf:resource=”CS”>
  <Shipbroker rdf:resource=”broker1”>
</Ship >
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  <Dimension rdf:resource=”m”/>
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  <Molded_breadth rdf:resource=”13.5”/>
  <Molded_depth rdf:resource=”7.5”/>
  <Waterline_length rdf:resource=”95”/>
  <Waterline_breadth rdf:resource=”13.5”/>
  <Molded_draft rdf:resource=”5.5”/>
</Molded_dimmension>
<Ship_tonnage>
   <Displacement rdf:resource=”5000”/>
  <Ship_speed rdf:resource=”12.5”/>
  <Deadweight rdf:resource=”3000”/>
  <Host_power rdf:resource=”1300”/>
</Ship_tonnage>
```

Fig. 2. OWL Describe of Data for Ship Preliminary Design

As shown in Fig. 2, “ship”, “Molded_dimension” and “Ship_tonnage” are described as class of OWL. the “ship” class includes attributes of “Ship_name”, ”Shipowner”, “Design_agent”, “Shipyard”, “Classification” and “Shipbroker”; the “Molded_dimension” class includes attributes of “Ship_length”, “Molded_breadrh”, “Molded_depth”, “Waterline_length”, “Waterline_breadth” and “Molded_draft”; the “Ship_tonnage” class includes attributes of “Displacement”, “Ship_speed”, “Deadweight” and “Host_power”.

4 Conclusion

For larger ship product, during the collaborative design, the designers of geographically distributed need share the design data. These design data usually are complexity, diversity and heterogeneity, to effectively achieve sharing, exchange, reuse these design data, the semantic web technology is employed to represent the ship product data, the ontology and OWL are used to describe product data of ship preliminary design.

Acknowledgments

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A Synthetic Subjective Preference Model for Collaborative Design Partners Selection

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Abstract. A synthetic subjective preference model for collaborative design partner selection is formulated, which contains prior preference and adjustable preference. Algorithms based on personality and history data are proposed to calculate these two preferences. The model and the algorithm are effectively supplements to current objective indices and can be used combined with the objective indices to make the selection more reasonable.

Keywords: Collaborative design, Partner selection, Subjective preference.

1 Introduction

Partner selection is one of the main issues during the collaborative design process under the CSCWD (Computer Supported Collaborative Work fro Design, CSCWD) circumstance. A well-selected partner plays an importance role to guarantee the success of the collaboration, as well as to accelerate the collaboration time and improve the design efficiency. Therefore, as the widespread application of CSCWD, partner selection has got more and more research attentions in recent years. A lot of selection methods are proposed by establishing mathematical models, evaluation indices and quantitative algorithms, which aim to solve problems such as fuzzy optimal selection, minimal collaboration time or cost, evaluation indices quantification, and so on [1],[2]. However, the meaning of collaborative partners studied in most methods refers to working units such as companies, professional teams, or departments composed in virtual working alliance, while personal partners in collaborative design are seldom considered. In existed several personal partner selection methods, evaluation indices are mainly objective indices which can be explicitly calculated. For example, the general objective indices to select and evaluate partner candidates include design abilities and skills, designer's workload and working status [3]. However, which should be emphasized is, subjective preference is also an important consideration factor during the selection process, which may impact the collaboration efficiency, design quality, and especially the inspiration of the human resource.

Aiming at this problem, this paper formulates a synthetic subjective preference model for collaborative design partner selection, which contains prior preference and

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adjustable preference. Algorithms based on personality and history data are proposed to calculate these two preferences. The model and the algorithm are effectively supplements to current objective indices and can be used combined with the objective indices to make the selection more reasonable.

2 Synthetic Subjective Preference Model

Subjective preference is the subjective feeling of the collaboration raiser to the candidate. According to cognitive science, subjective preference can be divided into two kinds. One kind is prior preference which is stable and seldom changed with time [4]. For example, in collaborative design, people like to cooperate with those who have common working characters with them. This kind of preference belongs to prior preference. Another kind of preference is adjustable preference. This kind of preference will be changed by collaborative experience such as communication feeling, work time, and design result.

In partner selection, the collaboration raiser would consider these two kinds of preference synthetically. Therefore, the synthetic subjective preference of the collaboration raise P_i to partner candidate P_j at time t can be modeled as the following forum:

$$P_{ij}(t) = af_{ij} + (1-a)g_{ij}(t) \tag{1}$$

Here, f_{ij} is the prior preference from collaboration raiser P_i to partner candidate P_j; $g_{ij}(t)$ is the adjustable preference from P_i to P_j at time t; α is the weight value of the prior preference.

3 Algorithm for Prior Preference

There are many factors influencing prior preference such as culture, interests, and personalities. As this paper focuses on collaborative design domain, the influence of the personality is more obvious than that of culture and interests. As a result, we take

Table 1. Interval data of the personality language utility value

Interval data $[b_h^l, b_h^u]$	[0,0.2]	[0.1,0.3]	[0.2,0.4]	[0.4,0.6]	[0.5,0.7]	[0.7,0.9]	[0.8,1]
Communication character	very introvert	introvert	relatively introvert	medium	relatively extrovert	extrovert	Very extrovert
Decision character	Very conservative	Conservative	Relatively conservative	medium	Relatively progressive	progressive	very progressive
Cooperation character	autarchic		submissive		cooperative		

the personality matching as the main consideration of prior preference. According to the survey of collaborative design cases, three kinds of characters are derived from personalities and used to evaluate prior preference, which are communication character, decision character, and cooperation character (Table 1). The value of each character is evaluated by experts using language utility value. Then the language utility value is converted into data value by fuzzy interval number $[b_h^l, b_h^u]$ (h=1, 2, 3). Here, b_h^l is the lowest limit of the interval, b_h^u is the highest limit of the interval.

Then, the prior preference value can be defined as the matching degree between the collaboration raiser and the partner candidate. Let $[c_h^l, c_h^u]$ (h=1, 2, 3) be interval values of each character for collaboration raiser, $[a_h^l, a_h^u]$ (h=1, 2, 3) be interval values of each character for partner candidate, w_i is the weight of each character, then the prior preference of the two partners can be calculated as follows:

$$f_{ij} = \begin{cases} \sum_{i=1}^{3} w_i \dfrac{\left|c_i^l - a_i^u\right|}{c_i^u - a_i^l}, c_i^u > a_i^u \\ \sum_{i=1}^{3} w_i \dfrac{\left|a_i^l - c_i^u\right|}{a_i^u - c_i^l}, a_i^u > c_i^u \end{cases}, \quad \text{h=1,2,3} \tag{2}$$

4 Algorithm for Adjustable Preference

Impacted by collaborative design experience, adjustable preference can be calculated from history data. Three factors must be considered during the calculation.

First is the satisfactory degree of each collaboration experience. Let α_{ijk} be the satisfactory degree for collaboration k, it can be evaluated by collaboration raiser himself according to his subjective feeling and described by language utility value [excellent, very good, good, relatively good, medium, relatively bad, bad, very bad, terrible]. The language utility value then can be converted into data value to [0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3, 0.2, 0.1].

Second is the impact weight of each collaboration experience. Suppose there are totally K times of collaboration between collaboration raiser P_i and partner candidate P_j from time t_0 to time t, let ω_{ijk} be the impact weight for collaboration k, then ω_{ijk} can be evaluated by comparing the importance of all former collaboration experiences. The impact weight satisfies the constraint of $\sum_{k=k_0}^{K} \omega_{ijk} = 1$.

The third factor to be considered is time. As the impression of the collaborative experience is declined as the time passing, the algorithm should consider the memory recessionary function $y_k(t)$. According to [5], the memory recessionary function can be calculated by $y_k(t) = e^{-\beta(t-t_k)}$, here, t_k is the happening time of collaboration k, β is the recessionary rate factor.

Based on above considerations, the adjustable preference can be calculated by:

$$g_{ij}(t) = \sum_{k=k_0}^{K} \omega_{ijk} \alpha_{ijk} e^{-\beta(t-t_k)} \tag{3}$$

Combine forum (1), (2), and (3), the synthetic subjective preference can be calculated by:

$$P_{ij}(t) = af_{ij} + (1-a)\sum_{k=k_0}^{K} \omega_{ijk} \alpha_{ijk} e^{-\beta(t-t_k)} \tag{4}$$

5 Conclusion

Although subjective preference plays an important role in collaborative design partner selection, it is difficult to evaluate because of the lack of indices and quantitative algorithms. This paper try to provide a straightforward and feasible method to evaluate subjective preference of the designers and therefore to make the selection more reasonable. The method can be used together with those objective indices so as to help collaborative designers to find out their desire partner.

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Partner Selection for Interfirm Collaboration: The Context of Ship Design

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Abstract. There is a growing body of research devoted to the issues of cooperative design. However, there are still gaps in the existing knowledge on partner selection for cooperation. This paper intends to explore partner selection issues in the context of collaborative ship design. The study aims to fill a gap in the partner selection literature by proposing a quantitative technique based on formal concept analysis. An illustrative example of the selection of a partner for a project-based alliance in a naval architect firm is presented. The study has implications for practitioners and researchers.

Keywords: cooperative design, partner selection, shipbuilding, interfirm collaboration.

1 Introduction

Despite the volume of research focusing on the criteria for partner selection and methods of partner selection, there is still a gap in the knowledge of the mechanism of partner selection. Partner selection and evaluation is a complex process. This paper seeks to contribute to the partner selection aspect of interfirm cooperation in the context of the ship design process. A research question that guided this research is: How formal concept analysis can be applied in the partner selection process in the context of the ship design industry? There are few publications which have employed quantitative techniques to support decision making when choosing an appropriate partner for interfirm cooperation. Among the most popular quantitative techniques are fuzzy set logic, the agent-based perspective, mathematical programming, the analytic hierarchical process and the analytic network process approaches [4,5,6,8]. We suggest a methodology of partner selection using formal concept analysis.

The paper is structured as follows. First, formal concept analysis is discussed. Next, an intelligent support procedure for partner selection based on formal concept analysis is proposed and illustrated with an example of partner selection. The paper ends with some concluding remarks.

2 The Formal Concept Analysis

A lattice is a network-like classification structure that can be generated automatically from a term-document indexing relationship. Such a network structure outperforms

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hierarchical classification structure since the former enables many paths to a particular node while the latter restricts each node to possess only one parent. Hence lattice navigation provides an alternate browsing-based approach which can overcome the weakness of hierarchical classification browsing [1]. Formal concept analysis [7] started as an attempt of promoting better communication between lattice theorists and users of lattice theory. Since 1980's formal concept analysis has been growing as a research field with a broad spectrum of applications. Various applications of formal concept analysis are presented in [3].

Let *P* be a non-empty ordered set. If *sup*{x,y} and *inf*{x,y} exist for all *x,y* in *P*, then *P* is called a lattice [2]. In a lattice illustrating partial ordering of knowledge values, the logical conjunction is identified with the meet operation and the logical disjunction with the join operation. A *context* is a triple *(G, M, I)* where *G* and *M* are sets and $I < G \times M$. The elements of *G* and *M* are called *objects* and *attributes* respectively. The set of all concepts of the context *(G, M, I)* is a complete lattice and it is known as the *concept lattice* of the context *(G, M, I).*

3 Illustrative Example

This illustrative example is intended to show the utilization of the technique of formal concept analysis for alliance partner selection. Suppose that the ship design firm intends to sign a contract to make design of the new type of platform supply vessel which is supposed to be used in the Arctic waters. The ship design firm has a broad experience in designing this type of vessel, but little competence in the design of the ships which are intended to operate in the Arctic. Therefore, the ship design firm seeks a partner firm which has the necessary competence to collaborate with. There are five prospective partners: Firms 1, 2, 3, 4 and 5. All of them have the necessary competence in the design of vessels for Arctic navigation. Other characteristics of the candidate firms are presented in Table 1 using the following abbreviations: P – Reputation; N - Competence in Nupas software use; A - Competence in AutoCAD software use; D - Competence in new product development; K - Knowledge of partner's internal standards; C - Complementarity of partner's resource contribution, T - Trust between the top management teams; M - Competence in using modular product architecture; E - Experience in computer-aided design's technology applications; B - Competence in strength and buoyancy calculations.

Table 1. Characteristics of candidate firms

	P	N	A	D	K	C	T	M	E	B
F 1	x	x	x				x			x
F 2		x	x	x		x			x	
F 3	x			x	x		x	x	x	
F 4		x	x		x	x			x	x
F 5			x		x		x	x		x

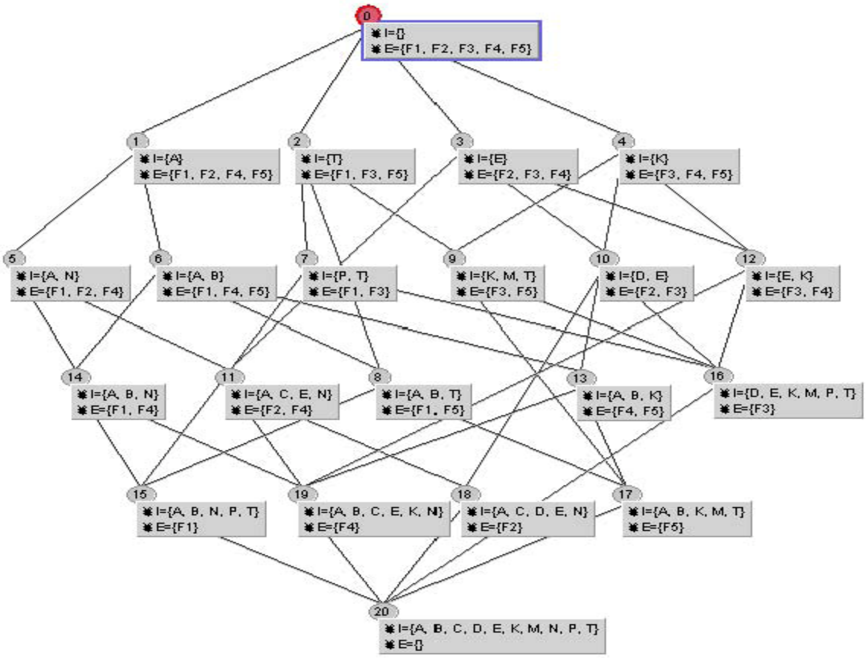

Fig. 1. Complete lattice relating firms and their characteristics

Graphically, a concept lattice is visualized by a Hasse diagram (or line diagram) with nodes representing formal concepts and edges representing the subconcept - superconcept relations between formal concepts. Concept lattice allows the investigation and interpretation of relationships between concepts, objects, and attributes. Each edge represents a concept. The concepts are arranged hierarchically, i.e. the closer a concept is to the supremum, the more attributes belong to it. Moving from one vertex to a connected vertex which is closer to the supremum means moving from a more general to a more specific description of the attributes, if an object occurs in both concepts.

Concepts are presented by the labels attached to the nodes of the lattice in the Figure 1. The meaning of the used notations is as follows:

- Node number 5 has a label *I = {A, N}, E = {F1, F2, F4}*. This means that firms *F1, F2, F4* have two characteristics in common, *A* and *N*.
- Node number 11 has a label *I = {A, C, E, N}, E = {F2, F4}*. This means that firms *F2* and *F4* have four characteristics in common, *A, C, E* and *N*.
- Node number 14 has a label *I = {A, B, N}, E = {F1, F4}*. This means that firms *F1* and *F4* have three characteristics in common, *A, B* and *N*.

Nodes 8,11,13, and 14 represent the most interesting concepts with respect to choice of partners and characteristics. These four concepts show couples of partners to choose from provided certain characteristics are of special importance.

4 Conclusions

This study focused on cooperative design in shipbuilding. The paper contributes to the formalization of the partner selection process for cooperative ship design. Partner selection is one of the most important issues influencing the success of the design process. We have outlined resource-based and competence-based criteria for use in the partnership selection process.

Our study offers a quantitative technique for partner selection based on formal concept analysis. This quantitative technique covers a methodological gap in the literature on cooperation. This technique also has important implications for practitioners who need to form cooperative arrangements. Knowledge of resource-based and competence-based factors might be important in selecting the most suitable partner for cooperative relations in ship design represents for formation of project-based alliances which are rather common in shipbuilding and ship design. Our study is limited to a single industry. Future research may apply the partner selection technique based on formal concept analysis in other industrial contexts.

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Probability-Based Determination Methods for Service Waiting in Service-Oriented Computing Environments*

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Abstract. Cooperative business processes (CBP)-based service-oriented enterprise networks (SOEN) are emerging with the significant advances of enterprise integration and service-oriented architecture. The performance prediction and optimization for CBP-based SOEN is very complex. To meet these challenges, one of the key points is to try to reduce an abstract service's waiting number of its physical services. This paper introduces a probability-based determination method (PBDM) of an abstract service' waiting number, M_l, and time span, τ_i, for its physical services. The determination of M_i and τ_i is according to the physical services' arriving rule and their overall performance's distribution functions. In PBDM, the arriving probability of the physical services with the best overall performance value is a pre-defined reliability. PBDM has made use of the information of the physical services' arriving rule and performance distribution functions thoroughly, which will improve the computational efficiency for the scheme design and performance optimization of the collaborative business processes in service-oriented computing environments.

Keywords: cooperative business process (CBP); performance evaluation; probability-based determination; service waiting number.

1 Introduction

The performance prediction and optimization for collaborative business processes (CBS) involves all the abstract levels and aspects of a service-oriented enterprise (SOEN), especially the CBS which integrated the services, activities, resources, enterprise partners, and etc. The three main levels for CBS performance prediction and optimization are service matching and binding of an abstract service with its physical service, service orchestration centered on a specific service, and service choreography from a global perspective involving many services and their environments. All CBS should be analyzed and optimized before being actually implemented.

Cardellini et al [1], Hu et al [2] and Kalepu et al [3] researched on the service waiting, service selection and service performance evaluation which based on the quality

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of services. Dai et al [4] and Zeng et al [5] proposed some performance indicators and corresponding performance evaluation methods for service composition and service-oriented business processes. Shen [6] introduced an online service selection method which could calculate the overall performance for a composed service when the abstract services are waiting for the physical services' coming. Zheng et al [7] proposed an interactive-event-based workflow simulation in a service-oriented environment. Tsai et al [8] used modeling and simulation for service-oriented software development. Chen extended the Petri-net, communicating sequential processes (CSP), and QoS (quality of service)-aware methods and technologies for processes/services composition in a service-oriented environment [9].

The main problem existing in the above researches is that the abstract service could neither predict the determined waiting number nor the time span for its physical services. Usually, we suppose there are sufficient physical services, and the waiting time is very long that almost any potential service composition schemes could be evaluated until the optimal or satisfied solution is found. It increases the computational complexity sharply, and it does not take full advantage of the historical information of the service selection which will hinder the enterprise integration based on the collaborative business processes in service-oriented environment.

2 Complexity of Performance Optimization for Collaborative Business Process-Based Service-Oriented Enterprise Networks

The multi-echelon inventory system of a supply-chain in service-oriented computing environments can be rechoned as a service-oriented enterprise network (SOEN). It comprises *K* echelons and each echelon may include *J* inventories. In the service-oriented computing environment, each inventory can be rechoned as a service-oriented business process (SOBP) which is made up of many abstract services and other types of activities[5]. A typical SOBP model of the node inventory (*j*, *k*) in SOEN is shown in Fig.1.

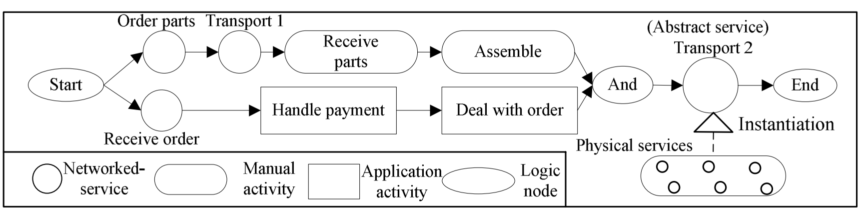

Fig. 1. Typical service-oriented business process model of a node inventory

The typical sub-processes of the SOBP are: (1) order parts from the suppliers, (2) produce well-configured products, (3) try to meet the next echelon customers' needs. The SOBP has several abstract services (ASV). Each ASV may be instantiated by one of the numerous corresponding physical services (PSV) which is published on the networks. For example, the ASV named *Transport 2* may be instantiated by one of the six potential PSV as shown on the right side of Fig.1.

Suppose the SOEN has K echelons, each echelon has J inventory nodes, each node has N ASV, and each ASV contains M potential PSV. The possible configured schemes of the SOEN system could be: $|\Theta| = (((M)^N)^J)^K$. Since the SOEN contains large number of uncertainties, we can use a simulation method, such as the Monte Carlo method to estimate the SOEN's performance expectation:

$$Q(\theta) \equiv E_{\xi}\left[P(\theta,\xi)\right] = \lim_{R} \frac{1}{R}\sum_{s=1}^{R} P(\theta,\xi_s) \tag{1}$$

Where θ is the system parameters, ξ is the diversified randomicities of the system, and $P(\theta,\xi)$ denotes the system performance.The expectation of Equation (1) is as to all the randomicities of the SOEN, and the last item is a limitation. When R is sufficient large, the limitation is approximately as: $1/R\sum_{s=1}^{R} P(\theta,\xi_s)$.

Therefore the problem of performance analysis and optimization for SOEN can be defined as to search the possible scheme $\theta \in \Theta$ to minimize the system's performance $Q(\theta)$. Here Θ is the system design and search space which contains all the possible θ. If a Monte Carlo simulation experiment takes too much time, it is difficult to search the minimum in the whole Θ space by the method of infinite enumeration.

The performance analysis and optimization of SOEN is just such a problem. Most of the SOBP model of SOEN in supply chain usually has a large number of ASV and PSV which result in an extremely large but limited design space. One valuable key solution is to minimize an ASV's candidate PSV.

3 Probability-Based Determination Method of Abstract Service's Waiting Number and Time Span

The control logic of performance analysis and optimization for SOEN which based on the analytical hierarchy process (AHP) method and probability-based uncertainty theory includes the following steps.

3.1 Step 1 Wait for the Physical Services' Arriving

The purpose of this step is to determine the ASV's waiting number and time span needed for its corresponding physical services.

Denote the i-th ASV of a SOBP as ASV_i, the ASV_i's j-th PSV as $\text{PSV}_{i,j}$, and the $\text{PSV}_{i,j}$'s h-th dimension performance index as $P_{i,j}^{h}$. Once ASV_i has published its request, numerous $\text{PSV}_{i,j}$, j=1,2,…, will successively respond to the ASV_i, and provide the values of each performance index, $P_{i,j}^{h}$, k=1,2,…K. The ASV_i may confirm its waiting number, m_i, and time span, τ_i, for the coming $\text{PSV}_{i,j}$ by the PSV's arriving rules and the distribution functions of the performance index values.

3.2 Step 2 Calculate the Abstract Service's Waiting Number, M_i

Without losing the universality, suppose the sequence of the coming $\text{PSV}_{i,j}$ is arriving as a Poison process, $\{N(t), t\geq 0\}$, with parameter λ_i, here $N(t)$ stands for the number of arrived physical services in the time span [0, t]. Let S_0=0, S_n (n≥1) stand for the time point when the n-th physical service arrives, then the time span {$X_n=S_n-S_{n-1}$, n≥1} is independent and it follows the exponent distribution function with the same parameter λ_i.

Therefore the probability that the number of arrived physical services is larger than or equal to m_i in the time span [0,τ_i] (τ_i>0) is:

$$P(S_m \le \tau_i) = P\{N(\tau_i) \ge m_i\} = 1 - e^{-\lambda_i \tau_i} \sum_{k=0}^{m_i} \frac{(\lambda_i \tau_i)^k}{k!} = p_1 \tag{2}$$

Namely it has p_1 probability to ensure that the number of the arrived physical services in a waiting time span τ_i is no less than m_i.

Basing on the analytical hierarchy process (AHP) performance evaluation method, we can calculate the overall performance of a physical service. Let $u_{i,j}$, j=1,…, m_i, denote the overall performance of the j-th physical service of ASV$_i$. According to the values of the performance indicators $P_{i,j}^{\,k}$ of the arrived m_i physical services and the AHP-based overall performance evaluation method, we can get all the values of each $u_{i,j}$. Furthermore, we can infer their performance distribution function, $F(X_i)$. Without losing the universality, suppose the $F(X_i)$ follows the exponent distribution function with the parameter u_i , namely:

$$F(X_i) = 1 - e^{-x_i / u_i} \tag{3}$$

Here the agonic estimation of u_i is: $\overline{u_i} = 1/m_i \sum_{j=1}^{m_i} u_{i,j}$.

Suppose the design requirements for the overall performance of ASV$_i$ is larger than or equal to x_i. The probability that the best one among the arrived m_i physical services meets the design requirements would be:

$$P\{\max(X_{i,1}, X_{i,2}, ..., X_{i,m_i}) \ge x_i\} = p_2 \tag{4}$$

With equation (4), the value of m_i is:

$$m_i = \left\lceil \frac{\ln(1 - p_2)}{\ln(1 - e^{-x_i/u_i})} \right\rceil \tag{5}$$

Namely it has p_2 probability to ensure that there exists one physical service PSV$_{i,j}$ which satisfies the ASV$_i$'s design requirements among its m_i arrived physical services. Here the x_i is a pre-defined parameter. For example, if x_i is specified as the Top 10%, namely the overall performance of the ASV$_i$'s selected physical service must be the better 10%. Therefore the x_i should be about 2.3u_i according to the Equation (3).

3.3 Step 3 Determine the Waiting Time Span, τ_i.

Let $n=m_i$, λ=($\lambda_i\tau_i$) in equation (2). If the values of n and λ are among the Poison distribution table, i.e. the National Standards with the number of GB-4086.6[10], we can calculate τ_i by the table.

Else if the values of the n and λ are not among the Poison distribution table, it is said the distribution can be expressed with χ^2 distribution function by the national standard mentioned before, namely:

$$P(x;\lambda) = \sum_{y=0}^{x} \frac{\lambda^y}{y!} e^{-\lambda} = \int_{\lambda}^{\infty} \frac{y^x}{x!} e^{-y} dy = \int_{2\lambda}^{\infty} f_{\chi^2}(\chi^2; 2(x+1))\, d\chi^2 \tag{6}$$

Where $f_{\chi^2}(\chi^2;n)$ is the χ^2-distribution, n=1,2,3… is its freedom.

On the other hand, with the definition of the upper location detaching point, α, of the χ^2-distribution, for a given α , $0<\alpha<1$, we have:

$$P(\chi^2 > \chi^2_\alpha(n)) = \int_{\chi^2_\alpha(n)}^{\infty} f_{\chi^2}(\chi^2;n)\, d\chi^2 = \alpha \tag{7}$$

By the unified computing with equation (2), (6), and (7) we can get the following solution:

$$\tau_i = \frac{\chi^2_{(1-p_1)}(2(m_i+1))}{2\lambda_i} \tag{8}$$

If $n=2(m_i+1)\leq 45$, namely $m_i<22$, we can get the value of τ_i with equation (8)by searching the χ^2-distribution table.Else if n is sufficient large, R.A. Fisher had proved that the χ^2-distribution can be approximately calculated by:

$$\chi^2_\alpha(n) \approx 1/2(z_\alpha + \sqrt{2n-1})^2 \tag{9}$$

where z_α is the upper α location detaching point of the standard normal distribution. With the equation (8) and (9), we can get the answer as below:

$$\tau_i = (z_{(1-p_1)} + \sqrt{4(m_i+1)-1})^2 / (4\lambda_i) \tag{10}$$

4 Case Study

To demonstrate the implementation process and validity of the proposed PBDM, here we calculate the waiting numbers and time spans for the abstract services shown in Fig.1.

The four abstract services in Fig.1 are: ASV_1 "Order parts", ASV_2 "Receive order", ASV_3 "Transport 1", ASV_4 "Transport 2". Suppose the i-th ASV's physical services are arriving as a Poison distribution with the parameter λ_i and their overall performances are complying with the exponential distributing with the parameter u_i. The values of λ_i, u_i, x_i, p_1, and p_2 are shown in table 1.

Table 1. The parameter values of the abstract services in Fig.1

ASV_i	λ_i	u_i	x_i (Top-10%)	p_1	p_2	m_i	τ_i
ASV_1	2	0.8	1.84	0.9	0.9	22	15.64
ASV_2	1	u_2	$2.3u_2$	0.9	0.9	22	31.27
ASV_3	3	u_3	$2.3u_3$	0.9	0.9	22	10.42
ASV_4	4	u_4	$2.3u_4$	0.9	0.9	22	7.82

Here we present the calculation processes for ASV_1, so do the other abstract services:

- Here the physical services, $PSV_{1,j}$, of ASV_1 follow the Poison distribution with parameter λ_1=2, and their overall performances comply with the exponential distribution with parameter u_1=0.8.
- The physical service with the best overall performance expectation of the arrived physical services is required to be lie in the better 10% of all the potential services, namely $x_1=u_1 ln10=1.84$. Let p_2=0.9, viz. having 90% probability to ensure that among the arrived former 22 physical services there exists the one whose overall performance is better than x_1. Here the m_1=22 is calculated by equation (5).
- Since $m_1 \geq 22$, and p_1=0.9, namely having 90% probability to ensure that more than or equal to 22 physical services will arrive in the 15.64 waiting time span. Here the waiting time span τ_1=15.64 is calculated by equation (10).
- An example of the arriving time points of the ASV_1's physical services, $PSV_{1,j}$, in the case is shown in Fig.2. Their overall performance and its optimizing process are shown in Fig.3.

The seventh physical service, $PSV_{1,7}$, satisfies the design requirement with the overall performance $u_{1,7}$=2.49, that is better than x_1=1.84 in Fig.2. And its corresponding arriving time point $t_{1,7}=10.97<\tau_1=15.67$ is shown in Fig.3. The one with the maximum overall performance is the 56th physical service.

Similarly, we can calculate all the waiting numbers and waiting time spans of the other abstract services and show them in Table 1. Therefore, as for the service-oriented business process in Fig.1, its waiting time span is the maximum τ_i, that is 31.27 and the waiting number is 22.

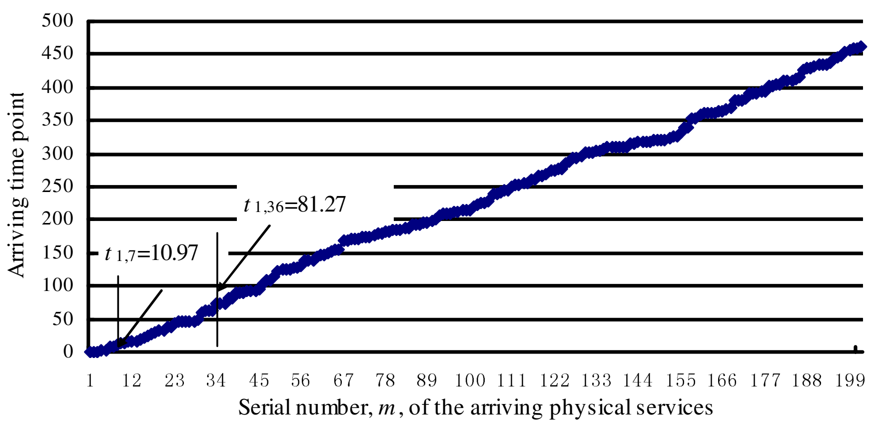

Fig. 2. Arriving time points and serial number of ASV_1's physical services

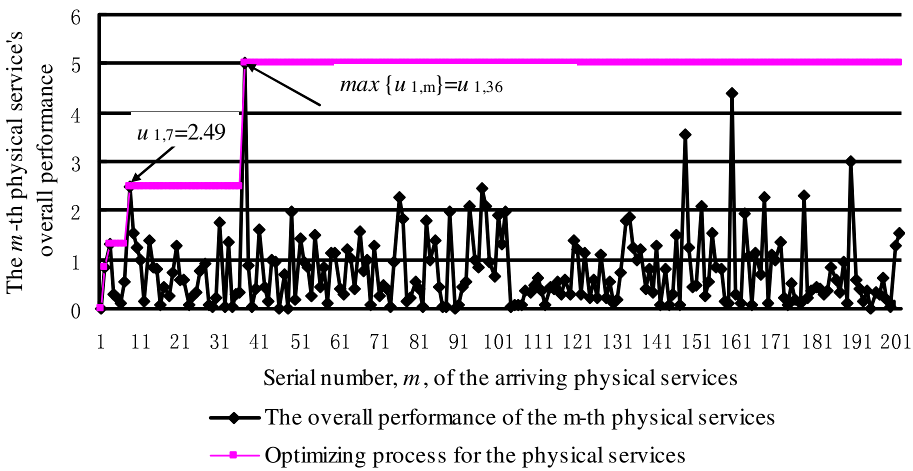

Fig. 3. The overall performance and its optimizing process of ASV_1's physical services

5 Conclusion

The performance prediction and optimization for CBP-based SOEN is very complex. Because the SOEN is configured dynamically with large quantity of services. The space of its input variables is very large, and the variables can be different types, such as continuous, discrete or logic ones. In addition, the performance analysis problems have multiple objectives and minima.

To meet these challenges, a probability-based determination method (PBDM) of an abstract service' waiting number, M_i, and time span, τ_i, for its physical services is proposed in this paper. The PBDM has made use of the information of the arrived physical services' arriving rule and performance distribution functions thoroughly, which will improve the computational efficiency for the scheme design and performance optimization of the collaborative business processes in service-oriented computing environments. The PBDM can be used combining with intelligent methods and simulation-based optimization methods to improve the computational efficiency for the service choreography and orchestration in service-oriented environments.

Although we premise that the physical services' arriving rule follows the Poison process, and their overall performance follows the exponential distribution function, the PBDM is also suitable to deal with the physical services which follow the other types of processes or distribution functions.

Farther researches should be spread to the reliabilities of the PBDM by the uncertainty theories and test the effectiveness of the method in realistic collaborative business process in service-oriented environments.

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A Process Management System for Networked Manufacturing

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Abstract. With the development of computer, communication and network, networked manufacturing has become one of the main manufacturing paradigms in the 21st century. Under the networked manufacturing environment, there exist a large number of cooperative tasks susceptible to alterations, conflicts caused by resources and problems of cost and quality. This increases the complexity of administration. Process management is a technology used to design, enact, control, and analyze networked manufacturing processes. It supports efficient execution, effective management, conflict resolution, cost containment and quality control. In this paper we propose an integrated process management system for networked manufacturing. Requirements of process management are analyzed and architecture of the system is presented. And a process model considering process cost and quality is developed. Finally a case study is provided to explain how the system runs efficiently.

Keywords: networked manufacturing, process management, process model.

1 Introduction

In today's manufacturing environment, competition is marked by shorter product life cycles and increasing demand for product customization. Manufacturing enterprises must take a smarter, more objective-driven and process-wide approach to product design and manufacturing [1]. During the last years, various new technologies such as networked manufacturing (NM), reverse engineering (RE) and rapid prototyping (RP) have emerged and are regarded as enabling tools with abilities to shorten the product development and manufacturing time. NM is a manufacturing paradigm in which distributed entities share information, resources and responsibilities to jointly plan, implement, and evaluate a program of activities to achieve a common goal through network. A typical example of NM is the case in which a team of experts from several research institutes jointly develop a new product and then transfer through internet to a cooperative venture to produce.

Under the networked manufacturing environment, there exist a large number of cooperative tasks susceptible to alterations, conflicts caused by resources and problems of cost and quality. This increases the complexity of administration. Process Management (PM) is a technology used to design, enact, control, and analyze networked manufacturing processes involving humans, organizations, applications, documents

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and other sources of information. It supports efficient execution and effective management. This paper primarily focuses on the Process Management System (PMS) for NM. We develop a process model, propose an architecture of the PMS and present the implementation of the system.

2 Related Research and Requirements

Substantial investments have been made to support the research and practice of NM from both the academic community and industrial bodies all over the world in recent years. Strategies and frameworks have been proposed [2]. And integration and interoperability issues are discussed [3].

As central entities in NM, processes has emerged as one of the major developments to ease the understanding of, communication about, and evolution of NM systems. The topics addressed cover areas like process modeling, analysis and verification of business processes, process mining and workflow management, and moreover case studies.

Workflow is "the automation of a business process, in whole or part, during which documents, information or tasks are passed from one participant to another for action, according to a set of procedural rules [4]". There are many process model representations for workflow management implemented by different vendors and proposed by researchers [5]. Today workflow management systems are readily available [6, 7] and workflow technology is hidden in many applications, e.g., ERP and PDM systems. However, the traditional workflow based approaches to enterprise process automation show various limitations when it comes to model collaboration acts occurring in the enterprise and involving or not business partners [8].

An area of research closely related to workflow technology is Business Process Management (BPM). And BPM can be considered as an extension of workflow management systems and approaches. The International Conference Series on BPM shows that BPM are currently of interest to both software vendors and scientists. And a large number of literatures present improvements in this field [9, 10].

Process modeling is used in different phases of a business process management project: to design interaction with an information system by human and automatic participants, to analyze existing processes with the objective of redesigning them for improvement of work practices, and finally to enact processes providing support for automatic or semiautomatic execution of the process on the basis of its process model. The requirements posed by the different phases have lead to the definition of a variety of process models. Technologies including Critical Path Method (CPM), Graphical Evaluation and Review Technique (GERT), IDEF, Petri-Net, Design Structure Matrix (DSM) and Event-Driven Process Chain (EDPC) are applied to establish process models.

Making an intensive study on existing literatures, we identify that following aspects have been paid much attention: (1) the adaptability and reuse of process; (2) activity decomposition and dependency; (3) process interoperability; (4) strategy and framework. However, there are few literatures noticing quality and cost of PMS.

The ultimate objectives of NM initiatives are to increase business agility and the quality of customer service, and shorten the product development and manufacturing time. In NM, experts from different entities are able to coordinate complex transactions, share latest information, collaborate on product planning, communicate product design ideas, and integrate their workflows. In order to realize above objectives and functions, repeating poorly done work must be avoided and low cost is advocated which will contribute to shorter product development and manufacturing time and higher profits. Therefore control of cost and quality becomes an important supplementary method to realize above ultimate objectives.

In addition, we believe that considering following issues ignored in existing literatures may assist in the smooth process implementation: (1) auxiliary tools such as decision making and online group collaboration; (2) customer-oriented and authorized client interface.

3 Process Model and Control

3.1 Process Model

Process model is the basis of process execution and monitoring. To support cost and quality control besides common features of existing process models, a process model is developed which is composed of following components, depicted as Fig.1.

- A (Activities);
- R;
- RES (Resources);
- BA={name, Type, State, …};
- Constraints={S, Q, C}

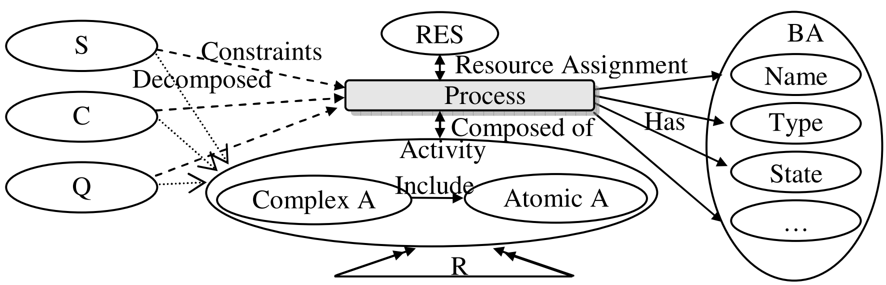

Fig. 1. Process model

A process model is composed of a set of activities. An activity can be complex or atomic. A complex activity includes a set of activities as its children while an atomic activity has no child activities.

R defines the relationship among the activities. According to workflow management coalition, six ordering structures may appear in a process: (1)SEQUENCECE: an activity has a single subsequent activity; (2)AND-SPLIT: an activity leads to multiple parallel activities that will all be executed; (3)XOR-SPLIT: an activity leads to multiple but mutually exclusive alternative activities and only one of which will be executed; (4)AND-JOIN: multiple parallel executing activities join into a single activity; (5)XOR-JOIN: multiple but mutually exclusive alternative activities join into a single activity; and (6)LOOP: one or more activities are repeatedly executed until the exit condition is satisfied.

RES represents all kinds of disposable resources, such as facilities, information, software, hardware, etc. They can be assigned to the process and be used and controlled throughout the process.

BA represents basic attributes of the process denoted as {PName, PType, PState, …} where PName, PType, PState are the name, process type and state.

Progress, quality and cost of the process are considered as constraints in our model denoted as { S, Q, C }. They react upon and constrain one another.

3.2 Quality and Cost Constraints

Usually there are some quality requirements in collaborative work. We use quality index Q={q_1,q_2, …, q_n} to represent these requirements. According to activity decomposition, Q can be decomposed, depicted as Fig.2. Mapping to activity breakdown structure, Q then is assigned to activities which are monitored and controlled throughout the procedure.

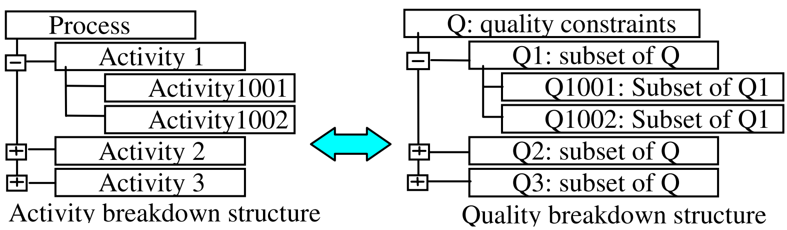

Fig. 2. Quality breakdown structure

For example, a process is modeled for developing a new type of fan and activities have been defined as overall plan, electrical motor design, blade design, model machine test, etc. In order to satisfy the requirements of high-end market, product life is emphasized. Then a quality index q_i can be defined as product life. According to activity decomposition, q_i then will be decomposed to electrical motor design and blade design because these two critical components will decide the product life.

Similar to quality constraints, C is denoted as {EC, LC, MC, OC} where EC, LC, MC, OC are equipment cost, labor cost, material cost and other cost. While a process is modeled, cost of each kind for the whole process will be budgeted. In order to control the cost, the budgeted cost then can be decomposed to activities according to activity decomposition. Resources are the key elements considered while the budgeted cost is break down.

3.3 Quality and Cost Control

In our PMS four stages are used to characterize the process quality management: Plan, Do, Check and Action. In the first stage, quality objects are defined according to specific process considering process features, goals, involved organization and quality requirements. And based on quality objects, quality indexes are designed and experts are assigned for future quality evaluation. Methods such as Quality Function Deployment can be applied in this stage. Quality index definition and expert assignment are fulfilled in PMS while quality object definition usually is asked to be completed out of the system. In the second stage, quality information is collected semi-automatically while professionals from different fields work collaboratively. Once an activity is submitted, it goes to the third stage where quality is evaluated. Methods such as analytic hierarchy process (AHP) are used in our PMS. If some problems are discovered, methods should be taken to resolve these problems through analyzing the cause. Fig.3 shows how quality is controlled in our PMS.

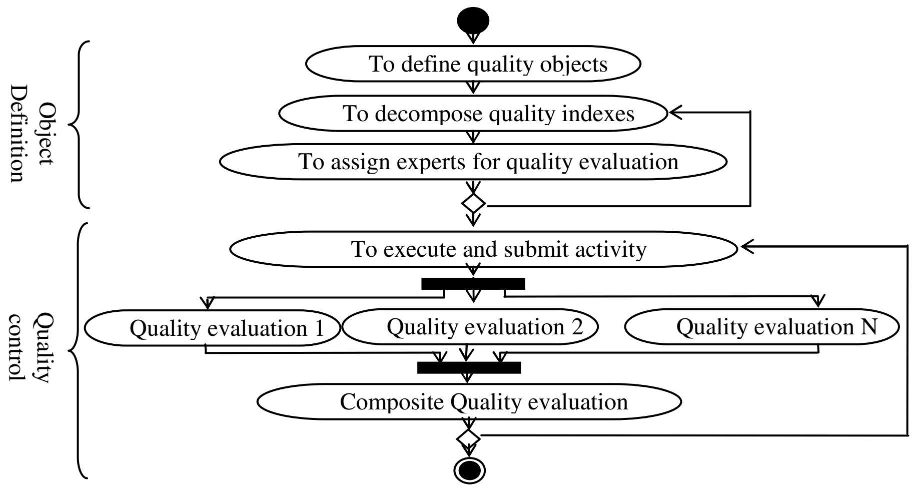

Fig. 3. Quality control procedure

Compared with quality control, the cost control procedure is similar. In the first stage, EC, LC, MC and OC are budgeted and decomposed to activities based on resource plan. Then while the process executed, actual cost is calculated and cost variance between actual cost and budgeted cost is computed and checked. If there is a great gap, action should be taken to narrow the gap and usually some change need to be made in cost plan.

4 Process Management System

Considering group collaboration, security requirements and most importantly system efficiency, a PMS architecture is proposed applying above model shown as Fig.4. There are three layers in the architecture: client layer, server layer and data layer.

Client layer provides web interface and downloadable PM client that is easy to install, simple to use, and packed with a variety of PM tools such as process modeling, process execution and monitoring, security tools and collaboration tools. These tools are mapped into server components on server layer. In order to support quick complex calculation, a local database is automatically setup at client point to record temporary and native data while downloadable PM client is installed. For example, the unfinished process model will be stored into local database until it is completed.

Server layer is the centric layer of the PMS composed of web server, socket server, PM server and auxiliary tools. Web server provides all kinds of system latest information extracted from PM server. Authorized system users can view that information through web browser wherever they are.

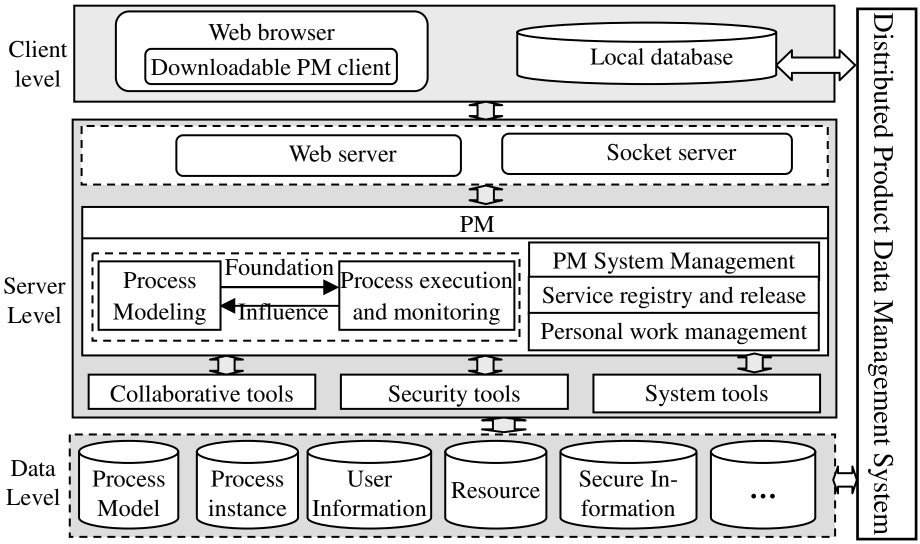

Fig. 4. Architecture of process management system for NM

Http protocol used between web server and web browser can not support large transfers and logistic calculation efficiently. However there generally exists synchronous collaboration, conflicts, logistic calculation in process management. For example, while an administration manager is modeling a new product development process, he usually needs to sound out the technical and production manager's views. Therefore in our PMS socket server is developed to support real-time group communication and large transfers through self-defined protocol in which KQML is applied. All PM tools use socket server for high efficiency.

PM server contains five main functions: (1) Process modeling; (2) Process execution and monitoring; (3) PM system management; (4) service registry and release; (5) personal work management. Not all functions are setup together at every client point. These functions are wrapped as services and corresponding client ends are packed as downloadable PM tools. Only authorized tools can be set up at client point and mapping service can be invoked according to system policy.

In order to help experts to do daily work smoothly, collaborative tools, security tools and system tools are developed as auxiliary tools. Collaborative tools, including file transfer, white boarding, application sharing and decision making, assist users to work together to share information and communicate with others conveniently. And security tools are used to insure data security.

Data layer is responsible for data storage and management and communicate with other enterprise software. It includes process models developed by professionals and mining models, process instance related information, shared resource information of cooperative enterprise, and system information such as user, security and so on.

5 Implementation

The PMS we developed has been applied in an institute owned more than 4000 employees. It has some manufacturing shops and seven technical departments in different areas. Our PMS is used in a shop and two technical departments.

Usually, an employee can view his task list through web browser. At the same time, he also can view latest information released from the system through downloadable PM client interface. If he has new work, then he needs to enter into downloadable PM client to start work.

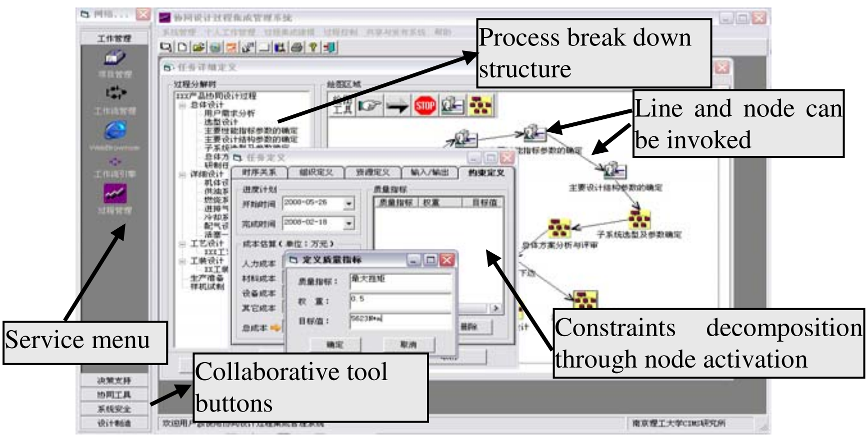

Fig. 5. Quality constraints definition while process model is developed

The main function of PMS includes process modeling, Process execution and monitoring, PM system management, service registry and release and finally personal work management. Process modeling provides graphical interface for employees to define models easily. Fig.5 is the graphical interface for process modeling. On the left part is the breakdown structure of a process and the process graphical network is presented on the right. Users can invoke the node and line of the network to define activity relationships, resources and constraints.

After the process model is defined, it can be invoked in PMS. Resources, quality, cost and progress can be monitored according to definition.

If collaboration is needed while a user is modeling a process or doing the defined activity, he can click corresponding tool's button to activate the service. First, our PMS will establish group communication channel based on team organization definition. Then, collaboration will be launched. In our PMS, once communication channel is setup, following collaborative services can transfer data through it until collaboration is finished.

6 Conclusion

We have proposed a process model and a PMS has been implemented. Compared with existing process models and PMS, the main contribution of our PMS is as follows: (1) Quality and cost are considered and integrated in process model; (2) A socket server is presented in PMS for large transfers and group communication which make latest released information separated from complex calculation and high efficiency is achieved for process management; (3) several auxiliary tools, such as collaborative tools are integrated to make the process management smoothly.

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Creating Shared Mental Models: The Support of Visual Language

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Abstract. Cooperative design involves multiple stakeholders that often hold different ideas of the problem, the ways to solve it, and to its solutions (i.e., mental models; MM). These differences can result in miscommunication, misunderstanding, slower decision making processes, and less chance on cooperative decisions. In order to facilitate the creation of a shared mental model (sMM), visual languages (VL) are often used. However, little scientific foundation is behind this choice. To determine whether or not this gut feeling is justified, a research was conducted in which various stakeholders had to cooperatively redesign a process chain, with and without VL. To determine whether or not a sMM was created, scores on agreement in individual MM, communication, and cooperation were analyzed. The results confirmed the assumption that VL can indeed play an important role in the creation of sMM and, hence, can aid the processes of cooperative design and engineering.

Keywords: visual language, cooperative visualization, cooperative decision making, shared mental model, multiple users.

1 Introduction

When involved in cooperative design, multiple stakeholders might hold different mental models (i.e., ideas and views; MM) of the problem at hand, the ways to solve it, and to its solutions. These different MM might stem from different worldviews, cultures, backgrounds, interests, and paradigms [1]. Initially, these different views are probably part of the reason to bring together these multiple stakeholders. However, different MM might cause problems in communication [2] and cooperation [3] and might result in a disappointing team performance.

Visual language (VL) is thought to support the creation of a (shared) MM. As such, VL can aid problems experienced with cooperative design. This research strives to discover whether or not VL supports the generation of shared MM (sMM) in cooperative design. Because of the complexity of the concepts MM and VL a brief explanation is followed next.

Different definitions of MM are used in different fields of research: e.g., [2,4,5]. From these definitions, we have inferred the following: a MM is the mental representation

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of (some aspects of) the dynamics of the external world, such as problems, tasks, actions, and products. In line with this definition, we define sMM as the overlap in both understanding and consensus of individual MM.

sMM can aid cooperative decision making and cooperative engineering through facilitating cooperation [3], anticipation [5], and prediction [5] of team members' behavior. Moreover, sMM are thought to support decision-making by having a positive effect on team processes and team performance [3]. sMM also affect the speed, flexibility, and implementation of a decision [5]. Last, sMM can support positive affect and trust [5]. Hence, sMM play a crucial role in cooperative design.

Par excellence, cooperative design processes could benefit from the advantages of using sMM. A sMM can be created through either experience [6], communication, or their combination [5]. This research focuses on communication; in particular, visual communication through visual language (VL). VL are said to aid the creation of sMM in cooperative design. However, most of these claims stem from experience and gut feeling of people, instead of scientific research.

VL is thought to support communication steps involved in creating a sMM; among other things, this should involve:

- explaining individual MM in order to establish meaning [2],
- initiating negotiations of meaning [7],
- persuading [8] in order to negotiate, and
- promoting group consensus [8].

In addition, the use of VL provides the following advantages:

- support efficient work and (faster) decision making [8,9],
- help to see the big picture, making things easier to understand [9],
- support collaboration between multiple users with different backgrounds and multiple points of view [10], and
- enable cooperative visualization of problems which is particularly of interest when having various stakeholders communicating.

In different fields of research, different definitions of VL exist, e.g., [11,12]. We use the definition of Robert Horn, who defines VL as tightly integrated communication units that are composed of words, images, and shapes [10]. Examples of VL are icons, resemblances, quantitative charts and graphs, tables, cartoons, diagrams, and blocks of texts [10]. In this research, cooperative visualization is used as VL; e.g., mind mapping on a large screen, visible to all the stakeholders, digital drawings on a large screen, and sharing individually made drawings or diagrams on another large screen, see also Fig. 1.

The claims made concerning VL clearly mark its benefits, in particular when creating a SMM. In line with this, we hypothesize that VL will indeed support the creation of sMM. In the next section (Section 2), we will denote how we operationalized our main research question: Do VL support the creation of a sMM?. Next, the results on the case study are presented (Section 3). We end with the interpretation of the results and conclusions, in Section 4.

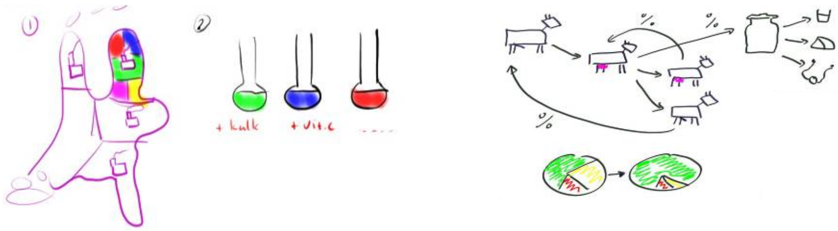

Fig. 1. Visualizations made by stakeholders on tablet PCs and, subsequently, shared, using a large screen. A capturer organized discussions, which resulted in mind maps including these visualizations. The left image depicts an idea that involves milk with different qualities (e.g., with extra calcium or vitamin c) produced in different parts of the Netherlands. The right image depicts a breeding program to produce milk that can be used for different dairy products.

2 Research

To determine whether or not VL can support the creation of a sMM, case studies were conducted both with and without (i.e., solely words) the use of VL. However, the determination of sMM is difficult since this concept is hard to operationalize. To tackle this problem, the paradigm of triangulation is adopted [13]; i.e., the use of multiple information sources, multiple analyses, or both to assess a concept.

Several ways of measuring sMM have been proposed, among which the amount of agreement among participating stakeholders and the efficiency of the team process in terms of communication and cooperation, e.g., [3]. Consequently, is hypothesized that VL will account for:

H1. More agreement in MM, assessed through questions on:
  a. the content of the task and
  b. expectations based on the MM that can be used to assess a sMM [14];

H2. Better communication through sMM, whose generation is facilitated by VL.

H3. Better cooperation through sMM, whose generation is facilitated by VL.

To assess the three hypotheses, a case study was conducted in which twelve participants were asked to cooperatively redesign the Dutch milk chain; i.e., how the milk gets from cow to consumer. The participants were asked to prepare stakeholders' roles; e.g., the farmer, breeder, and dairy processor. The case comprised a full-day session in a virtual reality (VR) laboratory; see also Fig. 2. This VR laboratory was designed to facilitate cooperative design processes for complex problems.

Fig. 2. The virtual reality (VR) laboratory in which the case studies were conducted. The twelve stakeholders were divided over two gaming tables (left and right of the center).

During the full-day session the stakeholders were asked to perform two tasks:

Task 1: Identification of the problem, defining the current milk chain, and thinking of some directions for solutions; see also Fig. 3. This task was executed in the morning.

Task 2: Definition of the future milk chain for one of the chosen solutions, its implications, and the things/changes/actions necessary to realize that future milk chain. This task was executed in the afternoon.

For Task 1, a group of six stakeholders was instructed to use VL; i.e., using/creating drawings, pictures, diagrams mind maps, or any other kind of visualization (i.e., Group B). The other six stakeholders were instructed to use no VL; i.e., only spoken words and typed words (e.g., no visual arrangement was allowed) (i.e., Group A). In the afternoon, the groups changed from VL to no VL or the other way around.

On both tasks, using Likert(-type) scaled questions, the following aspects were determined:

- perceived agreement in content; i.e., what has been discussed during the task,
- perceived agreement in expectations that could be drawn from the content,
- communication, for which a questionnaire was adapted from Eby, Meade, Parisi, and Douthitt [15], and
- cooperation, for which a questionnaire was adapted from Pinto and Pinto [16].

Two moderators and two capturers facilitated the session. Together, they will be denoted as raters. In addition to the stakeholders, the raters were also asked to fill in the questionnaires on communication and cooperation. This provided a set of unbiased scores on the issues communication and cooperation.

We used Mulder's [17] self-scoring method to determine the (perceived) agreement in MM concerning content and expectation. The participants wrote answers on questions on content and expectation. All answers were collected and one randomly selected answer (of one question) was read aloud to the team. All team members indicated, on a Likert-type scale, the extent to which the description read aloud corresponded with their written answer and with their perception of what the answer should be. In this test, the answers of three participants per question, instead of one, were read aloud to judge correspondence.

Fig. 3. This cartoon depicts one of the ideas generated in the visual language setting (a spectator of the experiment made this cartoon based upon the brainstorm of the participants). It describes an energy efficient solution in which the cow drives a meat processing machine.

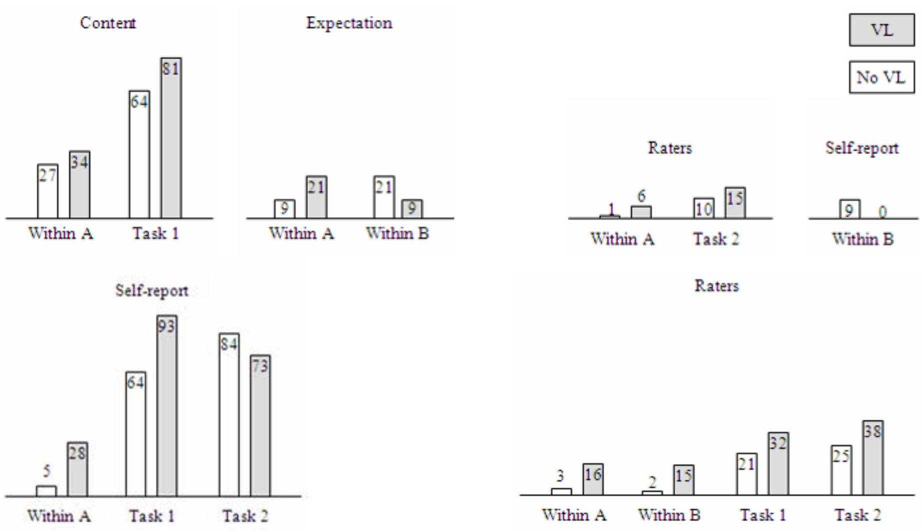

Fig. 4. The results on the first hypothesis (more agreement) are the two graphs at the top left: content and expectation. The results on the second hypothesis (communication) are divided in self-report results and rater results, presented at the top right. The results on the third hypothesis (cooperation) are presented at the bottom. Only significant differences are presented.

3 Results

The Likert(-type) scale answers were analyzed both between groups (Mann-Whitney tests) and within groups; i.e., between both tasks (Wilcoxon Signed Ranks tests). First, the results on agreement on content and expectation will be described. Second, the results of team processes (i.e., communication and cooperation) will be presented. With these analyses, T- indicates the amount of negative scores of Task 2 compared to Task 1, T+ indicates the amount of positive scores of Task 2 compared to Task 1. N stands for the total amount of comparisons (between scores of Task 1 and 2) and the tie-scores between the two tasks (not reported here) are n minus T- minus T+. The reported means are the means of the scores ranked from low to high (mean ranks).

H1. A significant difference in favor of VL was found in the results on the content of the sMM within Group A (T- = 27, T+ = 34, n = 72, p = .041), while no difference was found within Group B (p = .288); see also Fig. 4. A significant difference in favor of the VL setting was found between the groups for Task 1 (Mean A = 63.88, Mean B = 81.13, n = 144, p = .006). For Task 2, no difference was found between the groups (p = .429). For agreement in expectation, a significant difference was found within Group A in favor of VL (T- = 9, T+ = 21, n = 36, p = .011). Within Group B, the no VL setting scored better (T- = 9, T+ = 21, n = 36, p = .010). Between the groups no difference was found (Task 1: p = .146; Task 2: p = .436).

Table 1. An overview of the results per hypothesis with 95% reliability ($\alpha = .05$). The results on both agreement and cooperation support the added value of visual language (VL), whereas the results on communication are ambiguous. Note: Hx denotes hypothesis x.

	agreement in mental models (MM) (H1)		communication (H2)		cooperation (H3)	
	content	expectation	self-reports	raters	self-reports	raters
Task 1	VL				VL	VL
Task 2				VL	No VL	VL
Within Group A	VL	VL		VL	VL	VL
Within Group B		No VL	No VL			VL

H2. From the self-reports within Group B, a significant difference in favor of the no VL setting was found on communication (T- = 0, T+ = 9, n = 30, p = .003), see also Fig. 4. However, the raters (see Section 2) judged in favor of the VL setting within Group A (T- = 1, T+ = 6, n = 10, p = .062) and between the groups for Task 2 (Mean A = 15.13, Mean B = 9.80, n = 25, p = .034). In addition, no difference was found from the self-report results within Group A (p = .143) and between the groups for the two tasks (p = .292 and p = .306) and from the raters results within Group B (p = .190) and between the groups for Task 1 (p = .439).

H3. A significant higher score on cooperation was found in the VL setting from the self-report results within Group A (T- = 5, T+ = 28, n = 78, p < .001) and between the groups for Task 1 (Mean A = 63.62, Mean B = 93.38, n = 156, p < .001); see also Fig. 4. A significant difference between the groups was found, from the self-report results, in favor of the no VL setting for Task 2 (Mean A = 72.83, Mean B = 84.17, n = 156, p = .030). The results of the raters showed a significant higher score in the VL setting: within both Group A (T- = 3, T+ = 16, n = 26, p = .003) and Group B (T- = 15, T+ = 2, n = 26, p = .001) and between the groups for both Task 1 (Mean A = 20.81, Mean B = 32.19, n = 52, p = .003) and Task 2 (Mean A = 38.45, Mean B = 24.83, n = 65, p = .001). In addition, the self-report results showed no difference within Group B (p = .426).

The hypothesis that VL will account for more agreement in MM is partly supported by the results. The results on the content support the hypothesis while the results on expectation are less supportive. The results on communication do not support the hypothesis that VL supports the creation of a sMM. The results on cooperation, however, do support this hypothesis. For an overview of these results, see Table 1.

4 Discussion and Conclusion

This research presents a scientific foundation for the idea that VL supports creating a sMM. Various stakeholders participated in a full-day session in which they executed a task with and without VL. The results on agreement of individual MM indicate that VL supports creating a sMM (H1). A time or task effect might have occurred in the results on agreement in expectation because the scores were higher in the afternoon (in both settings). Although little is known about the effect of time on sMM [18], it is noted that common experience or team familiarity can lead to more common and/or compatible MM over time [19]. This might explain the higher scores in the afternoon. The higher scores on expectation might also be explained by group difference. Personal preference can be involved here [20]. We have tried to minimize the effects of group differences by asking the participants to fill in questionnaires on personality, communication competence, skills/experience, and team characteristics. No significant differences were found between the groups on these items. The participants were not used to work with each other and had different backgrounds. They were asked to prepare their roles by reading and searching for information. In normal decision-making settings the stakeholders often have different backgrounds and knowledge. Still, it might have been possible that group effects occurred.

The results of the team processes are denoted as issues on both communication and cooperation. The results of communication were ambiguous and did not show a more efficient team process because of VL (H2). The results on cooperation of both the self-reports and the raters strongly support the idea of a more efficient team process because of VL, which indicates a sMM at work (H3). It appeared that Group B outperformed Group A on both tasks (ergo, both settings). In addition, no significant difference was found within Group B. This can be due to the fact that Group B was cooperating well from the start and could not improve much more.

Some remarks can be made on the case used. First, measuring a sMM is difficult because it is mental. In addition, the questions asked on content and expectation were not validated. Triangulation to measure a sMM has already been applied but could be extended further; e.g., using physiological measurements, inter-subject correlation, and by participants indicating after each utterance, whether or not, they understood it.

Taken the results all together, sMM are shown to be beneficial in supporting cooperation [3], prediction [5], and positive affect towards the team [5]. sMM also account for speed, flexibility, and implementation of a decision [5] and for team performance. In addition, the stakeholders preferred VL over no VL. This all emphasizes that VL can indeed be a valuable tool for cooperative (re)design. Even its most simple implementations (i.e., pencil and paper) or tablet pc's can aid the process of cooperative design and engineering.

Visualization to support cooperative design and decision-making processes is already widely used. However, so far, the underlying assumption did have little or no scientific ground. It explained the benefits of VL through the concept of sMM. Although many issues remain a topic of investigation, this research can be considered as a first step toward a scientific foundation for the use of VL for cooperative design and decision-making.

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Visualization of Cooperative Decision Making

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Abstract. This work is devoted to application of ternary Analytic Hierarchy Process as an attempt to formalize decision makings in public organizations. The ternary version is chosen over the classical one because it can accommodate 'ties', requires less time and efforts from the decision makers, decreases the amount of inconsistency occurrences through the evaluation process and it is sufficient for the task.

Keywords: visualization, cooperation, multi-criteria multi-decision making.

1 Introduction

In this paper we consider four universities being members of a collaborating network organization. One of them is to be selected to host a computer based system that can be used by employees affiliated with any of the four member universities. The process of choosing the best candidate is a multi criteria multi decision process. We propose application of ternary Analytic Hierarchy Process (AHP). The ternary AHP is chosen over the classical AHP (9 point rating scale) because it can accommodate 'ties', requires less time and efforts from the decision makers, decreases the amount of inconsistency occurrences through the evaluation process and it is sufficient for the task.

Preserving consistency in a grading process is a challenge for most decision makers. Cycles in a graph associated with an AHP related comparison matrix imply inconsistency, [8] and [10]. Inconsistencies can be measured by the number of cycles in an associated graph, [6] and [7].

The rest of the paper is organized as follows. Related work and supporting theory may be found in Section 2. The decision process is presented in Section 3. The conclusion can be found in Section 4.

2 Paired Comparisons

AHP [8] employs paired comparisons in order to obtain ratio scales. Both actual measurements and subjective opinions can be used in the process. A decision committee makes pairwise comparison of independent alternatives with respect to each criterion and among the involved criteria.

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The elements $a_{ij}, i, j = 1, 2, ..., n$ in the obtained matrices satisfy the conditions $a_{ij} > 0, a_{ij} = a_{ji}^{-1}, a_{ii} = 1, i, j = 1, 2, ..., n$.

Decision makers' judgements are consistent if $a_{ij}a_{jk} = a_{ik}, i, j, k = 1, 2, ..., n$. In this content consistency means that if a basic amount of row data is available than all other data can be logically deduced from it. Application of eigen vectors leads to a very useful consistency measure called consistency index $CI = \frac{\lambda_{max} - n}{n-1}$ where n is the order of the comparison matrix and λ_{max} is its maximum eigen value, [8]. CI measures the transitivity of a preference that is a part of the pairwise comparisons. Existence of a weight vector in a pair-wise comparison matrix is proven by the Perron-Frobenius theorem, [4].

Binary and ternary AHP have been proposed for solving problems that do not require a larger scale of values representing the intensities of judgments [2], [3], and [13].

Addition or deletion of alternatives can lead to possible rank reversal [11], [12], and [14]. A change of local priorities can cause rank reversal before and after an alternative is added or deleted, [15]. In order to avoid rank reversal the authors suggest an approach where the local priorities should be kept unchanged.

3 Ternary AHP

Four universities are joint in a collaborative network across organizational boundaries. They are in a process of choosing one of them to host a system, accessible by all members of the network. A committee, formed by members of the four universities, is making all the decisions needed in the application of the AHP. Ternary AHP is further on inforced in order to decrease the amount of subjective judgment errors. This means that the committee members agree upon use of the following rules through the process of grading: write 1 if item i and item j are of equal importance; write $\theta, \theta > 1$, if 'item i is more important than item j', and; write $\frac{1}{\theta}$ if 'item i is less important than item j'. An item in our case is either a criterion or an alternative.

The process continues as follows: development of a decision hierarchy with an objective, alternatives and criteria; grading relative importance of criteria $C1, C2, C3, C4, C5, C6$ and $C7$ (see f. ex. Table 1) and preferences among the

Table 1. Pairwise comparison of the agreed upon criteria

	C1	C2	C3	C4	C5	C6	C7
C1	1	θ	1	$\frac{1}{\theta}$	$\frac{1}{\theta}$	$\frac{1}{\theta}$	$\frac{1}{\theta}$
C2	$\frac{1}{\theta}$	1	1	θ	$\frac{1}{\theta}$	1	θ
C3	1	1	1	$\frac{1}{\theta}$	1	$\frac{1}{\theta}$	$\frac{1}{\theta}$
C4	θ	$\frac{1}{\theta}$	θ	1	θ	$\frac{1}{\theta}$	1
C5	θ	θ	1	$\frac{1}{\theta}$	1	θ	θ
C6	θ	1	θ	θ	$\frac{1}{\theta}$	1	1
C7	θ	$\frac{1}{\theta}$	θ	1	$\frac{1}{\theta}$	1	1

four alternatives are stated based on pairwise comparisons; calculating priority weight vectors for the criteria based on the preference scores [1], [9]; calculating the final weight vector representing the priority ordering of the alternatives.

We reduce the amount of work related to locating and subsequently correcting inconsistencies by looking at the possible maximum length of cycles in a connected graph associated with a comparison matrix. Further on we perform a sensitivity analysis that illustrates how a change of a particular criterion can effect the final outcome.

Stability of priority ranking is often tested applying sensitivity analysis. Scores for the four alternatives related to criterion $C7$ are graphically presented in Fig. 1.

A head-to-head sensitivity analysis between two alternatives shows the relative magnitude of the alternatives compared with respect to the involved criteria, Fig. 2. The first alternative dominates over the second with respect to criteria $C1, C2, C3$ and $C5$.

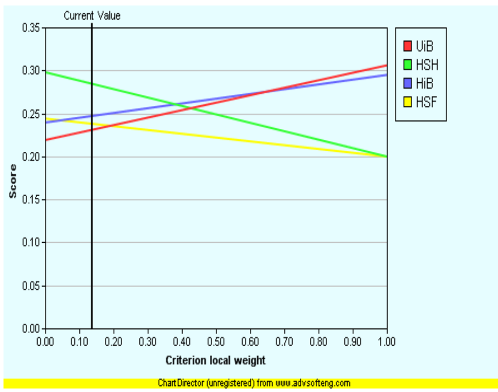

Fig. 1. Sensitivity analysis

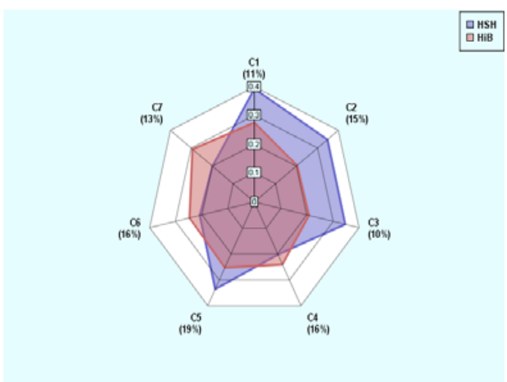

Fig. 2. Head-to-head analysis

Both Fig. 1 and Fig. 2 are obtained via the AHPproject - Free Web-Based Decision Support Tool [5].

4 Conclusion

Decision makers find AHP to be a very useful tool. At the same time, an increase of the number of alternatives and criteria results in a larger amount of pairwise comparisons. The latter is time consuming and thus increases the loads of the decision makers. The ternary AHP used in this work contributes to a better preservation of consistency in the grading process.

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Role-Specific Practices as Guidelines for Information Visualization in Service Systems

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Abstract. Today an important issue in Human-Computer Interfaces design is their ability to adapt to their context of use (i.e. plasticity). This issue is of paramount importance in highly collaborative domains such as the construction one. We suggest to define *role-specific practices* characterizing the actor's use of a tool in a domain-specific approach. Associated to visualization modes -and their ergonomic characteristics- we aim to improve visualization of cooperative context and therefore the appropriation of the tools and their ease-of-use.

Keywords: Cooperative applications, Human-Machine Interface, Model-Driven Engineering.

1 Introduction

The AEC business market is largely driven by building & infrastructure projects demand. Such projects involve temporarily teams of heterogeneous actors (architects, engineers, contractors, material providers, etc.) able to respond to the customer's requirements (namely his architectural program). Each of these heterogeneous firms has its own internal processes, methods and IT infrastructures. We underline that collective processes have not to be described in the details in order to be flexible. Then we think that numerous "process modeling" approaches are not adapted to this business field. But "working processes" could be described and agreed at a "high level", on the basis of a shared vocabulary between actors of the domain. Therefore, IT support services can be considered as support to these cooperative (best) practices. An example of cooperative practices and related IT services definition is given in [1].

The particular research work described in this paper emphasizes on user experience of groupware-oriented IT services. The issue that we address is related to appropriation of innovative technology *through improved user experience and related Human-Computer Interfaces*.

The paper addresses firstly the definition of Role-Specific Practices and the guidance they could provide in services and HCI model-based integration. Then we describe the ongoing and planned works in AEC-dedicated services and HCIs.

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2 Role-Specific Practices to Drive HCI Generation

Our main hypothesis is that visualization modes implemented in Human-Computer Interfaces of IT services have to fit *role-specific practices* ("RSP"). The concept of RSPs is based on organizational and operational roles of a project's actor, on his user profile (e.g. IT skills, work place) and on the available IT services in the collective project. Therefore visualization techniques of project context's information could be anticipated and have also to be dynamically adapted to the RSPs.

In our preliminary approaches, RSPs are identified through the following questions (Fig. 1): who performs it? (*who is the project actor concerned?*), what is the type of business task performed?, where is it performed (*i.e. context of use*), when? (*related to the ongoing project stage*) and how? (*what type of information is needed*).

This approach is based on business-specific collective work practices. RSPs are defined independently of any existing IT service or groupware functionality. In this sense it differs from the definition of "use cases" in UML or task models in HCI [2] while concepts are closed.

As RSPs are numerous and user-related, we have to choose a generic method to implement them in an IT infrastructure. In order to guide IT services design and HCI generation by RSPs, a model-driven engineering (MDE) approach aims to consolidate the three concepts in relationship: domain targeted (which one guarantees sector fitting), IT service, and view (Fig. 1). MDE recommends the use of meta-models to define domain languages. Models represent real systems. Each model has to be conformed to its meta-model [3]. The following parts described basic concepts of our set of metamodels.

2.1 AEC Domain Metamodel

We proposed two levels of modeling for the cooperative activity in the AEC domain [4]. First, a Cooperation Context Meta-Model (CCMM) allows us to describe the cooperative activity at a high level of abstraction. This meta-model is used to construct a specific model representing the particular context of a real construction project.

Our CCMM (M2) takes into account the existing relations between the different elements of a project. We identify three main categories of elements existing in every cooperation project: the activity, the actor and the artefact (associated with documents and objects related to an activity). CCMM strengthens the relationships existing between these elements of cooperation.

Based on this metamodel, M1 models have been instantiated to represent specific architectural design context and building construction activity dedicated context. Finally, these Cooperation Context Models (CCM, M1) also enable the description of particular project contexts (M0) representing the business knowledge in which actors cooperate.

2.2 IT Service Metamodel

The implementation of the business domain context through the use of IT services requires to use the same modeling framework to guarantee the alignment between the concepts introduced at each modeling level. The IT Service metamodel describes

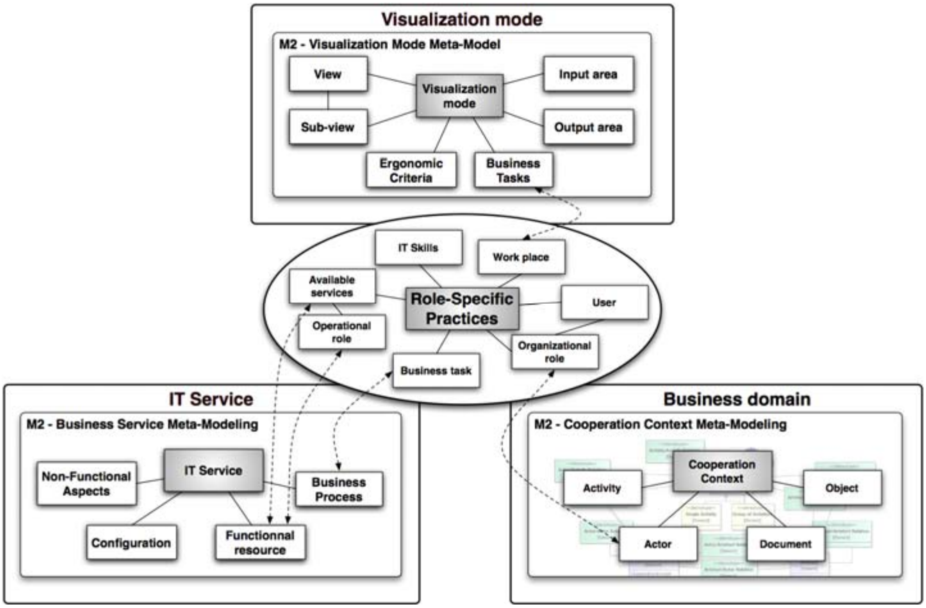

Fig. 1. Models infrastructure and Role-Specific Practices

business processes, functional resources and elements of services' configuration. This approach is inspired from other works such as the ones of IBM [5]. The metaconcept matching between metamodels enables to design IT services adapted to specific business cooperation contexts by using business concepts when configuring the IT service (service model level). In our previous developments the business-oriented services described above have been developed through the use of Web services [6].

2.3 Visualization Mode (VM) Metamodel

These previous and ongoing works on domain and IT service modeling target the design of services for specific collaboration situations in AEC (Dest2Co project). The definition of role-specific practices (RSP) aims at better understanding the services and HCIs use cases. The challenge is to improve information display for each user's RSP. We suggest defining a metamodel of the visualization modes used in groupware services in order to describe VMs and to enable their use in HCI generation.

A visualization mode is composed of a main view (and its potential sub-view(s)), which is close to the visualization information technique used. It provides input and output areas to interact with the user in order to perform business tasks. Finally defining ergonomic criteria enables to constrain the visualization mode selection to the type or quantity of data to visualize.

3 Conclusion and Future Works

As shown in Fig. 1 the definition of user's Role-Specific Practices aims to guide the service design and the HCI generation in accordance with the user (business tasks he has to perform and visualization modes better fitting his needs) in service-oriented IT environment. A scenario of implementation of this approach could be the following: the user selects RSPs of the same type (i.e. RSPs related to “monitoring the project”). Then the system configures adhoc visualization modes taking into account specific needs of the user in terms of business tasks, IT skills, ergonomics and so on.

Our future works are firstly to improve our service-based information system, especially to setup metamodel management and automated mapping techniques. On the domain side we envisage to consolidate our first set of RSPs. We are defining an experimental protocol aiming to 1) identify and 2) validate the pertinence of RSPs in the AEC field. RSPs modeling formalism is also important and could be based on UML / Task models existing formalisms. Finally an important work is engaged on the identification and modeling of Visualization Modes in a close relationship with Information Visualization theories.

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3D Virtual Environment Used to Support Lighting System Management in a Building

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Abstract. The main aim of the research project, which is in progress at the UTL, is to develop a virtual interactive model as a tool to support decision-making in the planning of construction maintenance and facilities management. The virtual model gives the capacity to allow the user to transmit, visually and interactively, information related to the components of a building, defined as a function of the time variable. In addition, the analysis of solutions for repair work/substitution and inherent cost are predicted, the results being obtained interactively and visualized in the virtual environment itself. The first component of the virtual prototype concerns the management of lamps in a lighting system. It was applied in a study case. The interactive application allows the examination of the physical model, visualizing, for each element modeled in 3D and linked to a database, the corresponding technical information concerned with the use of the material, calculated for different points in time during their life. The control of a lamp stock, the constant updating of lifetime information and the planning of periodical local inspections are attended on the prototype. This is an important mean of cooperation between collaborators involved in the building management.

Keywords: Cooperative visualization; 3D virtual world environments; Virtual reality; Building maintenance; Lighting system.

1 Introduction

Along the **lifecycle** of a building a great amount of data must be generated, analyzed, transformed or replaced. The information technology (IT) becomes an important support on the management of computer-based information, namely to convert, store, protect, process, transmit, and securely retrieve datasets. With the emergence of the relevant computer technology, method based drawing and the visualization capabilities were combined into one process, the three-dimensional (3D) models. The further enhancement of the computers resulted in the development of **3D visualization tools**, which facilitates a more real appreciation of the end product. At present, the management building planning could be presented in a 3D form and various materials can be assigned to the fixtures and furnishing enabling the user to be virtually placed in the building and view it from inside as well as outside.

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The improvements in computational performance have created needs for new systems that enable users to explore computation datasets in an intuitive and flexible manner. Interactive systems must incorporate the interactive techniques and input devices to perform visual exploration tasks. Furthermore, the models must attend information visualization, human-computer interaction, and **interactive interface** design. In the present case, a bibliographic research support had to be made regarding the lighting systems usually applied in a building and the characteristics of different types of lamps. Also programming skills had to be enhanced to establish the integration needed on the creation of a lighting virtual prototype. In addition, the structure of different kind of databases had to be study and implemented, integrating diverse type of information, needed to develop the virtual model.

The 3D model linked to a data base concerning the lighting system management characterizes a **collaborative virtual environment**. It means that it can be manipulated by partners interested in creating, transforming and analyzing data in order to obtain results and to make decisions. The process of developing the prototype interface considers this proposes. Then, the model is easy to use and not require sophisticated computer skills by users, as many are not computer experts. The human perceptual and cognitive capabilities were taken into account when designing this visualization tool. It uses an interactive 3D visualization system based on the selection of element directly within the virtual 3D world. Further more, associated with each component there are integrated databases, allowing the consult of the require data in any point in time.

2 Maintenance and VR

The performance of the maintenance of a building has been increased through the application of new modeling concepts, particularly the incorporation of **VR techniques** and the addition of time as a factor to be considered in the strategy of building conception. In the same vein, 3D models have been developed, related to the time parameter (designated 4D models [1]), focused in the beginning, basically, on planning the construction process. The geometric model of **construction** is presented as a progression of steps in its physical evolution following planning. The University of Stanford [2], and the Finnish Centre of Investigation VTT [3], have presented concrete applications in the design phase with considerable befits relevant to communication between specialists, constructors and promoters. In the construction domain, the VR models are used to show the physical evolution of the building, through 4D models, in different phases of its construction following specific planning [4] and the simulation of the operational evolution of the associated construction processes [5]. In the area of **architecture**, VR models are generally applied to the visualization of static physical models in the definition of itineraries of walk-through, as a means of transmitting the functional and geometric aspect of the building.

This paper contemplates incorporation of the 4th dimension, the time, into the concept of visualization. The focus of the work is on traveling through time: the ability to view a product or its components at different points in time during their life. It is envisaged that the incorporation of the time dimension into 3D visualization will enable the designer/user to make more objective decisions about the choice of the constituent components of the building.

One of the more recent targets of investigation is in fact, research into the **sharing of data** between applications, which can be manipulated by means of a common interface, as a way of rendering 4D tools efficacious and of wide use. Virtual reality is seen today as an integrating technology, with great potential for communication between project participants, and most recently, as a tool for the support of decision-making, made possible by the integration of distinct computer applications in the virtual model. In this context, the present work presents the development of a system based on VR technology, involving knowledge of the physical aspects of materials, in particular, those which refer to wear and tear (a function of time, use and environmental factors), integrating them in digital spatial representations. In this way, the indisputable advantage of the ease interpretation and perception of space provided by the visualization of 3D models, and the technical content underlying the real characteristics of the observed elements are brought together.

2.1 The Research Project

The interactive lighting system, described here, was developed within the research project in progress, *Virtual Reality technology applied as a support tool to the planning of construction maintenance*, PTDC/ECM/67748/ 2006, ICIST/FCT. In this first stage, just the lamps elements of a common building were implemented in the virtual prototype. It allows the examination of the physical model, visualizing, for each element modeled in 3D and linked to a database, the corresponding technical information concerned with the degree of use of each lamp, calculated for that period of time. The practical usage of this model is directed, then, towards supporting decision-making in the planning of maintenance of light systems.

The modeling of the lifecycle of infrastructures has, thus, in the VR technology a strong basis for development. The present project aims to bring important contributions to this domain, with the implementation of virtual models with capacities of calculation related to the behavior of materials, variable throughout the construction's lifecycle. During this investigation the basic knowledge of the topics involved (aspects related to the materials, the techniques of rehabilitation and conservation and the planning and costs of maintenance) has been studied and methods of interconnecting this knowledge with the virtual model were explored. The first prototype, implemented with the light system, was trialed in a concrete project. This kind of building element has a discrete lifestyle, so its maintenance requires the control of a lamp stock, the constant updating of lifetime information and the planning of periodical local inspections. In the future it is going to be applied in others situations of buildings, news or for rehabilitation.

3 The Lighting Interactive System

The paper describes the implementation process of the lighting component. First, the 3D geometric models of building case and the some light equipment were created (Fig. 1). The building consists of a ground-floor, a 1^{st} floor and an attic waters with allocation of housing.

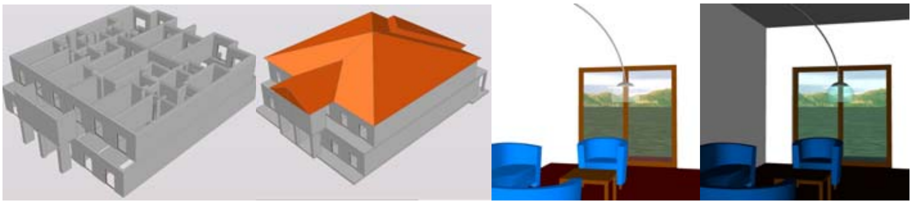

Fig. 1. Sequences of the 3D modeling process of the case study

The visualization of the lighting system in a building and the impact of time on its performance, require an understanding about the characteristics of lights, bulbs and lamps:

- The bulb type and its wattage are important parameters, which determine the amount of light produced by a particular bulb. The correspondent compatibility characteristics is also a significant management data in case of replacement of elements in a building;
- The life of the bulb is an essential factor in a maintenance analyses. By using the bulb lifetime and the related break-time distribution, it will be possible to represent the prediction of lifetime in a statistical form, that is, the time after which the bulb is likely to break;
- Bulb and lamps have discrete lifestyle. So the maintenance plan must include the control of bulb stock established for each type of element in a building, and a permanent updating of the lighting database.

These characteristics were included in a database concerning lighting elements, which was created and linked to the 3D model of the building. So, the virtual model gives the capacity to transmit, visually and interactively, information related to the compatibility of bulbs, in case of substitution, the expectation of break time and the number of items for each type of bulb. In any point of time is possible to analyze the state of the management of the light system. In addition, the model includes alert to periodic local inspections of observation of the real state of each bulb in the building. After inspection, automatically, the compatibility of each broken bulb is checked in the database, the element is replaced, the installation date is actualized, and the lighting stock is updated.

The interface of the lighting prototype was defined to be used in a very intuitive way. The model is organized in order to:

- Create an identity to each new lamp inserted in the 3D model of the building;
- Search in a general data base an adequate/compatible bulb to that lamp;
- Insert the installation date of the new bulb and the average number of hours of the predict functionality;
- Calculate the predicted break-time for the bulb based on the installation data and the statistic period of lifetime for that type of bulb;
- Planning a visual inspection periodicity to the real place;
- Consult and update the correspondent bulb stock established for the building;
- Walk-through the interior of the house model and observe the location and the information concerning each installed lamp.

3.1 Identification of Elements

To test the prototype, the 3D models of several types of lamps were created. The new elements were imported by the virtual system, EON studio [6] and the identification process is initialized. The identification of each new component of the building must be done to enable the monitoring of the maintenance control. For this propose, a database concerning bulbs usually used in a building was defined. The database is composed with the technique specifications of some commercial light elements. The identification process is based on the following steps (Fig. 2):

- Choose, in the virtual model, a not yet identified element (one lamp);
- Select the type of element for classification (lighting, wall, floor, or other);
- Pick a bulb in a list of elements included in the database. The information associated to each light element is composed by an image and the correspondent technical characteristics (commercial identification, wattage, power, compatibility, average lifetime, …);
- Identify the place in the building where the element is installed (room, kitchen, …);
- Insert the installation date and the average number of hours of the predict usage (low, average or high).

Thus, the relationship between the new light element and the individual database of the virtual model of the building is established. The virtual model includes a top menu that allows the user to access both data bases. Figure 3 shows the data base of a identified element and the list of lamp types included in a general data base.

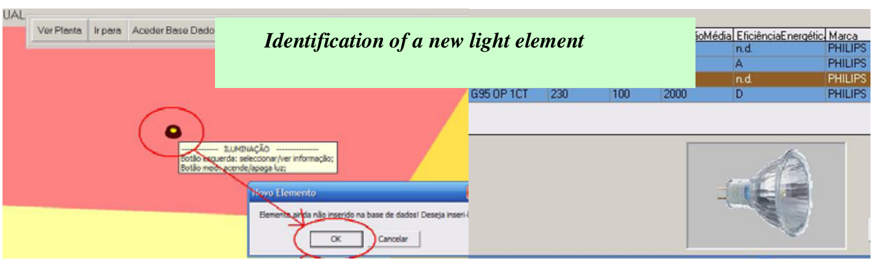

Fig. 2. Identification of a new element

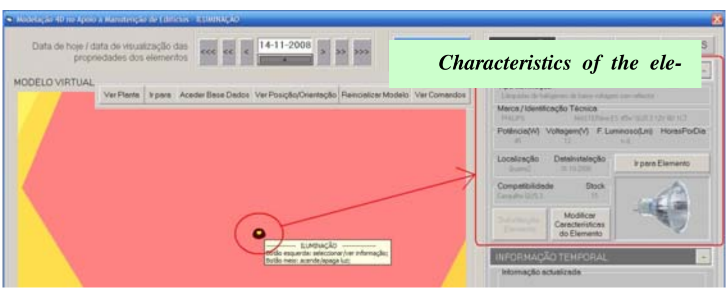

Fig. 3. Element identified in the virtual model

Now, the lamp is properly identified as a monitored element and the corresponding information can be visualized. By just clicking over the component in the virtual model, the element is selected and the associated information is presented. In addition, the researcher platform allows the user to select a parameter (localization, compatibility, wattage, …) and a list of the elements is then presented. They correspond to the selected specification.

3.2 Monitoring the Facilities Maintenance

The database contains the information necessary for the interaction with the model in function of the parameter time (installation date, period of average lifetime, next periodic inspection date and the actual date of interaction with virtual model). The result of the research and the adjustments/actualizations necessary to carry out are allowed through the interface of the characteristics of the each identified element. Figure 4 presents the interface with several characteristics of the map that can be modified. The virtual model allows the access to all the information of the selected element. So, the comparative information of dates of inspection/installation/re-placement and the average lifetime is controlled and visualized in the interface.

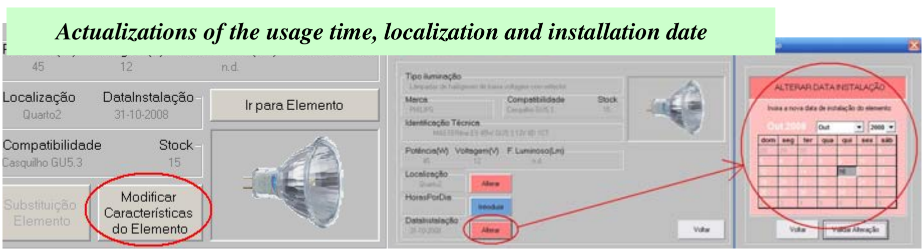

Fig. 4. Adjustments/actualizations of technical information

As, this type of building component, for maintenance proposes, has a discrete lifestyle, the elements have to be substituted when the real bulb is broken. The interactive model alerts when the predicted broken date is achieved. The calculation is based on the installation data and the statistic period of bulb lifetime. This verification could be occasionally (by the observation of the state of the bulb in the real place) or by periodic visits (this period was established and incorporated in the virtual model in order to alert of the necessity of inspection to the place). The model allows the definition of a report for each observed element. Figure 5 presents an aspect of the report were it is possible to visualize the inspection date and the options, bulb active and bulb broken.

To allow the substitution of an element the compatibility between the old bulb and the bulb to be installed must be verified. The virtual model alerts to this kind of problems. For instances, if the user chooses a wrong bulb the interface displays a message indicating that the selection made was incorrect. The database of each type of bulb must contain the number of elements that is admitted to be used in the building (management of stocks). After each replacement the number of light elements must be updated as well as the installation date concerning the new bulb.

Fig. 5. Periodic inspection of each element

3.3 Walkthrough and Orientation Inside the Model

In order to help the user to manage the model, detect the identified element and, in general, walk inside the house, a top projection of each floor was included located at the bottom left corner of the visualization window. A point focus was included in it indicating the position of the user and the direction of visualization (Fig. 6). It helps to go to any part of the house.

Fig. 6. Help orientation inside the model

This aspect is important in a collaborative virtual environment. In this prototype, when all the lamp elements were identified, any user can interact with it in order to obtain any information concerning each lamp, related to its lifetime or stock management. This developed capacity associated to the model was essential to make it more users friendly and in consequence, even more efficient.

4 Future Developments and Conclusions

In this first phase, a lighting prototype on academic scale was defined and it served as a test. The next step in to increment the model with others building components, namely, closures of interior and exterior walls, surfaces of floors, and doors and windows elements. Further more the prototype will be put to work on another concrete case of infrastructure. The study model will be trialed and the problems caused by an increase in scale (volume, new materials, and other interconnections) will naturally lead to the optimization of the initial model. A method of action will be established with a view to the generalization of the process of generating virtual models from 3D models. It will be promulgated in education, in related disciplines and training courses and on a professional level, to those offices concerned with lifecycle facilities management. The model is an important mean of cooperation between collaborators involved in the building management.

This paper introduces the concepts of VR and interactive visualization on the reflection of the state of a building through time, by focusing just one aspect of building maintenance, the lighting system. Here the simulation and implementation of time-related events, on the building components, has been highlighted. To this end, a model has been proposed to simulate visualization, and interaction with a database concerning the lighting component. The future work over this prototype must be based on: Systematization of concepts of planning of maintenance; Inclusion of new elements concerning other building components in database; Analysis the methodology to attend the application of the virtual system over other situations. In this way, it is promoted the application the system to any model 3D of buildings. Each concrete situation to be monitored, the virtual model will allow the day-by-day control of the maintenance activity.

The presented example concerns only a type of element, the illumination devices, but it was verified to be efficient in the identification of elements, in the promotion of alerts of inspection and in the management of stocks, all activities related with the maintenance and management of a building.

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A Framework for Link Sharing in Cooperative Cross-Media Information Spaces

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Abstract. We present a peer-to-peer version of a cross-media link server that allows users to create and share links between arbitrary forms of digital and physical media. As a specific example, we describe how it could be used to support collaborative forms of annotation of paper and/or digital design documents.

1 Introduction

The concept underlying hypermedia systems of being able to freely link arbitrary resources together has been being adopted to span digital and physical spaces. A fully generalised cross-media link server enables the model of information publishing and access on the web to be extended to any type of information resource and service, and to possibly link these to physical objects.

We have developed such a cross-media link server, called iServer, and used it to develop a wide-variety of applications ranging from mobile tourist information systems to interactive media art installations. In most of these applications, users browse pre-authored information and access services based on the defined information space. However, we also wanted to support cooperative, community-based models of cross-media information spaces, where users can publish, not only their own resources, but also links that they have created between existing resources as proposed in open hypermedia systems. We have therefore developed a peer-to-peer (P2P) version of iServer that enables users to share their link spaces. In this paper, we describe how it could be used to support the sharing of information in a meeting scenario.

We start in Sect. 2 with a motivation for cooperative cross-media information spaces and a discussion of related work. The iServer framework and its extension for cooperative information spaces is presented in Sect. 3. We then present our P2P architecture in Sect. 4 and describe an application of the framework in Sect. 5. After a discussion of the presented approach in Sect. 6 some concluding remarks are given in Sect. 7.

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2 Motivation

Nowadays digital information is often not only managed by a single application but associated with other digital resources forming part of a general information space. Hypertext and hypermedia models consider such an information space to be a connected graph where the nodes are resources and the edges are links. The source and target of a link can be either an entire resource or an element within a resource. In addition to the handling of associations between digital resources, physical hypermedia systems enable real-world objects to be linked to digital media, and vice versa, by allowing physical resources to also be included as nodes in the connected information space [2].

For improved flexibility, links can be managed in separate linkbases rather than embedding them in resources [5]. One of the benefits of this approach is that new links can easily be created by the consumers as well as the publishers of resources. Specifically, it allows annotations to be created by users where, not only the link, but also the target content created by the user, can be managed by a link server [3]. Such an open authoring system allows the information space to evolve over time based on user-generated links and content.

For example, participants of a design meeting could easily add their own links and annotations to a shared design space as shown in Fig. 1. In such a meeting, each participant might bring their own laptop or other mobile devices containing their personal resources as well as link information. During a meeting, users will not only work on their laptop but often also with dedicated presentation and interaction devices. These interaction devices may include large interactive surfaces such as interactive wall projections or interactive table surfaces. In addition to the digital devices for information navigation and capture, in many design meetings, paper documents still play an important role in supporting discussions as well as the creation of new, or annotation of existing, information.

If users can create their own links between resources during a design meeting, it is also desirable that this information can be shared with other participants to establish a community-based information space. Since there should still be a certain level of control about the sharing of information, a user has to be able to define if a new link is *private*, *shared within a specific group* (e.g. participants of the meeting) or *public* and accessible to everyone.

Instead of using a central server, a P2P architecture provides the potential for more dynamic forms of sharing such as in the described design meeting scenario where teams of people come together and information can be shared directly among personal mobile devices including laptops and fixed interactive surfaces. As explained later, also annotations captured from working with interactive paper documents could be linked into the cooperative information space.

An important detail about the presented scenario for sharing link information is that the supplemental shared information is not automatically stored persistently on each user's personal device. The shared information rather is treated as a supplemental transient annotation layer on top of the user's personal information space and is stored persistently only on an explicit user request. Furthermore, we do not want to make any assumptions about the resources available on

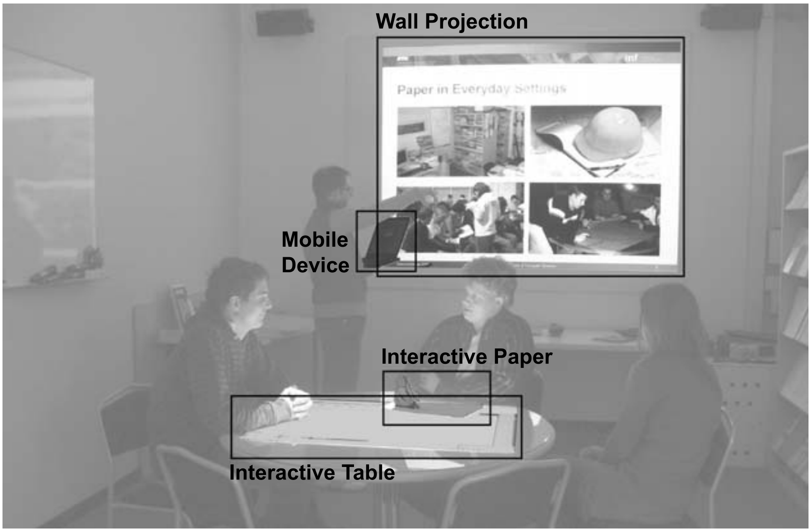

Fig. 1. Cooperative information space

an individual user's device. For example, if some participants of a meeting are from the same company, they tend to have similar resources which on the other hand might not be available to participants from other companies. In this case, the shared links could be filtered to prevent participants from receiving links between resources they do not have on their machine. The sharing of information is therefore not only based on the vicinity of different users but also depends on the availability of common resources.

While the idea of community link sharing behind our framework is similar to proposals in distributed hypermedia [1], the difference lies mainly in the approach to realising the goal. By building on advanced database technologies and concepts of metamodel-driven system engineering, we were able to develop a system that supports all of the above goals within a relatively short period of time. In the rest of this paper, we describe the architecture and implementation of the framework.

3 Cooperative iServer

The iServer framework offers a general cross-media link service capable of supporting an extensible set of digital or physical media and various kinds of applications. The framework is based on the RSL metamodel [8] and enables the integration of new media types based on a resource plug-in mechanism as indicated in Fig. 2.

In the RSL model, links are associated with one or more source entities and one or more target entities. An entity may be a resource, a selector or a link. While a resource represents an entire information unit or service, a selector is used to address parts of a resource, similar to the reference objects introduced in the FOHM [6]

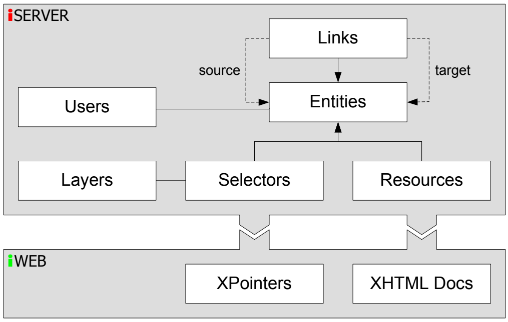

Fig. 2. iServer with iWeb plug-in

model. The RSL model and its iServer implementation further provide some user management functionality that allows access rights to be associated with single entities (and therefore also with links). Users may be either individuals or groups and each entity has exactly one creator who defines its access rights.

For a particular media type, we can extend the iServer platform by introducing a component that defines specific selectors and resources for that media type. For example, the iWeb plug-in for XHTML documents uses XPointer expressions as selectors to address parts of an XHTML document. In addition to the iWeb resource plug-in, we have developed iServer plug-ins for images, sounds and movies, as well as an RFID plug-in for tagging physical objects. Furthermore, the iPaper plug-in allows regions within paper documents to be linked to digital media and services based on Anoto's digital pen and paper technology[1].

To support the type of enhanced ad-hoc information sharing motivated in the previous section, we developed a P2P framework for iServer. In combination with the iPaper plug-in, this allows users to easily create and share handwritten annotations of paper documents in addition to any other form of link between resources or digital annotations. As mentioned earlier, we do not share the resources themselves but only new associations defined between existing resources. However, a handwritten annotation is a special type of link where the link target is represented by the newly created note. For these special types of annotation links, we therefore not only share the link information but also the captured annotation which is the target resource.

A variety of applications have been implemented using the iServer framework, including general browsers for cross-media information spaces, a paper-based mobile tourist information system [7] and an art installation for writing and accessing interactive cross-media narratives [9].

Existing proposals for cooperative hypermedia systems based on P2P technology, e.g. [4], apply P2P network functionality to replicate hypermedia documents and perform searches in the distributed network of peers. In contrast, we manage the resources separately from the annotations and links and use the P2P architecture only to share link and annotation data.

[1] http://www.anoto.com

In our approach, a client always accesses a resource from its original location and, only in a second step, is additional link metadata acquired over the dynamic P2P iServer network. The separation of content and metadata further implies that a resource should always be available provided that its host web server is running, whereas additional link information may change dynamically based on the set of iServer peers currently available in the network.

A user can access information from their personal iServer link database as well as retrieving link data from any other iServer peer. We distinguish between *persistent link data* that is stored in a personal iServer instance and *transient link data* received from the set of remote iServer peers. The availability of additional link information over the P2P network can be seen as an optional extension to information stored in a personal iServer instance. Users are free to use the new cooperative iServer functionality or to work solely with their personal iServer instance. The transient link data provided by other iServer peers represents optional suggestions by the members of the collaborative information space. However, if a user finds any suggested link information relevant, they can store a link persistently by adding it to the personal iServer instance.

While the quality of the persistent link data can be ensured by controlling the users who have access to a personal iServer instance, we do not have any direct control mechanism to guarantee the integrity of information provided by remote iServer peers. In a meeting setting this integrity might not be a problem but we will also discuss solutions for more open settings in Sect. 6.

4 P2P iServer Architecture

The general interaction between peers consists of sending single API calls from one peer to another, the execution of that request on the remote site and the transfer of the result back to the initiating peer. The information returned by the remote peers has to be combined and integrated with information that is available from the local iServer instance. The functionality of a remote iServer system is offered to a local iServer instance via a peer service. This service is implemented within a peer service platform that separates the aspects of *interaction* and *connection*.

The interaction architecture is shown in Fig. 3. For the sake of simplicity, we reduce service interaction to the transfer of request and response data between a requesting local system shown on the left-hand side and a responding remote system on the right-hand side. One-to-many and many-to-one interactions which typically occur in distributed iServer scenarios can always be represented by multiple one-to-one data transfers. We now describe the main steps of interaction labeled ⓐ to ⓗ in the figure.

ⓐ In the local system, a request handler is used to post a local request. Depending on the concrete peer service, data may have to be provided by the requesting client. ⓑ The handler creates a message object containing the request data and sends its XML string representation to a remote request handler. ⓒ On the remote site, the message is reconstructed from the string value received and

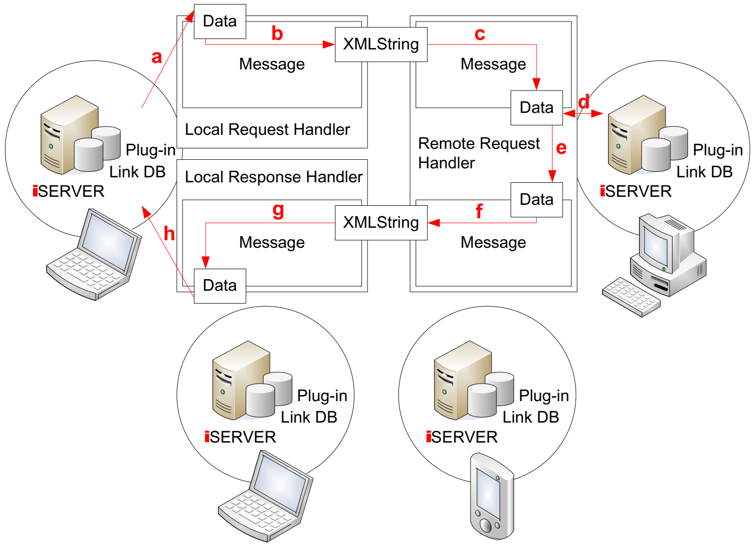

Fig. 3. Interaction architecture for peer services

the request data is extracted. ⓓ The remote request handler then processes the request which includes access to the iServer API yielding a response data object. ⓔ This response data object is wrapped with a message object and ⓕ its XML string representation is sent back to the local response handler. ⓖ The response handler reconstructs the message and extracts the response data. ⓗ Typically, the response is then integrated into the local iServer link structure.

We can identify three components each responsible for a particular aspect of service interaction: *handlers*, *data* and *message* objects. A `Data` class encapsulates the iServer API call while the `Message` class enables content-independent implementation of message formats such as plain XML, compressed or encrypted representations. Handlers implement the data object processing which consists of executing API calls and integrating results.

A request handler relies on a connection service providing the means to address a particular or multiple peers and to send and receive messages. This functionality is encapsulated in a connection service component. It consists of a peer abstraction that can be identified by other peers, a class representing the group of peers sharing links as well as resources and a connection handler creating and maintaining physical channels to remote peers.

5 Application

We now explain how applications built on top of the P2P iServer architecture can support the kind of scenario described in Sect. 2. The iServer API allows resources to be created as well as links to be defined between source and target resources. The set of resources and links therefore form a graph where nodes are resources and directed edges represent links. Each iServer instance manages a graph containing the resources and links stored locally and is able to transiently integrate links received from other iServer instances. A general authoring tool allows resources to be added by the user and new links to be created.

Using this authoring tool, a user may, for example, select a single slide of a particular slideshow as a source and link it to parts of a video resource. For this purpose, a PowerPoint iServer plug-in could be used that allows PowerPoint slideshows to be integrated as resources and provides the means to use each slide as a selector. Furthermore, an iServer movie plug-in introduces a movie resource type as well as a selector for using particular frames or sequences to be used as link sources or targets. Other resource types can easily be integrated into applications by developing new iServer plug-ins.

In our meeting scenario, assume a participant created a link from a presentation slide to a video before the meeting and that both the slideshow and video are stored on the company server and have been replicated on the user's laptop computer. The link would be shared with the company's iServer instance whenever the user entered the meeting room and was detected as a peer. As a result, during the meeting, they are able to show the slide on a wall projection and activate the link to the video.

Further, assume an interactive paper version of a brochure has been edited by a user on the way to the meeting. Using a digital pen, all annotations made on the brochure have been digitally captured and stored as linked resources in the user's iServer instance. The iPaper plug-in allows such annotations to be linked from particular areas of the brochure such as words, paragraphs or pictures. After entering the meeting room, the annotations would be shared with the company's iServer and the interactive table could be used to show the digital brochure document enriched with that user's annotations without them having to explicitly copy any information.

6 Discussion

The main interaction of iServer peers consists of exchanging resources and links. A common request is a query for in- and outgoing links from a particular resource as well as the linked resources. In the meeting setting, it can safely be assumed that users share data with trustworthy users and that the amount of data received is manageable. However, in other settings such as an educational environment where students may exchange annotations and additional information related to lectures, this is no longer the case. As a result, the user receives a potentially large set of links and resources from possibly unknown users.

Our framework supports individual users in deciding on their own levels of trust in certain users. A user who knows and is therefore able to rate a relatively small number of other users can infer ratings from a vast number of other users by exploiting the transitive propagation of trust.

Since a user receives responses from multiple users, the information on which a filtering decision is based consists of the sending user and the currently received item as well as the set of previously received items. In order to exploit all information available, we also take into account the frequency with which a particular item has been received. Therefore, we combine user ratings with response ratings to filter responses returned from remote peers. This may, not only help to improve the quality of information presented to the user, but also reduce the quantity, thereby preventing the information overload that could result from a large, highly-connected information space.

7 Conclusions

We have presented a notion of cooperative information spaces based on community-based authoring of links between arbitrary resources and elements within these resources. While many of the features of the iServer framework and its cooperative version can be found in other systems developed within the hypertext community, the main contribution of our work is to combine these in a single, extensible framework. Further, in contrast to most other approaches, we do not use the P2P functionality to distribute data persistently but rather to build a supplemental transient link layer on top of a user's personal information space.

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A Cooperative Personal Agenda in a Collaborative Team Environment

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Abstract. This paper reports on the implementation of a cooperative personal agenda integrated into a collaborative team environment. Concerning developers, traditional project management tools are mainly focused on tasks exclusively related to the project, failing to provide users with the capability of managing tasks not necessarily associated with the work at hand. Scheduling tasks from divergent domains towards a more efficient user planning becomes unfeasible. To overcome this inaptness, we have extended the Redmine platform with an agenda-like behaviour bearing in mind each user's individual constraints.

Keywords: collaborative design, cooperative engineering, scheduling, project management.

1 Introduction

Amidst the early 70's, Software development was at a crisis. The existing development processes could not properly tackle large projects, a concern pointed out by Dijkstra [2], in his ACM Turing Award lecture. Project management was becoming an infeasible task, as the size and complexity of software projects increased overwhelmingly. Undoubtedly a collaborative process, this discipline involves the concurrent editing of multiple artefacts by many teams of software engineers through its development stages [1]. Encompassing a set of participants, collaborative work implicitly demands that task scheduling accounts for restrictions that are peculiar to each actor. Despite existing multiple solutions with these purposes (e.g. Google Calendar and MS Outlook), they do not stand as an agenda with a personal scheduling assistant.

On the other hand, project management environments tend to treat all users enrolled in a project rather uniformly. A team element cannot customise her own data, according to her preferences. Similarly, the following scenario is common: two users enrolled in the same project and assigned with a common task. *User one* has only that task to complete, whereas *user two* has three other tasks pending. Furthermore, suppose that *user one* can only work on that project three days a week, while *user two*

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has a total of four days to spare. This situation brings about another issue: how to handle both users' restrictions through task scheduling and planning?

Granularity, therefore, is a key factor in this scenario. Accounting for users' individual restrictions within project management is expected to improve productivity. In the present work, individuals' activities are considered "peers" to project activities, while at the same time their peculiarities and context are maintained. To accomplish this, we take a web-based flexible and rich-feature project management tool and give it an agenda-like behaviour, while preserving its collaborative features. In other words, we intend to provide each user enrolled in a project with a personal assistant with task scheduling capabilities.

2 Related Work

The main issue in software projects is how to coordinate one or more teams to efficiently work together. Research areas such as Groupware and Computer-Supported Collaborative Work (CSCW) arose to address collaboration supported by software [4]. The fact that most groupware tools failed to be widely adopted made clear the need for a better understanding of how groups of people work together. CSCW then emerged in this scenario as "the scientific discipline that motivates and validates groupware design. It is the study and theory of how people work together, and how computer and related technologies affect group behaviour" [3]. Not surprisingly, recent trends such as mobile technologies, Web2.0, a strong commercial interest and the delocalisation of groups are presenting new challenges for CSCW researchers [9] as users are allowed to interact within a boundless environment seamlessly.

Effective communication, collaboration and coordination are the main contributing factors for the success of agile methods [5], which start to play a preponderant role in most team projects. Thus, tools are needed to support project management in these new emerging collaborative environments. Current available tools, however, fail to provide engineers with a personal agenda integrated into the tools aimed at managing their work in a collaborative project environment. For instance, Tasktop [8] is a task-focused environment especially devoted to productivity, which organises the user's digital work, showing only the relevant information for the task at hand. This feature suggests an interesting context awareness capability that fosters performance.

3 The Proposed Approach

Redmine [6] is a web-based flexible project management application that allows easy customisation through a Ruby on Rails API. As it is an open-source platform and considering its many features devoted to team development, Redmine seemed to be an excellent candidate to support our implementation. Following a "wiki" philosophy, this framework offers a collaborative task-oriented project management environment packed with a variety of features ranging from file management to scheduling.

However, Redmine fails to provide the desired level of task scheduling, where personal appointments, for instance, are not taken into consideration. As is, the platform is solely concerned with the project's needs, restrictions and goals as a whole,

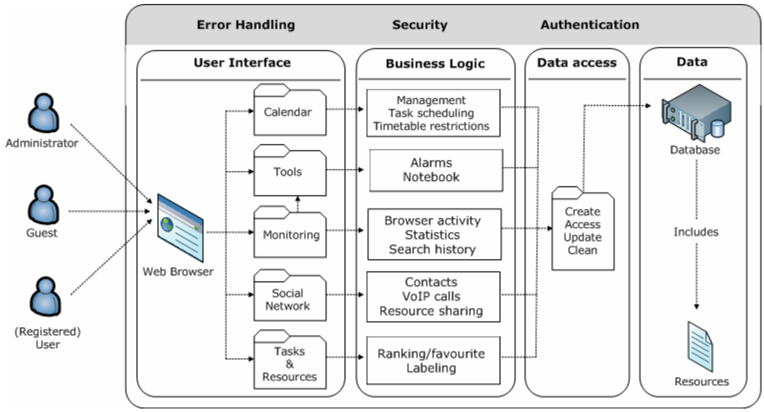

Fig. 1. The PersonalTaskManagement architecture

discriminating developer's individual restrictions. Our approach, called *Personal-TaskManagement*, was prototyped as a plug-in for Redmine to address this problem. The architecture, as depicted in Fig. 1, consists of five main functional modules, namely Calendar, Tools, Monitoring, Social Network and Tasks & Resources.

The *Calendar* module extends Redmine concepts of task and calendar, enabling each user to have their own agenda. More than a simple calendar, *agendas* are meant for registering events, tasks, activities and other relevant information to its owner. Furthermore, each item on an agenda has a finite lifespan and a priority. During planning, concerns such as task ordering and precedence, partitioning, and user availability must be considered for effective scheduling. A personal task planning and scheduling solution should then consider each user's context and inherent restrictions. Thus, we have implemented a semi-automated task scheduler that allows users to define temporal constraints on their timetable to be taken into account and choose to manually allocate tasks or let the scheduler do so.

The *Tools* module intends to enrich Redmine with a set of utilities such as a notebook, files and session manager. The features of this platform are extended so that it is capable of managing resources associated with a particular developer. One interesting feature of this module is the session management capability. Similarly to the philosophy of Tasktop, the session management goal is to preserve the session state of user's activities after a particular task is either interrupted or concluded. If a user signs out of the platform, the application saves its state so that, when she signs in again, the platform can be restored to its saved state. Additionally, this module provides a search engine for artefacts in the system and an alarm system for the user's tasks.

It is commonsense that categorising and organising information is a vital aspect towards work efficiency. This is only possible, however, if an adequate mechanism is able to recognise the relevance of each task in a given context. This becomes the responsibility of the *Monitoring* module, by implementing a background process that keeps track of the user's browser activity, saving all relevant data by active task. In the context of tasks performed in a web-based collaborative environment, the information is treated statistically, providing the user with productivity metrics so that she can improve her performance.

Towards a more social project environment, the *Social Network* module features Redmine with the concept of contact, which is a reference to another user. Skype [7] was enabled in our framework so as to allow the association of tasks and resources to contacts, which provides an enhanced cooperation and collaboration infrastructure.

The *Tasks & Resources* module extends Redmine's own files and resources management feature available to each user. In other words, instead of being strictly associated with a project, resources and files may be associated with each user and her personal tasks. Furthermore, it brings the concept of ranking to tasks, as well as labelling, allowing artefacts to be grouped, annotated or even prioritised.

4 Conclusions

The ever increasing diversity of daily tasks triggers much complexity in their efficient planning and scheduling. Even more challenging is to cope with conflicting contexts, often found when personal and project activities must be articulated. With the work presented in this paper, the authors contribute towards bridging the gap between managing personal activities and team project tasks on a cooperative basis. By enhancing each user's agenda, productivity is expected to improve in a project management scenario as less effort is required to articulate tasks which are external to the project. Developed in a plug-in form, PersonalTaskManagement is seamlessly integrated into Redmine, allowing for an independent and compatible evolution of both platform and plug-in. The next step is to devise a methodological approach to quantitatively evaluate the benefits of such a tool within the context of collaborative project management.

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The Cooperative Conceptualization of Urban Spaces in AI-Assisted Environmental Planning*

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Abstract. The literature on spatial environments concerns many disciplines, and the present study aims at broadly contributing from an urban-planning view. Indoor and outdoor townscapes, because of their dynamic complexity, seem to offer ill-structured holds to the typical spatial behaviour of an agent. Therefore, a question arises about the 'fundamentals' of spacescapes from the point of view of the needs of living and moving agents.

Following this thread, the paper deals with the diagnosis and the control of a structured simple space, a minimum arc of a graph. Conditions, situations, elements, behaviours are explored in their spatial-temporal dimensions, subsequently aiming at setting up a system architecture to let spatial agents control their de-structuring impact.

Text analysis and interpretation are applied to a questionnaire survey, exploring low level (movement orientation) and high level (memories and fantasies) behaviours in human interaction with a space. The experiment is developed in a large class of students from the Technical University of Bari, daily using a long and apparently amorphous corridor to reach professors' offices for explanations.

Keywords: Multi-agent systems, Cooperative spatial conceptualization, Environmental planning, Townscapes, Decision support systems.

1 Introduction

Such spatial environments as landscapes and townscapes have been studied by many scholars over time, and the present study aims at contributing by addressing a specific issue to the broader discussion. It emerges when considering that townscapes and cityscapes are the prevalent, knowledge-intensive, meaningful spaces and entities that

* The present study was carried out by the authors as a joint research work. Nonetheless, chapter 2 was written by D. Borri, chapters 1, 3, 4 and 5 were written by D. Camarda. The authors are grateful to A. Celino and M.Patano for their support, help and critical contribution to the review of the paper.

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humans adapt for their life. Because of their dynamic complexity, they hardly fit the typical spatial behaviour of an agent, even when simulated by mainstream AI robotics. Therefore, a question arises about the 'fundamentals' of spacescapes from the point of view of the needs of the living agents.

In fact, on one side, it seems commonsense to think that well designed space architectures or furniture make space more meaningful for humans to use – to live in – when compared with amorphous spaces. Conversely, discipline experts maintain that the drama of social marginality in cities largely depends on the abundance of landmarks and symbols that characterizes the city cores, which are inappropriate and alienating to poor people. Yet, on the background of these points, there is a potential naivety in speaking about spacescape 'fundamentals' as opposed to spacescape 'additional', 'ornamental' qualities, in a world where no clear practical and theoretical distinction can be made between content and form.

Understanding the way in which human agents think and operate in given spaces – i.e., space ontology– is commonly essential for AI robotics. In turn, because of the circularity between AI and cognitive science, the development of AI robotic devices help in understanding spatial human behaviours. Therefore, the comprehension/identification of space fundamentals by human agents can be of great interest in strategic planning, because they may represent structures, invariant, resilient characters of the environment, on which to build/plan town developments.

Basing on the above, the present paper deals with cooperative space conceptualization by humans according to the AI-based cognitive approach and the urban-planning domain knowledge approach of architects and planners. The research makes use of text analysis and interpretation, both applied to a cooperative in-class survey, exploring low level (movement orientation) and high level (memories and fantasies) behaviours in human interaction with a space. The experiment is developed by relying on a large class of students in the Technical University of Bari, daily using a long and apparently amorphous corridor to reach the lecturers' offices for exams and explanations.

The paper is structured as follows. After the present introduction, in the second section the main scientific issues connected with the cooperative conceptualization and representation of space are reviewed and discussed, as foundations of the present study. The third section synthesizes the results of cooperative questionnaire experimentation, with a discussion of the resulted knowledge base. Section four presents an example of a basic navigation-support module to help students' move in the corridor. Conclusion remarks are drawn out in the fifth and last section.

2 Cognition and Organization in the Space-Environment

This paper aims at exploring the mode of conceptualizing and representing the space by human agents in finding a way to reach a spatial objective through it [7][18][22].

The scientific context of reference is the engineering of intelligent artificial systems, oriented to plans and organizations involving biotic as well as abiotic agents [6].

The problem that we put down in the present work is connected with the general mechanism of spatial cognition-perception-decision, operating in a human agent who 'navigates' through a given indoor space-environment, for the execution of a specific task [8][19]. The task is in our case reaching a localized objective, namely finding out a professor, presumably at work in her room, by a student who needs some clarification on her course of lectures.

In general, we know that there is a problem of orientation and movement in navigation, which is diffusely studied in the broad interdisciplinary field of cognitive sciences [5][11][13][20]. However, in the present work we will bring up the specific problem of the role played in helping the navigation by different components of the space-environment in which the navigation develops. In particular, we will study the role played by its 'structural' components, made up by 'substances' or 'essences' such as the walls that limit the space, and by its 'ornamental' components, made up by anything integrating the structure from other –different- functional viewpoints, such as furniture.

In expressing this problem, we were inspired by some intriguing logical arguments by N.Goodman. His thesis, even with many contextual shades and exceptions, is in favour of a non-discriminability between primary and secondary components in human agents' perception of reality [12]. This is opposed to large robotics literature, which seems to prefer discriminability -particularly in the difference between navigating in 'structured' or in 'ill-' or 'non-structured' spaces [1][2].

The robotics distinction between structured and ill- or non-structured spaces mainly recalls the distinction between spaces with simple or complex geometries. The former are characterized by elementary geometries, rare unexpected events, rare secondary components, rare decision exigencies. The latter are characterized by composite geometries, frequent unexpected events, frequent secondary components and situations in which decisions are needed [3]. In the former, the robot's movement and related learning would be easier than in the latter, and then connected to a recognizable cognitive configuration. This would occur even if they characterize a major part of the real worlds and even if in fact particular difficulties for a human agents passing from a structured to a non-structured world seem to be absent.

An indoor space –e.g., a hospital- in which a human agent crosses a well identified section of it, geometrically simple, and empty (a long and desert corridor, characterized only by a sequence of doors and/or windows on sides and by an origin and an end without any lateral branch) is in fact rather simple to be navigated and does not require any particular attention from the human agent.

A outdoor space –e.g., a community fair- through which a human agent moves randomly, in a highly crowded context, without any easily recognizable geometry, form, origin, end, requires in fact particular attention. In it, it is often possible to loose or get lost, and a shrewd agent tries anxiously and previously to identify and memorize characteristic signs –such as a 'beacon' or a 'monument'- replacing a 'structure' or a 'geometry' that are nonexistent or not perceivable [4][9][15].

Let's now analyse the task of the navigation by the human agent in an indoor environment. Let's consider the structured space-environment of a university corridor, which is aimed at driving students, e.g., to the room of a professor. The research objective in our present work is to reflect –being aware of Goodman's scepticism- on a possible distinction between 'essence' and 'ornament', in both an individual and a social (multi-agent) perspective in that space-environment. In this context, we believe that the most interesting experiment should be the behaviour of the human agent-navigator who had never been in that space-environment. In fact, as soon as she has been there and has memorized the execution of the task, the problem is solved, and rather generates other interesting problems, e.g., concerning the management of the spatial memory connected to that task. Clearly the individual perspective is carrying out the task by an isolated agent, whereas the social (multi-agent) perspective is carrying out a task by a non-isolated agent, assisted by a adviser-agent and therefore immersed in an organization of spatial learning.

Finding out the corridor that serves the professors' rooms in a university department –a well structured space-environment in our experiment- by the human agent-navigator can be instantaneous or can require some time. It can be instantaneous because the building shows up to the navigator with its structure of rooms served by a corridor, without any intermediate environment among the external space from which the agent originates and the internal space of agent's destination. Yet, it can require some time to understand the layout of the building and the relationship between its part devoted to the professors' rooms and other parts (e.g., the entrance). In the cases of a localization of the corridor that is not immediately perceivable by external comers, as well as of an absence of a human agent-adviser at the departmental entrance, the task will be executed by the human agent-navigator with a *trial-and-error* method. She will be wandering 'actively' in the space-environment of the execution of the task, even if the presence of a map in the department entrance would surely facilitate the execution of the task (for a non-disabled person, as said before).

However, what appears interesting to our aim of distinguishing 'essence' and 'ornament' in a space-environment in order to navigate intelligently in it, is that some categories of actions can be drawn out from the above framework. They are: (i) self-driving of the agent-navigator through active navigation (meet the professor), (ii) self-driving of the navigator through localized signals (nameplates at the doors), (iii) self-driving of the navigator through geometrical signs (the department map with professors' names and rooms), (iv) driving the navigator through the help of a fixed or occasional human agent-adviser. In category (ii), an ornament (the nameplates) makes it possible to find out the essence (the room) in a 'continuous' (the corridor) which otherwise would not be usefully qualified for the execution of the task. If the nameplate is missing, the agent-adviser at the beginning of the corridor could suggest the navigator to number the rooms in her searching, e.g., the desired room is nr. x on the left. The adviser could also indicate the room through the ornaments on the professor's door, so as to distinguish the room from all the possible rooms. In this case, the ornament is a non-secondary attribute with reference to the specific task, even if it may be a secondary attribute with reference to the general conceptualization of the task.

To such implications of the characters of space is devoted the experimentation reported in the rest of the paper.

3 Features of a Cooperative Experimentation

The organization of the questionnaire in the cooperative survey is reported in figure 1. Although the questions laid within the interests of the study, some of them were developed with the practical aim of better addressing and focusing the agents' attention on the major themes to be investigated.

QUESTIONNAIRE

Situation 'A': You are at DAU (Town Planning Dept) and decide to visit a professor in that department, crossing the space in between.

Question A1: Find out the professor you want to know and declare the reasons for your visit.
Question A2: Describe the actions you carry out to reach the professor of your interest
Question A3: Describe in detail the "substantial elements" of the space in which you move, being of help or obstacle for your reaching the professor of your interest *("substantial elements" are intended as spatial elements and their physical qualities, or substances such as materials, dimensions, physical barriers/helpers etc...)*
Question A4: Describe in detail the "ornamental elements" of the space in which you move, conditioning the actions in your reaching the professor of your interest *("ornamental elements" are intended as objects, shapes, colours, lights, aesthetics etc...)*
Question A5: Describe in detail your general sensations and preferences concerning the "substantial elements" and the "ornamental elements" of the space in which you move.

Situation 'B': You are at DAU and decide to visit professor Selicato in his room, crossing the space in between.

Question B1: Describe the actions you carry out to reach the professor of your interest
Question B2: Describe in detail the "substantial elements" of the space in which you move, being of help or obstacle for your reaching professor Selicato.
Question B3: Describe in detail the "ornamental elements" of the space in which you move, conditioning the actions in your reaching professor Selicato.
Question B4: Describe in detail your general sensations and preferences concerning the "substantial elements" and the "ornamental elements" of the space in which you move.

Fig. 1. The questionnaire layout

The questionnaire survey involved 260 students of the course program, from October 2008 to February 2009, aging about 20. The questionnaire was delivered through an Internet homepage linked to the institutional didactical portal of the Town Planning Department at the Technical University of Bari, there were some cooperative working sessions during the normal classes, and related answers were delivered by email.

In the end, the answers to the questionnaires were 180 (96 women and 84 men), i.e., about 70% of the whole student population involved.

The analysis of the answer protocols was carried out using a double-level approach, essentially aimed at achieving a reliable robustness of results, given the quantity of the data gathered. The first approach was a statistical analysis of the texts of the answers, the categories of the questions and the gender profiles of the respondents. 'Structures' (or 'essences') and 'ornaments' were purposely singled out from the answers delivered under the different 'known target' (type-A answers) and 'unknown target' (type-B answers) perspectives. Also, they were further cross-analyzed with the categories of 'landmark' and 'beacon', as put down by recent studies [10][16], in order to retrieve significant clues. The analysis was carried out by using ad-hoc text-mining software (particularly Concordance 3.2 and WordStat 5.0), essentially focused on the frequencies, the deviations, the grouping, the clustering of keywords in the texts. However, this approach was clearly unable to ensure a minimization of the typical biases due to word excerpting from discourses [21]. For this reason, a second, complementary analysis approach was used, aimed at contextualizing the findings of the former statistical analysis in the text of the answer protocols. This approach was carried out visually, with no software support but a traditional reading and rescue of answers.

Statistical descriptors like standard deviation show that the two groups generally disagree on the nature of spatial elements, as statistically expected. This seems to be basically independent from the nature itself, except a slightly lower disagreement on ornaments, perhaps due to a misleading text in the questionnaire.

In general, it can be observed that the preferences expressed by the two profiles are not substantially different from one another, particularly in identifying ornaments. In a more focused detail, perhaps one can find out a slight presence of more 'traditional' essences in women (wood, frames, glasses) rather than in men. As an overall view, a top-down ranked list of spatial elements can be reported in table 1.

Table 1. Main essences and ornaments

- Ornaments: **doors**, models, **walls**, notice board, chairs, **furniture**, **rooms**, light, **wood**, floor, tables, windows, pictures, plants, **glass**.
- Essences: **wood**, **doors**, **glass**, frames, corridor, steel, handles, enquiry room, space, **rooms**, library, **walls**, offices, hall, **furniture**.

It is possible to note that some elements occur in both lists (in bold), even if the lists themselves have been previously corrected to minimize biases. Admittedly, by looking at those single elements, one may well expect that they can serve as ornaments but also as essences, given there major role in structuring built spaces.

A further analysis was carried out, to investigate if functional and geometrical features had been used to describe the elements in the protocols, within a context of other argumentative and/or qualitative features.

Geometrical features are prevalent on the functional ones, with a significant – perhaps even 'traditional'- prevalence in dealing with essences. However, it is interesting to note that the failing of using geometries in ornaments seems to be particularly due to women protocols, where geometrical features appears to be really marginal. An analysis of protocol texts reveals that in fact qualitative features are used more often by women to identify and argument on ornamental elements of space.

The last analysis implemented in the study concerned the landmark/beacon (L/B) character of spatial elements [10][16]. The main question addressed will then concern the possibility that (perceived) spatial elements are somehow credited to L/B features.

Because of the lack of explicit question contexts for L/B characters, it was decided to rely on indirect proxies to investigate such issues. A basic difference between A and B questions proved to be useful in this perspective, because in situation 'A' the target (a professor in her/his room) was surely known to respondents, who had chosen her/him in answer A2. The corresponding question in situation B is B1, but the target professor is mandatory and, in many cases, unknown. This situation is reflected by the elements used by agents in the different cases, reported in table 2.

Table 2. Proxies used to identify 'landmarks' and 'beacons'

1. Situation 'A', question 2		2. Situation 'B', question 1	
• Nameplates	15%	• Nameplates	10%
• Direct knowledge	35%	• Direct knowledge	15%
• Enquiry desk	10%	• Enquiry desk	20%
• Students	35%	• Students	45%
• Map	5%	• Map	10%

In order to find out possible beacons for the target, situation ‘A’ seems then more suitable, with particular reference to occasional students (35%) and nameplates (15%). Both of them can reasonably play beacon roles for the navigating agents, even with clearly different features. It is interesting to note that whereas nameplates are mentioned as ornaments by a small part of respondents in previous contexts, students encountered in the corridor are significantly cited in the essence list, particularly by men. Situation ‘B’ may conversely show interesting characteristics in the identification of landmarks for the navigation. In fact, since the target is mostly unknown by the agents, signs and indications can represent critical clues to reach it correctly. In this case, the enquiry desk (20%) and occasional students (45%) are most cited addressees for the target quest, followed by nameplates (10%) and departmental map (10%). Like occasional students, also the enquiry desk is cited as an essence in previous contexts, with greater emphasis. The departmental map, instead, is not included in the above lists: in fact, the answer texts reveal that it is looked up but without any help received, because the professors are not indicated on it.

4 Insights for a Basic Navigation-Support Module

From the observation of outcomes, it is possible to draw out some interesting insights for the definition of an embryonic layout to support the target-oriented navigation of students, based on a simple system of *IF-THEN-ELSE* logical rules. The above discussion suggests that the navigating agents recognize some characters of the simple environment investigated as basic ‘essences’ able to structure the space, as well as simple ‘ornaments’ of the same space. Therefore, it is possible to feed an expert system based on a logical tree of rules represented in figure 2.

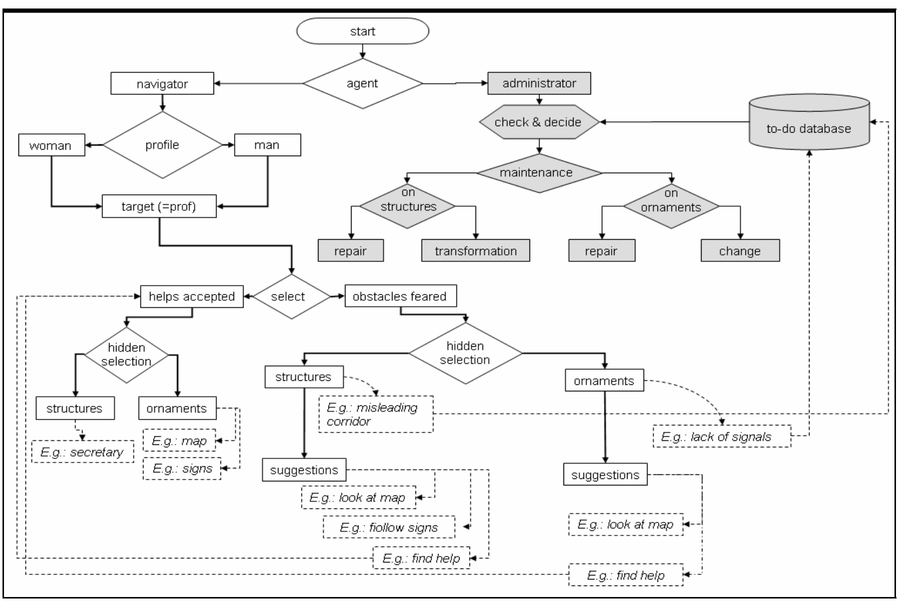

Fig. 2. Layout of the navigation support system

The assumption is that the system is divided into three parts: (i) the support of the space navigation, (ii) the building, feedback, amending of the knowledge base, (iii) the support of the environment maintenance. The main activity of the system is the cooperative building up of the knowledge base, which is carried out by a multi-agent different-time interaction of users as space cognitors.

Let's assume that the user selects her position as a navigating agent, then the system asks her gender. This decision rhomboid is put down because of the differences found in women/men protocols, e.g. concerning the identification of essences and ornaments. The subsequent steps should then take into consideration such differences in dealing with the attributes of the space, addressing specifically the gender of the navigator. However, because of the basic nature of this study, this feature has not yet been fulfilled and a unique gender profile has been instead considered.

The navigator then declares her target (a professor, in our study), and the system gives her access to the knowledge base previously built on the survey protocols. In order to facilitate the search for effective navigating hints, the system asks if the agent prefers to know and avoid the obstacles toward her target, or to receive direct hints and signs to reach it. A probable circumstance in the first condition is an agent with information on her target, wanting to avoid time-wasting ('beacon-like' condition). In the second condition, instead, information is less and then a close support is more needed ('landmarks-like' condition). Let's look at the 'beacon-like' condition, by making reference to the actual web-browser aspect of the interaction module (figure 3).

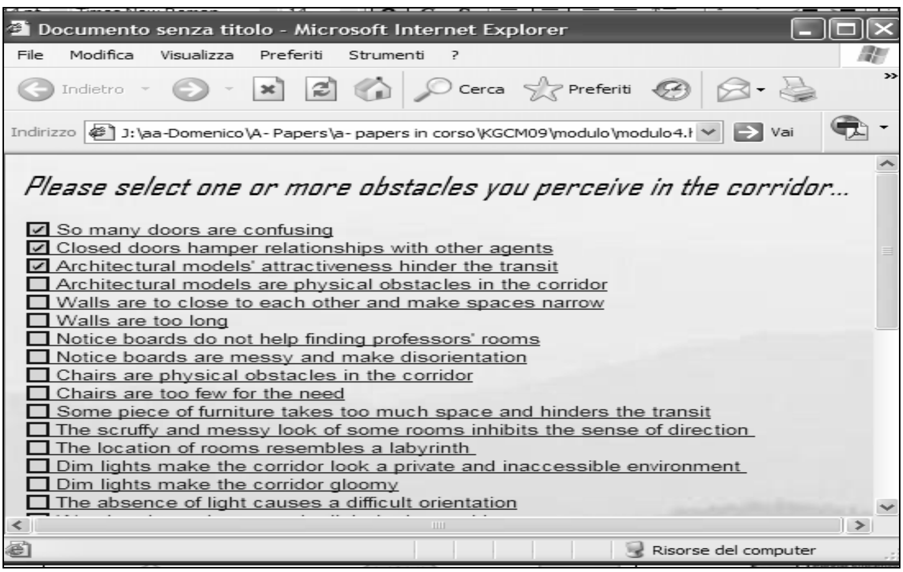

Fig. 3. Part of the obstacle selection step

In fact, after the selection has been made, the agent is driven toward selecting the conditions of obstacles that can be envisaged in her navigation. Each of these statements are intrinsically connected to the lists of space attributes –i.e., as 'essence' or 'ornament' nature- that have been previously put in the knowledge base. Of course, in order to avoid possible influences, misinterpretations or misleading clues, the nature of attributes is not revealed to the agents, but remains nevertheless associated to keywords as hidden characters in the knowledge base.

The need for keeping the essence/ornament difference is connected with the different actions to be carried out in the subsequent steps. However, if the selection operated by an agent reveals the need of an improvement or a repair action by maintenance units, then the systems stores the selection itself in a 'to-do' database, so as to let environment administrators perform the related activity in due course.

After identifying the obstacles feared, the system looks at the contexts in which these elements had been conceptualized in the survey protocols, from the knowledge base. This action can be performed as an automated or semi-automated routine, by using ad-hoc software for text mining, such as Concordance or Wordstat. This routine is useful to identify in particular rapid clues and suggestions to overcome the obstacles, taking them from the protocols themselves. If the hint cannot be found out, then the system recognizes the lack of information and then automatically addresses the agent to the second support condition, i.e., help needed (figure 4).

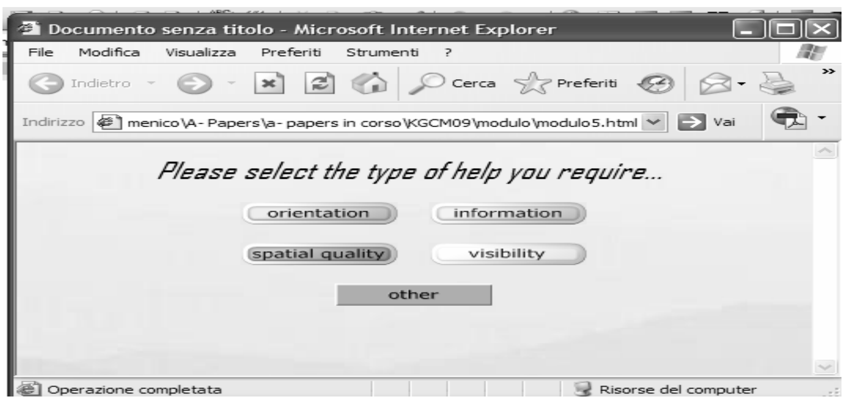

Fig. 4. Selecting help conditions

The support process in the 'landmarks-like' condition is similar to the previous one. In the last stage, if the navigator cannot find help from the protocol-scanning routines, then the module identifies possible agents to ask to (enquiry desk, students etc.).

Of course, in both conditions, clues and suggestions may come from other databases or from domain experts (sociology, psychology, engineering, architecture, etc.) previously connected and/or contacted. Also, the process can be iterated for different conditions and elements, until the navigator decides to end it up. If the agent is an administrator, then the process develops toward maintenance-oriented paths.

Now the layout is being based on an architecture built on Corvid Exsys 5.0, integrated with text-mining software (Simstat 2.06 with Wordstat 5.0) and fine-tuned with Dreamweaver 8.0 in its html interface.

5 Concluding Remarks

Although declared as an operational purpose, the real aim of the present paper has not been to build up a decision-support system for the navigation toward the reaching a professor's room. Rather, the paper deals with the cooperative conceptualization and representation of space, to be used as complex databases to support space-related decisions and navigation in spatial environments. The contextual aim is finding out a way to reach a spatial objective in a simple spatial environment, i.e., a university corridor. The space considered is supposed to be simple, in that it is highly structured and does not induce disorientation and consequent difficult decisions to the navigating agent. In this condition, it is possible to draw out indications on the nature of some attributes of the space, and check if spatial 'substances' and 'ornaments' play significant roles in helping (or hindering) navigation.

The study seems to confirm that the cooperative conceptualization of the corridor space is highly tributary to the existence of the two separate categories, whose presence, scarcity or lack can make the task of navigation more or less executable. Ornaments and essences come out rather clearly from the analysis, at times using the same words for different categories. It was evident that generally ornaments allowed the finding out of the substance looked for (the professor's room) and enhanced the structuring degree (usability) of the corridor for the execution of the task.

By looking at responses, some considerations can be drawn out about the structuration of the space-environment. Classical literature on robotics reports that an environment in which a robot can perform its activities is considered a structured space [1]. The structuration degree of the space in the present research is pretty high. In fact, it is a long simple corridor, but some elements highlighted by respondents were able to decrease the degree of structuration significantly. In the experimentation, the most evident one is certainly a geometrical element: physical obstacles (doors, furniture, chairs) or physical shapes (recesses, narrowings, deviations). However, some intrinsic features of the environment are also evident. In fact, the questionnaire respondents report a possible modification of the structuration of the corridor even in feature changes, such as floor material ("this section is not slippery because of the linoleum"), or wall colour ("this warm colour allows a better orientation"), or light ("where doors are not vitreous, the corridor is dark and disorienting"). In general, geometrical, non-geometrical, qualitative characters seem to define the real structuration degree of the environment. This would stress the commonsense difference in the general mechanism of spatial cognition-perception-decision, between a robot and a human agent who 'navigates' through a given indoor space-environment, for the execution of a specific task. Also, this would stress the importance of emphasizing (instead of reducing) the complexity of environmental elements in cooperative spatial decisions.

In the end, it is very important to underline, once again, that the aim of the study is not to build a navigation module. The construction of the module is only the occasion to better understand complex spatial ontologies and how do they affect a system architecture to support spatial decision. The experimentation context is deliberately simple, so as to make the singling out of logical rules possible and to avoid the redundancy and the unmanageability of the results in building up the architecture layout. In fact, the study has made it possible to single out logical if-then rules, and to draw out a navigation-support layout to help reaching a spatial objective. In this context, the building up of an actual system architecture to support spatial navigation in simple environments represents a fair future perspective for the present research.

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Remote Video Monitor of Vehicles in Cooperative Information Platform

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Abstract. Detection of vehicles plays an important role in the area of the modern intelligent traffic management. And the pattern recognition is a hot issue in the area of computer vision. An auto- recognition system in cooperative information platform is studied. In the cooperative platform, 3G wireless network, including GPS, GPRS (CDMA), Internet (Intranet), remote video monitor and M-DMB networks are integrated. The remote video information can be taken from the terminals and sent to the cooperative platform, then detected by the auto-recognition system. The images are pretreated and segmented, including feature extraction, template matching and pattern recognition. The system identifies different models and gets vehicular traffic statistics. Finally, the implementation of the system is introduced.

Keywords: Cooperative Platform; Remote Monitor; Feature Extraction; Image Recognition.

1 Background

From last century, many experts and scientists researched the functions of roads and intelligences of vehicles in USA, Japan and many developed countries in north Europe, many system frameworks on intelligent transportation were setup. The intelligent traffic system (ITS) can improve efficiency of the traffic system, decrease crowded, and protect environment. Currently, china and many countries are focusing on studies on ITS.

In ITS, recognition and flow statistics of vehicles are very important technologies. Recognition technologies include image recognition technology and radio frequency technology. The first one is utilized in recognition of vehicle branch picture; the second one is to use radio frequency senor to get to status of vehicles. In generally, images must be coded, compacted, enhanced, and corrected in pretreatment; then edge detection method is used to position and divide the Images, and start pattern recognition. Because of noise pollution and lighting effects to the original images, recognition precise is still to be improved. Radio frequency technology is precise, but the senor cost is very expensive.

In the paper, a remote video monitor system of vehicles in cooperative information platform is studied. The objective and motivation are to acquire the video information

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from the video monitors with the third generate wireless network; the video information will be collected and dealt with in a cooperative platform, in order to setup a wireless video sensor network for management and monitor. The remote video stream is got from the video monitors, and sent to the traffic control center; the video information will be dealt with and classified, then the vehicles will be recognized from the images, and flow of vehicles through every road will be accounted. In recognition of vehicle flow, there are video stream information acquire, vehicle flow detection, vehicle flow track, and vehicle check. Video information is collected from the remote video monitors, and divided to pictures in frame format. The pictures will be dealt with edge feature detection, and recognition. Vehicle flow detection is to judge if there is vehicle flow, and separate vehicles in dynamic and complex background. Vehicle flow track is to dynamically track the detected vehicle flow. Vehicle check is to account and query in vehicle model database.

2 System Framework of Video Monitor Cooperative Information Platform Paper

The video monitor cooperative information platform consists of the intelligent mobile terminals, software systems, integrated 3G, including GPS, GPRS (CDMA), Internet (Intranet), remote video monitor and M-DMB networks. See Fig.1 for more details.

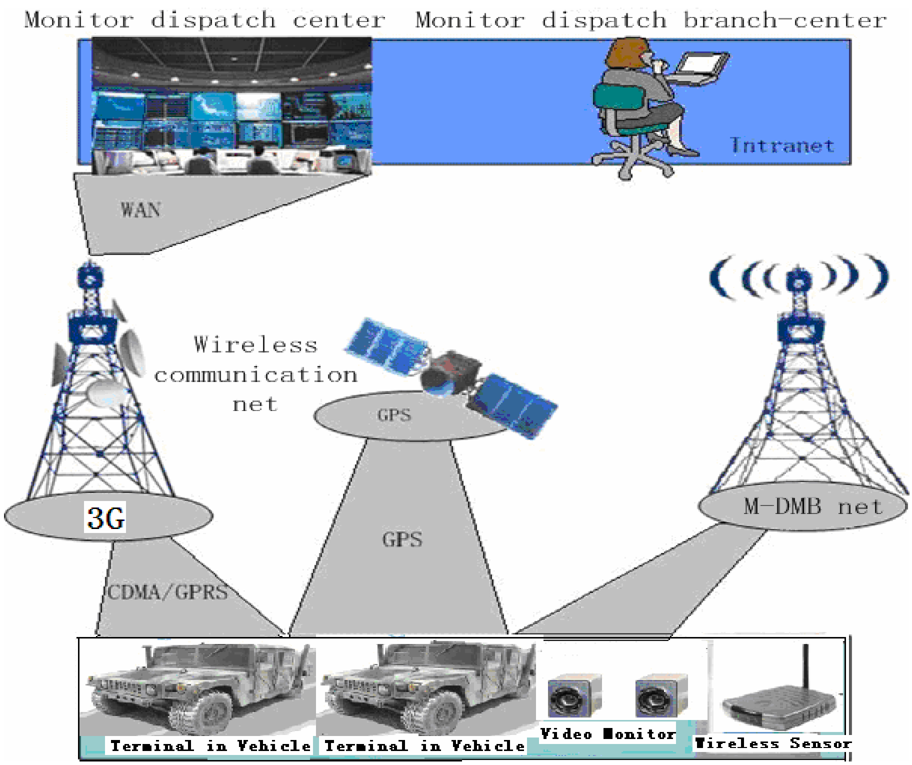


Fig. 1. System framework of video monitor cooperative information platform

In our integration platform, the vehicles' GPS information, driver request messages, and the control center command information are sent by the integrated WAN on 3G and Internet(Intranet). Different types of information, including messages, data files, stream media, etc can be sent and received freely and safely via public networks. The stream media can be acquired in real time. The GPS information and driver request are sent from the mobile terminals, and received by the control center in the platform.

The mobile terminals are the interface directly with the users. We have implemented a rich set of functions for them. They have the capability of sending and receiving information in real time. It integrates the mobile computing, picture recognition, intelligent control, communication, wireless sensor and media streaming. The video monitor is integrated to the terminal by CAN or USB interface.

In the cooperative platform, there are video stream acquire, frame image collect, image pretreatment, image enhance, image partition, image feature extract, sample database, image recognition, study network, network compute, account and statistics. DirectShow software is used to acquire video stream and divide the frame images. In order to improve the quality of the images, the noise must be filtered to decrease interferences. The images must be enhanced and transferred in pretreatment procedure in order to get the better clearance.

In image partition, objects and un-objects must be separated from background; the regions of the different objects must be divided according to their characters. In the divided regions, the basic characters must be extracted and described, including gray, texture, and geometric characters.

3 Image Recognition

Image pretreatment and image partition are very important procedures in image recognition. Image search algorithm transfer the color image to gray image, and enhance the image, then extract the edge characters. The image enhance is used to prominent some helpful information, Inhibit some helpless information, and expand the differences among the different objects. In order to acquire and recognition the object characters, the object must be divided from the background.

3.1 Image Pretreatment

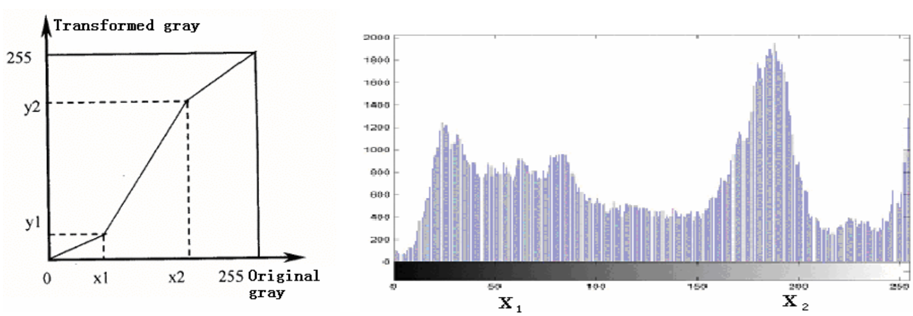
Images must be transferred from color images to gray images, and enhanced, according to the color transformed gray formula p=0.299*R+0.587*G+0.114*B, p is gray value of one pixel, R, G and B are respectively read, green and blue values in RGB color model [6]. Filtering is very important to restrain the noise. Generally, filtering algorithms includes average value filtering, Wiener filtering and middle value filtering algorithms [9]. In the paper, middle value filtering algorithm with the Laplace operator is utilized because it can restrain the noises and keep the clearance for the images[7][8]. It is an un-linear signal treatment method, and can give up the indistinct feature, remove the noises and protect the edge character in the images. In order to smooth the images, the second order differentiation is used to filter the noises.

After smoothing treatment for images, they must be enhanced so that the region of vehicles in the images can be sticking out from the background. The gray histogram linear tensile method is used to permanent the region of vehicles. Many parameters are adjusted to permanent a gray area in the images. The gray transform equation is as follow.

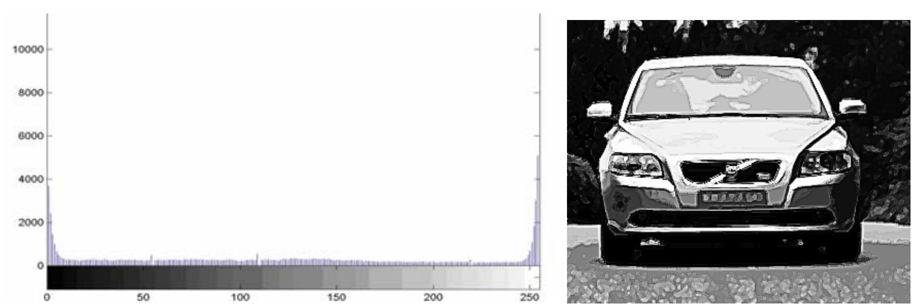
$$D=AX+B \tag{1}$$

$$f\ (x\ ,y)=\begin{cases}\dfrac{y_1}{x_1}x & (x<x_1)\\ \dfrac{y_2-y_1}{x_2-x_1}(x-x_1)+y_1 & (x_1\le x\le x_2)\\ \dfrac{255-y_2}{255-x_2}(x-x_2)+y & (x>x_2)\end{cases} \tag{2}$$

From Fig.2 (b), (c) and (d), the vehicle area is enhanced and sticking out form the background, the noises are constrained.



(a) branch--paragraph gray linear (b) original gray histogram



(c) transferred gray histogram (d) gray enhanced image

Fig. 2. Gray tensile

In formula (2), the two points (x_1, y_1) and (x_2, y_2) are coordinates in branch--paragraph gray linear tensile equation [10] as Fig.2(a). (x_1, y_1) and (x_2, y_2) are two pair statistics set points in (255,255), the gray value of every pixel is in (0,255). X axis is the original gay value coordinate axis, Y axis is the transformed gay value coordinate axis.

3.2 Image Segmentation

Image segmentation is utilized in many vehicle type auto-recognition systems. In order to extracting the features and recognition the type of vehicles, a canny edge detection algorithm for image segmentation is used to separate the edge area of the vehicle from the background image, which can eliminate the untruth edge, cancel out the vibration of the images and smooth contour of the objects with corrosion and expansion method in mathematical morphology.

The edges of the images are basic features, which are very helpful information about the objects. There are many algorithms on image edge detection, including Sobel, Prewitt, Robert, Laplace, Log, and Canny algorithms [10]. Sobel and Prewitt algorithms are used to difference and filter the images, their weight-right value is different, and the detected edges are thick. Robert algorithm directly computes the difference, doesn’t smooth the images, is sensitive to the background noises. Laplace algorithm uses the second order differential algorithm, and enhances the noises. Log algorithm uses Gauss function to smooth images, and uses the un-direction Laplace algorithm to extract the edges; but this method is easy to detect un-true edges in approximate gray area, is also sensitive to noises and not precise. Canny algorithm is used with anti-disruption and high precise.

In the paper, Canny algorithm is utilized to detect the object edges. Firstly, notify all prominent edges which are detected by the mini scale operator; secondly, forecast and compose the prominent edges to some continue large edges with the large scale operator; thirdly, compare the composed edges and the true edges, if similarity is very high, the composed edges will be notified. These large edges are accumulated to the edge graph.

The Canny algorithm is applied many image recognition system because of its adaptability. In the binary Canny algorithm, the Canny operator detects the original images and get the edge images, and adaptively adjusts the threshold. The non-isolated low gray pixel near the edges becomes the seed point, and fills the seeds in high threshold binary images; the edges will become the fences for the seeds. If gray value of the filled image pixel is below to the low threshold, the pixel color will be set to black, and many small connective regions will be delete as noises. The procedures of binary images include deleting un-true edges, sealing the near true edges, and choosing the seed point in objective regions. The binary image algorithm can be described as follow.

Algorithm:

(1) use Canny operator to detect the original image I, and get the edge images eI;

(2) delete the isolate small edges in eI. judge every point in eI, if it is an edge point, then push its four neighbor un-edge points into a temporary matrix T; if the

number of points in T is large than 1, then push the low gray points in I into the matrix lE, and push the remain points into the matrix hE.

(3) get the low and high thresholds as formula (3) and (4).

$$LT = \frac{1}{m} \sum_{(i,j) \in lE} I(i,j) \tag{3}$$

$$HT = \frac{1}{n} \sum_{(i,j) \in hE} I(i,j) \tag{4}$$

(4) push the points in the matrix lE into the matrix S as seeds.

(5) use the high threshold to get a binary image hbI, set the points in the matrix hE or eI as background points, and get the filled seed image.

(6) the seed point in S is used to fill the binary image hbI, and judge the weight of the filled edge seed; if the weight value is greater than a set threshold, then the filled point is a objective point; otherwise, it is a background point. The binary edge image sbI can be gotten.

(7) integrate the high and low thresholds to deal with the image lbI and get the edge scattered image hlI.

(8) connect the scattered edges to get the edge image rI.

The algorithm has many advantages, including utilizing the Canny smooth feature for the edges, decrease the gray Inconsistency for the objects, delete the un-true objects, and constrain the noises and balance the feature details with the high and low thresholds. Of course, new noises could be take place because of the un-looped edges.

4 Case of Video Monitor Cooperative Information Platform

A video monitor cooperative information platform is studied and developed. Many video monitors are integrated to a mobile vehicle terminal with CANBUS or USB interface. The video stream information with JPG image format is collected and sent to the video monitor cooperative information platform. In the platform, the continue JPG frames are transferred to a video file, the recognition software deals with the video file, and classifies the types of the vehicle, and gets vehicular traffic statistics. The case details of the algorithm can be seen as Fig.3. The white lines in mandarin are detected the contours of the vehicles with the improved canny operator. They are two contours of a small lorry and a small bus.

Fig. 3. Recognition software in video monitor cooperative information platform

5 Conclusion

In this article, a video monitor cooperative information platform is studied and developed, including an Automobile Automatic Recognition System based on image. The cooperative platform take use of several video monitors linked to the mobile terminal to get traffic images, then after image pretreatment and segmentation, do the works of feature extraction, template matching and pattern recognition, to identify different models and get vehicular traffic statistics. In future, the algorithms will be improved to precise of vehicle recognition. This article contribution is focus on setup a wireless video sensor network to collect the video information to a cooperative platform; the information will be dealt with and saved just in time by high computing performance of the platform for management and service. In future, the middle wares in cooperative platform will be developed and improved for management and service, including its Qos character of information responsibility and delivery.

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Cooperative Operating Control Based on Virtual Resources and User-Suited HCI

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Abstract. The paper presents concept of virtual resources (VR) which improve multilevel, remote Internet-based operation of real-time controlled industrial processes. In comparison to classical directly connected-to-plant operations, the VR-based system introduces all typical features of its flexible nature, hiding the unnecessary implementation details from the process operators. The user-suited, human-computer interfaces (HCI) improve cooperation between specialists who must carry out operating control of the process. Realisation of such a system is based on the concept of maximal usage of particular specialist's skills improving theirs cooperation. Although the proposed concept is dedicated to remote operating experimentation on real-time controlled industrial plants, it has also a more general aspect. As a case example, the cooperative operating control of a biotechnological pilot-plant is presented.

Keywords: Cooperative operating control, virtual resources (VR), Multi-Agent System (MAS), self-organising data base.

1 Introduction

The project life cycle of a technological installation involving a control system is characterised by a separate evolution of process engineering data and evolution of automatic control engineering data [1], [2]. In these works cooperation in the design, redesign and set-up phases of the process with its control and information system have been considered. Unfortunately, systems presented in those publications are ill suited in the process operation phase during normal exploitation of the process. That is because, information regarding the implementation of distributed control and information systems is not required during operating control and especially for cooperative operating control taking into consideration cooperation of operators having different goals. The later reason is a characteristic of modern control and information systems.

In order to eliminate those inconveniences the process-based Virtual Resource (VR) concept has been formed (Fig. 1). It is a virtual image of the pilot-plant that includes a range of data selected and configured by the users (process operators). It also utilizes real data, both current and historical. This data comprises on-line and off-line measurement, together with effects of computations based on mathematical models calibrated to the process. At the same time, the users may generate their own

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algorithms that will influence the plant subject to experiments. It should be noticed, that in our approach the result of adjusting of the designing process to user needs causes in fact the generation of user-suited and task-oriented human-computer interfaces (HCI). Those in turn enable evolution of the system (Fig. 1).

In this multilevel architecture, the VR layer is of special importance, because it separates cooperating process operators from the process and control systems. It is an intelligent, self-organizing database that shares with the operator (in the distributed access mode) the appropriate user-suited HCI that is necessary for completion of a particular task. Therefore, the particular HCI is user-suited and goal-suited for the appropriate tasks at a given time.

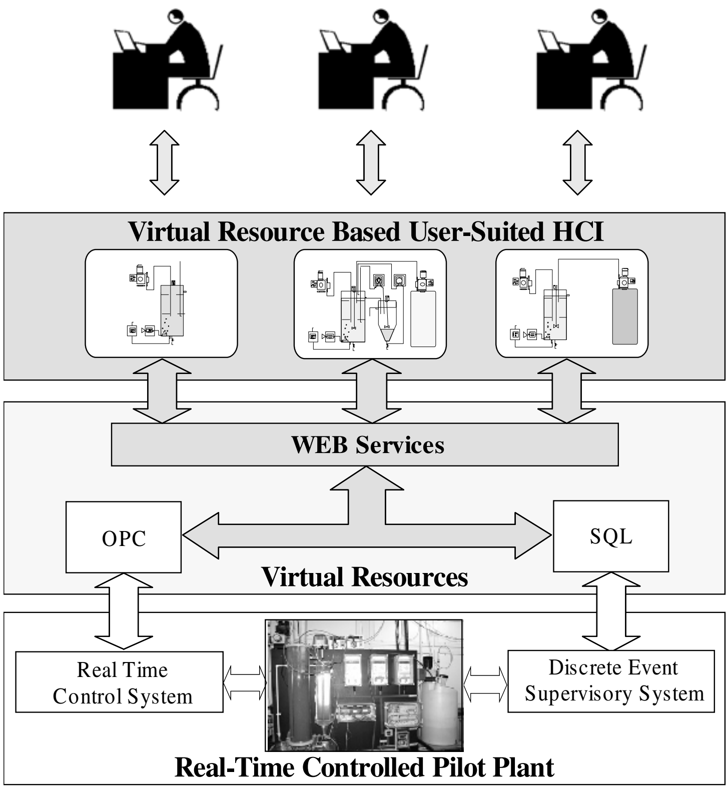

Fig. 1. The proposed system architecture

The paper is organized as follows. The second section presents short overview of the related work in the bibliography. After that, the concept of virtual resources in cybernetic approach is presented. Afterwards, the biotechnological pilot plant under consideration is presented as a representative application case. The following chapter presents the architecture and implementation of the proposed system and the heterogenic user interfaces that demonstrates realization concept of VR for user-suited HCI. Finally, concluding remarks summarizes this presentation.

2 Related Work

Problems presented above are mentioned in the literature of cooperative engineering. Main problems arising during cooperative engineering and similar engineering issues involving multiple engineers cooperation are subject to many publications (see for example [3], [4] and [5]). The distributed access notion in relation to computational systems was mentioned in early nineties for computer simulation [6], [7]. A problem of distributed access for source information sharing in virtual enterprise is presented in [8]. The notion Virtual Resources (VR) is mentioned in several publications [9], [10], [11], [12], [13] in different usages, but it represents (as in our implementation) always some kind of a virtual information system. The purpose of the studies presented in [14], [15] deal with problems in which way the trust evaluation method between co-workers and social presence turns into collaboration. Some characteristic properties of virtual resources seems to be similar to virtual networks (see for example [16], [17] and[18]). The paper [19] addresses some research questions recently studied regarding some of the human and organizational aspects of global product development and virtual training in the manufacturing and service industries, while the paper [20] describes the architecture of the first implementation of the new In-VIGO grid-computing system. As the related problems, implementation of computer resources for medical applications of virtual reality, as well as integrated resource management with distributed virtual computers [21], [22] should be mentioned.

3 More Details on Virtual Resources in Cybernetic Approach

For presentation of the proposed system realization it will be more interesting to show the way in which the proposed system works, rather than present software implementation details. From the cybernetics point of view, hence from the point of

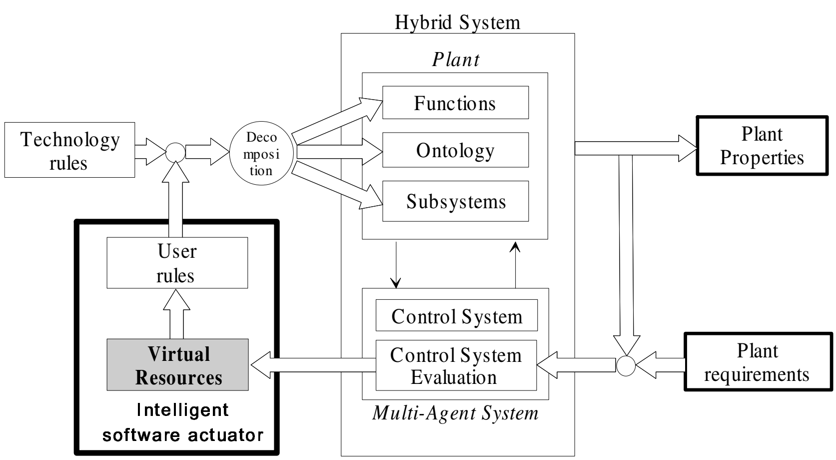

Fig. 2. Functional diagram of the operating control as feedback system

view of control considered as intentional influence [23], the operator control system proposed in this paper is presented in Fig. 2. The idea here is a non-typical usage of feedback. As it is the case in every feedback system, the key component is the actuator. In our case, the actuator is the proposed Virtual Resource and it is realised as a special software.

The controlled plant is a particular process represented in the information system by functions, ontologies and subsystems. It is within the operator control system that User Rules, by means of HCIs controlled by VR, are influencing the plant. Also, additional decomposed technology rules must be taken into consideration. A multi agent system synthesizes the appropriate data for the VR database by comparing the obtained process properties with the desired properties. Because, the comparison is indeed incorporating feedback into the system, this system should in most cases be stable, assuming that operators are truly cooperating and do not act violently.

4 Application Case: Biotechnological Pilot-Plant

The biotechnological process pilot-plant designed and operated at the Faculty of Automatic Control, Electronics and Computer Science serves as a platform for investigations regarding activated sludge process in aquatic environment. Apart from the standard activated sludge process, bioaugmentation process may also be investigated. The pilot-plant, shown in Fig. 3, consists of a biological reactor and a settler with a number of controls (pumps, mixers, heater) and measurements, together with a programmable logic controller capable of running advanced control algorithms (based on control systems of different vendors).

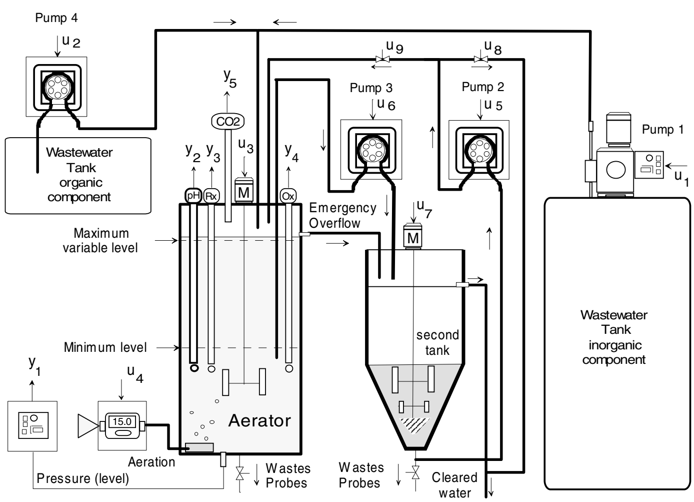

Fig. 3. Schematic layout of the biotechnological pilot-plant under consideration

Depending on the particular set of control algorithms applied, the structure of the biological process involved may be changed. For example, the plant may be operated as a continuous or sequencing activated sludge process, the later involving cyclic utilization of the biological reactor for reaction and settling phases, the former involving continuous sedimentation of activated sludge in the settler with recycle of the thickened sludge back to the reactor. Depending on the control of pumps interchanging the sludge between the reactor and the settler, the biological reactor may either be operated as a chemostat (constant reaction rate in the reactor) or as a turbidostat (constant concentration of biomass in the reactor). Investigations regarding batch processes may require a predefined initial concentration of biomass in the reactor, therefore the settler should be used as a buffer for the sludge and the reactor should be operated with changing level. And last but not least, bioaugmentation of biomass in the plant may or may not be involved.

Moreover, some experiments may require a sequence of configurations to be enforced in a specified time regime. Such sequences are referred to as scenarios. A particular configuration of the plant should be prepared prior to commencing experiments by a remote operator-researcher. To burden the researcher with preparing those conditions however, would make the whole process of remote experimentation [24] unacceptably complicated and dangerous for the plant. The remote researcher would have to posses all the information about local control systems, together with its particularities and constraints. A strictly control-engineering knowledge with control logic implementation language would also be required in order to enforce the proper configurations and scenarios.

Development of software systems enabling distant experimentation using the presented pilot plant, requires the cooperative operating control to be taken into account. In this case, virtual resource-based distributed access control and information system proposed here is an attractive solution.

5 Implementation

For the presented process, it is crucial for the cooperating process operators to be provided with specially designed HCIs [25]. It is also crucial for those HCIs to be suited for different operator tasks. The system presented in Fig. 2 realizes those requirements using decisions reached by the multi-agent system and by actualization of such a control using the VR-based software actuator.

The presented example requires the creation of different interfaces for different users referring to the same tasks using available and standard technologies. Fig. 4 presents interfaces of the same problem referring to control by changes of biomass retention. Those interfaces allow both observation of detailed information of the particular systems, parameterisation of agents realising selection of optimal parameters and remote control and supervision by generating code enabling simple selection of the needed state.

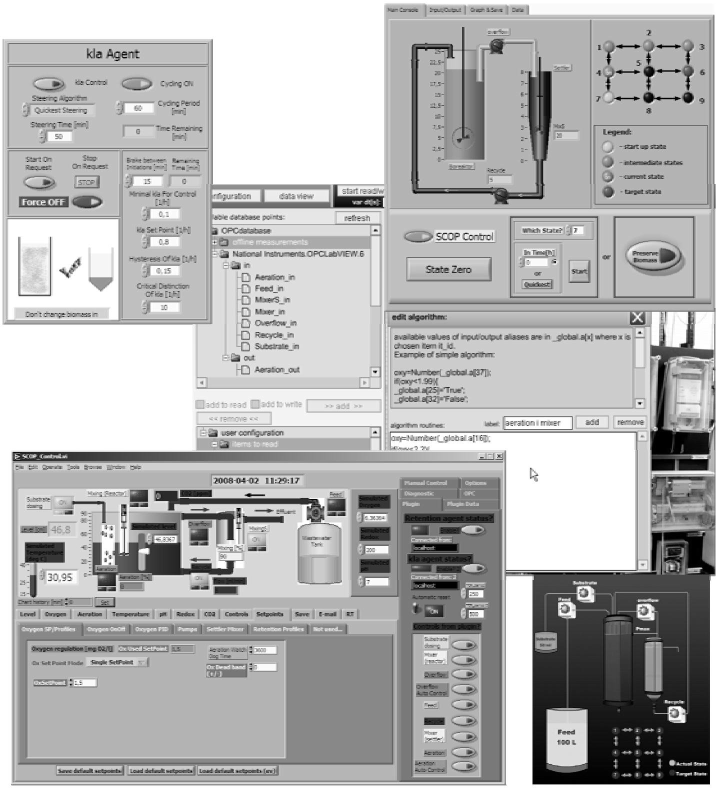

Fig. 4. Human-computer interfaces for the same tasks for different users in cooperation

6 Concluding Remarks

This paper presents a solution, the goal of which is to verify whether, by giving a much greater freedom of control to the software user, thus greatly complicating this software, would in effect result in a gross positive effects. Usage of the presented software by a multidisciplinary team of experimenters, shows the following advantages:

- Minimal action – the presented software enables complicated control algorithms to be implemented and performed by applying simple commands for state of the process to be changed.
- Resource safety – separation of the remote expert from the low-level control algorithm and from direct contact with the process equipment prevents unintentional failures to occur, since the presented software assures, that safety constraints are not exceeded.
- Readability – the remote researcher is not burden with the complicated plant specifics that is irrelevant for the particular experiment to be performed.
- Simplicity – by hiding details that are not important for the particular experiment the view of the pilot plant becomes simple for the remote researcher, thus allowing him/her to concentrate and sometimes notice the important phenomena.

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An Extensible Scientific Computing Resources Integration Framework Based on Grid Service

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Abstract. Scientific computing resources (e.g., components, dynamic linkable libraries, etc) are very valuable assets for the scientific research. However, due to historical reasons, most computing resources can't be shared by other people. The emergence of Grid computing provides a turning point to solve this problem. The legacy applications can be abstracted and encapsulated into Grid service, and they may be found and invoked on the Web using SOAP messages. The Grid service is loosely coupled with the external JAR or DLL, which builds a bridge from users to computing resources. We defined an XML schema to describe the functions and interfaces of the applications. This information can be acquired by users by invoking the "getCapabilities" operation of the Grid service. We also proposed the concept of class pool to eliminate the memory leaks when invoking the external jars using reflection. The experiment shows that the class pool not only avoids the PermGen space waste and Tomcat server exception, but also significantly improves the application speed. The integration framework has been implemented successfully in a real project.

Keywords: Grid Service; Integration Framework; Legacy Application Encapsulation; Class Pool; Reflection.

1 Introduction

With the rapid development of the Internet technology, more and more applications can be accessed through the Web, e.g., Google Documents, Picasa Web Albums, Google Maps and Earth, etc. Moreover, an exciting interactive Web application, Mashup [1], has emerged. It draws upon content retrieved from external data sources to create entirely new and innovative services. Web applications have brought too much convenience for the people. For example, most applications do not need to install the client, thus it is very easy to deploy and maintain them. However, many existing applications weren't designed for use in the Web, which were called legacy applications as usual [2]. In order to exert the greatest value of the legacy applications and provide computing services for more people, these applications should be encapsulated and published in a simple and friendly way [3].

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Reflection is a powerful technique and can enable applications to perform operations which would otherwise be impossible. However, reflection also has drawbacks, such as performance overhead, security restrictions and exposure of internals. Because reflection involves types that are dynamically resolved, certain Java virtual machine optimizations can not be performed. As a result, reflective operations have slower performance than their non-reflective counterparts. Moreover, because reflection needs to reload the external classes every time, and the PermGen space [4] that used to store the classes and class descriptions will not be released by the GC (garbage collection) mechanism, reflective operation swallows up the limited PermGen space very soon.

Our research motivation comes from a remote sensing data integration and sharing project. In this project, there are a variety of remote sensing images that need to be processed and shared. The processing algorithms, such as metadata extraction algorithm and cloud cover detection algorithm, have been made into EJB or COM components. These components have been proved to be stable and reliable after a long trial. The customer wants to reuse these computing resources in the project to protect the existing investment and shorten the development cycle.

2 Application Integration Framework Based on Grid Service

In order to integrate the legacy applications, we designed a legacy applications integration framework based on Grid service, as shown in Figure 1.

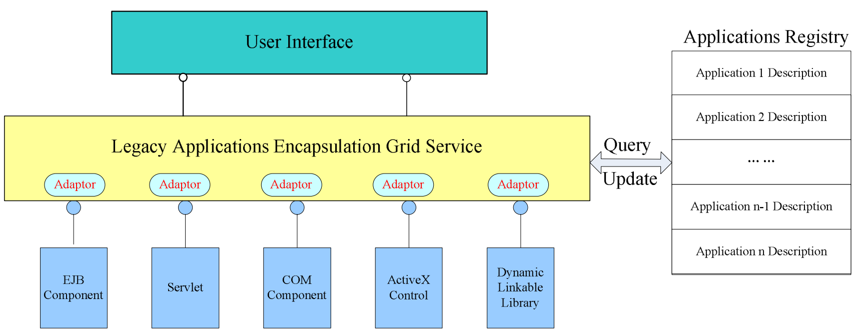

Fig. 1. Legacy Application Integration Framework Based on Grid Service

The Grid service has embedded several kinds of adapters, such as the adaptor for EJB component, COM component, dynamic linkable library, etc. Grid service itself does not achieve any specific function. When received an operation request from the user interface, Grid service will query the applications registry, and invoke the corresponding legacy applications using the adaptors. After the applications finished their tasks, Grid service will receive the results and return them to the user interface. In a word, Grid service provides an abstract and common invoke interface to shield the differences among the various legacy application interfaces.

Each legacy application must describe its detail interface information when registered into the encapsulation Grid service. Because the application interface types vary greatly, we should help users to create a standard interface description document. The best way is to define a XML schema to describe and validate the structure of the interface XML documents. Due to space restrictions, we can not give the complete XML schema description. In the following, an example XML document of the processing algorithms for Landsat 5 remote sensing images is given.

```
<applications
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" >
  <application appname="Image processing algorithm for
Landsat5" apptype="jar">
    <location>../lib/</location>
    <filename>LANDSAT_5.jar</filename>
    <class>TM.CloudCoverDetect</class>
    <methods>
      <method methodname="cloudCount" return="string"
function="CloudCoverDetection" object-
type="LANDSAT_5_TM" >
        <parameter paramname="lines" paramtype="int"
mapname="Lines"/>
        <parameter paramname="samples" paramtype="int"
mapname="Samples"/>
        <parameter paramname="imagefilepath" param-
type="string" mapname="FilePath"/>
      </method>
    </methods>
  </application>
</applications>
```

3 Grid Service Interface and Implementation

In order to describe the computing power that can be acquired through the Grid service, such as the application functions, parameters, etc, we designed an operation "getCapabilities" for the service. Its main purpose is to make the clients have a basic understanding of the Grid service before the use of invoke request, so that they can set the correct parameters. The operation is as follows:

```
String getCapabilities();
```

It returns an XML file, which contains the whole applications registry, as shown in section 2. In order to improve the versatility of Grid service, we defined an operation "invoke" as follows:

```
String invoke (String function, String ObjectType,
String ParameterSet);
```

Hereinto, the first parameter "function" depicts the function that users required, which can be found in the method's attribute of the registry, such as "CloudCoverDetection". In the next stage, we will define a standard functions set using the ontology, which can be accessed by both the application providers and the demanders. The second parameter "ObjectType" depicts the object type of the operation. Because we found that there are some applications having the similar functions but processing different type of objects, i.e., the cloud cover detection algorithms for LANDSAT 5 TM images and LANDSAT 7 ETM images, we utilize the object type to avoid misuse of the application methods. The third parameter "ParameterSet" encapsulates the parameters of the invoked method in a XML document. For example, users can submit a request with the "ParameterSet" as follows:

```
<parameters>
<parameter name="Lines" value="5000" datatype="int"/>
<parameter name="Samples" value="5000" datatype="int"/>
<parameter name="FilePath" val-
ue="ftp://UserName:Password@192.168.130.231:21/Landsat5
/ p121r34_5t19920824/" datatype="string"/>
</parameters>
```

After Grid service has received the invocation request, it searches the applications registry to locate the available applications according to the first two parameters "function" and "objecttype". And then, Grid service parses the third parameter "ParameterSet" and extracts each parameter name, value and datatype. These parameters are regarded as the input parameters of the invoked methods. According to different types of applications, Grid service calls different adaptors. As an example, we will introduce some methods of the adapter's implementation.

If the application is a COM component and its extension name is dll or ocx, we will use the open source project JACOB to invoke it. JACOB is a JAVA-COM Bridge that allows you to call COM Automation components from Java. It uses JNI to make native calls into the COM and Win32 libraries. The JACOB binary distribution includes: jacob.jar, a JAR file for the java classes which you must add to your CLASSPATH; jacob.dll: a small Win32 DLL which you must add to your PATH, and some examples. The example of controlling Office in Java using JACOB could be found in [5].

If the application is an EJB component and its extension name is jar, we will use the Java reflection technique to invoke it. Firstly, we should import several jar packages: java.lang.reflect.InvocationTargetException, java.lang.reflect.Method, java.net. URLClassLoader, etc. Secondly, we wrote the following code lines to create the necessary class and method object:

```
URL url = new URL(location+filename);
URLClassLoader ClassLoader = new URLClassLoader(new
URL[] { url });
Class xClass = ClassLoader.loadClass(class);
Object xObject = xClass.newInstance();
Method[] xMethods = xClass.getMethods();
Method xMethod = null;
for (int i = 0; i < xMethods.length; i++) {
if (xMethods[i].getName().equalsIgnoreCase(methodname))
{
    xMethod = xMethods[i];
    break;
}}
```

Thirdly, we can execute the reflection method. The parameter argsObject is an Object array, which contains all the necessary parameter values.

```
Object returnObject=xMethod.invoke(xObject, argsObject);
String returnStr=(String)returnObject;
```

At last, the variable returnStr contains the computing results of the application, which are returned to the Grid service and then returned to the users interface. At this point, Grid service has finished the implementation process.

4 Implementation of the Dynamically Loaded Class Pool

In order to improve the efficiency of remote sensing image processing, we provide an image batch processing function. However, when the Grid service has been invoked 69 times, the Tomcat server reports an error: java.lang.OutOfMemoryError: PermGen space. We then search the error on the Web, and found that the reason is due to the PermGen space, which is used to store the Class and Meta information. This space is different from the Heap regions that store the instances, and GC (Garbage Collection) won't clean up the PermGen space during the main program runtime. Thus, if Grid service loaded too many classes, it is possible to produce PermGen space error.

Apart from the Tomcat server error accidents, reflection invocation also eats up about 1M memory space each time, which will cause the available memory space decreased sharply. Again, because the external classes are required to reload each time, reflection invocation is much slower than its non-reflective counterpart. Someone online says that increasing the size of the PermGen space can prevent the Tomcat exception, but this is just a way to alleviate the problem and not a durable solution. The fundamental solution should be to avoid waste of memory space.

We found that when the Grid service method invocation ended, those dynamically loaded classes have become in-memory garbage, because there is no pointer to refer to them. If we can retain the pointers for these classes, then we need not reload them in the next invocation. This method not only avoids the waste of PermGen space, but increases the reflection invocation speed. Fortunately, Grid service provides us with the Grid Attributes [6]. As we all know, Grid service is a stateful Web service, which must conform to WSRF (Web Service Resource Framework) [7]. Grid Attributes can preserve the states of resources, thus we can use them to retain the pointers of the dynamically loaded classes.

Drawing on the idea of the database connection pool, we designed a dynamically loaded class pool to preserve all the loaded classes. When an application is invoked by the Grid service, the service will examine the class pool firstly. If the target class has already been loaded, then the service will execute the external application immediately. If the target class hasn't been loaded, the Grid service will load it and put the class pointer and description into the class pool for reuse later. Thus, the class pool size is relatively stable because the class number is limited. In the following, we will give the main implementation of the class pool:

```
@GridAttribute public Vector<String> jars, classes;
@GridAttribute public Vector<Object> objects;
@GridAttribute public Vector<Method> methods;
boolean invoked = false;
// See if the target class has been loaded in the class
pool. If so, then invoke it immediately.
while (JarIter.hasNext()){
  CurJar = JarIter.next();  CurClass = ClassIter.next();
  CurObject = ObjectIter.next();
  CurMethod = MethodIter.next();
  if (CurJar.equalsIgnoreCase(targetJar) && CurClass.
equalsIgnoreCase(targetClass)){
    retObject = CurMethod.invoke(CurObject, argsOb-
ject);
    invoked = true;
    break;
  }
}
if (!invoked) {
  // Add codes to load the external class and invoke
it.
  jars.add(extractJar);     classes.add(extractClass);
  objects.add(xObject);     methods.add(xMethod);
}
```

We designed an experiment to verify the effect of class pool when loading the external class frequently. There are four EJB components which can extract the metadata of four kinds of remote sensing images respectively. We take turns to invoke them for 25 times, i.e., the external classes are invoked 100 times in all. The comparative results of the traditional reflection invocation and the class-pool-based invocation is shown in Table 1.

Table 1. Comparison between traditional and class-pool-based reflection invocation

Invocation approach	Maximum number of loading external class	Average CPU time required to execute the class	Maximum memory consumption
traditional reflection invocation	68 times. In the next invocation Tomcat server will hit the java.lang.OutOfMemoryError: PermGen space	0.53s	84512KB on the 68th invocation and then Tomcat will crash in the next invocation
class pool	Unlimited	0.24s	6520KB

From Table 1 we can see, class-pool-based invocation is superior to the traditional reflection invocation in every aspect. The traditional approach needs to reload the external class each time, which could consume 1243KB memory. At last, when the application is invoked for the 69th time, there is no available PermGen space, and the Grid service failed forever. Moreover, the invocation time includes the external class load time and the application execution time, so it is much longer than the class-pool-based invocation.

The class-pool-based approach needs to load an external class on the first time it is invoked. When the external class is invoked for the second time or later, Grid service will search the class pool to obtain pointers of the invoked class and method, and execute the application immediately. Thus, the invocation time only includes the application execution time, which means application is only slower at first invocation. The maximum memory consumption is a little more than the size of each external class multiplied by the number of classes. Because the latter is relatively stable, the PermGen space can not be exhausted and Tomcat server will not crash either.

5 Related Works

Wang Bin et al. proposed a common abstract invocation interface for various applications, an "on-demand" factory responsible for creating and publishing scientific computing services, and a uniform monitor and manipulation interface [8]. The design idea of theirs is similar to ours, both of which aimed to provide a uniform interface for the upper application. But they need to encapsulate different scientific computing legacy application into scientific computing operation providers, which should implement the LegacyCodePortType and ManipulationPortType. In other words, all legacy application must be reformed to implement the operation provider interface. This was one difficult task for users, and which hindered its popularity.

Wang Xinyu [9] proposed a framework to reengineer a standalone legacy system into J2EE partition distributed environment. The framework consists of four steps: the translation form C++ to Java code; the extraction of the components using the clustering technology; the modeling of the component interfaces using some heuristic rules in J2EE environment; the deployment of the components in J2EE distributed environment. Their work focuses on the extraction of business logics for process-oriented large-scale legacy systems, which opens a new way to reuse the legacy systems. However, this job is too difficult, and a great part of the work requires manual processing.

So far we have not found the use of Grid Service resources property to avoid memory space waste caused by dynamically loaded external classes. SUN originally designed to consider the permanent region was fixed at the time JVM start, but they did not think that reflection is now so widely used. Moreover, this region has a special garbage recovery mechanism. Now after the class is dynamically loaded into the region, GC recycling simply no way! In 2003, when there is a bug report to the SUN, but until now, this bug has not yet close! Someone adds a sentence of reviews: A bug this critical is open since 2003? Absolutely shameful! We do not try to eliminate the bug in this paper, but think of ways to reuse those classes have been loaded. We designed a dynamically loaded class pool based on the idea of database connection pool, and used the Grid Attributes to retain the pointers of the classes.

6 Conclusions

In this paper, we designed and implemented a new scientific computing resources integration framework. The framework comprises of Grid Service and the legacy applications. Grid service does not achieve any special computing function, and it only utilizes the adapter to invoke the corresponding application according to the request type. Each legacy application should provide its interface description that satisfies the XML schema in section 2. The application descriptions are managed and exposed by the Grid service. As a result of this loosely coupled nature between the legacy applications and Grid service, the integration framework provides better flexibility and scalability. We also proposed a dynamically loaded class pool to solve the waste of memory space.

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Tools to Support the Design, Execution and Visualization of Instructional Designs

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Abstract. Describing CSCL scenarios can be performed in a standard way. To do so, *Instructional Design* or so called *Learning Design* (LD) can be used for describing CSCL scenarios by mean of a *de facto* specification known as IMS Learning Design (IMS-LD). A typical teaching/learning *scenario* based on this specification implies the use of several tools which must interact all together. This paper will show a set of tools that enriches the learning scenarios based on IMS-LD. The tools we are developing allow *graphical editing of instructional design*, a *generic engine* and a customizable *player*.

Keywords: Computer Supported Collaborative Learning, Learning Design, Conceptual Models, Collaboration Design.

1 Introduction

Learning Design (LD) is an approach focused on cognitive characteristics and on the learning process itself. IMS-LD [1] is the widest specification used to describe LD. In particular, it can be used for describing Computer Supported Collaborative Learning (CSCL) educational scripts. A typical teaching/learning *scenario* based on the use of IMS-LD supposes to manage several *tools* which must interact all together [4]:

- It is necessary the use of suitable ***editors*** for the creation of IMS-LD specifications. There are several tools for creating IMS-LD specifications. The most widespread are RELOAD[1], CooperCore Author[2], among others. The main drawback is that these tools are still too close to the specification, being necessary certain knowledge of the IMS-LD specification for creating instructional designs. To solve this, we propose the use of **graphical notation** to specify units of study, group activities, workflow, etc. [3]. With this, we provide a high abstraction level to

[1] *RELOAD Project,* http://www.reload.ac.uk
[2] *CopperAuthor Project,* http://www.copperauthor.org

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specify the different aspects involved in the CSCL modelling, and a subsequent translation to the appropriated low-level specification.

- Once the instructional design has been specified using IMS-LD, it is needed to run the specification. This requires two kind of tools:
  - The ***engine***: is the tool in charge of running the instructional design. As reference engines we can find Coppercore[3] and the IMS-LD engine included in the dotLRN[4] Learning Management System.
  - The ***player***: is the tool used by teachers and students for executing the support and the learning activities. One of the best known reference players is provided together with the Coppercore *engine*, but we can find others, such as the dotLRN IMS-LD portlet and more recently the SLeD[5] player that runs over the CopperCore engine.

Probably the main lack on the existing engines is that it is not possible to do runtime modifications on a loaded learning design specification. We have found this is necessary for providing an *ad-hoc* adaptation during the learning design execution.

On the other hand, one of the main drawbacks of the existing players is the low level of freedom to customize the interface. Moreover, all of them share the same way for representing the information related to the instructional design: the learning activities flow is shown with a tree based representation, very close to the structure of a XML file; all of them have the same static window distribution to show the learning flow, the activities resources visualization and the needed environments; etc. Things like a representation for the activities sequencing using a *graph* or a customized windows size and distribution will improve the environment making it more intuitive and usable for teachers and students.

This work focuses on providing a set of tools that enrich the scenario described above. We are developing tools for *graphical editing of instructional design*, a *generic engine* (that execute not only IMS-LD specification) and a more usable and customizable *player* to improve aspects related to user interaction. The following section presents briefly the features and appearance of this set of tools. Finally we present the conclusions extracted from this work.

2 The Tools

This section presents the implemented tools to support the scenario described above.

1. ***Supporting the design: the CIAT graphical editor.*** We propose the use of a graphical notation called CIAN as specification language of instructional designs and the corresponding mapping to IMS-LD [3]. CIAN is a graphical notation proposed in the context of a methodological approach called CIAM. CIAM (*Collaborative Interactive Applications Methodology*) [7] is a methodological proposal for the development of *groupware* systems that takes into account the modelling of group work and interaction issues. In [3] we analysed the suitability

[3] *Coppercore Project* http://coppercore.sourceforge.net/
[4] *DotnLRN Project* http://dotlrn.org/
[5] *Service Based learning Design Player (SLeD)* http://sled.open.ac.uk/index.php

of CIAN notation for modelling collaborative learning processes. One of the shortcomings of this proposal was the lack of a CASE tool that allows editing and validating the models specified using CIAN notation. We have improved the CIAM proposal by means of a tool called CIAT (*Collaborative Interactive Application Tool*). Fig. 1 shows a screenshot of CIAT. This tool supports the mapping process from CIAN to IMS-LD described in [3]. Using these high level of abstraction specifications, which can be mapped to computer-interpretable notations, such as IMS-LD, allows hiding the particularities of the standard to instructional designers.

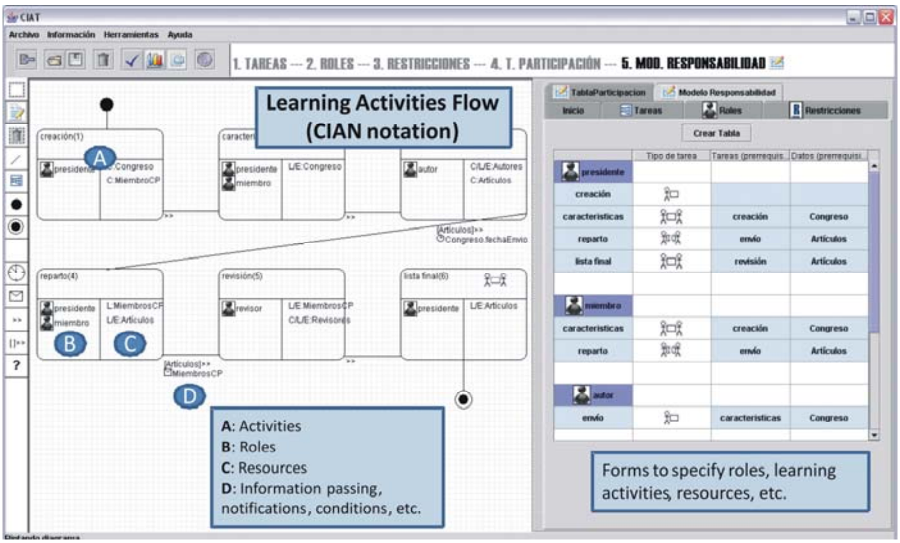

Fig. 1. An overview of the CIAT editing tool

2. ***Supporting the running: a generic engine.*** We are implementing a *generic engine* that will allow running not only IMS-LD specification, but also other existing instructional design specifications, such as those provided by MOT+ or LAMS. This generic engine is called Tuple-LD. To do so, we have studied and identified the common elements in this set of specifications. Thus, we are defining a generic specification language and its corresponding mapping to an abstract representation in form of tuples. As store and communication engine, Tuple-LD implements blackboard architecture by using a Tuple Space Server, which is basically a shared memory where clients can store and retrieve information formatted as tuples [2].
3. ***Supporting the interaction: the player.*** We are developing a *player* (called EDUNET) with improved visualization features. EDUNET is being implemented in Flash CS3 and ActionScript3. This allows including multimedia and enriched interactive capabilities. Up to now, this *player* connects to the Coppercore's engine, but we are working in the connection with our generic engine. In figure 2 we can see the appearance of the EDUNET tool. As we can see, this player presents some interesting features: a) Displays learning activities flow as a graph, instead of

the tree based representation closed to the structure of the XML file; b) Shows status information related to the student progress by mean of highlighting the activities using different colours; c) Allows personalized and flexible visualization for the different pieces of information, allowing to resize, to hide and to move panels.

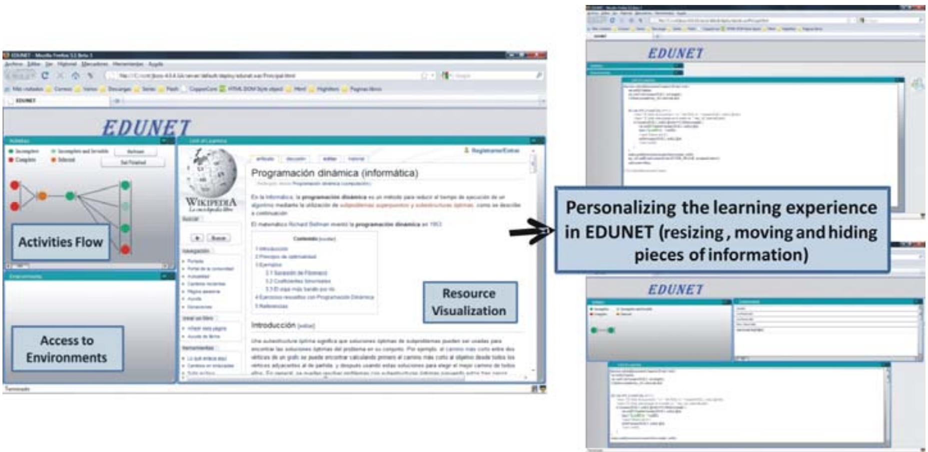

Fig. 2. An overview of the EDUNET player

3 Concluding Remarks

Our interest is centred on providing computational support to enrich educational experiences. In this sense, we propose alternative tools to those existing in the field of learning design. In particular, we are developing tools for graphical editing of instructional design, a generic learning design engine (that execute not only IMS-LD specification) and a more usable and customizable player, to improve aspects related to usability during educational experiences. We plan to realize a set of experiments that allows us to validate these tools and establishing the utility and position of our tools against others.

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Towards a Cooperative Traffic Network Editor

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Abstract. In this paper we explore the potential benefits of concepts such as visual interactive modelling and simulation to devise and implement a cooperative network editor embedded in a collaborative environment for transport analysis. Traditional approaches lack adequate means to foster integrated analyses of transport systems either because they are strict in terms of purpose or because they do not allow multiple users to dynamically interact on the same description of a model. The use of a common geographical data model of the application domain promotes the means for different experts to interact seamlessly in a collaborative environment.

Keywords: cooperative modelling, cooperative simulation, visualisation for multiple users, cooperative traffic and transportation engineering.

1 Introduction

Intelligent Transportation Systems (ITS) have recently gained a prominent role in everyone's daily lives. In fact, the information and communication infrastructure currently available is promising a great revolution and the Future Urban Transport (FUT) systems seem more feasible. ITS-based technologies toward FUT bring the user to a central spot and strive to address many issues concerning mobility and the quality of life in highly populated areas. These issues are rather related to the qualitative assessment by users with different perceptual abilities, which suggest a number of new performance measures that need to be accounted for and assessed through powerful and expressive tools [2]. In fact, transport problems have been traditionally tackled from different perspectives. Therefore, an imperative evolution, required for the sake of productivity, is the integration of tools, models and analysis methods into a common simulation framework [3]. More recently, however, cooperation mechanisms have been identified as imperative for such integration [1].

This paper follows up the work started in [1] and suggests the concepts of visual interactive modelling (VIM) and simulation (VIS) as crucial elements to foster the implementation of a cooperative network editor embedded in a collaborative transport analysis environment. In fact, the traffic network is the basis for virtually all transport models as it is the essence of the urban mobility infrastructure. However, different tools, with different purposes, have adopted different data structures and models to

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represent some concepts that transverse all subfields related to transport engineering and urban planning. Then, allowing experts with different perspectives to interact cooperatively onto a common urban model is a key ingredient to foster the so desired integrated perspective of transport analysis.

2 Cooperative VIS and VIM

The manipulation and visualisation through graphical representations of any attribute allow us to qualitatively evaluate the state of a system in an intuitive and quick way. Thus using visual interactive features in any simulation framework has become imperative, covering every step within the user interaction process. The visual interactive simulation (VIS) concept implies the use of interactive visual features aiming at steering the simulation process and allowing intermediate data visualisation and model parameters control. Such a concept has been initially approached by Hurrion [5] in the mid 70's, albeit its popularisation was effectively achieved in the 80's. In a similar way, aiming at increasing productivity during first stages of the simulation process through visual interactive features, e.g. model construction and data preparation, the concept of visual interactive modelling (VIM) was defined to cover all phases of the simulation project [4].

Considering the possibility of directly interacting with model's parameters, Marshall [6] identified three basic types of user-simulation interactions: post-processing, tracking and steering. Post-processing allows the user to graphically visualise simulation results only after an experiment has been concluded, thus no interaction is actually possible. During tracking, visualisation occurs while the simulation experiment is running. However, no interaction is possible as well, albeit the user can still interrupt the process. In the latter case, the user can steer the simulation process and interact with the model in runtime. Users can modify model parameters and entity attributes as the process evolves, and immediately visualise the results of such interactions.

In this work, we extend the boundaries of VIS and VIM beyond the integration of both concepts as suggested in [4]. In fact, issues related to the cooperative handling of simulation models in a way that different users can interact at the same time and still perceive how others' interaction will affect their simulation results remain to be addressed. Thus allowing post-processing, tracking and steering on a cooperative basis arises as an interesting and challenging research subject.

3 The Environment Architecture

Bearing the above perspective in mind, we can create an architecture based on white-box components capable of dynamically adapting themselves and interacting with each other as the current situation requires. Our approach is represented in the collaborative environment depicted in Fig. 1.

As most information in our application domain is geographically referenced, we use a specialised geographical information system (GIS) as a facilitator of the communication among multiple areas of interest. The GIS model will soon be extended into a geographical ontology, serving not only as a persistence and integration mechanism but also as the interface between different traffic network analyses tools aimed at diverse purposes. Thus practitioners from different backgrounds, e.g. traffic

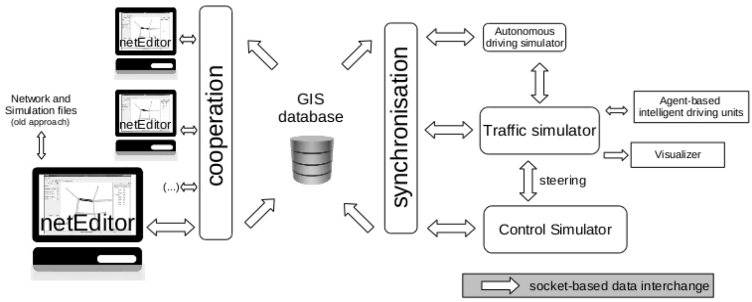

Fig. 1. A collaborative traffic analysis environment with cooperative modelling abilities

monitoring and control, urban planning, environment and pollution, public transportation, and many others, would have an environment where they could seamlessly interact and collaborate. In order to accomplish this, we started by featuring the GIS database with a proper meta-data for simple and compatible conversion between greatly used data formats, making it easy to migrate them into this approach.

The authentication mechanism intrinsic to most database management systems as well as access control policies facilitate controlling users who can edit, delete, create and read objects of the network model, whereas a log of every modification made is kept for diverse purposes. The proposed database-centric approach bridges two significant components, namely the cooperation and the synchronization layers. These two components distinguish between the modelling phase (on the left of Fig. 1) and the analysis phase (on the right of Fig. 1), where users can run different analysis tools from complex simulation to simple visualisation of results and objects' attributes.

The cooperation layer comprises all the edition tools needed to perform maintenance of the database. Different applications, such as instances of the traffic network editor (netEditor) we have implemented or a traffic signal editor can be easily attached to this layer, and the interaction with the database can be made in two ways, namely synchronously or asynchronously. In the former case, editors send all the updates to the database as quickly as the socket connection permits, allowing various users to cooperate on the same sub-network model as if they were working physically together. In the latter case, the user can lock a specific part of the network (only this user will have access to the selected sub-network model, thus minimizing the risk of conflicts) and commit all changes after manipulating it. After this, all applications connected to the database are updated, making changes noticeable to everyone.

The synchronization layer contains all the aspects related to the analysis processes, naturally including any simulation tools. These tools can either keep an on-line connection to the database while running any analysis processes or perform such processes on an off-line basis. In the former case, any modification to the database through the cooperation layer will directly affect the analysis processes running on the other layer. On the contrary, if analyses are run off-line a sub-network model image is kept on the right side, avoiding interferences from processes running on the left side.

According to the purpose of the analysis tool, a hole network can be simulated or just a part of it. This allows us to migrate across different granularity scales dynamically,

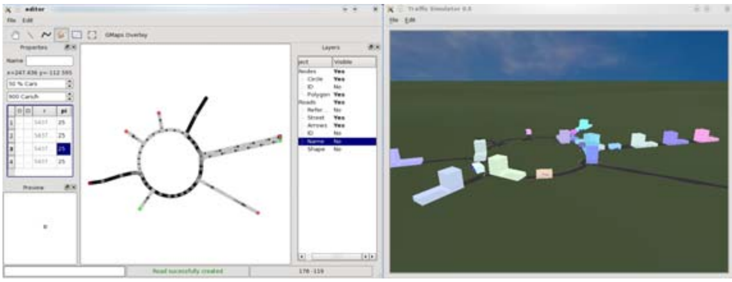

Fig. 2. The cooperative netEditor and a microscopic traffic simulator

favouring different simulation perspectives (e.g. micro, meso and macroscopic simulation). Fig. 2 depicts the cooperative network editor attached to the cooperative layer, whereas a microscopic simulator is running on the synchronisation layer.

4 Conclusions

Integrating different perspectives in transport analysis is a long-term goal that the scientific community has been striving to accomplish. Whereas first attempts targeted fully integrated stand-alone simulation frameworks, distributed environments that today underlie most computer systems favours cooperation on a distributed basis. In this work we turn back to the concepts of VIM and VIS, considering their potential application to improve cooperation on a distributed environment to feature a traffic network editor with characteristics such as post-processing, tracking and steering. The proposed cooperative architecture is an extension to the interaction mechanisms underlying the true concept behind the MAS-Ter Lab platform [1], while the implemented prototype demonstrated the viability of the approach with some graphical and interactive features tested. The improvement of the domain ontology to support dynamic and flexible interaction among different experts is the next step in this research.

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Mixture Model and MDSDCA for Textual Data

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Abstract. E-mailing has become an essential component of cooperation in business. Consequently, the large number of messages manually produced or automatically generated can rapidly cause information overflow for users. Many research projects have examined this issue but surprisingly few have tackled the problem of the files attached to e-mails that, in many cases, contain a substantial part of the semantics of the message. This paper considers this specific topic and focuses on the problem of clustering and visualization of attached files. Relying on the multinomial mixture model, we used the Classification EM algorithm (CEM) to cluster the set of files, and MDSDCA to visualize the obtained classes of documents. Like the Multidimensional Scaling method, the aim of the MDSDCA algorithm based on the Difference of Convex functions is to optimize the stress criterion. As MDSDCA is iterative, we propose an initialization approach to avoid starting with random values. Experiments are investigated using simulations and textual data.

Keywords: Cooperative visualization, attached files.

1 Introduction

Previous research in computer-supported cooperative work has shown that, most of the time, electronic cooperation relies on numerous e-mail communications. Consequently, in a cooperative context, the users often face the well known information overflow issue. In this context, however, studies have mainly focused on the messages themselves (see for instance Kerr [4] Otjacques et al. [5]) and very few of them have specifically explored the flows of documents attached to e-mails (Otjacques et al. [5] Allouti et al. [6]). Nevertheless, the management of attached files often requires significant resources. For instance, finding the successive versions of a document that has been exchanged many times by e-mail often

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appears as a hard task. Our research focuses on how to automatically classify and visualize such attached files in order to facilitate e-mail based cooperation.

In this work, we focus on the representation of the files without taking into account the conversation threads. Our initial purpose is to visualize the similarities between files. In addition, we limit our research to the textual content of files excluding other elements (e.g. pictures). To study this problematic we propose to use textual data clustering and visualization methods. A pre-treatment is necessary for obtaining data structured in the form of a table of files described by words where each value corresponds to the frequency of a word in a file. The data can also be presented in the form of a distance matrix.

2 Our Approach

We use the multinomial mixture models (Govaert and Nadif [2]) to cluster the set of files. We approach the clustering problem from a classification maximum likelihood (CML) standpoint and we use the Classification EM algorithm (Celeux and Govaert [1]). This approach allows proposing an approximation of the chisquare distance and therefore a distance matrix associated to data. From this matrix the visualization of obtained clusters is performed by MDSDCA. Like the Multidimensional Scaling method (MDS), the aim of the MDSDCA algorithm based on the Difference of Convex functions is to optimize the stress criterion (Le Thi Hoai and Pham [3]). As the MDSDCA is iterative, we propose an initialization approach based on the partition obtained by the CEM algorithm, the dissimilarity matrix and *bearing*.

Bearing is the angle formed by the AB oriented direction and the Y axis of the representation (see Fig. 1). It is counted positively from 0 to 360 degrees in a clockwise direction.

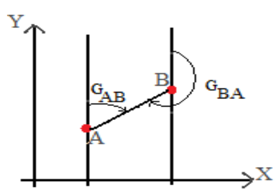


Fig. 1. Graphic representation of bearing

If the coordinates of point B are unknown, and if the coordinates of point A and the distance D_{AB} between points B and A are known, one can calculate the coordinates of B using the following formulas:

$$X_B = X_A + D_{AB}.\sin G_{AB} \quad (1) \qquad\qquad Y_B = Y_A + D_{AB}.\cos G_{AB} \quad (2)$$

Our initialization approach is detailed by the following points:

1. First, choose a file A randomly. Then, attribute to A the following coordinates: $A(X_A = 0, Y_A = 0)$. A serves as a reference for determining the bearings and coordinates of other files;

2. Next, associate a bearing to each cluster. That is to say we assume that, from file A, the files of a same cluster have the same bearing.

   Let gis_0 be the bearing associated to class C_0 and $gis_{(i+1)}$ the bearing associated to class $C_{(i+1)}$. gis_0 and $gis_{(i+1)}$ are computed using the following formulas:

$$\begin{cases} gis_0 = 360/\text{g}; \quad \text{where g is the number of clusters} \\ gis_i = gis_0 \times (i+1); \quad i > 0 \end{cases}$$

3. Finally, compute the coordinates of different files using formulas (1) and (2).

3 Clustering and Visualization

To evaluate our approach, we applied it to two types of data: synthetic data and real data.

3.1 Clustering of Synthetic Data

We simulated six tables according to a multinomial law with three-components and proportions ($\pi_1 = 0.3, \pi_2 = 0.3, \pi_3 = 0.4$). Table 1 presents the six simulated tables and the results of CEM. There are two structures of data: the first is a table of 100 observations described by 10 variables. The second is a table of 1000 observations described by 10 variables. We use the abbreviation *do* to denote the degree of overlap.

Table 1. Percentage of files wrongly classified by CEM

Data size	*do*(%)	CEM(%)	Data size	*do*(%)	CEM(%)
100×10	5	5	1000×10	4	5
100×10	15	17	1000×10	17	16.6
100×10	22	30	1000×10	24	27

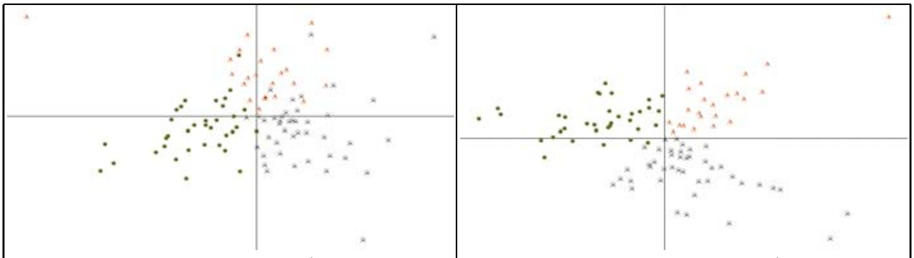
3.2 Clustering of Real Data

We used Classic3 *(ftp://ftp.cs.cornell.edu/pub/smart/)* which is a database composed of 3893 documents obtained by combining the summaries of CISI, CRANFIELD and MEDLINE. This database was used in the past to assess several information systems. We retrieved the abstracts associated with different documents. Then, a pre-treatment was carried out on the data in order to reduce the number of words. The number of words obtained after pre-treatment was 1442. The percentage of files wrongly classified by CEM was 3%.

3.3 Visualization

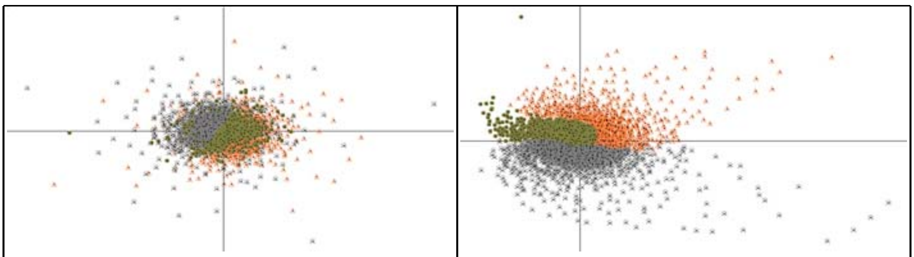
MDSDCA determines the coordinates of the different objects (documents) on a plane. Based on these coordinates, we developed a tool that displays the different file clusters on the plane. Same cluster objects are presented in same color and same geometric shape.

In order to evaluate our initialization approach, we present below the visualizations obtained using our approach (abbreviation O. A.) and using a random initialization (abbreviation R. A.) on synthetic data (see Fig. 2) and real data (see Fig. 3) respectively. We also illustrate in Fig. 2 and Fig. 3 the values of stress and the number of iterations (abbreviation Iter.) required to reach these stress values.



($R.\ A.$) Stress $= 30, 1.10^{-4}$. Iter $= 72$ ($O.\ A.$) Stress $= 29, 99.10^{-4}$. Iter $= 6$

Fig. 2. Results of MDSDCA ($100 \times 10(do{=}15\%)$)



($R.\ A.$) Stress $= 0, 22$. Iter $= 1033$ ($O.\ A.$) Stress $= 0, 22$. Iter $= 99$

Fig. 3. Results of MDSDCA (Classic3)

We observe that for the same stress level, the visualizations produced using our initialization approach are better than those obtained using a random initialization. In addition, our initialization approach avoids performing a large number of unnecessary iterations.

4 Conclusion

In this paper we presented an approach that consists in combining the clustering and visualization methods for textual data. Specifically, we used the multinomial mixture model to cluster the documents, and MDSDCA for visualization. The CEM algorithm was used to obtain the partition. Using these partitions, the dissimilarity matrix and *bearing*, we determined the starting point for MDSDCA. The results on simulated data according to multinomial mixture models and on real textual data are encouraging.

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Synchronous Communication Media in the Software Requirements Negotiation Process

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Abstract. This paper presents an empirical study in the requirements negotiation process. In particular, the study compares traditional face-to-face meeting and distributed communication by using two rich synchronous communication media (i.e., an enhanced chat, and a three-dimensional virtual environment). We have observed that there is a difference in the time taken to negotiate software requirements in favor of face-to-face meeting. As the only assessment of the time could not be meaningful, we have also analyzed the quality of the structured description of the negotiated software requirements. We observed that the quality of the structured descriptions is not influenced by the used communication media.

Keywords: Requirements engineering, distributed virtual environment, synchronous communication media, and distributed software development.

1 Introduction

Requirements analysis is a time consuming and difficult process involving many psychological and technical skills [7, 13]. One of the most challenging and critical activity in the requirement engineering process is perhaps the requirements elicitation. The requirement elicitation is mainly focused on the development of a common understanding of the software requirements and generally needs an intense collaborative process (i.e., the negotiation) involving stakeholders.

Currently, many software companies are moving their business to distributed virtual organization models, thus creating new software engineering challenges (e.g., time zones, distance, or diversity of culture and communication). In the global software development new methods and practices are required to overcome these challenges. In such a context, the need for collaboration creates additional challenges to effectively negotiate software requirements [4, 5, 6].

The large number of available lean and rich media could generate confusion in the management of software companies in case same-place interaction is problematic. In this scenario empirical investigations could be conducted to acquire a general knowledge about which method, technique, or tool is useful for whom to conduct which task in which environment [1, 14].

One of the most often investigated issues in the requirements negotiation regards whether group performance improves over face-to-face meetings if stakeholders

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communicate using communication media [5]. As a step in this direction, this paper reports on a preliminary empirical investigation to compare three synchronous communication media in the software requirements negotiation. Indeed, this study attempts to compare the effectiveness of a traditional face-to-face meeting, an enhanced chat [8], and a distributed three-dimensional virtual environment implemented within Second Life [15]. One of the main goals here is to verify whether the time to negotiate software requirements is influenced by the used communication media. Furthermore, as the only assessment of the time could not be meaningful, we have also investigated the quality of the structured description of the negotiated software requirements.

The remainder of this paper is organized as follows. Section 2 discusses related work, while Section 3 highlights the considered communication media. Section 4 and Section 5 present the design and the results of the empirical investigation, respectively. Final remarks and future direction conclude the paper.

2 Related Work

In the last two decades research effort has been devoted to define and/or assess tools for computer supported collaborative work in general and for supporting distributed meetings in particular [4, 9, 11]. As our contribution concerns the comparison between distributed and traditional face-to-face meetings in the requirements negotiation, in this section we present some tools/environments implementing distributed meetings. This section is not intended to exhaustively present all the available tools/environments. Note that research studies related to the investigation of communication media in the requirements negotiation is discussed as well.

2.1 Distributed Meeting

Nijholt *et al.* [12] proposed a virtual environment implementing the meeting room metaphor. In this environment, the authors restricted themselves to simulate a real-time meeting and embodied participants. Differently, De Lucia et *al.* [9] proposed a tool named SLMeeting to enhance the synchronous communication among users within Second Life. This tool proposes a distributed virtual environment to support the management of collaborative activities organized as conferences or Job meetings.

Instant messaging tools have been also used in collaboration scenarios [10, 11]. For example, in [11] the authors reported the RVM (Rear View Mirror) tool. This tool supports presence awareness, instant messaging, and group chat within geographically distributed workgroups. The results of the experience concerning the use of RVM have been presented and discussed as well. In [10] Drew (Dialogical Reasoning Educational Web tool) has been proposed. It provides a set of tools to support collaboration among students through previously defined pedagogical sequences.

2.2 Communication Media in Requirements Negotiation

Damian et *al.* in [4] propose an empirical study to compare five physical group configurations: one face-to-face and four distinct distributed communication settings. In case of distributed settings different relative locations of the stakeholders were considered. Differently from us, the stakeholders' communication was based on computer-conference communication. This study revealed that the highest group performance occurred when customers were separated from each other and collocated with the facilitator or system analyst.

An interesting empirical study aimed at investigating the effect of using mixed media (i.e., rich and lean) in distributed requirements negotiations has been proposed in [6]. The students used an asynchronous text-based tool and a synchronous videoconferencing based communication tool. The study reveals that the requirements negotiation was more effective when an asynchronous structured discussion was conducted before a synchronous negotiation meeting. Furthermore, they observed that asynchronous discussions were useful in resolving issues related to uncertainty.

Boehm and Egyedin [2] presented some lesson learned in the software requirements negotiation. They captured and analyzed requirements negotiation behavior for groups of undergraduate students, who were asked to develop library multimedia archive systems, using an instrumented version of the WinWin groupware system. Indeed, 15 different projects were conducted by about 90 students. Several real world problems were evidenced in this study (e.g., fuzzy requirements, conflicts with resources and personnel, Domain Expertise, and so on).

3 Investigated Communication Media

There is a common understanding on the fact that the infrastructure to negotiate software requirements in synchronous way is expensive to set up and maintain [4]. The coordination across organizational boundaries could be problematic as well. However, the media selected in this study (i.e., enhanced/structured chat and virtual environment) are simple to set up and maintain, thus making them appealing and potentially easy to use in the negotiation.

3.1 Face-to-Face

The face-to-face interaction used in the study is composed of two steps. In the first step the students organized in teams were asked to conduct the negotiation making the possible conflicts explicit. To facilitate the identification of the right decision the students for each conflict had to explicit: the relevant alternatives, the argumentations, and the underlying rationales. The right decision had to denote a decision rationally made evaluating the alternatives and selecting the best one according with the client expectations. In the second step a facilitator was asked to formalize the software requirement according to the template proposed in [3].

3.2 Enhanced Chat and CoFFEE

As enhanced synchronous tool to remotely negotiate software requirements we used the CoFFEE system [8]. This system has an extensible architecture designed to mediate the interaction of face-to-face group discussions in the classroom. Although, it is mainly aimed at improving collaborative learning in the context of computer support collaborative workgroup, the system offers good tools to support the synchronous collaborative activities during discussions. Discussions are organized in a session, which is divided in steps. The activities that can be accomplished within each step are defined combining one or more CoFFEE tools. In the experiment, we used two meaningful and well known tools: the chat and the threaded discussion. The chat tool enables the discussion in a group by using the so called synchronous conferencing and offering an interface based on the internet relay chat system.

The threaded discussion tool enhances the chat tool enabling the users to structure a discussion flow in threads. Notice that the threaded tool can be configured so that it is possible to instance multiple threaded chats with different topic called categories. A user can submit a contribution after he has selected the appropriate category and the other users can provide multiline contributes attached to the previous users' contributions. Furthermore, the threaded tool can be configured in order to tag the user contribution type (e.g., suggest, agreement, or revision).

In our study we have created a session composed of two steps. Each step is composed of a threaded chat and a chat tool. The threaded chat provides a discussion point for each entry within the structured description of the negotiated software requirement. In the first step the students had to interview the client to get clarification on the negotiated software requirement, while in the second step a facilitator was in charge of formalizing the negotiated requirement according to template proposed in [3].

3.3 Virtual Environment and Second Life

Virtual reality worlds have become increasingly popular in the recent years. Second Life is one of the most popular three-dimensional virtual worlds. It is based on a community where each member assumes an identity and takes up residency. Each member can create a customizable avatar, which can be moved in the virtual world using the mouse and/or the keyboard.

To perform the experiment within Second Life we leased some land and set up a virtual building where the meetings have been conducted. We tried to offer a successful approach of self-organizing systems inside the virtual world designing an open-space meetings room. Successively, within the building we arranged the groups of students around four tables. The student within a group could communicate using a chat and/or the voice. A slideshow was also provided to each group in order to present the template to be used in the modeling of the negotiated software requirement [3].

To take notes during the negotiation the students used a virtual object called note-card. The note-card is a simple text documents that every avatar can create and share with other avatars. In our experiment a note-card can only be shared with the students of the same group. This object was also used to reach an agreement on the structured description of the modeled requirement. In fact, a facilitator was in charge of specifying the software requirement when the negotiation was concluded. Once this software requirement specification was completed, the facilitator had to share it with the other developers, who could suggest or propose corrections to improve it.

4 Experimental Setting

This section presents the context of the empirical study experiment and its design.

4.1 Definition and Context

The context of the experiment was constituted of Bachelor students in Computer Science at the University of Basilicata. The total number of involved subjects was forty-eight voluntary students. Thirty two subjects have been attending a Software Engineering course and acted as developers, while the remaining twelve subjects have been attending an Operating System course and acted as clients. The developers had knowledge on methods and techniques widely employed in the requirements engineering. Conversely, the clients were familiar with neither software engineering nor requirements engineering, so they were only able to provide details on the problem domain and on their needs.

The subjects were randomly grouped in twelve software development teams. The teams were composed of three developers and one client. The experiment has been performed in a controlled setting within a laboratory at the University of Basilicata.

The experiment has been organized in two days. The first day was a training session where details on the traditional face-to-face meeting, CoFFEE, and Second Life were presented. Subjects have also used them on tasks not directly related with the experimentation (e.g., Open Source advantages and disadvantages). In the second day the subjects performed two tasks in two subsequent laboratory sessions. The tasks regarded the negotiation of two functional requirements of a software system on which they were familiar with, namely an E-Commerce Platform (ECP).

To perform the tasks we considered the following methods:

- FF (Face-to-Face meeting). It involves the communication between three developers and a client. The stakeholders are in the same place.
- SC (Structured Chat with CoFFEE). The communication is distributed and the subjects remotely interview the client to get clarification on the requirement.
- VFF (Virtual Face-to-Face with Second Life). The communication is distributed and is implemented within a virtual environment.

When the negotiation is concluded each facilitator (one of the developers) formalizes the discussed requirements using a structured description, which had to be compliant with the template proposed in [3].

Notice that the rationale for asking each team to define structured description of the negotiated requirements relies on the fact that the negotiation process should affect this description. It is also true that developers' ability could condition the overall quality of that description. However, all the developers had comparable background and experience on requirements engineering.

4.2 Research Questions

The first goal of the experiment was to verify whether the communication media influences the time required to negotiate a software requirement. To this end, the following research question has been formulated:

> **Q1.** Does the use of one of the considered media (i.e., FF, SC, or VFF) affect the time to negotiate a software requirement?

To assess the overall quality of the negotiated software requirements, the authors together with an external reviewer inspected the produced structured descriptions (without being aware of the used communication media).

To assess the negotiation quality we have considered the total number of defects within the structured description resulting from the inspection meeting. Therefore, the following research question has been formulated:

Q2. Does the use of one of the considered media affect the number of defects within the structured description of the negotiated software requirements?

4.3 Experiment Design

The design of the experiment is summarized in Table 1. In particular, this table shows the groups' identification, the number of teams for each group, the experimented media, the performed task (i.e., T1 or T2), and in which laboratory session (i.e., LAB1 or LAB2) a task has been performed. The subjects (i.e., developers and clients) were randomly assigned to a software team. Successively, the twelve teams composed of three developers and one client were randomly assigned to the groups S1, S2, and S3.

Within the two laboratory sessions the subjects were asked to perform the following tasks:

T1. Negotiate the software requirement *"create a new client within ECP"* and construct its structured description.

T2. Negotiate the software requirement *"remove a product from the catalog within ECP"* and construct its structured description.

Table 1. Experiment design

Group	Number of Teams	SC	EFF	FF
S1	4			T1, LAB1
S2	4	T1, LAB1		T2, LAB2
S3	4		T1, LAB1	T2, LAB2

Table 2. Descriptive Statistics of LAB1

Group	Method	Time			Defect		
		Med.	Mean	Std. Dev.	Med.	Mean	Std. Dev.
S1	FF	65	63.75	7.5	2	2.25	1.26
S2	SC	81	80.25	3.77	1.5	2.00	1.41
S3	VFF	79	75.50	13.07	1.00	1.25	1.26

Table 3. Descriptive Statistics of LAB2

Group	Method	Time			Defect		
		Med.	Mean	Std. Dev.	Med.	Mean	Std. Dev.
S2	FF	63	62.5	6.6	2.5	2.5	0.57
S3	FF	63.5	63.00	9.05	3	2.75	2.21

5 Results

Some descriptive statistics are shown in Table 2. In particular, this table shows the median, the mean, and the standard deviation (grouped by FF, SC, and VFF) of the negotiation time and identified defects of the teams within LAB1. These statistics show that less time is needed to negotiate software requirements when using traditional face-to-face meeting. Accordingly, we can affirmatively answer Q1. To further confirm the research question Q1, we performed a further analysis (see Table 3). This analysis revealed that on average the teams within S2 spent less time to accomplish T2 in LAB2 using FF (62.5 minutes) as compared with the time to perform T1 in LAB1 using VFF (80 minutes). Similarly the teams within S3 spent less time to accomplish the task in LAB2 (63 minutes) with respect to LAB1 (75.5 minutes).

Regarding the research question Q2, we can observe that the communication media slight influence the overall quality of the structured descriptions. In fact, the average number of defects is nearly the same for all the considered media. However, the average number of defects is larger in case the method FF is used (group S1). Furthermore, a slight difference was observed in terms of defects when the teams used a virtual meeting (i.e., VFF or SC) first and then FF, thus suggesting that the considered media does not affect the number of defects within the structured description of the negotiated software requirements (research question Q2). In fact, the teams of the groups S2 and S3 obtained worse performance within LAB2 in terms of defects within the description of the use cases. In particular, the average number of defects within LAB1 for the teams of the group S2 was 2, while in LAB2 was 2.5. Similarly, for the teams within S3 the average number of defects was 1.25 in LAB1 and 2.75 in LAB2.

6 Conclusion

According to media-effects theories, face-to-face communication is the richest medium as compared to all the other communication media (including computer conferencing). Moreover, most theories assert that the negotiation performance decreases when less reach media are used because of a mismatch between the negotiation needs and the medium's information richness. In this study we investigated these assumptions in the context of requirements negotiations. Similarly to the empirical investigation presented in [4], our study do not support traditional claims that groups using the richest communication medium generally perform better than those using leaner media. Indeed, we observed that subjects using face-to-face meeting are able to negotiate software requirements in less time. Differently, no difference was observed in terms of the number of defects in the use case structured descriptions.

In the future we plan to conduct a further analysis on the gathered data using statistical tests. For example, we will investigate whether the order of laboratory sessions and the subjects' background influence the achieved results. The effect of the conflicts aroused in the requirement negotiation according with the used communication media will be considered as well. This further investigation could provide some directions from a socio-psychological perspective. In particular, a question that could be addressed is whether stakeholders with conflicting requirements better manage conflicts in case they are physically separated. Future work will be also devoted to conduct empirical studies in different contexts, thus confirming or contradicting the achieved results.

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IMSF: Infinite Methodology Set Framework

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Abstract. Software development is usually an integration task in enterprise environment – few software applications work autonomously now. It is usually a collaboration of heterogeneous and unstable teams. One serious problem is lack of resources, a popular result being outsourcing, 'body shopping,' and indirectly team and team member fluctuation. Outsourced sub-deliveries easily become black boxes with no clear development method used, which has a negative impact on supportability. Such environments then often face the problems of quality assurance and enterprise know-how management. The used methodology is one of the key factors. Each methodology was created as a generalization of a number of solved projects, and each methodology is thus more or less connected with a set of task types. When the task type is not suitable, it causes problems that usually result in an undocumented ad-hoc solution. This was the motivation behind formalizing a simple process for collaborative software engineering. Infinite Methodology Set Framework (IMSF) defines the ICT business process of adaptive use of methods for classified types of tasks. The article introduces IMSF and briefly comments its meta-model.

Keywords: framework, IMSF, methodology, process, software engineering.

1 Introduction and Motive

The Infinite Methodology Set Framework is an adaptive software development approach, supporting software development by defined methods. It uses an open set of methodologies and supports learning from previous faults. The methodologies (i.e. descriptions of the methods) can be structured hierarchically and are interlinked with a hierarchy of software development task types. This approach is suitable for a large enterprise environment, which can benefit from process formalization, but is probably too robust for small companies. The following paragraphs explain the motive and briefly introduce the formalized meta-model. Although the ideas, which the IMSF is based on, are not revolutionary, the formalized meta-model has been missing, and thus it is the main contribution of the underlying work.

Following are the five main reasons for introducing the approach of the IMSF: (1) A universal methodology does not exist. Each methodology is a generalization over specific approaches, and works well only for specific types of task. (2) Creating or customizing an ad-hoc methodology is time consuming, thus not efficient for tasks of one type. (3) The same methodology used for tasks of the same type produces similar

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outputs, which can facilitate alignment with other ICT business processes, such as project management, architecture, operation support, maintenance, service desk and many others. (4) A methodology portfolio is a higher quality process than an ad-hoc one. For example CMMI level 3 [1] demands process description and repeatability. The presented approach provides both the process definition of the IMSF, and individual software development process definitions. Continuous process refinement, required by higher CMMI levels, is achieved with the adaptive behaviour of the presented approach. (5) Enterprise staff fluctuates often quite rapidly, partly through natural movement and partly as a result of team lifecycles in collaborative, cross-enterprise projects. Heavy use of outsourcing deepens the problem more. IMSF reduces the fluctuation impact. The methodology framework, described methods, tools and task types allow the new staff to quickly adapt and adopt. The growing know-how is saved in the enterprise.

2 Related Work

The aforementioned CMMI has the related aim of measuring process quality to help improve ICT business processes. IMSF attempts to conform to some of the CMMI requirements. The Essential Unified Process, introduced by Ivar Jacobson [2], is a similar approach to IMSF. It uses so called ‘practices’, in some ways comparable to the tools of the introduced approach. According to the available materials it does not seem to focus on task types, but on specific tasks (project or team issues). It does not therefore explicitly build a reusable hierarchical methodology pool. This is the key difference – the IMSF builds on structuring methods into methodologies and focuses on reuse. It formalizes how to organize such structuring and reuse.

3 IMSF Description

Fig. 1 illustrates the core artefacts of IMSF as a view on a static part of its UML meta-model. The main benefit of IMSF use is to have systematically developed software. *MethodologyPool* is a container for the set of methodologies usable for development. All development is thus controlled by a *Methodology*, and the basic techniques are therefore repeatable and evaluable. *Tool* is a description of tool that can be used by a *Methodology*. *Tool* can include various types and techniques, from project management techniques like iterative development, to use case modelling, UML, and Java. The processing of artefacts goes according to a process model summarized by the following scenarios.

Standard Development

1. The *TaskType* is selected or created according to the nature of the solved task;
2. The appropriate *Methodology* is found in the *MethodologyPool*;
3. The *Methodology* prescribes the set of described tools, as *Tool* instances, that should be used;
4. The task is done (i.e. a piece of software is developed or the project is stopped), driven by the selected *Methodology*.

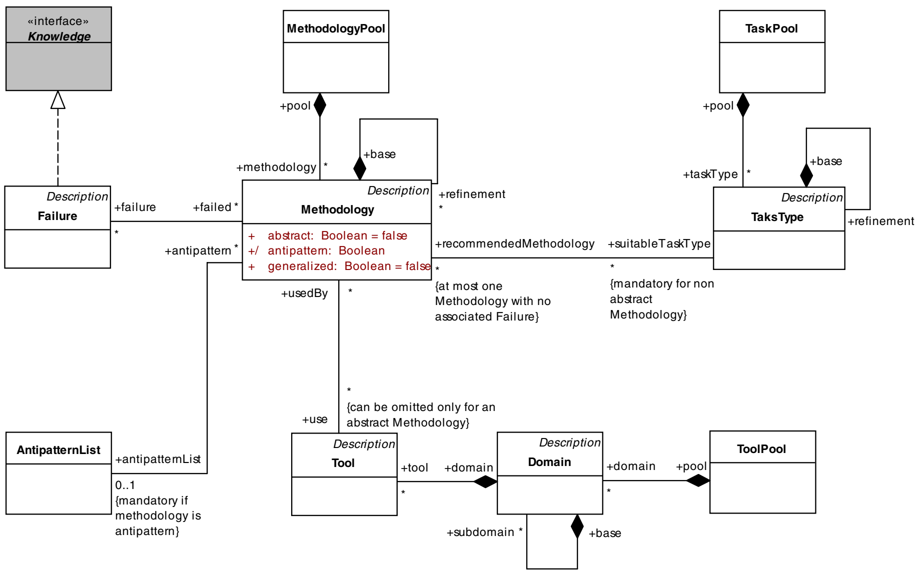

Fig. 1. Structural Model – Core View

Development with Methodology Change
The scenario starts after step 4 of the *Standard Development* scenario, when this step has signalled that the used *Methodology* needs a refinement.

a. The *Methodology* is changed: either refined, or marked as an *antipattern* (fault).

Development with New Methodology
The scenario starts when the step 2 of the *Standard Development* scenario fails (i.e. no *Methodology* found in the *MethodologyPool*). It never returns control to the standard scenario.

b. An appropriate *Methodology* is not found in the *MethodologyPool*;
c. An (ad-hoc) *Methodology* is introduced/customized, with the previous fault descriptions (supported by the *AntipatternList*) as input to help to prevent relapse;
d. The task is done (i.e. a piece of software is developed or the project is stopped), driven by the newly introduced *Methodology*;
e. The newly introduced *Methodology* is reviewed and then either generalized (it can be postponed for refinement) for further use, or marked as an *antipattern*.

The implemented model can be started as an empty database, i.e. as a set of the singleton instances *MethodologyPool*, *TaskPool*, *ToolPool* and *AntipatternList*. Real use would step by step fill the pools with appropriate instances. Since some practices are already known, it would be beneficial to initialize the database with some nontrivial antipatterns [3, 4] to benefit from previous failures. The antipatterns are represented then by *Failure* instances, which should be supplemented by linked *Methodology* instances to create an effective antipattern database. This start-up widens the knowledge base for introducing new methodologies. Our complementary research activity, called

Effectively Supported Business by ICT (ESUB), has collected a set of best practices suitable for user centric information systems. It can be used as a top (or a high level) *Methodology*. The prioritized list of *Tools* by ESUB is: 1. Business Driven Development, 2. Efficiency First, 3. Knowledge Base, 4. Extended Subset of Model Driven Architecture, 5. Subset of Literate Modelling, 6. Business Modelling and Architecture, 7. Service Oriented Architecture, 8. Use Case Driven Approach, 9. Business Rules Separation, 10. Architecture-First Approach, 11. Using Patterns, 12. Component Based Development, 13. Test First Design / Test Driven Development, 14. Iterative Development, 15. Prototyping, 16. UML Colouring, and 17. Aspect Oriented Programming.

4 Conclusion

IMSF – Infinite Methodology Set Framework is a formalized framework for collaborative software development across large enterprises. It is a compilation of contemporary know-how and experience in software engineering. This work brings the missing meta-model formalization, which is outlined here but could not be presented in full form because of its volume. It helps enterprises to manage and systematically improve their processes, know-how and quality. It can be a basis for systematic process measurement [5], and for achieving quality certification. Since the outcomes were formalized into the presented framework, future work involves implementing, measuring and evaluating the framework.

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A Tool to Enhance Cooperation and Knowledge Transfer among Software Developers

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Abstract. Software developers have been successfully tailoring software development methods according to the project situation and more so in small scale software development organizations. There is a need to share this knowledge with other developers who may be facing the same project situation so that they can benefit from other people experiences. In this paper, an approach to enhance cooperation among software developers, in terms of sharing the knowledge that was used successfully in past projects, is proposed. A web-based tool is developed that can assist in creation, storage and extraction of methods related with requirement elicitation phase. These methods are categorized according to certain criteria which helps in searching a method that will be most appropriate in a given project situation. This approach and tool can also be used for other software development activities.

Keywords: Method, Software development, Cooperation, Knowledge Transfer.

1 Introduction

Software systems are getting increasingly complicated today; the knowledge needed for the implementation is vast and unlikely to be held by any individual software developers [7]. Methods and techniques for software development are normally general in nature and they can not be used directly without adapting them according to the characteristics of the project. It is also important for the software engineers to learn from their own past experience as well as experience of others. Therefore, there is a need to enhance the cooperation among software developers and software development organizations must have a mechanism to support the sharing of knowledge held by different software developers to remain competitive.

In this paper, an approach to enhance cooperation and knowledge sharing among software developers is proposed with the help of a web-based tool. Methods that are used successfully in past projects, along with project characteristics, can be stored and shared with the help of this tool. This tool also provides support for the reuse of existing methods to create new methods.

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This paper is organized as follows: In next section, criteria to classify different requirement elicitation techniques are established. In section 3, use of the tool for storing and sharing the methods is explained. Finally, the paper concludes in section 4.

2 Criteria for Classifying Requirement Elicitation Techniques

IEEE [5] defines requirements engineering as the process of studying user needs to arrive at a definition of whole system requirements. There are variety of techniques that can be used to understand user and stakeholder requirements. Because of the relative strengths and weaknesses of the available approaches, most projects require a combination of several techniques in order to produce quality results [6]. Clearly requirement elicitation does not occur in a vacuum and is highly dependent on some characteristics [3]. We studied different requirement elicitation techniques and their suitability in different project situations. With this knowledge, following criteria are formed to classify different requirement elicitation techniques.

- Experience of the requirement engineer
- Requirement elicitation period
- Experience level of the company's customer
- Possibility of meeting between development team and customers
- Project budget
- Project's user interaction level
- Project Complexity

3 Tool Description

A new, user friendly and progressive web-based tool for requirement engineering phase is designed to demonstrate the proposed solution. We preferred to develop a web-based tool because the project members can be in different physical locations still they can easily access it.

There are two types of user in the system as shown in Figure 1: admin and user. Admin can perform all the action which a normal user can perform. Additionally, admin can add/delete user(s) in the system, allocate password(s) to the users, delete a method.

Methods that are stored can be viewed by View Method module. User can search methods based on the criteria (explained in section 2) to best suit the project situation at hand. If the desired method is not found, our system enables user to create a new method. There are three ways to create a new method. A method can be created by an empty method template, by modifying a method stored in the repository and by combining two methods stored in the repository. This type of storage provides flexibility to the user to emphasize and transfer his/her experience. Methods are considered as a single, whole unit for reuse purpose because it is important for the user to see complete method so that he/she can understand it and if require can create a new method by updating an existing method or by assembling two methods.

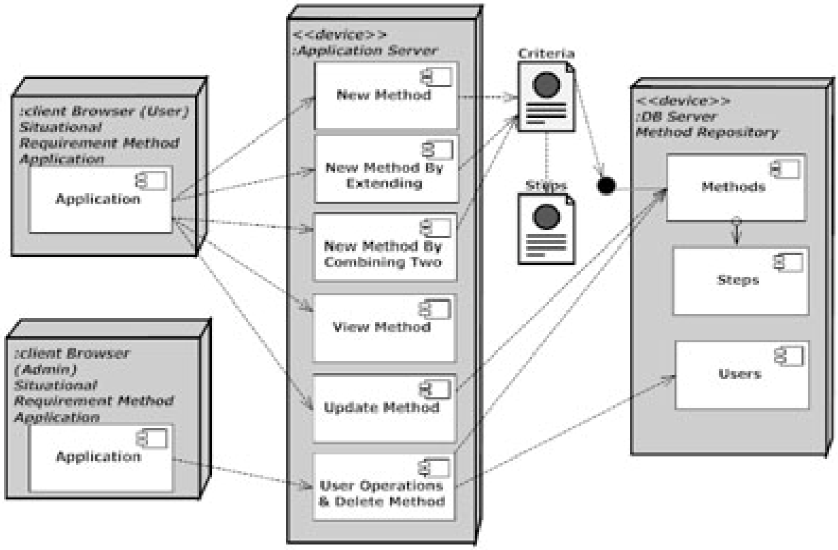

Fig. 1. Structure of the Tool

If user wants to add new method, it can be done by using "Add New Method" functionality. Method name is entered and the criteria related with the method are selected from the form then Add Step page is displayed to enter the steps of the method.

If user wants to add new method by extending an existing method stored in the system, "Add New Method By Extending One" functionality is used. It first lists all methods stored in the system then user selects the method and later the method information is listed. User is required to enter the new method name and asked to change the criteria for the new method (if required) and then change/add new steps.

If user wants to add new method by combining two methods stored in the system, "Add New Method By Combining Two" functionality is used. It first lists all methods stored in the system then user selects any two methods. After that the methods information are listed. User enters the new method name and selects the criteria and then selects the steps he/she wants to add from existing two methods he/she has chosen.

If user wants to update an existing method, Update Method module is used. All of the methods available in the system are listed in Update Method page. User selects the method he/she wants to update then all related information of the selected method is listed. First the criteria are updated then the steps are updated. Only the author of a method can update the method using the tool.

Although there exist several studies in the literature which explores situational method engineering but there are very few academic tool prototypes and tools to use for this issue. One of the tools for situational method engineering is Decamerone [2]. It has own language and interpreter so the user should learn the language of that tool to be able to use it. Another technique is the Noesis technique that allows recursive and decompositional structures to be captured in the meta-models and situational methods to be obtained by the assembly of method fragments [4]. This technique also requires more expertise to use. Our tool is more easy to use and flexible. Middle level expertise is enough for the usage.

James Martin & Co.'s CAME tool which supports many of seven features of Harmsen's [1] offers a choice of project objectives. Based on these, tool can generate an appropriate methodology. Despite this, our tool stores the methods as a whole so influence of user on the selected method is more than the other tools. Moreover, CMMI also supports storing lessons learned databases which can be facilitated by using our proposed tool.

4 Conclusion

It has been found that software developers are successfully tailoring standard software development methods according to their project situations. The main problem is that this knowledge and experience is not communicated to other people who might be facing the same project situations especially in small software development organizations. A simple and formal approach to method tailoring, and storage can solve this problem and developers can learn from each others experiences. This will also enhance their productivity. We have developed a simple approach for method storage, sharing and retrieval according to project characteristics with the help of a web-based tool. New methods can be developed from scratch, by extension or assembling existing methods. We applied this approach and tool specifically for requirement elicitation methods but this approach and tool can be applied for any software development phase.

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Architecture of the DICTE Collaboration Platform

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Abstract. The aim of the DICTE study is to pave the way for the practical implementation of a collaboration platform that addresses collaboration from both a cultural and technical perspective. This means that the DICTE platform needs to be user friendly (e.g. adequately performing) and have a well structured interface, so as to induce people to collaborate: this will be achieved providing a flexible and dynamic architecture. DICTE architecture design does not aim to offer a collection of collaborative services. The added value of the DICTE architecture is the middleware that supports the use of collaborative services and not the services themselves.

Keywords: Collaboration, knowledge sharing, collaborative platform, collaborative culture, roadmap, architecture, Web2.0.

1 Introduction

Diffusing Information and Collaboration Technologies in ESA (DICTE) is a study project commissioned by ESA under the General Study Programme with the overall objective to '*pave the way for a practical implementation of an ESA-wide technical collaboration platform, based on an advanced ICT infrastructure (e.g., very high speed connectivity, sharing of computing and storage resources, sharing of tools, common web based services).*'

The European Space Agency (ESA) is a geographically dispersed pan-European organisation with important operations, research and development divisions located in many different countries. Much of the project work involves multi-national consortia composed of ESA staff, independent scientists, academic institutions and industrial organisations working together to define and support space missions.

In the current study we have examined collaboration from the perspective of an essentially human activity that is influenced by wider cultural issues and aspects of working practices that are independent from the introduction of technology per se and

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which must be understood before we can reap the benefit of true collaboration. We present some conclusions arising from an analysis of the cultural issues (the first results of the DICTE study have been already published in a short paper [1]) that can influence the effectiveness of existing working practices in relation to the introduction of new technology. We proceed to describe the underlying requirements for an architecture to support a standard technological collaboration framework.

Section 2 gives an overview of the collaboration as we intend it and suggestions to achieve a good collaboration environment. Section 3 deeply presents the DICTE proposed architecture. Finally, in Section 4 conclusions are provided.

2 The Nature of Collaboration

It is a demonstrable fact that the introduction of technology alone will not create an efficient collaborative working environment, while on the contrary, true collaboration can flourish without the need for any new technology or radical overhaul of existing IT infrastructure. At the same time it is recognised that once collaborative working practices have been developed, accepted and adopted there are a wide range of technologies that can increase efficiency and magnify the benefits. The fact remains however; the collaborative ‘culture’ must come first.

Contributing freely to the communal knowledge base and participating in the open exchange of ideas and opinions is the basis of collaboration and relies on a higher level of participation than implied by mere cooperation or the simple coordination of project tasks. The effectiveness of collaborative working relies less on the choice of technology and specific tools than on making sure the nature of collaboration is understood, accepted and is encouraged by the prevailing organisational culture.

Applying this approach to the selection of technology, the objective becomes one of how to support collaboration while not enforcing the use of a narrow or prescribed set of tools. People must be able to collaborate using whatever tools are most convenient or familiar to them. This is in direct contrast to a demand for a change of working practices in order to incorporate a particular toolset. The selection of technology must assist collaboration without imposing working practices or placing artificial restrictions or limitations on participation [2].

There is an associated risk that instead of imposing restrictions to collaboration, the introduction of technology may, in fact, be an inducement to share more information than the participants feel comfortable with.. In other words, the extent and nature of collaboration is not universal and fixed - each project partnership or consortia will need the flexibility to decide on the appropriate level of collaboration in terms of sharing information and joint decision making. The rules that define this relationship – the nature of the collaboration – will be different for each collaboration and the eCollaborative infrastructure must support a flexible working model capable of implementing subtle distinctions based on user profiles and assigned roles and responsibilities.

A survey of attitudes to collaboration in ESA provided the basis for deriving user requirements for the technical architecture. The survey addressed the extent of current collaborative activities and questioned longer term future collaborative objectives. Individual attitudes to collaboration and current working practices reveal the prevailing ‘culture’ of the organisation and will have an important impact on any attempt to promote collaborative working.

The experience in ESA shows that while formal collaboration within projects is generally well supported there is a less informal collaboration within the organisation as a whole. Collaborative technology must support the ability to manage collective knowledge and whenever there are many distributed and heterogeneous sources of information the key problem becomes the interoperability between them. This issue needs to be addressed on at least three levels; the syntax level, the structural level and the semantic level.

Throughout this study DICTE has sought to concentrate on 'enabling technologies' rather than specific toolsets or collaboration utilities. An enabling technology may be described as a 'capability' upon which specific applications and services can be constructed. In the same way the proposed collaborative platform should be general enough to host any combination of collaborative services to support any type of collaboration.

3 Architecture

3.1 User Requirements

The requirements for the DICTE collaborative platform are driven by the need to satisfy ESA business objectives. ESA is not a commercial organisation in itself but is very important in representing a focus for excellence in space missions and related R&D. The multifarious business objectives can be stated as:

- Space mission planning and design
- Space mission operations
- Providing archiving facilities and access to mission (science) data
- Leading R&D in space technologies
- Public relations

Collaboration is crucial in all of these areas and includes knowledge management between domains and across the organisation as a whole. Collaboration in this sense is not defined by advanced communications technologies but represents the complex interactions of many hundreds of people working in very different but related fields. Leveraging the use of collective intelligence is the ultimate challenge for the DICTE collaborative platform.

3.2 Reference Architecture

A system architecture implies more than selecting a toolset and deciding which products to use, it represents the generic framework underpinning any number of specific implementations. The point of a Reference Architecture is to provide a template, a common vocabulary and a representation for the framework under discussion. The Reference Model of Open Distributed Architecture [3] and the *"4+1"* view model elaborated by prof. Philippe Krutchen [4] have been reviewd. However in the DCITE study we have adopted a methodology presented in a paper by Stefan Decker et al. [5]. This model has been adopted by the Open Collaboration Architecture (OCA) Working Group and is based around 'viewpoints'' that can serve the perspective of the people that refer to it.

- *User Level*: provides a basis for describing and understanding the functions a collaborative environment provides to its human end-users.
- *Building Block Level*: provides a basis for understanding the common high-level structure of collaborative environment software.
- *Sw InterfaceLlevel*: provides a basis for interoperability of software for collaborative environments.

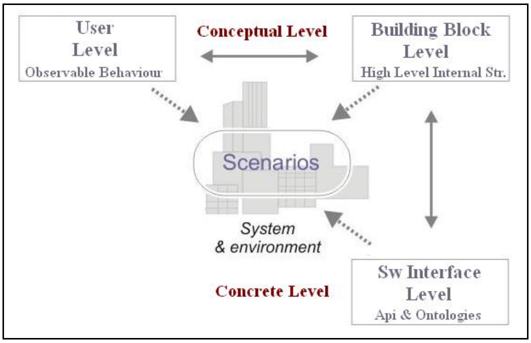

Fig. 1. OCA reference model architecture

3.3 DICTE Architecture

A primary objective for the DICTE architecture is to allow interoperability between distributed systems by the provision of basic collaboration services. We are not proposing to ‘integrate’ tools into a single monolithic application but advocate the use of existing systems (where they work and are liked by project members) within an environment where they can become part of the solution: interoperability is the key point.

A collaboration service is an abstraction of a collaborative ‘pattern’ or activity which is essentially a complex human interaction. These services are implemented following the principals that govern Service Oriented Architecture (SOA) – they are loosely coupled, discoverable and self-describing. Many collaboration services go even further in that they regard the network as the platform and their intrinsic value is proportional to the number of users. This approach is broadly in line with the Web2.0 paradigm. Table1 presents the User Level architecture viewpoint.

Table 1. DICTE User Level services arranged into six main groups

Grouping	Services
Administration	Problem/Knowledge tracking, Online Questionnaire, Statistics
Scientific Data	Search Data, Share Raw data, Share processed data, Exchange Information, Collaborative Data Processing Activities
Virtual Labs	Online Seminar, Project Workshop, Online Training Class
Meeting, etc	VOIP, Conference, Email, Virtual meeting, Chat
Workspace	File Sharing, Calendar, Skill Inventory, Project Control
Knowledge Capitalization	Wikis, Semantic web, Search Engine

It is important to make a distinction between four categories of services that we have identified:

- *Simple Services* are services like: email, IM, chat, calendar, file sharing, etc.
- *Data Services* include services strictly related to data production and consumption (very important issue in ESA)
- The *Semantic and Knowledge Services* are the ones related to semantic search and exploiting ad-hoc ontology.
- The *Complex Services* include the combination of two or more atomic services included in the previous blocks.

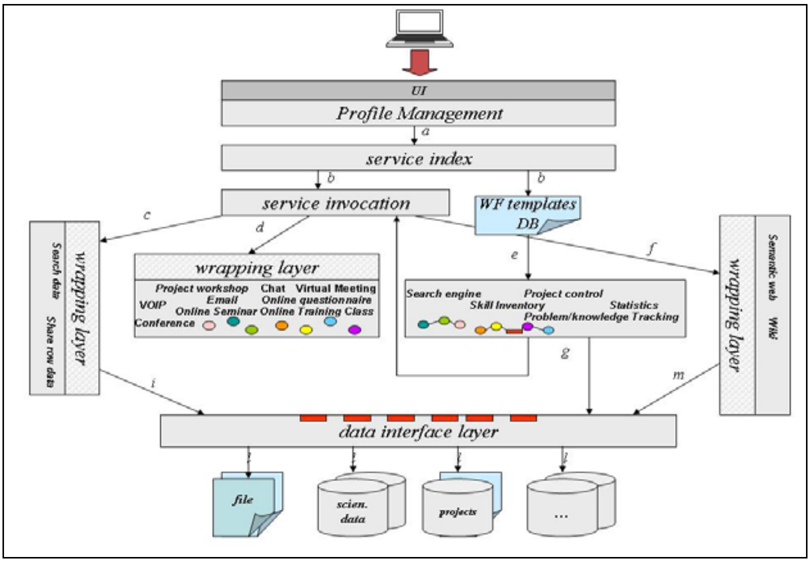

Fig. 2. The Building Block architecture illustrates the implementation of DICTE open SOA

Figure 2 illustrates the Building Block Layer. The User Interface is the access point to the DICTE platform. From the UI the user can choose the required service and specify any parameters. The UI service is bound to the Profile Management block which is responsible for maintaining user profiles, Virtual Organisations, etc. The Profile Management communicates with the Service Index **(a)** which is responsible to identify the chosen service and decide which kind of service it is. The service index can directly communicate with the Service Invocation **(b)** or it can communicate with the templates repository.

In Table 2 a short description of the building blocks involved in **(a)** and **(b)** is provided.

Table 2. Description of the First set of Architecture Building Blocks

Building Block	Short Description
User Interface	It should be accessible from the intranet and from the internet as well. It should be customizable depending on the user role and needs
Profile Management	Supports the creation and maintenance of transferable user profiles and Virtual Community ([6], [7]) that may be temporary or very long lived. A user should be able to be a member of many VC's but retains his unique identity across the entire environment.
Service Index	Each service offered by the DICTE platform should be registered in the Service Index. For each service it should be given a short description, a list of the interfaces and related parameters, a tag telling if the service is simple or complex.
Service Invocation	It is responsible for the invocation of the different type of services: it is responsible for the invocation of the simple services, the data services and the semantic & knowledge services. Each service is not directly called but the SI serves as a filter.
Workflow Template DB	It is a repository of workflow templates Complex services when registered in the Service Index, should come with a workflow template that should be stored in the WF database. In this way the complex service can be decomposed before executed.

The Service Invocation provides a middleware capable of connecting the applications with the simple services **(c)**, with the data services **(d)** and with the Semantic and Knowledge **(f)**. The Service Index, once a template is retrieved communicates with the Service Composition **(e)**.

In Table 3 a short description of the building blocks involved in **(i)**, **(g)** and **(m)** is provided.

The Service Composition can invoke, via the Service Invocation, Simple Services **(g)** or/and Data Interface Layer **(g)**. The semantic & knowledge layer the data interface layer **(m)**. It could take advantage of the service composition if needed **(n)**. The data service layer directly relates with the data interface layer **(i)**. The data interface layer offers a web service interface that enables data storage and data retrieval and hide the type of data **(l)**.

Table 3. Description of the Second set of Architecture Building Blocks

Building Block	Short Description
Wrapping Layer	It should ideally be able to offer a wrapping for every type of service available on the shelf. This means that the platform can use any implementation of a specific service; the wrapping layer will enable the communication with the upper invocation layer.
Simple Service	This block contains all the simple services available on the shelf. Such services are the ones like email, chat, calendar, etc. This block includes the services already available OTS and treats them as black boxes.
Data Service	This block includes the services that specifically deal with data manipulation. The services can be services already existing in ESA to upload and retrieve data. In addition new data manipulation services can be added.

In Table 4 a short description of the building blocks involved in **(c)**, **(d), (e)** and **(f)** is provided.

Table 4. Description of the Third set of Architecture Building Blocks

Building Block	Short Description
Semantic & Knowledge	This block includes the services related to semantic and knowledge (based on ontologies). In this block is included services like distributed search, skill inventory, etc.
Service Composition	The main functionality of this block is to reading, parsing and executing workflows. The workflow templates describe the behaviour of the complex services and they are mainly a sequence of steps that involve simple services and data, as explained so far.
Data Interface	This layer permits to hide, to the upper services, the kind of data, the way they should be retrieved, etc. The main functionality of this block is to hide complexity and to offers easy access to data, permitting to access different types of databases and repositories.

The User Level view and the Building Block view are strictly related even if the correlation between groups of services and building blocks is not one to one.

3.4 Validation

A number of use cases have been designed with the intention of validating the DICTE architecture. Analysis of the user requirements (derived from [1]) highlights a number of future scenarios that would need to be possible using any proposed collaborative platform. The selected use cases include:

1. Select/Use collaborative services from a standard palette available across the organization
2. Perform domain specific search across heterogeneous information repositories
3. Monitor collaborative service use and collect metrics to indicate real use and benefit of collaboration
4. Create, store, manage, locate and disseminate information using a standard ESA wide document and knowledge management utility

An available partial validation of the proposed reference architecture is given by the FLL, pre-existing to the DICTE study and that strongly contribute to the study [8].

4 Conclusion and Future Work

The DICTE study addresses the dichotomy implicit in the separate cultural and technical aspects that are essential to any form of eCollaboration. Cultural issues are shown to represent a barrier to collaboration whereby initiatives are often confined to particular groups and not made visible to the wider organization. This situation creates isolated pockets of collaboration governed by processes specific to individual business units. In turn, this lack of organizational level governance results in poor internal collaboration with groups not being aware of innovation pioneered in other places. General metrics on the success or efficiency of collaborative initiatives are either completely unknown or wildly inaccurate repressing only a piece of the picture. The culture of collaboration needs to be provided at the ESA organizational level breaking down barriers so that implementation can be achieved in shorter timescales and at lower cost.

The proposed DICTE collaborative platform is designed to be both technology and policy neutral in the form of an open Service Oriented Architecture capable of providing collaboration services to a wide variety of ESA domains.

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A Spatial Faithful Cooperative System Based on Mixed Presence Groupware Model

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Abstract. Traditional groupware platforms are found restrained and cumbersome for supporting geographically dispersed design collaboration. This paper starts with two groupware models, which are Single Display Groupware and Mixed Presence Groupware, and then discusses some of the limitations and argues how these limitations could possibly impair efficient communication among remote designers. Next, it suggests that the support for spatial faithfulness and Tangible User Interface (TUI) could help fill the gap between Face-to-Face (F2F) collaboration and computer-mediated remote collaboration. A spatial faithful groupware with TUI support is then developed to illustrate this concept.

Keywords: Spatial faithfulness, computer supported remote collaboration.

1 Introduction

With the booming of network and information technology, people could virtually collaborate anywhere in the world at any time. However, this convenience comes with a cost, which is the unfamiliar collaboration environment people have to get used to before they can benefit from it. As stated by Kock [1], human beings favor Face-to-Face (F2F) co-located communication since they have developed their sensory and motor organs extensively in F2F communication environment. The use of computer-mediated collaboration tools, such as groupware platforms, could lead to increased cognitive load, which might further compromise the results in remote collaboration.

Traditional remote collaboration technologies and platforms are found restrained and cumbersome for supporting geographically dispersed design activities [2]. For example, most conventional computers are designed for single user to use; therefore simultaneous input from multiple users is not properly supported. Alternative turn-taking mechanisms are either implemented by the platform or informally developed by designers.

This paper consists of five sections. Section 2 reviews the literature of two groupware models, Single Display Groupware (SDG) [3] and Mixed Presence Groupware (MPG) [4]. In section 3 some of the limitations in remote collaboration are discussed as compared to F2F co-located collaboration. Then a spatial faithful groupware with TUI support is carried out in section 4. Followed by conclusions in section 5.

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2 Related Work

2.1 Single Display Groupware

Single Display Groupware was initiated by Stewart, Bederson, & Druin [3]. This model allows each co-located designer to interact with the system. It consists of two major components: an independent input channel for each designer (e.g., keyboards and mice) and a shared output channel (e.g., a single display on each designer's side). Typical systems such as shared whiteboard with one shared monitor and single table-top applications fall into this category. The SDG model is one of the early attempts for creating a framework that enables collaborative work for collaborators who are physically close to each other.

SDG is a model for F2F collaboration thus it focuses on supporting co-located collaboration. Moreover, it points out several issues with existing systems for co-located collaboration and how these issues could be tackled. It is worth noticing these issues since they could be generalized to remote collaboration systems.

As suggested by the authors, one of the issues is that traditional computer systems did little to encourage collaboration among multiple designers. Apparently, this issue applies to remote design collaboration system as well. In order to solve this issue, SDG provides each user with individual keyboard and mouse as his/her individual input channel. Studies showed that individual input device could improve learning collaboration; even simultaneous input was not supported [5]. Having their own input devices made them feel they were involved and connected with each other, which encouraged them to participant. In remote design collaboration, improvements to these input channels might further encourage collaboration. *TUI* with *simultaneous user interaction* could be technological options for these improvements.

2.2 Mixed Presence Groupware

Mixed Presence Groupware [4], on the other hand, follows distributed groupware approach and extends SDG with distributed user interaction support. Both distributed and co-located users could work together in a shared virtual environment at the same time. This groupware system connects users from various physical sites through network. It visualizes remote users on displays in the shared collaboration virtual environments (CVEs) so that both co-located and remote users can perceive each other. Some systems use conventional PC monitors, which are considered to be insufficient to maintain awareness for collaboration [6, 7]. Others provide larger displays, such as tabletops and projection screens, to support better sense of immersion in the CVEs [8, 9, 10].

Despite the efforts with large displays to convey high fidelity of presence, Tang et al. [4] found two major limitations in MPG as compared to co-located groupware, which were display disparity and presence disparity. Display disparity refers to the discontinuity of the virtual space and the uncertainty of the orientation when homologous displays (such as horizontal tabletops and vertical displays) are used. Presence disparity refers to the different perception of the existence of others when others are remote. These two issues result in poor awareness and increased cognitive load. In order to address these two issues, various technologies have been developed.

Early systems like VideoWhiteboard [11] and Clearboard [9] allowed shared drawing and sketching activities. Shadows of each collaborator's arms and bodies were captured to maintain mutual awareness. In addition to that, Clearboard system allowed eye contact through a specialized half mirror polarizing film projection screen. By visualizing the content of drawing and remote users, better collaboration performance and presence could be achieved.

Other than improving the awareness and presence of collaborators, some systems took other approaches to highlight the awareness of the objects and the workplace. For instance, Distributed Designers' Outpost [12] and Blue-C [13] are two typical systems that focuse on post-it notes and tabletops. The former one employed transient ink to indicate changes made to the post-it notes; the later one further investigated half mirror projection screen and provided a spatially immersive environment with 3D stereo projection.

Recent research that concerns human behaviors tends to move towards the Human-Computer Interaction HCI that is also essential in effective remote design collaboration. As an example of this trend, TUIs have been widely integrated in remote collaboration systems. Styluses [14], multi-touch surface [15], and gestures [16] have been widely used to replace legacy keyboards and mice.

3 Issues in Remote Collaboration

Tuddenham and Robinson [10] suggested that many remote tabletop projects were inspired by co-located tabletop research (including SDG). CVEs tend to mimic physical F2F environments in order to reduce the cognitive load in users' brains. For example, the artificial shadows mentioned above afforded information about illumination and approximated positions of others, which is similar as F2F communication. However, due to the current technical difficulties, not all sensible stimulus can be replicated by network devices and computers. Senses of smells and tastes are two examples that computers cannot directly support. Some issues and limitations arise because of these difficulties, which lead to the gap between F2F collaboration (like SDG) and remote collaboration (like MPG).

Spatial faithfulness is one of the features that worth looking into to in order to fill the gap. Nguyen and Canny [17] defined three levels of spatial faithfulness, (1) Mutual spatial faithfulness, which simultaneously enables each observer to know if he/she is receiving attention from other observers/objects or not. (2) Partial spatial faithfulness, which provides a one-to-one mapping between the perceived direction and the actual direction (up, down, left or right) to the observers. (3) Full spatial faithfulness, which is an extension to partial spatial faithful systems. It provides this one-to-one mapping to both observers and objects. As shown in Figure 1, F2F collaboration provides full spatial faithfulness according to this definition while most remote collaboration systems only support mutual or partial spatial faithfulness. Hence, these systems cannot precisely preserve clues like directions and orientations to each user. Consequently, perspective invariance [18, 19] can happen, which interferes correct awareness of the environments. This phenomenon occurs when images and streaming videos of remote users are taken from inconsistent angles, from which the local users perceive these images or videos. This might lead to misunderstandings as illustrated in Figure 1(b).

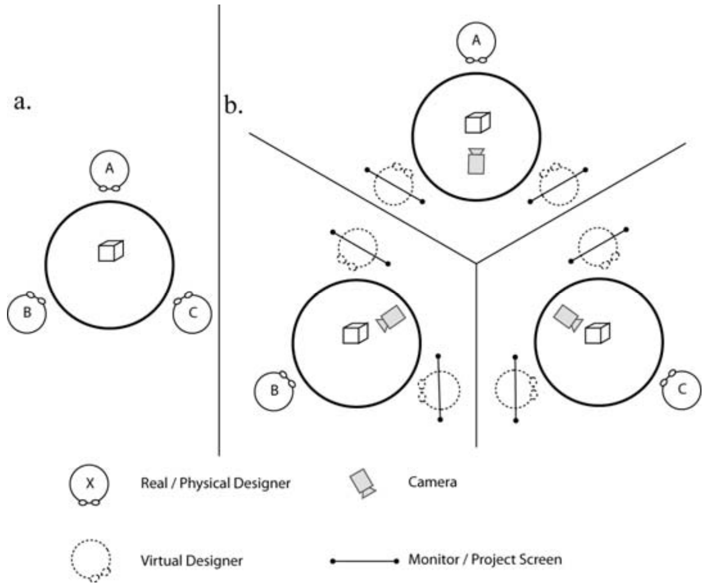

Fig. 1. Overview of various collaboration system setups: a) co-located F2F environment, b) MPG system

Suppose three users are using remote collaboration groupware platforms for a design task. They would like to perceive each other as if they are talking F2F. Typically, a camera, which faces the local user, is used at each site to capture the streaming videos of the local user for both remote users. Additionally, two monitors or projection screens facing local user are used to display the videos received from the corresponding remote user. When A looks at his/her front direction, both audiences B and C will have the feeling that A is watching them even they have different virtual positions in the CVE. However, what they would expect and recognize in their brains is something like Figure 1(a), in which everyone perceives others' gaze correctly. The perspective invariance would cause false impression to the users and lead to distorted mental space of the working environment. It requires additional cognitive process to map the direction faithfully in their minds.

Another limitation is the sense of touch in remote collaboration systems. Many traditional remote collaboration systems support conventional PC and imply the keyboard/mouse approach as the Human-Computer Interaction (HCI) method. However, other novel approaches emerge for supporting different interaction methods and better user experience. *Tangible User Interface* [20] and *simultaneous user interaction* are two typical types of novel interactions that could be supported in remote collaboration.

Experiments showed that *TUI*s could affect designers' spatial cognition and creative design processes in 3D design [21]. Designers work together to design goods and products. The final products could be tangible, for instance, dresses, furniture, and buildings. Also they could be intangible, for instance, ideas, poetry, and music. Both forms of the collaboration could benefit from *TUI*.

For tangible products, designers could naturally create and manipulate 3D objects through gesture interactions powered by *TUI*s. This intuitive perception of the tangible products could help to reduce spatial cognition load and thus enhance design creativity. On the other hand, for intangible design tasks, *TUI*s could visualize design information and context so that designers could have some concrete impressions other than abstract concepts. For example, designers who write poetry might be able to move the words around to easily compose phrases and sentences through *TUI*s. Such interaction paradigm facilitates brainstorming to generate new ideas.

Simultaneous user interaction is another interaction paradigm that remote design collaboration systems should support. Unlike remote training and education systems where a small portion of users (trainers and teachers) dominates the interactions, remote collaboration systems require and value each designer's participation. Remote collaboration in the context of this paper mainly refers to synchronous collaboration, where users could communicate back and forth at the same time. Therefore, simultaneous input from designers should be coordinated properly as if they are expressing their ideas in F2F environment. In this case, both efficiency and simultaneous interactions could be achieved.

4 A Conceptualized System for Remote Collaboration

The issues mentioned above implies a new design of remote collaboration system, which supports full spatial faithfulness, the use of TUI and concurrent multiple inputs. By adopting these technologies, the system could mimic F2F environment and provide remote collaborators with a better immersive environment.

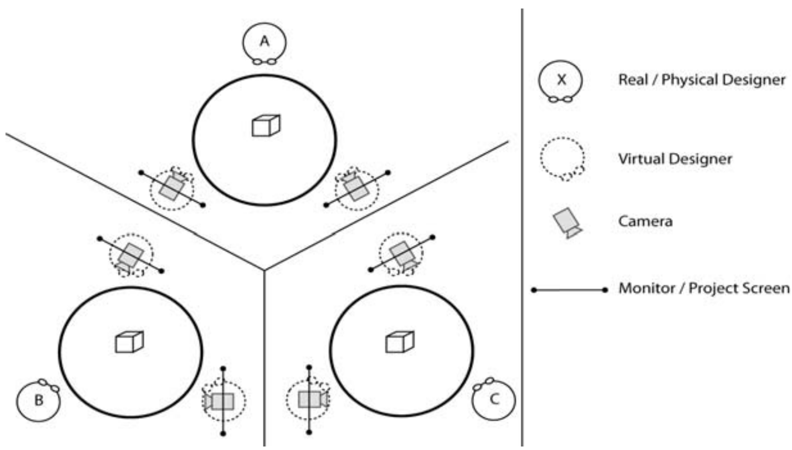

Fig. 2. Proposed remote collaboration system with full spatial faithfulness and TUI support

Figure 2 depicts the concept for this system. It extends the MPG and provides a higher level of presence with regards to full spatial faithfulness. Three remote users collaborate in a shared virtual environment. Multiple cameras and displays are leveraged to embody the virtual perspectives and locations of the remote users. Each pair of the camera and display is used to capture the local user to one corresponding remote user and show the streaming video of the same remote user. The seats are evenly distributed around the round table to ensure the consistency over three sites. Thus, if B and C are looking at A, all the three users can correctly recognize this.

In addition, the round table is a horizontal tabletop to facilitate object manipulation through gestures. This setup could eliminate the display disparity problem discussed above. Users could move, rotate the digital objects on the tabletop by their hands and fingers as if they are physical ones. Some advanced operations like resizing, deletion, and duplication are also supported for convenient cooperation. This provides users intuitive perception of both the objects and others in the shared environment. It helps reduce spatial cognition load by implementing spatial faithful clues and tangible interfaces support.

This system could be easily extended to support collaborations among more than three users. In practice, each site could arrange certain amount of seats in advance, for example ten seats. During the collaboration, people can freely join others whenever there is an empty seat, which has not been taken by a local or remote user.

5 Conclusion

This paper discussed some issues in remote collaboration systems. These issues were raised due to certain technical difficulties, which resulted in the gap between co-located, face-to-face collaboration and remote collaboration. Spatial faithfulness and TUIs are suggested to help fill this gap and reduce the cognitive load of collaborators.

A conceptualized system is illustrated to help understand and address these issues. It is equipped with multiple cameras and tabletops to facilitate spatial faithfulness and natural gesture in remote collaboration. This system is at the concept stage and more experiments will be carried once a prototype is developed in the coming future.

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A Cooperative Group-Based Sensor Network for Environmental Monitoring

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Abstract. Sensor networks can be used in many types of environments. The environmental monitoring is one of the most used. Communications in sensor networks should be as efficient as possible and collaborative methods can enhance their performance. In this work, we propose a monitoring group-based sensor network which uses the cooperation between groups. When a group detects an event, it warns the alert, jointly with the parameters measured, to its neighboring groups. Cooperation with other groups could change the direction of the alert propagation and the level of the alert. According this cooperation, the sensor network will be efficient and the sensors will have a longer lifetime.

Keywords: cooperative group-based networks, environmental monitoring.

1 Introduction and Related Works

One of the main features of the sensor networks algorithms is their efficiency. Many sensor networks use an ad-hoc communication to a sink node [1]. This node is responsible for carrying out the management processes in the sensor network. When the data are managed, it sends information to the ad-hoc network. Sensors are also responsible for routing the information. The logic communication between the sensor network and the sink node is centralized. In these cases, the network intelligence rests on a single point and this gives the disadvantages of centralized networks.

A group-based network is a network split into groups or areas according to some features [2]. A group is a small number of interdependent nodes with complementary operations that interact in order to share resources or computation time, or to acquire content or data and produce joint results. So far, in this type of group-based networks when an event is detected by a node, the node sends this information to all members of the group. In addition, the groups can share information and the information can reach all nodes of the network. This feature is adequate if we want to distribute an event to the whole sensor network. An example from the same authors is given in [3].

A. Nosratinia et al. present a work about cooperative communication in wireless networks, but from the physical level point of view, in [4]. They show several techniques and conclude the work indicating that the wireless devices may increase their effective quality of service via cooperation. The work shown in [5] presents a cooperative architecture for sensor networks. The architecture is based on 6 layers. The

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first 3 layers are performed at the node and the next 3 layers require communication between nodes. The authors state that this type of networks can make improvements in: signal processing, communication, synchronization, geolocation, power saving, etc. Another work where the authors use cooperative sensor networks is presented in [6]. A stochastic sensor scheduling framework is applied to the position estimation of multiple emitter targets using a cooperative sensor network.

We have shown several works where the authors use the cooperative term to develop different node roles in the networks. In our case, we propose an environmental monitoring network based on the cooperation between groups. The events detected in a group will only be transmitted to the closest groups.

The rest of this paper is organized as follows. In section 2 is described the cooperative group-based network design. Section 3 shows its operation and messages exchanged. Finally, in section 4 we will show the conclusion and future works.

2 Cooperative Group-Based Sensor Network Description

This proposal of cooperative sensor networks is based on the group-based idea presented in [3] by J. Lloret et al. The group-based network formation is performed in the same manner but here we introduce cooperation issues. In addition, each group selects the best connection between neighbors through the proximity and the nodes' capacity [7]. In order to have an efficient group-based sensor network, the groups will communicate with their neighboring groups. When a group detects an event, it warns the alert, jointly with the parameters measured, routing the information to its neighboring groups (not to all groups) based on the position of each group. The position of the sensors (it could be entered manually or using GPS [8]) and a position-based routing algorithm [9] are used to know the group situation. Neighboring groups will reply to the first group if any of the parameters is changed in the place of that group in order to take the appropriate actions. Cooperation with other groups could change the direction of the alert propagation and the level of the alert.

In Fig. 1 shows a group-based topology example. In a group-based network, all groups will be aware of an event produced inside the Group 1. The network efficiency would be yet higher than in a regular topology [2]. But, in cooperative group-based networks this efficient is greater, because only the neighboring groups will be aware of it. The other groups could be in sleep mode. The sleep groups will be saving energy and they would not transmit unnecessary information.

3 Cooperative Group-Based Sensor Network Operation

We define 3 alert levels. *Level_1* means the maximum alert level and *Level_3* the lowest. This cooperative group-based architecture runs following the next steps:

1. A sensor detects a warning event.
2. It senses other parameters (it could be done using a multi-sensor).
3. The node assigns an alert level for each neighboring group and routes the information for each group using a position-based routing algorithm [9].
4. The destination group senses the same parameters when it receives the information.

5. If the parameters are close, the neighboring groups will accept the alert level, if they are not close, they change the level according to the measured parameters and send the new parameters to the source group.
6. When the source group receives the information, it analyzes the level that should give to the neighboring groups and sends them the new level. Then go to step 4.

Fig. 2 shows the flow chart of the steps explained. Taking into account Fig. 1 (right side), the messages sent are shown in Fig. 3. Let's imagine that a plague of insects produces an event in Group 1, and the other parameters sensed are the wind direction and speed (now called pIni). $Node_i$ calculates the level for each group and sends the

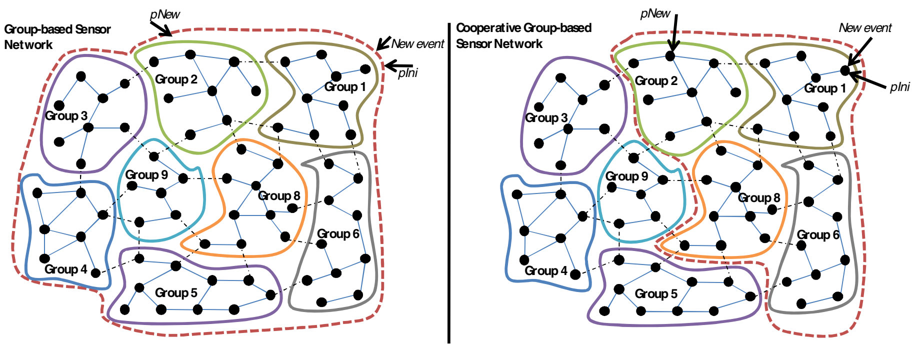

Fig. 1. Comparison of group-based and cooperative group-based sensor networks

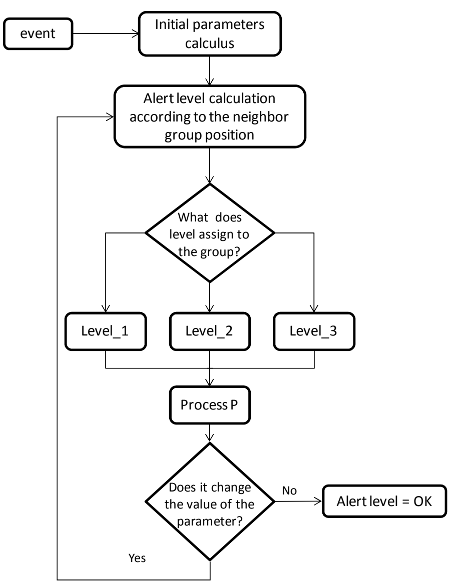

Fig. 2. Cooperative architecture operation

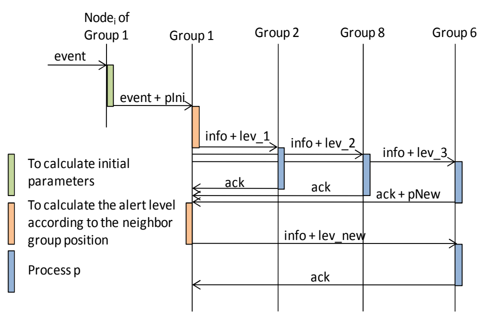

Fig. 3. Messages exchanged

```
If (pNew ≤ pIni*1.1 || pNew ≥
  pIni*0.9)
  Send ack to source group
  Alert level assigned = OK
Else
  Send ack + pNew
End
```

Fig. 4. Process p operation

alert and pIni to all nodes in its group. Each message will be also routed to the appropriate neighboring groups as in [3]. The information reaches Group 2, Group 8 and Group 6. Let's suppose that the wind comes from east, so Group 2 has *level_1*, Group 8 has *level_2* and the Group 6 has *level_3*. The *p* process is executed in each group when the information arrives. Fig. 4 shows the algorithm. If the parameters sensed are close to the initial parameters, the alert level does not vary. Let's suppose that Group 6 detects changes in the wind direction (pNew). This group will send the new wind direction to Group 1, and then this group will estimate the new alert level.

4 Conclusion

In this paper we have presented a cooperative group-based sensor network. When a sensor detects a new event, an alert is sent to its group and it is distributed to neighboring groups. The cooperation between groups is used to send messages between groups in order to obtain the right alert level. This system is going to be developed as a fire detection system where the wind, humidity and temperature parameters are also measured. There are other application environments such as Rural and agricultural monitoring and natural crisis.

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WAVA: A New Web Service for Automatic Video Data Flow Adaptation in Heterogeneous Collaborative Environments

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Abstract. The progressive needs of video streaming for different applications in varied domains have created a new set of heterogeneous environments especially in Virtual Collaborative Environments. In order to get the best performance of such environments, video streaming has to be adapted to the different parameters that characterize these environments, namely: bandwidth, CPU, GPU, screen resolution, etc. In this paper, we define a new Web Service, named Wava *(Web Service for Automatic Video Data Flows Adaptation)*. Wava allows multimedia platforms and collaborative application servers to adjust the adaptation at two levels: at the static level during initialization and at the dynamic level according to the variation of the environment.

Keywords: Adaptation, Asynchronous, Collaborative Environments, Multimedia, Real-time, Streaming, Synchronous, Terminal, Video, Web service.

1 Introduction

Multimedia environments providing access to media contents from heterogeneous environments are commonly called UMA "Universal Multimedia Access". In heterogeneous environments systems clients differ in their hardware and software capabilities and limitations. These differences might be found on the communication level, for example the variation of bandwidth from 50 kb to 20 Mb. Variations may also involve the terminal specifications *e.g.* CPU, memory, display capabilities and GPU encoding-decoding capacities. Therefore when we talk about video adaptation systems we should take all conditions into account. By heterogeneous applications we mean the variation of usage, entertainment or work (for example tele-medicine) and programming languages. These applications are distinguished beetween two types: synchronous and asynchronous applications. In order to solve these differences, and because we mostly work on the Internet, XML files and Web Services are involved.

In the first section of this paper we present the state of the art in this domain. In the following section, we define our new Web Service Wava *(Web Service for*

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Automatic Video Adaptation) which allows platforms to adapt the stream at two levels: at the static level (during initialization) and at the dynamic level according to the variation of the environment, and its performance. The last section presents the conclusion and future work.

2 State of the Art

The development of multimedia applications puts in evidence the necessity of new research. The arrival of HD video by the Internet and the increase of multiple formats of video generate a lot of studies in each part of this domain. In this section, we focus our study on adapatative systems and especially on UMA (Universal Media Access) systems based (Wang 2007).

2.1 Adaptation with the UMA Model

The General architecture of the UMA system consists of four main components described in (Wang 2007) and illustrated in the figure 1:

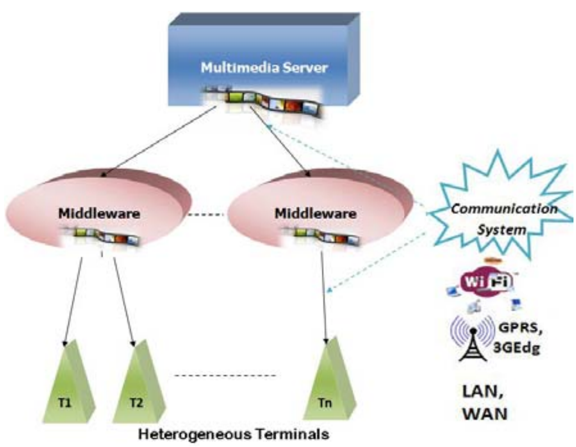

Fig. 1. UMA Adaptation System

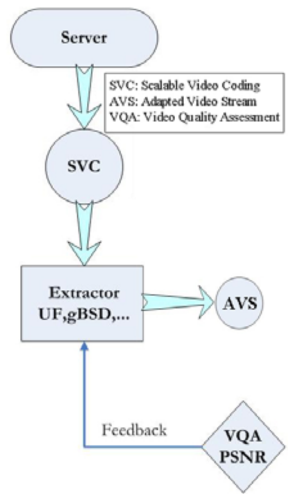

Fig. 2. System Chart

Multimedia server
Research which focuses on the adaptation aspect performed by the multimedia server (Prehofer 1999) considers the server is responsible of coding and forming the high quality Scalable Video bitstream (Sprljan 2005). That means that it can be scaled (adapted) to be in adequacy with specifications. In addition, the server can adapt the video. However, the adaptation process consumes larger amount of calculation power than a real time system can actually bear. In order to further adapt the video bitstream in a convenient way, the middleware has to

decode and then to recode the bitstream to the adapted format. Therefore, the server transmits specific bitstream description helping the middleware to avoid the decoding-recoding step. The server role in adaptation system can be summarized to, forming scalable bitstream (Sprljan 2005), performing adaptation, and transmitting video information with the SVC (figure 2).

Middleware

The main purpose of middleware is the adaptation process, it receives the scalable bitstream, operates the adaptation and then sends the scaled bitstream to the terminal. In real time systems, studies are concentrated on middleware and proposed adaptation solutions like UF *(Utility Function)* *(Chang 2002)*, *(Kim 2005)*, *(Wang 2007) or gBSD* (generic Bitstream Synt. Desc.) (Iqbal 2007). The main factor used in the adaptation process is the constraints (Feedback) received from the terminal. The feedback consists of terminal-transmitted information necessary for helping the middleware in the adaptation process to choose the right video bitstream.

Communication system

The revolution of communication systems in the last decade has created various media, paved the way for real-time Collaborative systems. From this viewpoint, it is very important to analyze the communication mediums for the adaptation. Terminals can use a medium to communicate and pass to an other. This step is the main reason for performing the adaptation. For example, a mobile client could change his Internet connection from GPRS to Wi-Fi (Ruiz 2002). If the system allows a client to notify the system of these changes, it is called an adaptable system. If the system is able to notify itself about the changes of the environment, it is called an adaptive system.

Terminal

In addition to decoding the video, terminals have one of the most important tasks in adaptation systems that is creating feedback. Terminal application has to calculate the feedback and send it to the middleware or the server, which in turn should make the right decision. Many factors can influence the feedback, such as computation capacity of the terminal or free resources to store video and others. The most important resources to take into account are: Bandwidth and its variation, the available RAM and Hard disk capacity to store buffered video, the CPU capacity and load, ang GPU Capacity for Displayable Resolution and codecs supported Software.

Feedback is the major factor to choose the adapted video, many techniques are used to calculate it: produced as a mark from the terminal, created either by testing the hardware of a terminal or by using mathematical methods such as PSNR (Wang 2004) or VQA (Zhai 2008) (see part 2.4).

2.2 Use of Adaptation in Video Applications

Collaborative environments are used more and more due to the increase of data transmission capacity. Now a user can easily be noticed by chat or voice-chat, and more and more by video-conferencing. Video applications vary from entertainment purposes like watching films on VOD and channels of television but also for medical applications, such as video conferencing for Telediagnosis(Jung 2005), e-learning... These applications are classified in two main categories, real time (synchronous) video applications and stored video (asynchronous) applications.

Stored video applications. Thess kind of applications are easier to perform, there is no need to consider the time factor in all parts of the system. A video is available on the server and the application has to adapt it with terminal capabilities.

Real time applications. These applications need special solutions to ensure the time contract and quality of service are respected. Collaborative applications must ensure synchronous data exchange and consistency. The obvious the goal of the middleware is: saving time for the adaptation process.

2.3 Multidimensional Video Adaptation

In terms of performance, the adaptation process has three main factors or three main dimensions which are: time, resolution, and quality. And they are referred as: temporal, spatial and SNR, respectively:

- Temporal (Kropfberger 2004) and (Leopold 2003): Frame rate (from 1 up to 30 fps fig. 3a.)
- Spatial: Screen and GPU Resolution capabilities (figure 3b.)
- SNR: Signal-to-Noise Ratio (Low, mid, high): Extended for video by PSNR and VQA in depth.

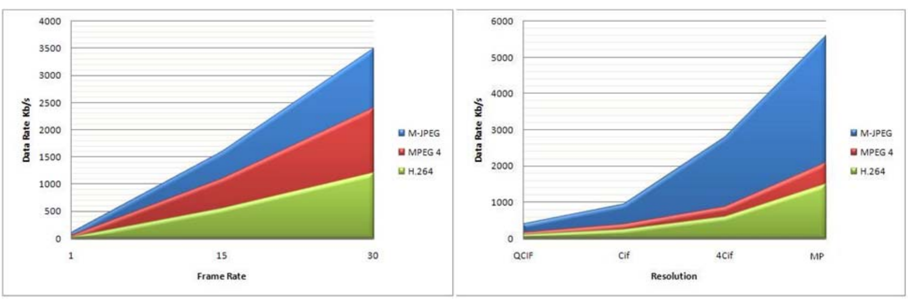

Fig. 3. Bandwidth consumption depending on: a. Frame rate and b. Resolution

2.4 PSNR and VQA in Depth

PSNR: Peak Signal to Noise Ratio is a method to calculate the noise ratio of a signal depending on the measurement of MSE (Mean Squared error) (Wang 2004). However, PSNR does not compute the real performance of a video stream. For this reason, it is not applicable to measure the performance of the multidimensional video adaptation process. Furthermore, it has been proven that there can be different videos with different qualities that have the same PSNR. These experiments was correlated by HVS (Human Visual System) in (Zhai 2008), which depends on human notice for giving the result. HVS is also called perceptually VQA.

VQA: Video Quality Assessment is a value that is calculated in subjective(HVS) or objective (mathematical) manner (Zhai 2008). In this paper, we focus on the objective method in calculating VQA, because it can be calculated mathematically. The differences between these VQA types are the amount of video features sent with the adapted video.

3 A New Web Service for Automatic Video Adaptation: WAVA

When users have to communicate, they do not have to be impacted by the weaknesses of the others. Clients does not feel the latency of the adaptation process. But hey can not determine themselves the optimal feedback all the time. With regard to this, we propose a solution that automatically and periodically detects the changes of the environment without user's interaction. In order to provide transparent processing, enhance the performance and facilitate the usage of the system, we propose the following architecture.

3.1 WAVA Architecture

In the beginning of our work, we used a client-server JAVA application, where the client sends his mark manually and the server reacts according to this mark. We automatized this process by making a simple detection of the load of the CPU and the network congestion. In another experience, we created a client application that reads the terminal performances (CPU frequency and load, Screen resolution, network bandwidth) and sends the corresponding mark to the server. The latency generated by the calculation did not allow an efficient and satisfactory work. Furthermore in a collaborative environments, heterogeneous client can connect to the system. The best solution to resolve this problem is the use of Web Services. Because of their portability and independence from programming languages, Web Services can handle any kind of platforms. Furthermore, we save the feedback calculation time of the terminal. When the client chooses a video, the collaborative system automatically detects terminals performances with the WAVA marks and sends back adapted videos.

So we propose a new Web Service design that detects each terminal property and calculates the related mark. Depending on this mark, the server decides whether it sends a high or low quality video matching the terminal's exigences. The quality is determined by the decrease of the resolution and frame rate. It is possible to integrate this system in a web page with a script that reads the terminal performance and sends an XML file in a Virtual Awareness Card

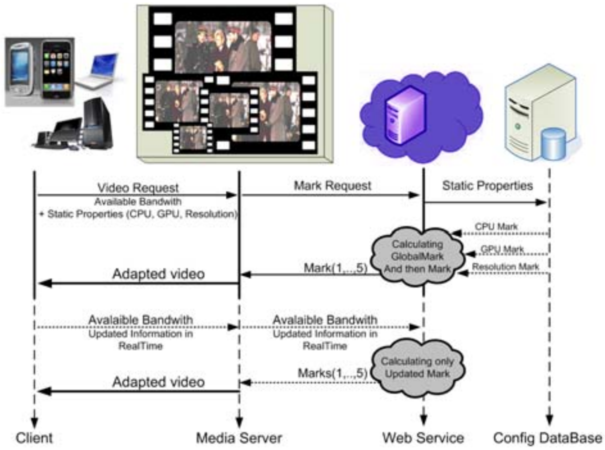

Fig. 4. WAVA Processing

format like in (Aupet 2009) to the WAVA web service. Subsequently WAVA uses an algorithm to produce the corresponding mark. At the media server we have two choices. The first is to make a video pool that contains all the videos in all the codec formats, which match with all the marks: the same video will be repeated for all formats. The second choice is to use one video source that would be converted in real-time either by the server or by the middleware to adapt it to the marks received from the Web Service. We have chosen the second solution for the video conferences, where we have the camera as the only source. So we directly adapt the stream to match the feedback.

3.2 WAVA Processing

The *Mark* represents the terminal performance. We classify CPUs, graphic cards, resolutions, and bandwidth into groups. Each group contains the individuals that perform in an identical manner in terms of video streaming. Then, a mark is attached to each group. We apply this design by using a database which stores devices attaching to their marks. The database is automatically filled with the unknown devices of terminal by giving a mark calculated with the average mark of the terminal performance. We distinguish two categories of mark: the static mark that does not change during a session, we call them Global Marks (Mg). This mark refers to CPU (Mcpu), resolution (Mres), and graphic card (Mgrph), and obviously remain unchangeable during one session. Mg is calculated as the minimum value of Mcpu, Mres and Mgrph. The second category of mark is the dynamic mark that refers to the bandwidth (Mbw) that changes during the video streaming session. In order to get the final mark (M), we calculate the minimum value between Mg and Mbw.

We always use the smallest value because we need the system work optimally: we adapt our collaborative system to the weakest value. After calculating the

```
If INIT then
    Read from data base (Mcpu,Mres,Mgrph)
    Mg = min (Mcpu,Mres,Mgrph)
    Calculate (Mbw)
    M = min (Mg  , Mbw)
    Return (M)
Else
    Calculate (Mbw)
    M = min (Mg ,Mbw)
    Return (M)
EndIf
```

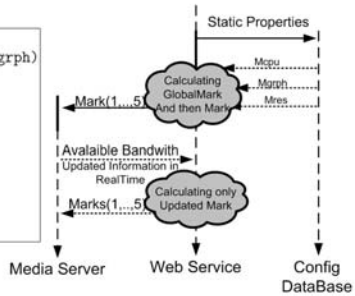

Fig. 5. Wava Algorithm

mark, WAVA sends it and saves the global mark. Periodically WAVA receives the bandwidth information of users, calculate the new Mbw, then calculates the mark which remains the minimum between the Mg and the updated Mbw.

3.3 WAVA Performance

In order to test our system, we make a pool of videos in different formats to test several terminals. With these videos we have tested the proportion of packet loss during the streaming transfer. We used the Mpeg-H.264 codec to produce these videos in five different qualities. We changed the resolution and frame rate. Results are in the figure 6a.

Periodically the bandwidth mark is sent and the new adaptation mark is updated to provide the best video quality that fits the real conditions of the user. We describe a scenario-based test (fig. 7) to show the decrease of packets loss by using WAVA Web Service. We can show the technical performance of WAVA in figure 6b. In facts, when the adaptation is well done, participants can work efficiently.

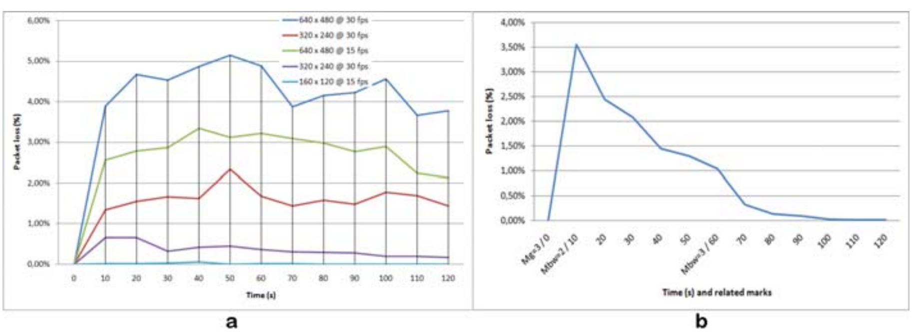

Fig. 6. a.Packets loss - b.Wava Performance

```
Init :
    CPU == P3 && RES == 4CIF && GPU == GeForce256
     Mcpu = 4 ;   Mres = 3 ;    Mgpu = 3 ;
     Mglobal = min(Mcpu,Mres,Mgpu);
     SendMark (Mglobal);  //Adaptation with Mark=3
OnStart :  DetectBandwith(BW);
 BW == 512 Kb
     Mbw = 2 ;  Mark = min (Mglobal , Mbw);
    SendMark (Mark);  //Adaptation with Mark=2
every min  : DetectBandwith(BW);
    BW == 2 Mb
    Mbw = 3;
     Mark = min (Mg , Mb);
     SendMark (Mark);    //Adaptation with Mark=3
End
```

Fig. 7. Scenario-based Test

4 Conclusion and Future Work

In this paper, we showed that video adaptation is one of the main matters of multimedia development in heterogeneous collaborative environments. Therefore researche has been conducted in this domain which focused on the UMA model. We proposed a new Web Service based system for automatic video adaptation (WAVA). The Web Service is used to calculate the best adaptation that matches the system capabilities, for both, static parameters (during initialization) and dynamic parameters depending on the variation of the environment. We implemented and tested our system, and we exposed the performance results. Wava significantly improves the use of mobile terminals for collaborative work.
Our future work focuses on how to test Wava not only with a mark for each terminal, but also for a whole collaborative environment. We imagine a process to adapt media during a session of medical tele-diagnosis between remote mobile practitioners: we are working on new distributed algorithms for shared marks calculation and optimising adaptation to each participant.

Acknowledgements

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Test Suite Cooperative Framework on Software Quality

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Abstract. Software testing has gradually played an important role in controlling the quality of software product. In this paper, we study the characteristics of test suites in software testing and analyze their structure. A novel test suite cooperative framework is presented for software testing based on the existing test suite. The framework can analyze different test suites with ontology and taxonomy, and help cooperation among the test suites to some extent. A tool has been developed with .NET platform to meet the requirements of designing cooperative test suite in software testing projects.

Keywords: Test suite, cooperative design, software testing, software quality.

1 Introduction

Nowadays, software has been an important part in enterprise information system. Software testing is one of the key factors in software development and maintenance. The software with low quality will lead to failure of information system [1]. There are many measures to improve software quality, such as reviewing, auditing, testing, and so on. The quality of software testing has great effect on the quality of the software product [2].

Therefore, a lot of research efforts have been devoted to improve software process quality and software product quality, especially in the area of software testing. According to investigation in the prevalent software life cycle, the software testing process is as important as software development process. In some critical applications and regions, such as real-time control system and embedded system, the process of software testing is superior to the process of development. Also, the importance of software quality control is more significant [3]. Therefore, software testing is the most effective means in software quality control.

For software testing, a test suite guides the test engineer to execute the test script with the relevant testing data [4]. Furthermore, one test suite is the basic minimal test unit to support special function requirements or non-function requirements [5]. Essentially, in software testing, the quality of test suite is considered as a critical factor. In other words, test suite with high quality can find more malfunctions, which are inconsistent with the requirements. Generally, a test suite consists of some test cases which are intended to test specific behaviors related in the requirements [6]. As we can see, a

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typical test suite usually not only includes collection of test cases, but also includes test purpose, test scenario, test oracle, test requirement, system configuration to be used during test execution activity, and so on.

A test suite is usually created on the basis of test purposes and requirements, which are defined by test engineers. The test cases are designed in details, while the test data are generated on the basis of test scenario. Test scenarios serve as the test preparation for the consecutive execution of test cases. Finally the test script will be constructed according to test cases.

During the software testing, the test suite design is always regarded as an important stage. In a software project, engineers work a lot on the test suite design, of which the workload is close to the workload of the software development. Thus, if the time of test suite design can be saved, the software testing efficiency can be improved. In this paper, we adopt a cooperative model to reuse existing test suites. The next section will introduce the test suite cooperative framework and section three will describe the tool implementation. The last section concludes the paper.

2 Test Suite Cooperative Framework

The cooperative test suite framework is shown in Figure 1, which demonstrates the principle of inter-operation among the test suites.

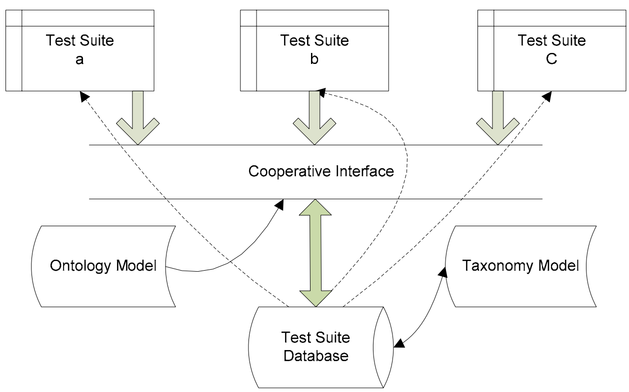

Fig. 1. Test suite cooperative framework

The framework is composed by a set of specific test suites, the cooperative interface and a fundamental database. The test suites should conform to the standard pattern defined in [8] with five basic elements: the test description, test scenario, a set of test cases, test input, and the test oracle.

The cooperative interface is located between the test suite layer and the fundamental database layer. The fundamental database provides information about historical test suites. There are two models that support the inter-operation of test suites. These two models are the ontology model and the taxonomy model. The ontology model is to provide conflict resolution or difference analysis among test suites, which have the same function or relevant functions. The taxonomy model is for improving the cooperative level for similar software categories.

The ontology model (OM) resolves the semantic description for test suites. The test suites include some important descriptive information for the function points. Engineers could find the most suitable keywords through the descriptive information. However different keywords for the same description may make it hard for the engineers to understand and design the test suites [9]. Therefore, the ontology model can help to guarantee the original meaning among all the test suites.

The taxonomy model (TM) improves the cooperative level among test suits. In the test suite description, application field is a category, which denotes the regions of tested software. Obviously, considering the same region in a category, for example, a finance application and an insurance application, the business process in function requirements can be similar. Thus, the functions in the similar application regions can be cooperative among their test suites, especially in test scenarios and test procedures.

In order to understand the cooperative flow of test suite among different designers, a typical process is shown in Figure 2. The flow of cooperation contains two paths. One is the keyword transform based on ontology model, and the other is the category analysis based on the taxonomy model. The keyword and category are recognized as indispensable descriptions for a cooperative test suite.

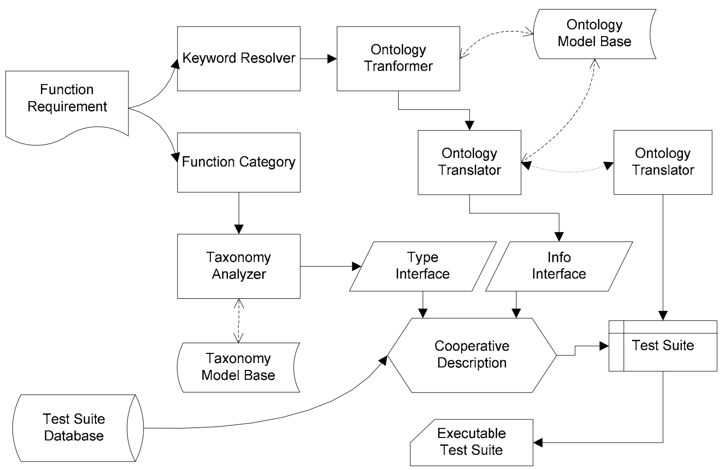

Fig. 2. Typical flows of test suite cooperation

3 Tool Implementation

A tool using cooperative design for test suite has been developed successfully in our test suite library project with .NET platform. The tool implements three main modules. The first is the cooperative module which supports the test suite cooperation based on a fundamental test suite database. The second is the management module which manages the present test suites and the historical test suites in the project. The last one is the executive module which provides the interface to record and replay the test suites.

The cooperative module has been developed using our cooperative framework. In practical test projects, test suites are classified into ten regions and an ontology model is created. The test suite database has more than 1000 test suites. Each test suite consists of at least ten test cases approximately. According to the statistics of finished test projects, the cooperative module could reduce 20-30% design time and improve the test efficiency substantially.

4 Conclusion

In this paper, we present a cooperative supporting framework for software testing suit design, which has been implemented based on ontology and taxonomy. We have used the framework in our practical software testing projects. The result shows that the framework can improve the efficiency substantially. In the future, we plan to study the cooperative method for test data in software testing to further improve the software testing efficiency.

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Model Based Testing for Horizontal and Vertical Collaboration in Embedded Systems Development

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Abstract. While model based development is common practice in software industry, model based testing is only at an emerging stage, though very promising in terms of production flexibility, collaboration support, and output quality. We present a new approach for automating the validation of critical and complex embedded systems, based on a dedicated language, TBSL (for Test Bench Scripting Language), used to derive test sequences from the modeling of the system under test and the properties to check. TBSL allows both updating easily tests sequences according to the evolution of the system and its use requirements, and solving operational issues related to the different level of abstraction between textual specifications and effective test routines. It is integrated in a collaborative programming framework and has been proofed in validating high-class sensor prototypes for the automotive industry.

Keywords: Model Based Testing; Collaborative test; Embedded systems.

1 Introduction

From early stage of conception to commercial releases, the test of smart systems such as sensors used in automotive industry has become crucial. As a matter of fact, these products embed more and more intelligence and cutting edge applications, whereas the complexity of their controlling software increases exponentially with each additional feature [1]. In whole, their life cycle faces 3 main challenges involving test issues: (1) in order to timely respond to the market with stable and robust solutions, embedded software applications have to be validated before their hardware support is available; (2) all functionalities with their exponential number of use cases are to be tested as exhaustively as possible to ensure safety of numerous critical applications and avoid customers dissatisfaction; (3) test phases must be re-run for every new release of the product required both by new integrations (e.g. automotive sensors successively bought by different car makers) and by its own evolution cycle.

Tests are commonly divided in validation, which ensures that functional and other usage requirements are met, and verification, which checks that every life cycle step yields the right product. Typically, validation and verification require multiple procedures related to the elementary functionalities of the product [2], and every modification in the product is to be incorporated in a set of interdependent test procedures. As

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a result, tests are invalid until all procedures are completed, which overburdens the testing process, and delays the commercial releases of the product. Such constraints are thus particularly inappropriate to nowadays' powerful systems, which integrate a lot of software, making changes readily available.

The situation calls therefore for automated testing tools with following capabilities:

- thorough process of a whole product according to its specifications
- automatic determination of tests necessary to meet specified criteria
- easy update to accommodate frequent changes performed on the product.

As shown in the remainder, more straightforward and efficient test procedures will also be better integrated in the collaborative development cycle of the product.

2 Collaborative Model Based Testing

In traditional local testing, for each task, test sequences are first defined according to the properties to check. Then, though almost entirely controlled by computer, they are executed manually and separately on the test bench made of the system under test (SUT) and all auxiliary peripherals (like power supplier, environmental equipment, dedicated software) [3]. Automating test procedures will consists therefore in building a unified software framework that will allow extracting tests sequences from abstract specifications, executing them through interfaces with the physical test bench, and controlling and monitoring the automatic execution through a dedicated user interface. Thanks to this centralized framework, the different industrial actors who collaborate horizontally to develop a set of functionalities, of vertically to integrate multifunctional layers in a single product, will also be able to improve their collaboration for the testing of the integrated product.

It is today common practice in software development to begin with building a model of the targeted application, showing the architecture, functionalities and interdependencies. Out of this model, application components are straightforwardly generated, or manually implemented. Similarly, Model Driven Testing (MDT) creates models of the behavior of a SUT, and uses generation tools for automatically deriving a set of computer-readable tests. These sets are further deployed to check for success or failure [4]. However, the theory of MDT is still an evolving field, with two practical unresolved issues. First, test cases derived from the model are on the same high level of abstraction as the model, and cannot be directly executed on concrete test benches essentially made of a low-level communications. Second, testing of a whole system is an experimental process, based on empirical heuristics that cannot be integrated in a general model or a generation tool. Consequently, there is no available MDT test environment suitable for a complex system developed on standard hardware/software interfaces such as CAN, LIN, or MOST [3,4].

By contrast, we develop a collaborative model based testing (CMBT) approach that resorts to abstract modeling as a reference to unify the objects and procedures involved in the test bench, but uses an intermediary layer to process different levels of abstraction. This intermediary layer gives freedom to parameter and adjust test sequences. It is realized by a dedicated language, called Test Bench Scripting Language (TBSL).

3 Test Bench Scripting Language

As an alternative to automatic test generation, TBSL constitutes the kernel of the CMBT approach, and allows parametric building up of test sequences. The challenge is to keep enough genericity to interpret the high-level requirements of a wide range of hardware devices and use-cases, while processing them into machine executable instructions. Developed on XML format, TBSL is an extended scripting language that includes 3 basic semantic categories of items: (1) definitions of low-level drivers (2) extendable test description elements (3) execution instructions linking the items of the 2 preceding categories. It is implemented into 3 separate modules.

The high-level interface accepts as inputs specifications and properties models written in UML and extracts the information into category 2 items. In embedded software engineering, several approaches are based on UML to describe complex systems with their properties, and extract test patterns. In particular, [5] represents the SUT and test use-cases in the shape of constrained state diagrams that are in turn described in UML format. Such information from UML can be compiled into TBSL items through the XMI intermediary format.

The graphical user interface (GUI) allows the non-computer specialist to program tests sequences from categories 2 and 3 items with high-level commands. It also contains a database for archiving and retrieving test sets. Thus, some standardized packages, like the ISO UDS (Unified Diagnostic Services) test protocol for automotive industry are ready to include and parameterize in a new TBSL program. This module is responsible for ensuring the coherence of the data from the different abstraction levels (model instances, checking heuristics, machine instructions).

The low-level interface interacts with the concrete test bench with the help of categories 1 and 3 items. It constitutes a Hardware Abstraction Layout were all communication protocols (such as CAN, LIN, USB, Ethernet…) with physical devices, masked to the user's view, are implemented. Two versions of TBSL are available: in standalone releases, protocols are addressed through standard or native API; a more general version is being developed on top of Vector CANoe generic communication framework [6], and uses Vector API to handle all low-level translation.

In view of supporting the cooperation, TBSL modules are designed for deployment on a client-server architecture, allowing developers to share the view and the control of the same physical test bench. This architecture also complies with contradictory requirements of the software. Real-time hardware communications, and combinational complexity of the processing of generic models are handled on the server, while the resources consuming GUI is executed locally.

4 Practical Use

The CMBT approach is being proofed in partnership with automotive supplier industry. Samples of hardware / software systems are selected to ensure the adequacy between expected and realized specification, and assess the results of the whole process. In particular, we have successfully run functional tests with a 3D Time-Of-Flight optical sensor, which represents about 63,000 lines of embedded code. The sensor is to be used aboard a vehicle to detect the position of the passenger, in view of improved control of the safety systems. The sensor has been specified using constrained state diagrams, from which we have selected 4 use-cases, dealing with power delivery, system start and reset, recognition of the passenger position… Thanks to this comprehensive benchmark, we were able to review all aspects of TBSL development and interface platform.

These experimental trials have also illustrated how the model based approach support the collaborative work in the setting and execution of test procedures. We distinguish 4 teams in the product development: Design; Software Development; Hardware Integration; Production & Validation. Following ISO layers classification and industry usage [7], the collaboration is called *horizontal* within the same team and *vertical* between them. As regard horizontal collaboration, tests sequences programmed in the GUI or retrieved from the associated database are used to organize teamwork efficiently in order to assign unit tests, share results, and avoid redundant checks. Vertical collaboration is facilitated by the use of a common model by all teams, which participate together in the setting of the tests, and can filter the view of the model according their abstraction level. In case of a modification, tests are re-generated and all developers have direct access to the pertinent information.

5 Conclusion and Perspectives

In view of the first results, the major outcomes of the approach are the easy handling of the test bench by non-expert users as well as its quick setting even for a SUT as an early prototyping stage. Moreover, in case of new use requirements, the test bench can be straightforwardly updated through the programming interface or recompiled from a released UML model. As TBSL is targeted to check commercial products that are for the most part highly safety critical, it needs to guarantee a 100% accuracy. The biggest challenge for now on is thus to exhibit a scientific proof of the total correctness of the design of the TBSL platform and the software it contains.

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Towards Supporting Phases in Collaborative Writing Processes

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Abstract. This paper reports on an exploratory pilot study that has been conducted to investigate which collaboration technologies are suitable (and which are not) to support collaborative writing. The study confirmed known requirements covered by existing tools, but also revealed some requirements that are not met by available technologies.

Keywords: Collaborative Writing, CSCW.

1 Introduction

Collaborative writing has been studied extensively since the 90s. Research was conducted mainly in the scientific field, since collaboration is quite common in writing papers for journals or conferences (e.g. [1]). There was also some research in the educational area. Results included that texts worked on by more than one student are of higher qualities than texts exclusively written by one student [2]. The degree of collaboration in writing tasks varies significantly between different groups. Some groups tend to only use second opinions for review or correction stages of their work, while others divide the workload between members or even work together on the same texts ([2], [3]). For some time now, research has been conducted to design tools to improve the collaboration between writers (e.g. [4]). Different tools for different aspects of a larger writing process (e.g., planning, actual writing, review) have been developed, but they often only cover one aspect of the cooperation. Quilt for example did not include any communication options [5]. Other tools like EditGrid and Writeboard do not allow the export of the resulting texts. Both older and more recent empirical studies suggest that these (often specialized) tools are rarely used in practice ([6], [7]). The reasons for this are manifold and include the users' unwillingness to learn to use new tools (even though they might benefit from them), since their subjective feeling is that a combination of common and simple software like their favorite word processor and Email already fulfills most of their needs.

Yet, technology advances at a rapid pace. New approaches for supporting collaboration (like Voice over IP or Instant Messaging) are emerging and have become commonplace in today's private and professional environments. As a result, today's users are different from those ten years ago. They are more familiar with many kinds of collaborative technologies and often have experience in web based cooperation that

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might have an impact on the way that collaborative writing software should be designed. In this paper, we therefore take a fresh look at the behavior of today's users who write together in groups, on the requirements this implies for modern collaboration technology, and how these requirements can be met by currently available technology (if at all).

2 Design of the Pilot Study

To gain information on the needs of collaborative writing, an exploratory pilot study was conducted. The study was mainly intended to investigate coordination and communication patterns, work behavior and social behavior.

The setting was designed so that participants needed to collaborate. In the study, groups consisting of four university students were asked to write six fictional short stories (with a length of at least 900 words) about a given topic within a time limit of four hours. Each of the six stories was supposed to be written from one of six predefined perspectives, and the stories were supposed to be interwoven and to take place at the same time. One session topic was "an afternoon at the soccer stadium". The roles/perspectives included a player, the opposing team's coach, a reporter and others. The second topic was "movie award celebration", including the roles of an actress, a personal assistant and technical crew person (and three more).

The groups were told that their stories have to meet quality requirements in terms of spelling, writing style and consistency between stories. As such, the students were required to cooperate and communicate in order to connect their stories and to divide the work (a strict 1-to-1 relation between students and stories was not possible, since there were two more stories to write than group members). For the study, two conditions were prepared: a co-located setup and a remote setup.

The *co-located* condition made use of the following technologies: In one room, six computers were placed. Each computer ran one version of the open source program Terpword. This tool offers all standard editing tools of a word processor including a word count. One feature missing is the option of a spell checker. This was intentionally not included in this version to increase the need for manual revisions and participants helping each other. Each computer allowed editing one of the six texts (i.e., students had to walk around if they wanted to see or edit multiple texts). The setup allowed to see if people work together at the same computer and allowed to easily relate locations to stories. Each user had to log into a computer before he had access to the text. If a user was idle for a longer time, the system automatically logged him out. Besides the word processor, no other software was directly offered. The room included a white board and the participants had the option of using paper if needed and were free to communicate and walk around as they wanted.

The *remote* condition included a similar version of Terpword. Here the users (sitting in different rooms) had more options than just saving the current text. They were allowed to switch between the six different texts as long as no one else was using the desired text at that time (if that was the case, a message told them who was blocking it). For communication, a conference call with Skype was generated. The other communication options of Skype were not discouraged.

The study was conducted using two groups of 4 students each. The students came from different backgrounds and no member knew any other group member before the study. In the two days of the study, each group had to work in both conditions. One group started with the remote setting, while the other group started with the local setting.

In the co-located condition, groups were filmed during their work to be able to analyze the social interaction and the "real-world" coordination. The audio conference of the remote group was taped for the same reasons, and all remote users' screens were captured. Also, the text in the editors was saved, including information about the time of saving and the current user working on it. These files and the server log file allowed the analysis of when a remote user was accessing a text and how much of each text was written by each user. This was designed to see possible patterns in the productivity of the group. Productivity is hard to measure, but word count and the time needed are indicators of a person's and group's productivity. After the study, semi-structured interviews were conducted with the students, asking them individually about their impressions of the work done, their perceived group performance in the different settings, and about their suggestions for improving group coordination and performance. The students were also asked about the tools and their perceived usefulness to support the group. After the study, two teachers individually graded the student's texts for errors, logical inconsistencies and general writing quality and provided a ranking of the groups.

3 Results of the Study

A main finding of the study is that, irrespective of the condition (remote vs. local), there are different phases of work in this kind of collaboration: A **coordination and discussion** phase, a **writing** phase, and a **correction** phase. In the first phase, one feature used by one group is the chat of Skype. They used it as a whiteboard where they posted a general outline of the "soccer-game story plot" before starting to write the individual stories. In the interview, they stated that this strategy reduced their need of paper to keep information while keeping everyone on the same level. The first phase ended with the beginning of the active story writing by the participants. This phase had a clear ending and lasted for about 20-25 minutes in all 4 settings (as observed in the screen-captured and local videos). The ending time of the writing phase varied between group members. Once a writer finished his part of the stories, he started to review any finished stories for spelling errors and inconsistencies.

The different conditions of the study did not lead to different results in terms of text quality. While group 2 was better than group 1, the ratings given by the teachers (who agreed with each other) did not show a difference between conditions: the story collections written in the remote condition were as good as the ones written in the co-located setting. All four sets of stories (two by each group) were well written, and overall the stories contained in each set were well aligned and interwoven.

Studies in the past have shown that usually, remote learning and working is not as good as meeting face to face. One reason for this is that social factors, like trust, are more difficult to develop in remote collaboration [13]. Our (albeit small-scale) study confirms these problems, but also indicates that the remote setting had certain

Table 1. Overall ranking of the group assignments

	remote (grader 1/grader 2)	co-located(grader 1/grader 2)
Team 1	3 / 3	3 / 4
Team 2	1 / 2	2 / 1

Table 2. Error quotient (errors/words*100)

	remote	co-located
Team 1	1.5	2.0
Team 2	0.9	2.0

Table 3. Inconsistencies

	Remote	co-located
Team 1	0	2
Team 2	1	5

advantages. Comparing the results of the remote work with the results of the local writing, both groups had a larger rate of errors per words written when they were working locally (p=.58) and also had more inconsistencies between the stories in this setting.

This indicates a more thorough reviewing process in the remote condition. An analysis of the video logs confirms this: participants of team 2 were more willing to press a button to switch between texts than to actually get up and move to a different computer. This behavior had an impact on the consistency of the stories. While the local groups stated that they had more discussions concerning the stories and how they might be interwoven, they also produced more inconsistencies between the stories (but not more "connected" stories). Inconsistencies could be different times for events. E.g. one group had different times for a goal in the soccer scenario. One participant mentioned in the interviews that he would have also liked an option to place different texts next to each other to easier spot inconsistencies.

One student attitude that could be observed through all the groups is that the students normally wrote one or more stories alone (i.e., real collaboration in the actual writing/typing of a story was rare). Looking at the logs of each text and the amount of words changed from each user, each text has most words written by one user. With one exception, more than 95% of the texts were written by one user. Other users did minor spelling, grammar and consistency changes frequently, but these resulted in word total changes in the area of less than 10 words added/removed. There was only one exception to this: in one case a story was written to 3/4th by one writer, while another writer expanded on this story 15 minutes later. The first writer was out of ideas and reading another story. A second student read it for correction and included some of his ideas to reach the word limit. This was done in a remote setting.

One interesting result was that in the co-located setting no two participants were working together at the same text at the same time. The only exception was during the correction phase, where two people checked the text of a third person.

4 Requirements for a Collaborative Writing Tool

The different phases spawned different requirements for supporting collaboration. All groups used some kind of help tools for their plot outlines in the *discussion and coordination phase*. This was physical paper in the local groups, where each participant wrote the important information down. Paper did not easily allow all the participants to share their notes and keep a general consistency without investing a lot of time and effort. In the remote setting, the outline was discussed by one group using the Instant Messenger. Here, the outline was written by one writer and each participant had the text visible all of the time. They could also add new information and send it around for all to see. But this way of information sharing was unstructured and did not allow editing existing texts, only to write new texts. All this shows clearly that some kind of plot organizer is an important element for a collaborative story writing tool. Even though no such tool was available in our study, the students creatively used other available devices to make up for this lack - a more advanced plot organizer might have lead to even better and more connected stories.

Another aspect which users found helpful with the meeting in one room was the feeling that they were able to talk more freely and easily. In the interview one student stated, that this helped them to get to know each other, resulting in off-topic communication. He stated that this increased his “group-feeling” and that he enjoyed the group work more. So a system should emulate this face-to-face feeling to allow an open and free communication. Attempts to address this challenge can also be found in recent literature [8]: Even video conferencing does not completely emulate face-to-face meetings [9], and attempts to reduce this problem [10] are not integrated in current environments.

Yet, designing collaboration software so that it fully emulates a face-to-face situation may not be the best of all choices: Some students mentioned in the interviews that the remote setting allowed them to work more independently. One participant stated that she had a much easier time writing and also listening to the chat at the same time. Since no one saw her, she could just continue working while listening to less important parts of the conversation. When she was in the same room, it would have been “rude” to continue working while participating in the conversation. As such, a compromise between the advantages of remote work and local work seems to be a reasonable research and design goal.

Most communication during the *writing phase* can be classified as one of the three following types:

- Coordination who is blocking which text and the way to change between them (only remote setting). Awareness information and parallel access to texts would be required to reduce this need for communication.
- One person gives ideas which might be used in another ones writing (in the remote setting often done using text chat). This information should be presented via a non-invasive communication channel or with a shared notekeeping/outlining tool.
- The third part was mostly coordination of the contact points in the story. Since this requires often more than 2 people this also requires a shared outlining/notekeeping tool. For already existing texts awareness of existing parts would reduce the need for disrupting communication.

The communication focus in the *correction phase* was on the coordination of text access (in the remote setting only), and on the discussion of inconsistencies. Here, easy and fast access to all the texts is very important to allow a fast comparison of texts: The co-located groups switched between texts less often than the remote groups, even though the switching between texts often required coordination between users (see table 4).

Table 4. Average numbers of text changes (std. deviation)

	Remote	**co-located**
Team 1	12 (~3.39)	10
Team 2	26.3 (~4)	10

While awareness about the content of already written texts is important in the writing phase, it is even more so in the correction phase to spot inconsistencies. Awareness functions which bring more than one text to the screen of writers could help for finding inconsistencies. Also, the participants mentioned in the interviews that it would help them to see what each user is working on. This helps for asking the person who is writing about a certain character and if he already was past a certain (connection) point of stories.

5 Towards an Integrated Collaborative Writing Environment

Currently, there are no tools that satisfy all the requirements of the table below. While current tools successfully satisfy some of the requirements, they do not cover all of them (e.g. Google office does not include a communication module).

The requirements mentioned before can be categorized in three groups: *Process awareness* informing about the group actions, *product awareness* helping with the texts, and *time/effort saving* components. Since not all requirements are needed in all phases, the system should reflect the phases of the work process without the requirement of different tools needed to be open in different phases.

The different requirements for an integrated synchronous writing environment, including existing or possible solutions, are presented in table 5.

One approach for addressing many of the (primarily social) requirements in some of the work phases seems to be the use of 3D CVEs (collaborative virtual environments). While their main use is still in the area of entertainment, they have become a research topic for CSCW and CSCL [11]. Clearly, using 3D for text editing does not seem like an obvious tool. Yet, CVEs offer a lot of awareness options like the current position of the other users and what they are working on. They also often allow for communication (e.g. VoIP and chat) increase the immersion of the users though avatar customization, and open new communication channels through the use of gestures. These options might increase the building of social bonds and therefore seem worth investigating specifically for the discussion and coordination phase.

During the writing phase however, the requirements are different. Here, users should have an easy access to product awareness information but should also have a relatively undisturbed working environment which allows them to focus on their

Table 5. General requirements and design ideas

Category	Requirement	Existing solutions	Phase
Process awareness	Build social bonds	Advanced video conferencing; Collaborative 3d environments	Discussion and Coordination
	Allow communication	VoIP, IM, email	all
	Awareness of participants current work		Writing and correction phases
Product awareness	Show/ help design plot outline	Shared whiteboard; plot outlining tools [12]; shared notes	(Help design) discussion phase. (Show) other phases
	Allow access to text parts with same topic		Writing and correction phase
Time saving	Fast switching between texts		(mainly) correction phase

texts. Here, a 2D interface seems more appropriate. Another important aspect is to create product awareness. The group members should have an easy access to other parts of written texts and know what is going on in the text production. One option here, which we will investigate in our future research, is to create an algorithm which checks the current writing of a user against existing writing of others, and presents relevant parts of the other texts (e.g., to support users in avoiding inconsistencies).

6 Conclusion

This paper presented the results of an exploratory study for collaborative writing. The most interesting results are that a co-located and a remote setting did lead to different results in terms of the resulting product, even though the remote setting made use of relatively “low tech” tools. Users in both settings went through the same three phases during their writing activity: a discussion phase, a writing phase and a correction phase. This paper also presents general requirements for a tool meeting the requirements of all three phases for this kind of work and discusses one possible implementation fulfilling these requirements. Future work will include an example implementation and a validation of the requirements.

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Determining the Reliability of Cooperative Decisions by Sensitivity Analysis of Quantitative Multicriteria Decision Methods

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Abstract. Quantitative multicriteria evaluation methods may be effectively used in decision making by a cooperative group, because its members are seeking the solution of the problem by joint efforts. Solving multicriteria problems with conflicting aims, the cooperative group members behave like experts, making decisions based on their views and opinions [1].

The present paper considers the variation intervals of the criteria values and sensitivity of quantitative multicriteria evaluation methods to the initial data of multicriteria problem. Monte Carlo method is used for generating sets of initial data, and the analysis of sensitivity of multicriteria methods is made using a number of sensitivity analysis methods. The outcome of the analysis will be the development of methodology or an algorithm which could help to increase the reliability of decision making based on the use of quantitative multicriteria decision methods or their sets.

Keywords: Cooperative decision making, multicriteria decision making, diverse interests, sensitivity analysis, Monte Carlo method.

1 Introduction

Consensus is a pivotal concept in cooperative decision making. Usually, the consensus is achieved by the experts shifting their opinion towards a point of mutual consent. In many cases, the shift is the result of laborious negotiations, which escalate the cost of reaching the consensus. Moreover, in many cases, the cooperative decision making is multicriteria oriented, and experts should agree on each criterion separately.

Practically, it is very unlikely that a group of experts will share the same opinion, especially, in the case of a multiple criteria decision problem. Yet, in many cases, such a consensus is a necessity in order for a group to reach a mutually agreed decision. Consensus as a process of aggregating experts' judgments has many forms of implementation such as a problem of investment in construction, judging figure skating or monetary civil suits (suing for damages). It is clear that implementation has a different level of agreement required from the experts. [1]

The problem of investment in construction is of paramount importance because investments determine the potential of construction and the structure of expenses.

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Several parties are involved in decision making about the investment projects in construction. These are customers, contractors, designers, etc. who are interested in the effectiveness of a particular investment project and may be referred to as a cooperative decision making group. The successful performance of a company is also closely associated with the investment policy, since the latter embraces the expenses required as well as considerable financial resources. Efficient planning and management of investments have become not only an important but also a complicated problem in the dynamically changing environment. [11]

In this paper, we use a set of quantitative multicriteria decision making methods, which are presented in the block diagram in Figure 1. This block diagram is used to check the consensus of experts' judgments by W. Kendall's concordance coefficient. Group evaluation may be considered to be reliable only if the estimates elicited from various experts or the members of a cooperative decision making group are consistent. Therefore, when statistically processing the data provided by experts, the consistency of expert estimates should be assessed, and the causes of information ambiguity should be identified. [12]

Suppose that, according to the concordance coefficient, the experts' estimates are in agreement. However, it does not guarantee the reliability of the final decision to be made by a cooperative decision making group. The present paper addresses the problem, arising when the estimates of the cooperative decision making group members of the initial data of the project being evaluated differ considerably. In this case, they differently define the quantitative values of the criteria describing the alternatives. For example, one of the experts thinks that the initial cost of the project is 10.000 EUR, while the second expert believes that it is 10.100 EUR, and the third expert assesses it to be worth 9.900 EUR, etc. Therefore, in this environmental, the use of quantitative decision making methods may be recommended to the cooperative decision making group to handle the initial quantitative data for making a decision about the most effective alternative. The question arises if the final decision changes considerably, when the initial data change by 5 or 10 percent. To determine the reliability of decision making, the authors of the present paper suggest performing sensitivity analysis of a set of quantitative multicriteria decision making methods (MCDM-1). For this purpose, Monte Carlo method will be used for generating the initial data, when their average value is fixed and standard deviation (in one case – 5%, in the other – 10%) is chosen. The reliability of the result of decision making will be expressed in terms of confidence level (in percent).

2 Related Works

The significance of quantitative criteria is usually determined with some errors. This may be explained by the fact that the decision maker cannot always provide consistent value judgments when different quantifying procedures are used. Different decision makers using the same approach may give different weights because their judgments are subjective. Therefore, inconsistent ranking results, leading to ineffective decisions may be provided. If measurements are not accurate, the result obtained is not accurate either, but sensitivity of the result may be checked by varying the parameters. [2]

A particular procedure is used to determine the sensitivity of an alternative to parametric changes. If a small change in a parameter results in relatively large changes in the outcomes, the outcomes are said to be sensitive to that parameter. This implies that the parameter should be determined very accurately or that the alternative has to be redesigned for low sensitivity. [5].

In [12], the authors (Ustinovicius, Zavadskas, Podvezko, 2007) presented a set of quantitative multicriteria decision methods facilitating multicriteria decision making. However, when these methods are used, the analysis of the initial data (the criteria values x_{ij}) is not made, and, therefore, the confidence level of the final decision is not clear.

Usually, the data in MCDM problems are difficult to quantify, or they are easily changeable. Thus, the decision maker often needs to assess the data with a certain degree of accuracy first, and later to estimate more critical data with higher accuracy. In this way, the decision maker can rank the alternatives with high confidence, not overestimating less significant data. Finally it leads to the need of performing sensitivity analysis of a MCDM problem. [10].

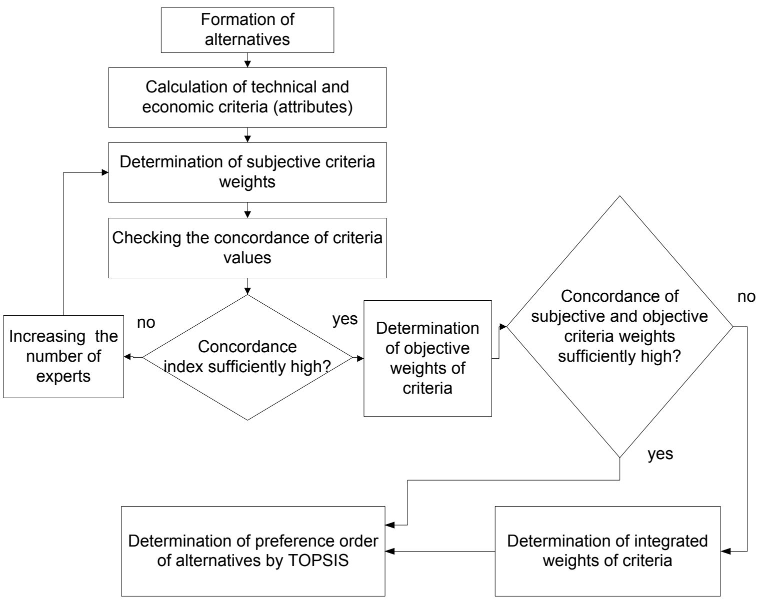

Fig. 1. MCDM-1, part 1 [12]

3 Suggested Approach

The suggested approach is based on the algorithm of a set of quantitative multicriteria decision making methods presented in Fig 1. By using these methods, a decision maker (DM) can arrange the alternatives in the order of preference. The most suitable alternative gets the highest rank, being number one on the scale of evaluation.

Suppose that we have a cooperative decision making group consisting of a number of experts, who should arrive at the joint decision. At the beginning of evaluation, each expert provides his/her variant of the initial data, i.e. the criteria values. Most probably, these initial data will differ from expert to expert. In this environment, the methods described below may help a group of experts to obtain a reliable result, i.e. not only to determine the most effective alternative for decision maker, but to define probability of its being the best one.

Step 1. Using the algorithm given in Fig 1, sets of m alternatives and n criteria describing them are generated.

Step 2. The criteria values x_{ij} are determined, i.e. the average values of the criteria x^{t}_{ij} elicited from k experts are calculated:

$$x_{ij} = \frac{\sum_{t=1}^{k} x_{ij}^{t}}{k} \tag{1}$$

where k is the number of experts, i is the alternative number, j is the criterion number, t is the expert's number.

Step 3. Based on the judgement of each expert and applying the method MCDM-1, the objective and subjective values of the significances of the criteria used are determined.

The subjective values of the criteria significance determined based on experts' pairwise comparison. The values of $\overline{q_j}\,(j = \overline{1,n})$ are found by solving the optimization problem:

$$\min\left\{\sum_{i=1}^{n}\sum_{j=1}^{n}\left(b_{ij}\overline{q_j} - \overline{q_i}\right)\right\}, \tag{2}$$

when the unknown values of $\overline{q_j}\left(j = \overline{1,n}\right)$ satisfy the constraints:

$$\sum_{i=1}^{n}\overline{q_j} = 1, \quad \overline{q_i} > 0; \left(i = \overline{1,n}\right) \tag{3}$$

Group evaluation may be considered to be reliable only if the estimates elicited from various experts or the members of a cooperative decision making group are consistent. The level of agreement of expert estimates can be determined by using W. Kendall's concordance coefficient (see [12]).

The next step is calculation of the objective significance values of the criteria by using the entropy method [6].

Step 4. If the level of the agreement between the objective and subjective values is sufficiently high, subjective values may be used for determining the effectiveness of alternatives by the method TOPSIS.

Yoon and Hwang (1981) developed a technique based on the idea that the optimal alternative is most similar to an ideal solution (being closest to it and at the longest distance from the negatively ideal solution). This method is known as TOPSIS – *Technique for Order Preference by Similarity to Ideal Solution*.

A relative distance of any $i-th$ variant from an ideal one is obtained by the formula:

$$K_{BIT} = \frac{L_i^-}{L_i^+ + L_i^-}, i = \overline{1,m}, \text{ where } K_{BIT} \ [0,1] \tag{4}$$

where L_i^+ is a distance between the compared *i*–th variant and the ideal one; L_i^- is a distance between the compared *i*–th variant and the negatively ideal alternative. The nearer to one is K_{BIT} value, the closer is the *i*–th variant to $a+$, i.e. the optimal variant is the one which has the highest value of K_{BIT}.

Step 5. The calculation results, with which other decision making data obtained by changing the initial data will be compared, are recorded.

Step 6. New initial data are generated by using Monte Carlo method, when the average value of each criterion is previously calculated for respective x_{ij} value, while standard deviation makes *5%* of the respective criterion value. For example, $x_{22} = 80$ and *5%* of this value is *4*. Then, a set of random values is generated ($\mu = 80$, $\sigma = 4$) and one of the obtained values is *77,891*.

Step 7. The alternatives are evaluated following MCDM-1 algorithm. The estimates obtained and ranking results are presented graphically.

Step 8. The reliability of the final decision is assessed in terms of confidence level:

1) The alternative will be given the rank which has the highest frequency of occurrence in the iteration of mathematical procedures applied to the generated data.
2) The reliability of rank determination is calculated by the formula:

$$p_i = p(A_i) = \frac{n(l)}{r} \cdot 100\% \tag{5}$$

where $p_i = p(A_i)$ is confidence of evaluation of the alternative A_i; r is the number of tests with the generated data; l is the rank of the alternative A_i with the highest frequency of occurrence; $n(l)$ is the number of iterations with the rank l of the alternative A_i.

Step 9. Coming back to step *6*. The average values of the initial data are left the same for their new generation, while standard deviation is taken as *10%* from the average criterion value. Then, step *7* and *8* are performed.

Step 10. The results of decision making process and the data obtained in sensitivity analysis are presented.

4 Case Study

To illustrate the technique developed, some alternatives of purchasing an office building for a company are considered. Suppose that the clients (DMs) need to purchase office premises. There are four variants ($A_1 - A_4$) of office location. Four criteria are considered: X_1 is price (10,000 \$); X_2 is office area (m^2); X_3 is distance from home to work (km); X_4 is office location (in points). The criteria X_2 and X_4 are maximized, while X_1 and X_3 are minimized. The data describing office purchasing for a firm are presented in Table 1.

Table 1. Data on office purchasing

Criteria / Alternatives	X_1	X_2	X_3	X_4
A_1	3.0	100	10	7
A_2	2.5	80	8	5
A_3	1.8	50	20	11
A_4	2.2	70	12	9
	min	max	min	max

Having made the calculations, we obtained the following significance values of the criteria. They are presented in Table 2.

Table 2. Subjective values of criteria significances $\overline{q_j}$, j = 1, 2, 3, 4

Criteria	X_1	X_2	X_3	X_4
Subjective values of criteria significances	0,092	0,264	0,184	0,460

In Table 3 (below), we see the data, obtained by calculating the effectiveness of the alternatives by algorithm MCDM-1, part 1.

Table 3. The data obtained by calculating the effectiveness of the alternatives by MCDM-1

Efficiency value of alternative / Method	A_1	A_2	A_3	A_4
Alternative's evaluation by MCDM-1	0,514	0,391	0,583	0,638
Rank of alternative	3	4	2	1

According to the results of evaluation, a decision may be made that the alternative A_4 is optimal.

Ten values of each criterion x_{ij} were generated with standard deviation of 5% from the average value of each criterion. The alternatives are evaluated according to MCDM-1 algorithm. The graphs show the results of alternatives' evaluation and ranking.

Based on the data obtained, it may be concluded that for the alternative A_2 the rank of the highest frequency of occurrence is *4*. In the results of *10* experiments, the rank *4* occurred *10* times, therefore, the alternative A_2 was assigned the rank *4*. According to formula (5) in this case the confidence level of evaluation is 100%.

Other alternatives were ranked and the confidence level of evaluation was determined in a similar way. Thus, the alternative A_1 was ranked third with the confidence level of 100 %; the alternative A_4 was ranked second with 60 % confidence, and the

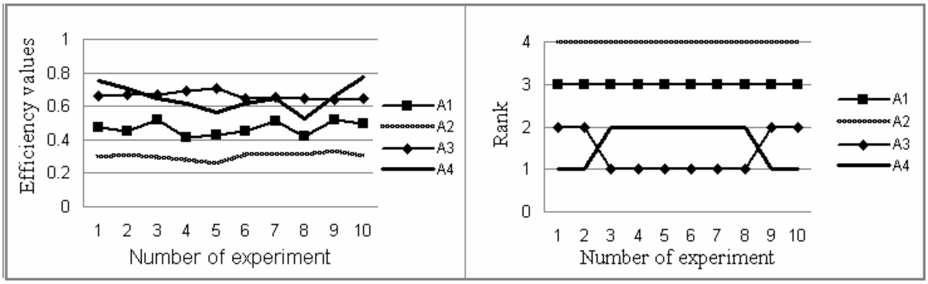

Fig. 2. a) Estimates of alternatives; b) Ranks of alternatives

alternative A_3 was ranked first with 60% confidence. When the data obtained were compared with the initial result of decision making process, the alternatives A_3 and A_4 changed places.

Ten initial data items have been generated once again, with 10% standard deviation chosen. The data obtained in calculations according to MCDM-1 algorithm are graphically shown in Fig. 3.

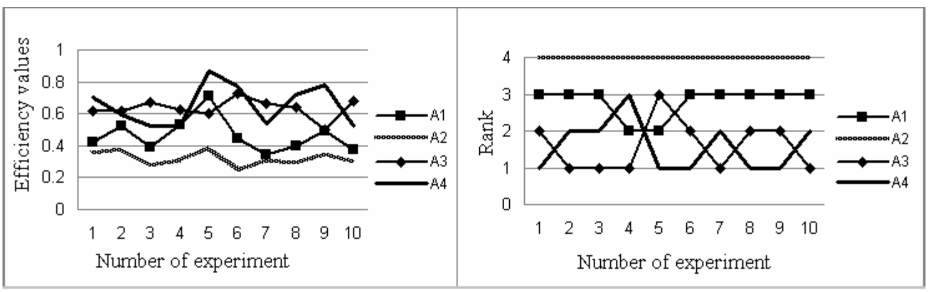

Fig. 3. a) Estimates of alternatives; b) Ranks of alternatives

The data obtained in the process of decision making and sensitivity analysis allow the authors to state that the rank of alternative A_2 is four, with 100% confidence, the rank of alternative A_1 is three, with 80% confidence. The comparison of the results obtained, based on the initial decision making data, did not allow the authors to determine the ranks of the alternatives A_3 and A_4, because their confidence level was the same (50%).

It can be seen from this investigation that, to determine which of the two alternatives, A_3 or A_4, is most effective, the initial data should be revised. Sensitivity analysis is required to determine the confidence level of the decisions made.

5 Conclusions and Future Works

The paper addresses the problem of determining sensitivity of a set of quantitative methods MCDM-1 used for decision making by a cooperative group. The performed sensitivity analysis of MCDM-1 with respect to initial data allowed the authors to draw the following conclusions:

1. If experts' estimates of the initial data (values of the criteria) differ by 5%, the effect of the variation on the final decision is insignificant. However, if the initial data differ by 10% from the average criterion values, the results obtained can hardly be considered reliable;
2. It is supposed that a decision maker, or a group of experts, using decision making methods, should know the degree of reliability of the decision made. Then, they can decide if the result obtained satisfies them;
3. The authors suggest performing sensitivity analysis of decision making methods with respect to the initial data, which may be not sufficiently accurate. This applies both to the values and weights of the criteria used. The final decision should be provided alongside the results of sensitivity analysis;
4. In their future work, the authors are planning to perform sensitivity analysis of quantitative multicriteria decision methods using some other techniques described in the literature (see for example, Sallteli, 2008)

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A Collaborative Reasoning Maintenance System for a Reliable Application of Legislations

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Abstract. Decision support systems are nowadays used to disentangle all kinds of intricate situations and perform sophisticated analysis. Moreover, they are applied in areas where the knowledge can be heterogeneous, partially unformalized, implicit, or diffuse. The representation and management of this knowledge become the key point to ensure the proper functioning of the system and keep an intuitive view upon its expected behavior. This paper presents a generic architecture for implementing knowledge-base systems used in collaborative business, where the knowledge is organized into different databases, according to the usage, persistence and quality of the information. This approach is illustrated with Cadral, a customizable automated tool built on this architecture and used for processing family benefits applications at the National Family Benefits Fund of the Grand-Duchy of Luxembourg.

Keywords: Collaborative tools; Decision-Support; Knowledge Representation.

1 Introduction

Automated reasoning techniques are gaining popularity in administrative and legal fields. In particular, when a huge amount of heterogeneous reasoning knowledge must be taken into account, they allow both ensuring the coherence of the system and making the decision process equitable and more efficient. The interest of these techniques is to provide a modeling of the reasoning, as well as a means to perform it in a mechanical, standardized, and justified way [1]. Decision support systems have therefore taken a significant importance to solve problems in area where the knowledge is half formalized, which is especially the case for identification, planning, optimizing and decision making tasks [2], and, in the juridical and administrative domains, for the efficient and equitable handling of problems consisting in opening rights or according some pre-defined status [3].

In the Grand-Duchy of Luxembourg, the daily operating of the National Family Benefits Fund is characterized by the combinational complexity of the juridical framework. The mission of the Fund is the attribution of family allowances and parental leave for more than 160,000 individuals, including 100,000 families and one third of cross-border workers. However, the legal situation of the beneficiaries depends on several factors, among which the nationality or the country of residence. In

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addition to five main legal frameworks, two international agreements are considered for processing the files. In cooperation with the Fund, we are therefore developing Cadral, a tool for the automatic treatment of the demands, which has long been waited for by the administration, as being the only means to cope with the continuous increasing of the work, in amount and complexity, due to the demographic and economic expansion of the country.

2 Procedural Modeling

Modeling juridical texts into logical formalism has been proposed, in order to directly apply inference mechanism in the context of the law [3], [4]. Several formalisms and resolution algorithms are available and well-tried, such as the first-order and backward-chaining architecture of Prolog, the modal or deontic logics [5]. However, the heterogeneous nature of the texts (fuzzy formalism of general agreements, vs. precision of national administrative code), and the numerous implicit definitions that are used (e.g. certificate validity, pre-natal, post-natal allowance...) make the translation into a formal and univocal computer language a very long and minute challenge.

Our starting point for building Cadral is the national legislation regarding family allowances. It consists however not in a monolithic structure, but forms a constellation of national laws, and international agreements. Nevertheless, in the daily work of the administration, the legislation is not constantly referred to. Operators have in their brain the condensed information that are relevant for most of the cases, and refer to the law only when necessitated by some subtlety of a treatment. Accordingly, instead of the whole modeling of the law, we decided to concentrate on the explicit drawing of the mental procedures that governs the processing of the applications, and the relations between these procedures to the legislation. The operating knowledge of the system is therefore a procedural modeling of the legal texts.

An example of a procedure can be: "If a child is going to school, and is less than 18, the beneficiary is entitled to receive the education allowance". Such a procedure is modeled in the shape of a multi-valued acyclic n-are graph, with nodes representing a factual state (e.g. child going to school) used as a condition, and the edges denoting the necessary steps (e.g. showing a school certificate) to enter the state. Moreover, we ensure that a state is always unique in the graph (there are not 2 nodes with the same label), though it is fully possible to go to the same state by different ways. The modeling of the full law article is therefore a procedural graph where all the states are distinct and such that we can define an isomorphism, which associates every node in the graph with an alinea. When the procedures are translated into a collection of inference rules for an expert system, such isomorphism is used concurrently with the trace of the inference engine in order to memorize the legal references made during the reasoning performed according to the procedures.

3 Implementation

Our graph-procedural modeling of the law has guided our choice relative to the technology used to model the procedures and infer with them. The reasoning on a law article consists, indeed, in proceeding from one state to another according to the procedures and the conditions (labeling the edges) that are satisfied. All the paths and all the states must be effectively checked, in order to ensure that no case provided by the law for a given application is left. This consideration orientates our choice towards a rule-based inference system proceeding by parallel forward chaining (contrary to the Prolog like scheme, which proceeds by backward resolution in a depth-first manner).

The Cadral resolution system is developed on top of the Soar IA architecture. Soar is a general-purpose rule language whose inference engine is based on the Rete algorithm [6], and works in a forward-tracking manner: the rules (also called productions) are "if A then B" statements whose meaning is: "if the situation A is satisfied, then create (or produce) the situation B". Soar's purpose is to propose a Unified Theory of the Cognition [7]. One advantage of Soar is that it can communicate in many ways (through sockets or procedural routines), and allows us to place in the rules requests for information concerning the allowance demand or the beneficiary data.

However, writing rules in the Soar language can soon become intricate, with respect to the syntax as well as to the management of the inference algorithm. Moreover, when slightly modifying the rule base, the behavior of the whole base can change drastically, in a way that the understanding of the change is not intuitive. For this reason, the heart of Cadral is an intermediate language with simplified syntax that is compiled into true Soar formalism. This upper-level layer is designed to provide the user with useful or necessary subroutines in view of the specialized topic of the program. All the subroutines are documented with a stable and proven behavior, corresponding to the expected modeling of the procedures. In particular, the intermediate language implements the required controls on the Soar resolution engine in order to manage the notion of state used within the procedures, and on-the-fly communications.

4 Collaboration Issues

This automated framework supports collaborative work both in the decisional processing of the applications and with correlated services within the administration.

Internally, Cadral is characterized by its flexibility. The knowledge it contains in order to process all applications is based on legal texts, and as such, is subject to frequent evolution, dismissal, or addition. Cadral thus offers a unified platform, where operators, with different user rights corresponding to their responsibility, can view or edit the knowledge about the effective processing applications, and assign, share and check their tasks.

Moreover, Cadral complies with strict integration requirements. First, to receive inputs required in the benefit applications, an interface is maintained with a customizable list of input data, which is edited when changes occur in the legal knowledge model. Data can be entered either through an OCR-enabled processing module for the paper documents and files, or with the administration Website for applications filled online. Second, the system retrieves all the parameters that are to be taken into account for the processing of the demand, including the check for the presence of required certificates. The data is here dispatched on several databases tables, and special care is taken to recombine all the information. For example, a cross-border worker is entitled to receive child allowance, but the amount paid by the administration will deduct the amount of the allowance of the same kind possibly received from the residence country.

5 Conclusion

The Cadral tool under development is designed as an inference system for supporting collaborative editing and operational work, in which rules implement the administrative procedures used to process the applications filled by the beneficiaries to receive the allowances. In the forthcoming version, the Cadral replies on the acceptance of an application for allowances. The information and material supplied through the application is formalized and passed as inputs to the engine processing the rules. Upon completion of the inferences, the demand is accepted, rejected, or the system asks for more information or additional documents. An extension performing the automatic calculation of the allowances is targeted for the subsequent versions of the system.

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Web-Based Visualization of Student Cooperation during Distributed Laboratory Experimentation

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Abstract. This work addresses the problem of visualizing hardly formalized relations i.e. connections between distributed collaborating experimenters. These dependencies are not measurable and hard to determine. It is proposed to determine the relations using the measurable and determinable connections between software agents acting on behalf of the users. A connection between the agents is treated as the proof for relation between their owners. A method of system structure data acquisition is proposed, which consists of capturing and interpreting the communication traffic between the agents. The content of the traffic is analyzed and presented in formalized form, according to the developed XML Schema. An example of graphical visualization is provided, presenting the mesh of inter-user relations as an interactive graph. An automated spatial clusterization of the graph components is performed, resulting in optical information on the current state of collaboration.

Keywords: visualization, distributed cooperation, remote learning, industrial process control, collaborative experimentation.

1 Introduction and Motivation

As a part of the teaching quality improvement at the Department of Automatic Control, a framework for collaborative experimentation with semi-industrial pilot plants was deployed [1]. The framework, designed to support both research and learning, incorporates few semi-industrial plants and an office-grade computer network. A specifically developed protocol enables users to develop and execute software agents interacting with the plants. It is possible to conduct multiple concurrent experiments, each of them involving multiple users (students, teachers, researchers). Collaborative problem solving enables students to gain skills useful in their future professional life [2], however collaboration and cooperation during experimentation poses several problems that require attention.

At the same time, there may be multiple users present in the system, performing different tasks, at different stages of progress. The most obvious problem is an emergence of conflicts between users of different classes competing for an access to the plants, which are scarce resources in this case. The problem is solved, since the

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conflicts are avoided through the careful planning of workflows and developing a hierarchy of priorities for the classes of users (see [3] for the previous work on this topic and [4] for general further analysis of this field done by Babič et al.).

The other pressing problem requiring solution is related to the student learning process itself. A tool was needed to enable the teachers to watch the students as they divide their project into tasks and split themselves into clusters to progress in fulfilling each specific task. A two-way visualization is needed. On the one hand, a visual representation of current user configuration is needed for the human supervisor of the framework. On the other hand, a unified open interface is needed to support automated supervision of the student collaboration (see [5]).

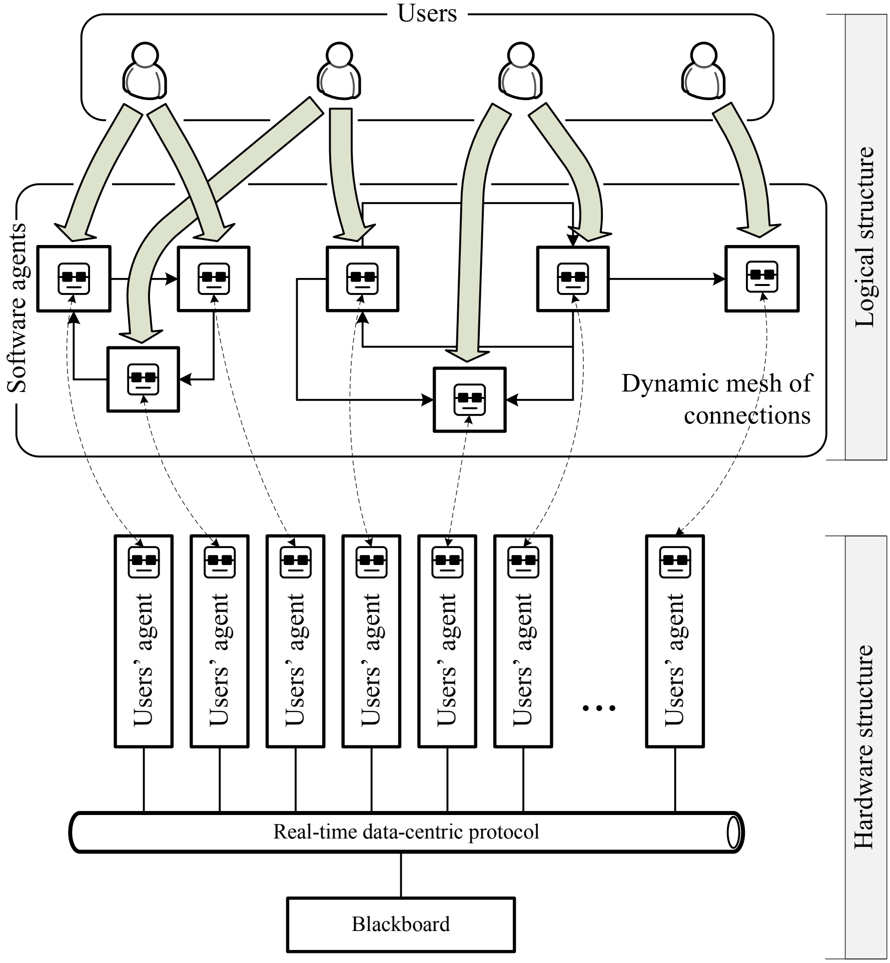

Fig. 1. Logical structure compared to the physical network structure of the system

There are many visualization environments for software agents available (e.g. VizScript [6]). Their concept is quite general, but they always require that software agents are developed according to a given specification. While this requirement is not a problem in software systems, the considered framework is strongly bound to the hardware plants. This makes it hard to adapt the framework to visualization environments, or to implement additional network nodes for data acquisition (as in [7]). Because of this, a custom visualization engine was developed, as it is done in other domain-specific collaboration environments (e.g. for architecture design [8], creating story-outlines [9], quality systems [10], privacy risks [11]). The proposed approach to the visualization of user collaboration progress is based on a block diagrams idea, particularly popular in engineering [12]. Block diagrams are well fitted to display dependencies between components of the system. In case of the framework, the users and their software agents are the visualized components.

2 Architecture of the Cooperation Environment

The framework is based on the real-time networking protocol, designed specifically for the software agents interacting with the hardware plants. The main purpose of the interaction is to perform automated control of a physical process in the distributed and collaborative manner. The protocol is based on the blackboard principle, both the hardware bound agents and the user-programmed software ones, are treated a the equally privileged network nodes (Fig. 1). A mesh of connections between the users, on behalf of which the software agents operate, is not available in a physical wired form. The mesh is purely logical and embedded partially in the content of the blackboard and partially in the communication stream transmitted through the network. Because of this, the visualization engine is required to capture the communication stream to infer the structure of the mesh. This idea was introduced in [13], however it was limited to the structure of the software agents only. In this work the collaborative aspect of the learning process is introduced and the visualization is expanded to take the user aspect into account.

The presented idea of network traffic capturing is reusable in all similar systems, in which the connections structure is not clear but is embedded in a communication between actors. The most evident class of such systems is the class of self-organizing systems [14] in which aims of participating agents are not clearly exhibited at the agent level, but may be inferred at the system level only. It is particularly true for the multi-user systems, especially distributed ones, where intentions of the users are generally unknown.

3 Visualization

The method proposed for serving the gathered data on users structure in the framework is a standard web service. Such a method helps to keep the openness of the visualization framework, and enables it to be integrated with the Semantic Web. The data served by a web service may be easily incorporated into external software applications.

In the presented case, due to the existence of two data sources (the blackboard and the captured network traffic) two web services were implemented (Fig. 2). The *Values Interface* serves the data collected in the blackboard, giving information on number and values of the variables present in the system and exchanged between all the agents. The *Structure Interface* serves the connection mesh data bounding the variables to the specific agents and their human owners.

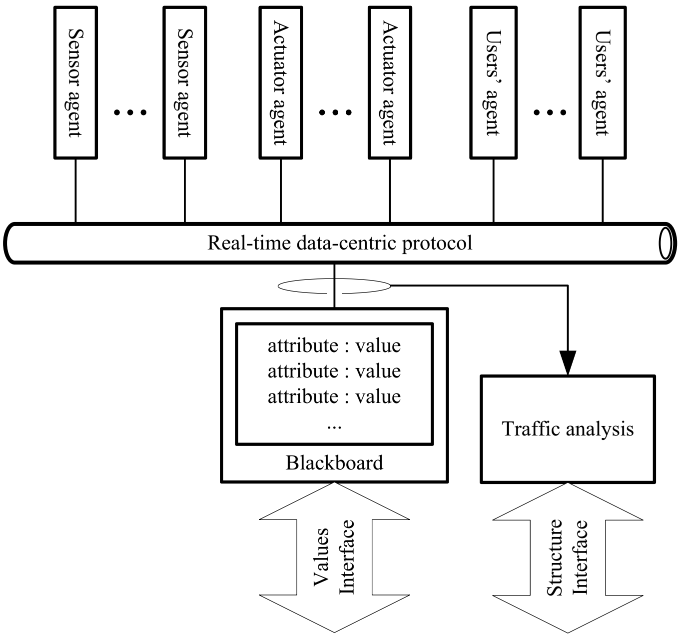

Fig. 2. The Web Services implemented

A format of the data served by the Values service is very simple and requires no specific attention – the blackboard content is simply converted to an XML structure in the form of *attribute: value* pairs. The Structure Interface serves more complicated data, which required a specific formalization. The structure of the system is described using hierarchy of classes pictured in the Fig. 3. The hierarchy describes a typical directed graph, augmented with an additional class of users, which are treated as the owners of software agents. Each of the agents has exactly one human owner, and all the actions performed by the agent are treated as if they were performed by that user of the system. From the presented hierarchy of classes an XML Schema was derived, which describes the format of the data served by the Structure service. This formalized structured description may be visualized in a graphical form for the human supervisor, or may be imported into any automated inferring system.

As a proof of concept a simple visualizing application was developed which presents the graphical mesh of user relations, which may be interpreted as a block diagram (for reference see [12]) or a relation map (similar to [15]). The visualization application is actually a SVG document generated dynamically by an ECMAScript

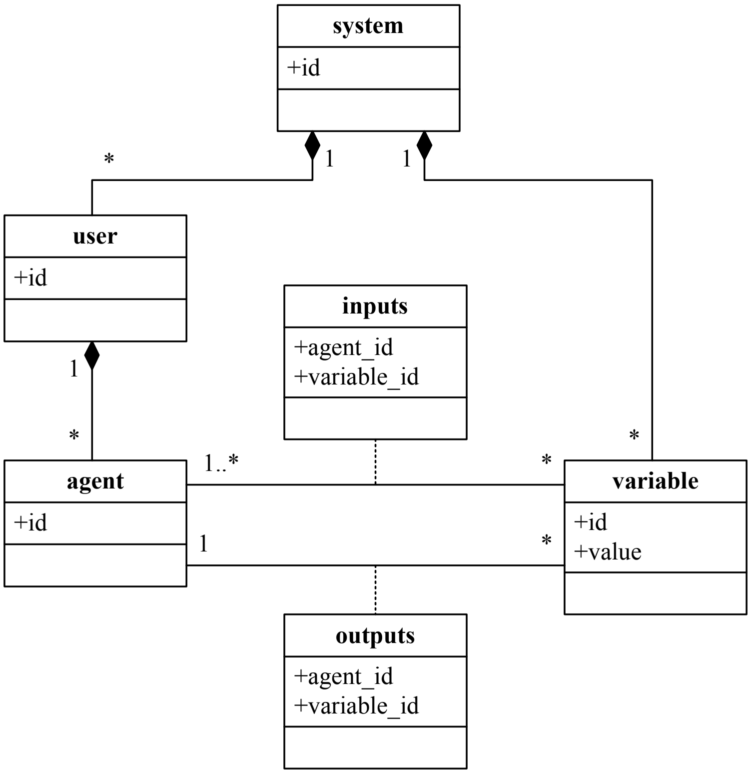

Fig. 3. Hierarchy of classes for visualization

program. Members of each class of the system structure (human users, software agents, blackboard variables) are represented by different graphical symbols. Users are shown as grey rectangles, agents as white rectangles and variables as small grey circles. These graphical elements are placed in the screen space and are connected with directed arrows. Thick arrows connect the agents with their owners, while thin arrows display the flow of information between the agents and the variables from the blackboard. All the graphical components are positioned in the screen space with the use of the gravitational model, which leads to automated clusterization of the agents depending on their owners and connections with other agents, resulting in optical information on the current structure of the system. The Figures 4 and 5 show screenshots of the working visualization applications.

An example of the achievable visualization of the user collaboration is shown in the Fig. 4. It is seen that there are three clusters of agents and users, a skilled supervisor can easily infer that there are currently two process control experiments performed and one additional monitoring process is executed. Students involved in each part of each experiments may be clearly identified, and their role is easily distinguishable.

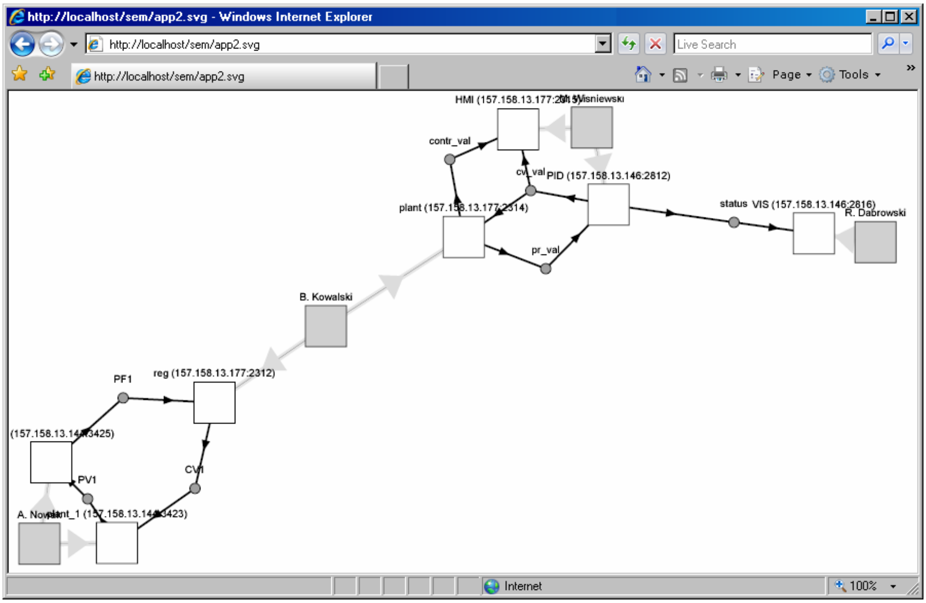

Fig. 4. The visualization of the logical connections in the system with user associations taken into account

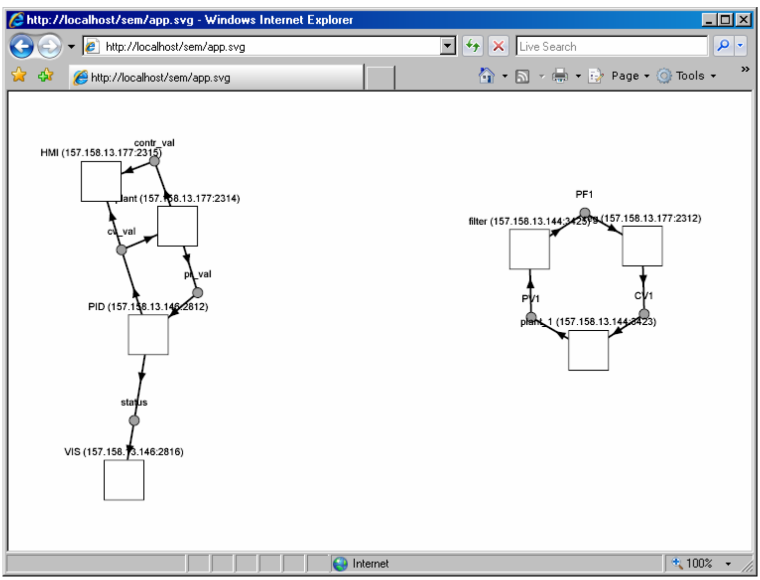

Fig. 5. A version of visualization application not showing any user associations

It should be noted that the presented graphical visualization is only the last stage of the whole visualization process. The essence of the proposed approach is the aggregation of all the distributed information on the system structure in the one place i.e. in the XML structure served by the web service. Although the XML description is usually hardly readable for human users ([16]) it can be easily used by any external application. Due to the development of the XML Schema and implementing the web services, the visualization engine is compatible with the Semantic Web. It is possible to develop software agents which will analyze the structure and formulate conclusions in fully automated manner, granting answers for typical questions of the human supervisor, e.g. "*Does the user A engage the plant X?*", "*Do the users A and B cooperate in the same experiment?*", "*Which variables of the blackboard hold the values produced by agents owned by the user A?*".

In the Fig. 5 the previously existing [3] version of the visualization application is shown, which did not take an user factor into the account. While it shows exactly the same structure as the Fig. 4, due to the lack of the user factor visualization, it may be derived that there are two distinct experiments being performed in the framework, as there are two non-connected clusters of software agents. It is therefore clear that the information on owners of the agents is vital, and it can considerably change the interpretation of the structure.

4 Concluding Remarks and Future Work

This work focuses on the visualization of the hardly formalized relations i.e. connections between distributed collaborating experimenters. These dependencies are not measurable and hard to determine. Therefore, it is proposed to determine the relations using the measurable and determinable connections between software agents acting on behalf of the users. A connection between the agents is treated as the proof for relation between their owners. The method of system structure data acquisition was proposed, which consists of capturing and interpreting the communication traffic between the agents. Although this method is applicable only when there exists a proper place for capturing the communication stream (e.g. shared communicational medium in case of networks or a blackboard in case of agent systems), it solves the issue of the distributed data acquisition without creating additional network nodes.

In future it is planned to develop other methods of graphical visualization of the system structure described with the proposed hierarchy of classes. Removing the users blocks from the visualization space and developing alternate methods of the agents owners visualization is a particularly interesting direction of development. These alternate methods include graphically marked potential fields, or adding another dimension to the visualization, where the position of an agent in additional spatial dimensions depended on its owner.

Acknowledgments

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An Agent Based Collaborative Simplification of 3D Mesh Model

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Abstract. Large-volume mesh model faces the challenge in fast rendering and transmission by Internet. The current mesh models obtained by using three-dimensional (3D) scanning technology are usually very large in data volume. This paper develops a mobile agent based collaborative environment on the development platform of mobile-C. Communication among distributed agents includes grasping image of visualized mesh model, annotation to grasped image and instant message. Remote and collaborative simplification can be efficiently conducted by Internet.

Keywords: Agent, mobile agent, mesh simplification, co-visualization.

1 Literature Introduction

Nowadays with development of three-dimensional (3D) scanning technology, such as coordinate-measuring machine (CMM), laser scanners, structured light digitizers, or computed tomography (CT), more and more digital product model can be measured directly from physical object. Measured model are usually described in 3D coordinate point cloud and is necessary to be conducted to build up 3D geometrical model for the further product design by using computer-aided design (CAD) technology and other digital engineering analysis. Point cloud is usually be tessellated into polygonal approximations called meshes. Triangle mesh is the most popular format to reconstruct point cloud. The advantage of triangle mesh is its simple data structure and efficient rendering. However, complex triangle meshes face challenge in real-time rendering performance, storage capacities, and heavy transmission workload. Mesh simplification is an efficient approach to reduce the size of complex mesh. The simplified coarse mesh model can reduce disk and memory requirements and speed up network transmission, and also accelerate real time display.

On the other hand, in the current modern product design, concurrent design stream requires real-time information communication and collaboration among complex concurrent processes. It is highly desired to build up an efficient collaborative communication environment to coordinate activities among design teams and to guarantee the effective interoperation among parallel engineering process.

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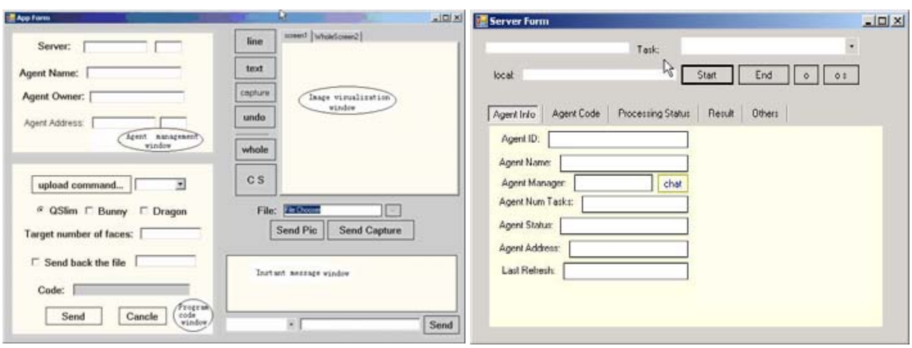
In this paper, an Internet based communication environment for collaborative mesh simplification among distributors is investigated. Mobile-agent technology is adopted to establish the internet communication environment. A prototype is developed based on a development platform of Mobile C. Image grasped collaborative visualization and communication environment is built up by image transmission and instant message exchange. This research is useful to internet-enabled collaborative product design and collaborative measurement in reverse engineering.

2 Introductory to Agent Technology

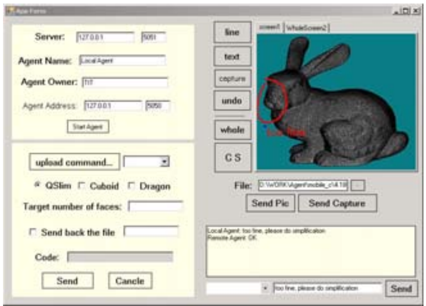
In agent-based collaborative design systems, agents have mostly been used to support cooperation among designers, providing semantic glue between traditional tools, and to provide a collaborative environment for sharing of design information, data and knowledge among distributed design tram members. Agent based approach has also been used to solve complex process of distributed manufacturing. Weiming Shen et al did a complete survey about agent-based distributed manufacturing process planning and scheduling, and regarded. Agent –based approach to be an effective way to realize adaptive and dynamic integration of process planning and manufacturing scheduling [1]. Xuan F. Zha et al developed a knowledge intensive multi-agent system for collaborative assembly modeling and process planning in a distributed design environment [2]. Dejan Milojicic introduced a mobile-agent based management system of satellite image data and compared with conventional client-server design, [3]. Bo Chen et al integrated mobile agent technology with multi-agent systems for distributed traffic detection and management systems [4].

Currently, there are many agent development platforms like Aglet [5], JADE (Java Agent DEvelopment Framework) [6], Agentbulider [7], and so on. These platforms choose Java as developing language. Mobile-C is an embeddable C based agent platform to support agent be written in C/C++, and interpreter –Ch is used as agent execution engine [8]. In this paper, Mobile-C platform is adopted to develop collaborative visualization environment for product design.



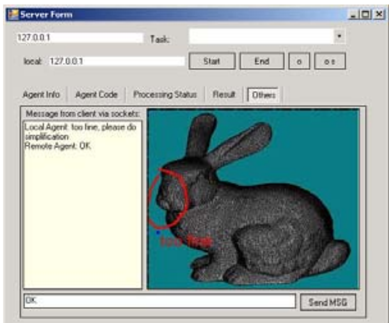
(a) Local agent (b) Remote agent

Fig. 1. Developed GUI

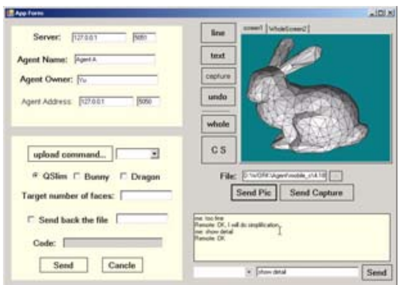


Original mesh model with 69453 triangles and file size of 14366KB; grasped image file size of 19K.

(a) Visualization of grasped image on local agent transferred from remote agent



(b) Response of instant message on the remote agent



Simplified mesh model with 10000 triangles and file size of 424KB; grasped image file size of 17K.

(c) Visualization of simplification model on local agent transferred from remote agent

Fig. 2. Collaborative mesh simplification process

4 Developed Prototype

A prototype is developed based on Mobile-C platform. Figure 1 demonstrates the GUI (graphic user interface) on the both sides of remote and local agents. It includes four windows: agent management window, image visualization window, program code window and instant message window.

Collaborative simplification process is demonstrated by selecting the Stanford bunny as the objective. When a local agent receives a grasped image of the visualized original mesh model from a remote agent shown in Figure 2 (a), annotation drawing can be performed on the visualization window. Then, the annotated picture can be sent back to remote agent as shown in Figure 2 (b). At the same time, opinion can also be exchanged among agents. Mesh simplification can be conducted by remote agent and a grasped image of the simplified model can be sent back to local agent as shown in Figure 2 (c). The advantage of this grasped image collaborative simplification is that file transmission load is lessen by transferring small size of grasp image rather than large-volume mesh model, which results in quick visualization and high collaborative efficiency.

5 Conclusions

This article investigates a mobile agent based collaborative environment for mesh simplification. Grasped image based model visualization and transmission can help to enhance collaborative efficiency. Annotation to image and instant message makes remote communication to be convenient. This study is useful to the further collaboration research in reverse engineering.

Acknowledgement

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The Incremental Launching Method for Educational Virtual Model

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Abstract. This paper describes the application of virtual reality technology to the development of an educational model related to the construction of a bridge. The model allow the visualization of the physical progression of the work following a planned construction sequence, the observation of details of the form of every component of the works and carry the study of the type and method of operation of the equipment applied in the construction. The model admit interaction and then some degree of collaboration between students and teachers in the analyses of aspects concerning geometric forms, working methodology or other technical issues observed using the application. The model presents distinct advantage as educational aids in first-degree courses in Civil Engineering.

Keywords: Cooperative visualization (CV); 3D virtual world environments; Simulation visualization in construction; Educational model.

1 Introduction

The aim of the practical application of the virtual reality (VR) model, presented in the text, is to provide support in Civil Engineering education namely in those disciplines relating to bridges and construction process both in classroom-based education and in distance learning based on e-learning technology. The process of developing the prototype interface considers the propose of conceive a collaborative virtual environment. It means that it can be manipulated by students, construction professional or teachers. The virtual 3D model presents a menu concerning the development of the activity linked to each step, so the teachers and the students can interact with it when explaining the method or studying it. The human perceptual and cognitive capabilities were taken into account when designing this visualization tool. Further more, associated with each new component or step there are integrated information concerning the construction activity, allowing the consult of the require data in any phase. The model attends the incremental launching method of bridge deck construction (Fig. 1). This model follows another VR models developed within the Technical University of Lisbon at the Department of Civil Engineering, concerning construction works (Fig. 1): one model shows the execution of an external wall, a basic component of a building, and the other presents the cantilever method of bridge deck construction [1].

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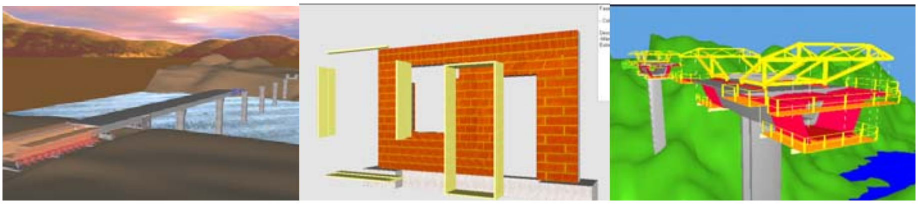

Fig. 1. VR didactic models related to construction

The developed applications make it possible to show the physical evolution of the works, the monitoring of the planned construction sequence, and the visualization of details of the form of every component of each construction. They also assist the study of the type and method of operation of the equipment necessary for these construction methodologies. Specialist in construction processes and bridge design were consulted and implicated in the execution of the educational models in order to obtain efficient and accurate didactic applications. The pedagogic aspect and the technical knowledge are presented on the selection of the quantity and type of elements to show in each virtual model, on the sequence of exhibition to follow, on the relationship established between the components of the construction, on the degree of geometric details needed to present and on the technical information that must go with each constructive step. From those applications it is possible to obtain 3D models corresponding to different states of their shape, simulating distinct stages of the carrying out processes.

In order to create models, which could visually simulate the progressive sequence of the process and allowing interact with it, techniques of virtual reality were used. When modeling 3D environments a clear intention of what to show must be planned, because the objects to display and the details of each one must be appropriated to the goal the teacher or designer want to achieve with the model. In addition, the use of techniques of virtual reality on the development of these didactic applications is helpful to education improving the efficiency of the models in the way it allows the interactivity with the simulated environment of each activity. The virtual model can be manipulated interactively allowing the teacher or student to monitor the physical evolution of the work and the construction activities inherent in its progression. This type of model allows the participant to interact in an intuitive manner with the 3D space, to repeat the sequence or task until the desired level of proficiency or skill has been achieved and to perform in a safe environment. Therefore, this new concept of VR technology applied to didactic models brings new perspectives to the teaching of subjects in Civil Engineering education.

2 VR Model of the Incremental Launching Method

An interactive model concerning construction of deck bridges to support Civil Engineering education was created [2]. The construction of bridge decks using the method on incremental launching exist from the 60s but their implementation did not occur in the same way in different countries. The developed VR model provides a contribution to the dissemination of information concerning this construction method, through a recording of visual simulation of the phases and the equipment that comprises the construction process.

The method of construction to apply has a great influence on the selection of the cross section of the deck and, consequently, on the structural solution. The incremental launching method consists of casting 15*m* to 30*m* long segments of the bridge deck in a stationary formwork to push a completed segment forward with hydraulic jacks along the bridge axis. This method is appropriated in viaducts over valleys and mountains with spans about 50*m*. The application of the process requires that the cross section of the deck is constant, because each section will have different states of bending moments and thus different tensions. The adequate type of section is the box girder (Fig. 2). Every elements needed in the virtual scenario were modeled and then the interaction was programmed using the some software based on the virtual reality technology, the EON Studio [3]. The 3D model of all elements was generated using AutoCAD (Fig. 2 shows the 3D model of the metallic launching nose). With the objective to allow some immersive capacity to the model, the river was represented by a surface with mixed colors and the selected panorama simulates a typical environment of river banks.

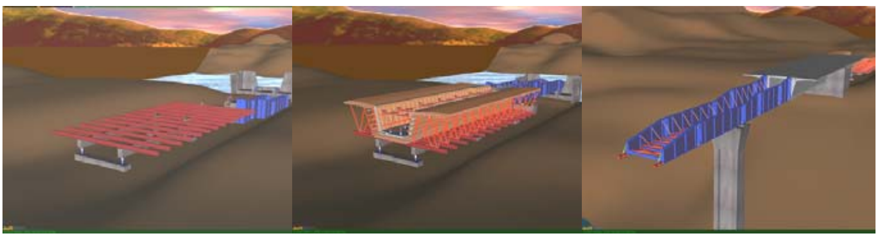

Fig. 2. The casting yard, the deck with constant cross section and metallic launching nose

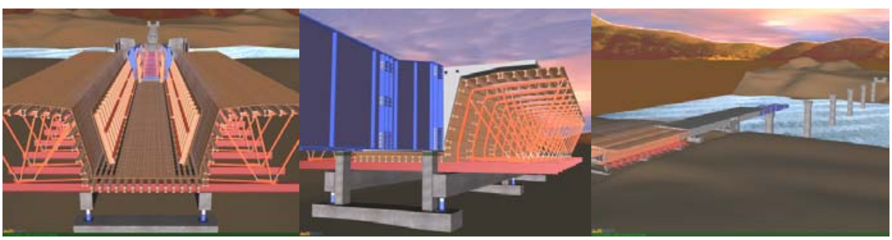

Fig. 3. Initial sequence of the incremental launched of the deck

The interaction with the model begins on the casting yard (Fig. 2). The elements supporting the form and the formwork itself are composed by beams and panels, made of wood. After placing the external panels of the shuttering and the reinforcement mesh, starts the visual simulation of the casting work (Fig. 3). The elements that make up the interior false work are placed incrementally, starting with the metallic support, followed by the longitudinal beams and finishing with the implementation of shuttering panels. Next, the assembly of the launching nose is installed (Fig. 3). The camera is adjusted to allow the correct visualization of this work. After casting the first segment the displacement of this element takes place. For that the temporary support of the nose is removed and the segment is separated from the shuttering.

The arrival of the nose to the first pier is achieved during the advance of the second segment. In it the small brown parallelepiped are the launch pads and are placed manually by workers between the nose and the temporary support placed over each pier. To represent the advance of the deck, the launching equipment appears in detail, and it consists of two parts located under each web of deck, provides the launching of the segments. This cycle is repeated until the progress of the first segment reaches about 31*m* (Fig. 4). Already in the final phase of construction, the nose arrives at the abutment (Fig. 4), the yard is removed and the space is covered of land. Finally the guards are positioned and also other finishing elements (Fig. 4). In order to report an overview of the construction place the camera points initially to the casting yard. During the animation, the position of the camera and its movement are synchronized to show the details of the elements or the assembly type and also an overview of the working place.

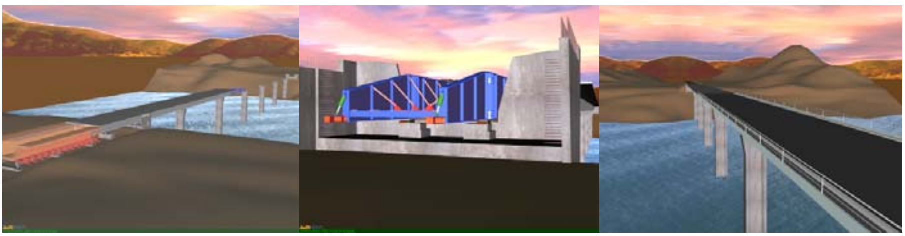

Fig. 4. Visualization of the deck displacement, of the nose and the final aspect of the bridge

3 Conclusions

The model was placed in a repository created under the activities of e-school, a platform developed in the Technical University of Lisbon, to be accessed by students and teachers of another institutions related to Civil Engineering. The application is oriented, not only as a learning tool, but also to professionals related to the construction of this kind of bridges. The model provides an immersive capacity inherent to virtual world and it has a menu of events display allowing the students and teachers to select a specific part. So, the model could be an important support to teachers to illustrate bridges construction issues in class and after, by themselves, using there PCs. In addition, the model, helping the understanding of technical aspects concerning construction, that is an incentive to the collaboration between students and teachers in order to develop the present model with more details or based in this create new models.

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Experimental Investigation of Co-Presence Factors in a Mixed Reality-Mediated Collaborative Design System

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Abstract. This paper argues how a Mixed Reality-Mediated collaborative design system should be featured after considering co-presence factors. This paper also presents an experiment to examine some of the co-presence factors, with a focus on the image size and viewing distance. The experimental results show that larger images and appropriate viewing distance could bring better sense of being in the Mixed Reality space and participants feel more involved in the design tasks. Therefore, by considering the co-presence factors, higher level of co-presence and better effects in the Mixed Reality-mediated collaborative design system could be achieved.

Keywords: co-presence, collaborative design, mixed reality, collaborative virtual environments.

1 Introduction

Collaborative Virtual Environments (CVEs) are computer-enabled, distributed virtual spaces or places in which people can meet and interact with others, with agents or/and with virtual objects [1]. CVEs can help meet some of the communication requirements that have traditionally been recognized as important to interactive real-time discussion, particularly when negotiation plays a key role and complicated topics are being discussed. CVEs clearly have the potentials to enable innovative and effective distance design techniques by creating a shared virtual environment for distributed participants. The emphasis can be placed on the human-to-human interactions mediated by computers as common understandings are negotiated and developed across different knowledge, skills and attitudes between multiple users. The increased sense of co-presence provides the feeling that people are actually "working together" [1].

As a user experience, the feeling of "being there", or called presence, is actually independent on any specific type of technology [2]. It is the product of mind. However, with the improvement of immersive displays, computing and network technologies, more accurate reproductions and simulations of reality could be created. This makes people increasingly aware of the relevance and importance of the presence experience. The concept of presence has become an important research in such

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areas as cinematic displays [4], virtual environments [5], telecommunication and collaboration [6], and so on.

One of the conceptual definitions of presence involves the idea of transportation [7]. Three distinct types of transportation can be identified: "You are there," in which the user is transported to another place; "It is here," in which another place and the objects within it are transported to the user; and "We are together," in which two (or more) communicators are transported together to a place that they share.

Co-presence is also a critical factor of remote collaborative work within a shared environment. Co-presence consists of two dimensions: co-presence as mode of being with others, and co-presence as sense of being with others. Mode of co-presence refers to the objective physical conditions which structure human interaction; while sense of co-presence refers to the subjective experience of being with others that an individual acquires within interaction [8]. Effective CVEs should provide high level of co-presence, which could encourage effective collaboration and communication between distributed users.

IJsselsteijn et al. [9] suggested that presence could roughly be divided into two broad categories – physical and social. Physical presence refers to the sense of being physically located in mediated space, whereas social presence refers to the feeling of being together, of social interaction with a virtual or remotely located communication partner. At the intersection of these two categories, co-presence, or a sense of being together in a shared space, could be identified as combining significant characteristics of both physical and social presence.

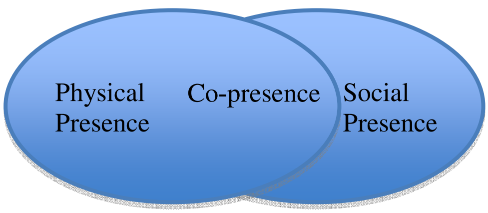

Fig. 1. Relationship between physical presence, social presence and co-presence, adapted from [3]

In our previous work [10], a Mixed-Reality-mediated system, *MR-Collab* has been designed. The purpose of creating *MR-Collab* system is to facilitate the collaborative design process by increasing the level of co presence. In the following sections, factors that could affect the level of co-presence will be discussed; an experiment that measures certain factors of co-presence has been implemented.

2 Presence Factors

There are a number of factors that could affect the level of co-presence and some of them that are related to the *MR-Collab* system will be discussed. Those factors could be characterized into two types: physical presence and social presence. Number and consistency of sensory outputs, quality, size and viewing distance of image, motion, colour, dimensionality and interactivity could be recognized as physical presence; the social realism is recognized as social presence.

2.1 Number and Consistency of Sensory Outputs

It is generally believed that the greater the number of human senses for which a medium provides stimulation, for instance, media sensory outputs, the greater the capability of the medium could produce a sense of presence [11]. Therefore the *MR-Collab* system has multiple channels of outputs including virtual objects and real world images, as well as audio chatting.

2.2 Image Quality

The perceived quality of an image depends on many characteristics, including resolution, color accuracy, convergence, sharpness, brightness, contrast, and the absence of "ghosts" or other noise. Neuman's research [12] showed that very high resolution images could evoke more self-reported presence than standard resolution images. Therefore the *MR-Collab* uses high quality texture images to evoke higher level of presence.

2.3 Image Size and Viewing Distance

The size of a visual image has received greatest attention from researchers concern with presence among all of the formal features. Larger images have been shown to evoke a variety of more intense presence-related responses. And along with larger images it is logical to expect that when people are physically closer (but perhaps not excessively close) to an image, they feel a greater sense of being a part of the image and therefore a greater sense of presence. But these two variables also act together to determine the value of a third variable, the proportion of the user's visual field that the image occupies, also known as viewing angle [13] and field of view [14].

Since the image size and viewing distance could act together on the level of physical presence, the use of egocentric such as Head-Mounted Displays (HMDs) might be a good solution instead of projector with big screen as mentioned in the previous factor. The *MR-Collab* system adopts HMD as display solution, and a webcam is attached on the HMDs and the virtual scene changes when the user changes his/her viewpoint. However, due to the technique limitation, the HMDs usually have lower resolution than computer displays do. To balance those variables, further experiments should be carried out.

2.4 Motion, Colour, and Dimensionality

It seems reasonable to conclude that moving images that provide the illusion of continuous action can more easily evoke presence than still images [15]. Color images should evoke more presence than those in black and white. Although it is lack of research in this area currently, this feature is worth to be considered in the *MR-Collab* system development. Three-dimensional virtual objects with colour images are adopted in the *MR-Collab* system.

2.5 Interactivity

The interactivity of a design system is another key factor that could evoke higher level of presence. The degree to which a medium can be said to be interactive depends on a number of subsidiary variables such as the number of inputs, number (and type) of characteristics that can be modified by the user, the range or amount of change possible in each characteristic, the degree of correspondence between the type of user input and the type of medium response, and the speed with which the medium responds to user inputs. To achieve higher level of co-presence, the ranges of those variables should be broaden. In *MR-Collab* system, multiple types of user inputs are adopted with wide range of changes that user could work on.

2.6 Social Realism

As anyone who watches movies or television knows, the storylines, characters, and acting in some media content is more realistic than in others. In a dramatic film or an interactive video game if the story makes sense and doesn't depend only on coincidence, if the characters act in consistent and understandable ways, if the actors skillfully and convincingly create their personae, the experience is more likely to evoke more senses of “being there”. In *MR-Collab* system, social realism is considered to evoke co-presence. For instance, video conferencing images of designers’ faces are used instead of cartoon styled images.

3 Experimentation on Presence Factors

As discussed in the previous section, it is inferred that the image size and viewing distance could affect level of co-presence in the context of Mixed Reality–based collaborative design systems. The focus of this section is to experimentally validate how the size and viewing distance of visual image could affect the physical presence (further affect co-presence level) of the real-scaled collaborative design environment, as compared against the down-scaled collaborative design environment. Figure 2 depicts the design scenario with down-scaled visual display. Participants could move small markers on a desk and get down-scaled virtual furniture visualization. *MR-Collab* affords the real-scaled testing treatment, which is shown in Figure 3. Larger markers are used and virtual objects (for instance, the virtual bed in figure 3) have the same scale with real objects (the chair in figure 3) in the room.

In this preliminary experiment, a group of participants (consists of 11 individuals) were recruited to perform an interior design task in both the down-scaled design environment and the real-scaled environment. Those participants have been assigned the task of arranging the furniture in a room. They use markers, which could represent the virtual furniture for the arrangement. In the down-scaled environment, they moved the markers around on a table; while in the real-scaled environment, larger markers were used to represent virtual furniture, which is the same size as real ones, and the design space is the entire room. Both of the two scenarios adopt Augmented Reality techniques for visualization and differ in the sizes of virtual objects and points of view in order to analyze the factor of image size and viewing distance. After the design, each participant was asked to complete a set of questionnaires for both treatments regarding their co-presence experience.

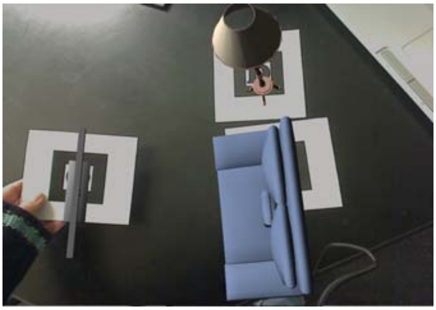

Fig. 2. Down-scaled scenario

Fig. 3. Real-scaled scenario

Two sets of questionnaires (10 questions for each) for both down-scaled and real-scaled systems are handed to participants. 7-point scale was used in the questionnaires. The questions include:

1. How natural did your interactions with the environment seem?
2. How much did the visual aspects of the environment involve you?
3. How much did your experiences in the virtual environment seem consistent with your real world experiences?
4. How compelling was your sense of moving around inside the virtual environment?
5. How real did you feel the virtual objects were?
6. How well could you examine objects from multiple viewpoints?
7. How involved were you in the virtual environment experience?
8. How much delay did you experience between your actions and expected outcomes?
9. How proficient in moving and interacting with the virtual environment did you feel at the end of experience?
10. How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?

The better experiences the participants get, the higher mark is expected to be given. For instance, if the participants feel it is completely natural when they interact with the real-scaled environment, they might give more points up to 7; and if they feel it is extremely artificial when interact with the down-scaled environment, they may want to give a lower mark compared to the real-scaled environment.

The results show that the factors of image size and the viewing distance could affect the design process in *MR-Collab* system. However, some drawbacks of the real-scaled system have also been identified. Figure 4 shows the average points the two sets of systems have received for each question.

The average points for each question in the two sets of experiments are in the range of 4 to 6. In some aspects, the real-scaled and down-scaled environments have received similar or even same points such as interaction with the environments, moving around inside the environments and the involvement when working in the environments; in some aspects, the real-scaled environment has more advantages, such as the visual aspects and the realistic of virtual objects; while in other aspects the down-scaled environment receives higher marks such as the delay, proficiency and the concentration on the task.

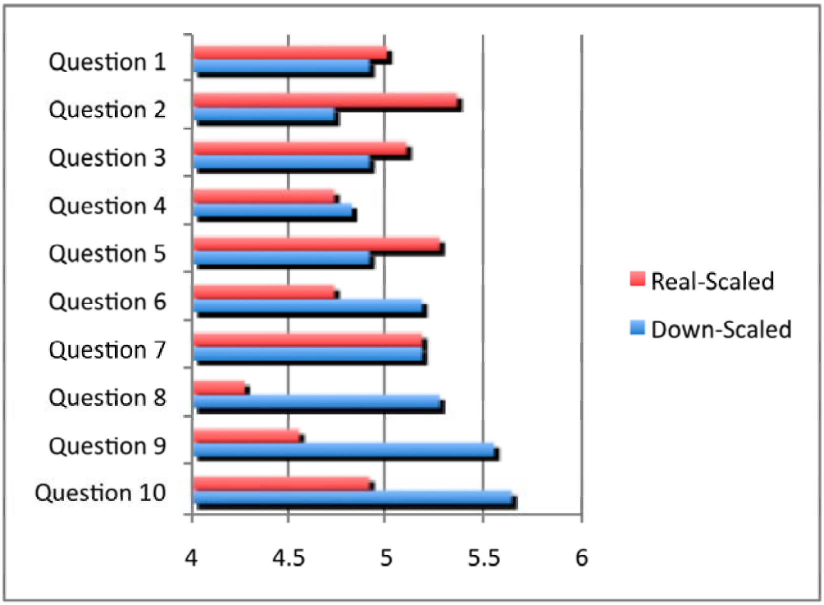

Fig. 4. Experiment results from questionnaire

Comments are also collected from participants. For the down-scaled environment, it is recognized as "very easy in controlling but seems not real and weak in the feeling of being involved"; "small objects are not as real as large objects, it is difficult to recognize details of virtual objects; however, it has flexible movements"; "With down-scaled objects, it is relatively easy to move them around, since the objects are put in a small area range, and the delay is shorter; however, as we can only see those objects from an eagle-eye view, it might be harder for those who are not familiar with this view".

For the real-scaled environment, comments are collected as "it is more real and easier for the operator to be involved in the surrounding environment"; "the head movement is limited and less flexible than that with small objects; however it is better immerged in the environment and we can find more details of the virtual objects"; "For the real-scaled objects, they look more real, which could give the participants better experience/understanding of the objects; however, as they are real-sized and being put in a large area, it is more difficult to move them around due to the limitation of the wired HMD and camera".

Some of the participants give suggestions that the types of environments with different scaled virtual objects should be adopted together when implementing the design task as both of them have their own advantages. When making the arrangement of the virtual furniture, the down-scaled system could be adopted because it is easier to move objects around on the table and it could give an outlook of the entire room; and after the arrangement, it could be switched to the real-scaled environment to give users a more immersed and realistic view of the designed room.

4 Discussion

From the result of the experiment, it could be identified that real-scaled virtual objects with larger texture images could bring better sense of being in the Mixed Reality world and the participants felt more involved in the environment. However, due to some limitations, such as the HMD is heavy and it has wire, which actually limits the movements of the participants, people could not move to wherever they want to be in the real-scaled environment when performing the design task. As a result, the participants think it is harder to examine virtual objects from multiple viewpoints, less proficient in moving and interacting with the virtual environment and less concentrated on the design tasks with the real-scaled system. It is assumed that if better technology has been developed and a wireless HMD is adopted in the real-scaled environment, with which people could walk to wherever they need to, the results could be different. Considering the current limitation on technologies, when designing and developing the collaborative design system, different co-presence factors should be considered together with technology to achieve best effects. To sum up, by analyzing the co-presence factors, higher level of co-presence and better effects in the collaborative design system could be achieved.

5 Future Work

In this paper, an experiment examining how image size and viewing distance could affect on co-presence has been conducted. However, these factors are a small part of co-presence characteristics. To better understand the effects of co-presence factors and to design a better collaborative design system, further experiments that focus on other co-presence factors should be conducted. For instance, in order to evaluate how different outputs affect co-presence, each channel of outputs could be disabled at one time; in order to examine how dimensionality could affect the level of co-presence, an experiment comparing the use of two-dimensional image and three-dimensional virtual objects could be implemented. Through collecting and analyzing those data, it could lead to better design of Mixed Reality mediated collaborative design system.

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Dynamic Resilient Workflows for Collaborative Design

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Abstract. Large-scale simulation and optimization are demanding applications that require high-performance computing platforms. Because their economic impact is fundamental to the industry, they also require robust, seamless and effective mechanisms to support dynamic user interactions, as well as fault-tolerance and resiliency for multidiscipline applications. Distributed workflows are considered here as a means to support large-scale dynamic and resilient multiphysics simulation and optimization applications, such as multiphysics aircraft simulation.

Keywords: Collaborative Design, Workflows, Resiliency.

1 Introduction

Large-scale multiphysics applications, e.g., aircraft flight dynamics simulation that takes into account aerodynamics and structural loads, are considered today fundamental by aircraft manufacturers in order to gain leading position on highly competitive innovative markets world-wide. The same goes for mobile phones manufacturers.

Not only are organizational problems put forward, because of the risk-sharing partnerships that are often implemented, but technological and scientific challenges are addressed because verification and validation of numeric models are necessary in order for virtual prototypes to allow drastic reduction in time-to-market design [5].

Multiphysics approaches are considered here in order to better combine and synchronize the intricate relationships between the various disciplines that contribute to the integration of complex new products, e.g., acoustics, electromagnetics and fluid dynamics in aircraft design [7].

High-performance computing also opens new perpectives for complex products definition, design and tuning to market needs. However, high-performance computing platforms also raise new challenges to computer scientists in order to fulfill the design bureaus requirements, e.g., the management of petascale volumes of data, the management of distributed teams collaborating on large and complex virtual prototypes, using various remote computerized tools and databases, etc [9].

This paper focuses on the design of distributed workflows systems that are used to define, deploy, configure, execute and monitor complex simulation and optimization applications. It emphasizes the need for resilient and dynamic workflows.

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2 Dynamic Workflows

Workflow techniques have long been used in the industry and service sectors [1]. The control techniques used were usually dedicated to documents and project management in the business sector, implementing a control flow approach. During the last decade, the e-science sector has also shown a growing interest in workflows [3, 4]. In contrast, it has extensively used a dataflow approach for the processing of large numeric data sets [5, 6].

The integration of large industrial projects contribute nowadays to a combined use of these two approaches in order to gain orders of magnitude in delays corresponding to preliminary design, detailed design, prototyping, testing, manufacturing, delivery and support [2].

Important challenges are raised in using integrated approaches and using computerized support: distributed integration platforms that combine heterogeneous data and tools are used by various remotely located teams collaborating on large and complex projects. They are nowadays distributed worldwide: current partnerships involve hundreds of companies located in North America, Europe and Asia for one single large project.

Also multiphysics design in aeronautics includes several disciplines and various tools that pertain to each particular expertise involved. This includes CAD tools, meshers, solvers, analyzers and optimizers, which in turn are used to modify the meshes in iterative and incrementally optimized design processes (Figure 1).

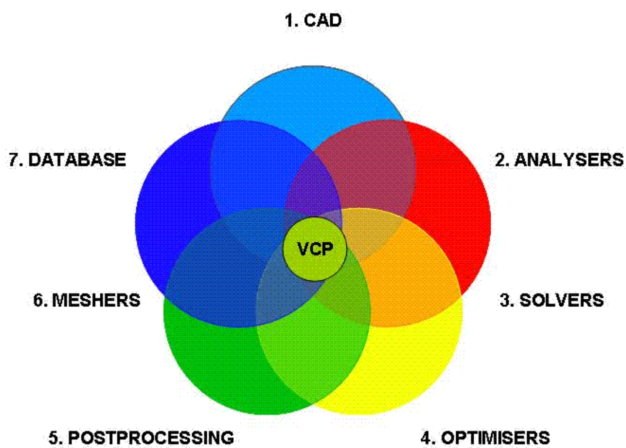

Fig. 1. Tool interactions in collaborative design

Multiple solvers and analyzers are used cooperatively to solve multiphysics challenges (Figure 2). In turn, subsequent optimizers are used to reach global optimum under the various constraints of the disciplines involved, and possible uncertainties that are taken into account, for example uncertainties concerning the angle of attack or Mach number for the flight conditions considered [8, 11].

The distributed and collaborative nature of the design requires highly fault-tolerant systems. Indeed, distributed computing is inherently subject to unexpected failures, whether in communication networks or in computer software systems.

Further, high-performance computing systems introduce new failure hazard due to the complex harware and software technologies that are used: large PC-clusters including thousands of compute nodes, memory hierarchies, network latency, etc.

Even more, simulation and optimization applications require versatile parameter inputs in order to numerically test, assess and compare tens of solutions and prototype configurations: wing profiles, engine nacelles and cabin geometry for noise reduction, etc.

It is therefore essential that the computerized systems executing the multiphysics applications support dynamic interactions with the users. The workflow system is then qualified *dynamic*.

We consider here only distributed workflow systems as the infrastructure for these applications [10]. A sophisticated approach is to build composite workflows, i.e., workflows that are not limited to hierarchical constructs, but include also interactions among sub-workflows whatever their level in the hierarchy. This builds workflow graphs. They are useful for complex applications that involve iterations among sub-workflows, for example aero-structure optmization applications that are used for aeroelasticity stress and deformation computations in aircraft design (Figure 3). They involve CAD systems, mesh generation codes, computational fluid mechanics (CFD) and computational structure mechanics (CSM) solvers, data analyzers, CFD and CSM optimizers, databases and visualization tools.

3 Resilient Workflows

Pause, resume, abort facilities are required in distributed workflow systems in order to update input parameters for the simulation and optimization processes.

This calls for dynamic logging mechanisms, interleaved checkpoints management, distributed pause, resume and abort mechanisms. They can be used also as building blocks for supporting resiliency (Section 3.2).

Past research in distributed systems tells us that distributed recovery algorithms are implemented using partial order among checkpoints. This guarantees that if updates can be serialized, then pause and restart mechanisms are safe, i.e., they are robust in case of failure. Further, backup and restart mechanisms restore the data and processes in a previously saved state, if correctly scheduled.

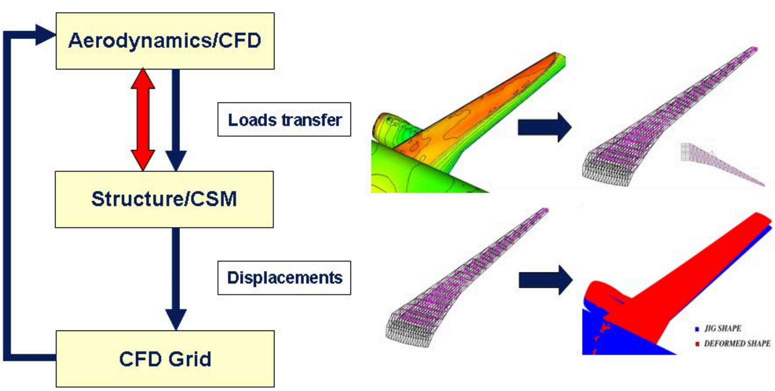

Fig. 2. Aeroelasticity and wing interactions (courtesy Alenia Aeronautica)

This guarantees that the executing application codes can be paused and resumed after dynamic parameter updates by the users. It also guarantees that the executing applications can be restored after system or application failures. The whole workflow system, including the running applications, is then qualified *resilient*. This departs from fault-tolerance, which focuses only on hardware, system and communication failures.

In case of erratic application behavior, it it also clear that the users can invoke these services to abort them as well as pause and later update the execution parameters in order to restart the simulation processes.

The infrastructure required to implement these services can benefit from the appropriate functionalities developed in existing grid middleware, e.g., Globus, UNICORE, gLite [12, 13]. Also, high-performance visualization tools like parallel display walls can be interfaced with the workflow systems, e.g., CUDA programming tools on GPU-clusters, in order to compare various design alternatives in real-time.

3.1 Fault-Tolerant Workflows

Because distributed systems are potentially faced with unexpected hardware and software failures, adequate mechanisms have been devised to handle recovery of running systems, software and applications.

Checkpoint and restart mechanisms are usually implemented using the local ordering of the running processes. This implies that the safe execution of all the running processes is not guaranteed, i.e., there is no way a randomly aborted distributed process can be restored in a consistent state and resumed correctly. The solution would be to use a global synchronization and clock, which is practically unfeasible and very constraining.

On the application side, this is used by transaction systems, e.g., airline reservation and banking systems, because compensation in case of failure is fundamental.

However, design, simulation and optimization applications bear specificities that require less stringent mechanisms than transaction systems. Design is a stepwise

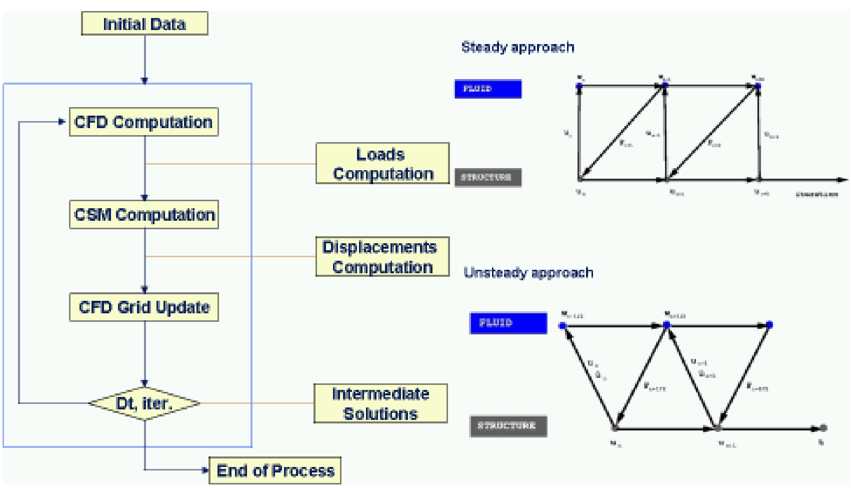

Fig. 3. Aeroelastic wing deformation computation

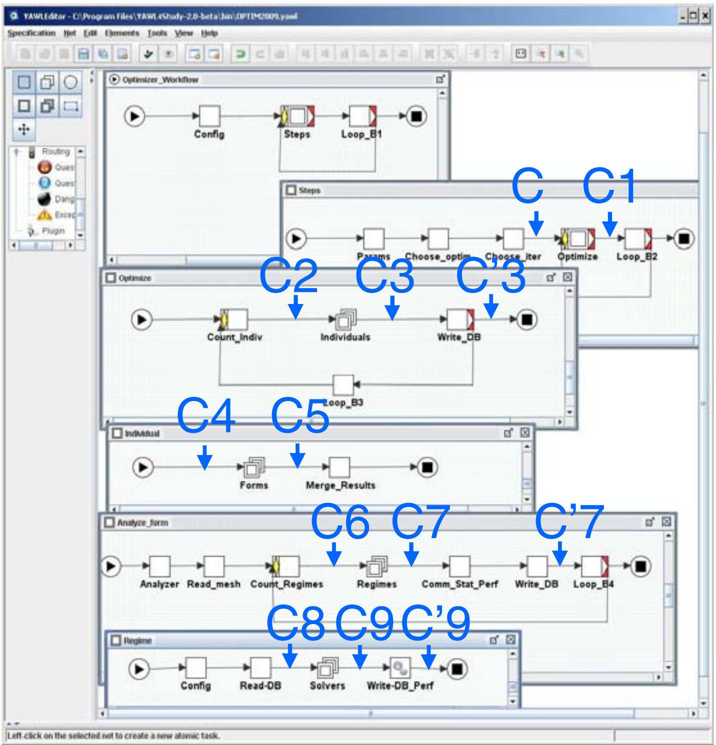

Fig. 4. Fault-tolerant workflow: checkpointing the wing optimization

process that does not require global synchronizing, except when and only when dynamic update propagation is required. This can be executed during limited time periods and does not impair the usual stepwise approach.

The same goes for simulation and optimization, where long duration processes are executed, which can invoke many composite components. These components may be invoked by sub-workflows. They bear a similar nature: global synchronization is not required, only synchronization for composite sub-workflows with their running components. Even so, asynchronous executions using pipelining of intermediate results can been devised.

Thus, checkpoints must be inserted in the workflow composite hierarchy. They can bracket critical parts of the hierarchy, e.g., the most demanding CPU components (unsteady flow calculations over a 3D wing model, for example) and the following optimization components which might be less CPU demanding, but are fundamental to the application because they allow for the comparison of various optimized solutions .

For example, the wing optimization workflow depicted by Figure 4 can use the following bracketing checkpoints:

- C0 and C1 to save the intial parmeters and the optimization results
- C2 and C3 to save the individual solutions (alternatively, C'3 can save the results)

- C4 and C5 to save the individual solutions geometry variants (the forms)
- C6 and C7 to save the various flight regimes results (C'7 if the database is saved)
- C8 and C9 to save the results of the various solvers executions (and C'9 to save the database)

Should some random hardware and software failure occur, it is easy to see that each optimized solution (called here "Individual") computed so far is saved, corresponding to every geometry (called here "Form"), every flight regime and every solver computation is saved. This minimizes the process of resuming the optimization workflow when aborted due to some external cause. This is an implementation of fault-tolerance.

The approach implemented here lends itself smoothly to sophisticated restart procedures because the inherent parallelism of the composite workflows is automatically taken into account. For example, the checkpoint C6 supports the resuming of the composite and parallel sub-workflow "Regimes". The latter can be restarted entirely or partially if some of its component "Solvers" resumed correctly. Their results are checkpointed by C9 and alternatively C'9 if they are stored in the database DB_Perf (Figure 4).

This implements a coarse grained approach, which can be sufficient in simulation and optimization scenarii. In case of unexpected hardware and software failure when one of these components is executing, the CPU demanding or optimization processes can be restarted, saving the whole workflow which has not to be restarted entirely. This is not adequate for resiliency, however, which requires a fine-grained approach.

3.2 Resilient Workflows

Resiliency differs from fault-tolerance because it is related to the ability of the applications to survive to unpredictable behavior.

In contrast with fault-tolerant workflows which can survive hardware and system failures, using ad-hoc bracketing by checkpointing mechanisms, resilient workflows need to be aware of the application structure in order to implement automated survival procedures. These procedures can use the bracketing of sub-workflows also, but in addition, they need specific logging of the workflow components operations and parameters to restore incrementally previous states and resume partially their operations (Figure 5).

In case of failure or erratic behavior, an iterative process is implemented that chooses a particular checkpoint and executes several steps forward. If the application does again behave erratically, it is supposed to be stopped by the user. The checkpoints are then choosed further backward in time in the workflow execution and the application is then again partially resumed with updated parameters or pre-specified user operations. This resiliency mechanism iterates until the workflow resumes correctly or is aborted.

Further, parallel branches of the workflow that failed need later to be re-synchronized with the parallel branches that resumed correctly. This requires that the results of the successful branches are stored for further processing with the failed branches results, if they resume correctly later. Otherwise, these results are discarded if the failed branches never succeed.

3.3 Implementation

At the lowest level of the workflow compoenents, the execution of the parallel instances of the basic tasks need specific mechanisms to be implemented. The most common approach is to use threading of parallel executing branches. This is particularly suited to multi-core and parallel processors. Because threads are basic operating systems features, this is a very effective implementation of parallel instances of tasks. They however lack important features: the restore and checkpoint basic mechanisms.

Watchdogs are implemented to scrutinize the application behavior. Erratic executions and abnormal results can then be detected without waiting for some dramatic craches. Indeed, this possibility needs large portions of the application to be restarted if no fine-grained warning mechanisms are implemented.

Because there is no awareness of the successful branches on the possible failures of parallel branches in the workflow, time-out and synchronization signals must be exchanged on a regular basis to notify each branch of the current state of the others: alive or not responding.

Additional mechanisms are therefore used that implement the watchdogs, i.e., time-outs and alarms. These are based on the sophisticated exception handling mechanisms that are available in the YAWL workflow management system [14, 15].

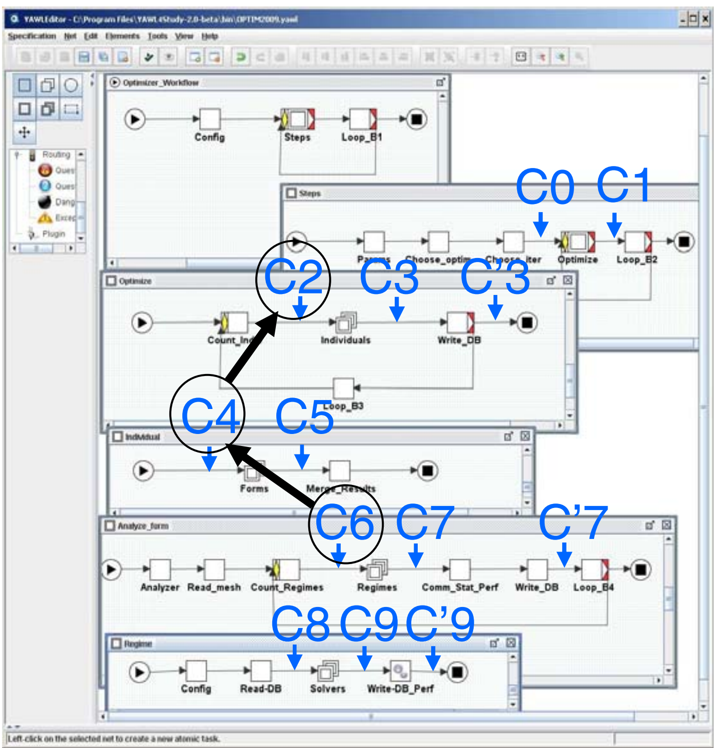

Fig. 5. Resilient workflow: iterative recovery of the wing optimization

Resiliency is therefore implemented using the complementary interactions of several features:

- exception handling
- watchdogs
- time-outs
- alive notifications
- synchronization signals

3.4 Example

In the wing optimization example depicted in Figure 5, if the “Regimes” component workflow fails for some unpredictable reason, the resiliency process will restore the workflow state at checkpoint C6. This means that all solvers calculations for the current individual solution will be restarted. Note that some particular solver computations that resumed correctly so far for the current individual solutions are already saved at checkpoint C9.

Should this process fail again for some reason, the resiliency mechanism will step backwards to checkpoint C4. This means that the whole geometry calculations for the current individual solution will be restarted. Note that the computations already finished for other individuals are not affected and have been saved at checkpoints C9, C7, C5 or C3 if no synchronization barrier have been defined.

The successful solver computations can be saved for later comparison or scrapped. Earlier parameter might be modified in order for the whole solver process to resume, in which case, the comparison might be useful for this indivual geometries and flight regimes.

Should again the whole “Regime” component workflow fail, the resiliency mechanism will step backwards again to checkpoint C2, which means that the whole geometry, regimes and solvers computations will be restarted for the current individual solution being processed.

Because it uses extensively checkpoints, data and parameter logging, this approach incurs an overhead on workflow execution. It is therefore appropriate for critical parts of the hierarchic workflow applications, e.g., the various geometries of the wing, the flight regimes of interest and the different solver computations, which might include uncertainties or not.

4 Conclusion

The complexity and technologies inherent to large industry projects requires sophisticated tools to support the integration of data and of various disciplines.

This in turn calls for powerful computer infrastructures that can support sometimes opposite requirements: seamless user interfaces, intricate multiphysics interactions among disciplines and dynamic user interactions with the design, simulation and optimization applications.

Distributed infrastructures exhibit also potential hazards to the executing processes, due to unexpected hardware and software failures. This is endangered by the use of distributed high-performance environments that include very large clusters of multi-processors and multi-core nodes. This requires fault-tolerant workflow systems.

Further, erratic application behavior requires dynamic user interventions, in order to adapt execution parameters for the executing codes and to run dynamic application re-configurations. This requires resilient workflow systems.

This implies applications roll-back to appropriate checkpoints, survivability procedures, fault-tolerance to external failures and support for resiliency to internal application failures. Dynamic and resilient workflow systems appear therefore as powerful tools to support large-scale collaborative design projects.

Basic mechanisms used to implement a resiliency procedure are presented. They are based on synchronization signals, alive notifications, and exception handling features that are used to build watchdogs. They act as primitive warning and alert mechanisms to solicit dynamic user interventions or trigger automated roll-back and restart procedures.

This avoids costly runs of uninterruptible tasks or bizarre codes that would otherwise have to be aborted, checked, updated and run again.

The appropriate integration of these dynamic and resilient workflow systems with existing dataflow approaches used elsewhere in e-science applications as well as multi-core and multi-processor systems is a challenging open issue that still requires important efforts.

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Optimization of Product Development Process Based on Multi-agent Simulation

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Abstract. In order to improve dynamic process performance of the development project, human-centered simulation of product development process is realized based on multi-agent modeling principle. Based on the multi-agent simulation, process evaluation indices of the product development project are proposed, including planning deviation rate, process risk, and design error level. Algorithms of these indices based on the simulation process data are studied and realized in the simulation program. A real development project is simulated, and the simulation results show that the simulation evaluation indices can effectively reflect the process performance. Based on the simulation, further optimization analysis to improve the process performance is carried out by rearranging task-flow, human resource, and organization structure. The evaluation and optimization methods using multi-agent simulation provide a new way for the development project process analysis and improvement.

Keywords: Product Development, Multi-agent Simulation, Organization Evaluation, Optimization.

1 Introduction

Forecasting, evaluating, and optimizing the product development process (PDP) using computer simulation keep being an important research direction in product development planning and process management. At present, most simulation researches establish task-flow model of the product development process according to the discrete event dynamic simulation (DEDS), in which designers are assigned to tasks as design resource. Evaluation indices of this kind of simulation include time, critical path, resource utility, and so on. For example, Design Structure Matrix (DSM) is constructed process model based on, and analysis the development time and cost by simulating task flow. [1, 2, 3, 4]. Besides DSM, Petri net is another important tool used for PDP modeling [5, 6]. Above researches play an important role in evaluating the product development project, however, process problems related with human and organization factors are often neglected. These problems including: additional design

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time caused by design errors of designers during the design process; rework process caused by insufficient communications among organization; design risk caused by process problems not resolved in time. The reason for the neglecting of these problems is that it's difficult to describe complex behaviors such as human error and organization interaction in task-centered process models. As a result, it's also difficult to evaluate and improve these factors in the development process [7, 8].

To solve the problem, multi-agent simulation model of the product development process is proposed to realize human-centered process simulation [9]. In this paper, some new evaluation indices based on the multi-agent simulation process are formulated and calculated to reflect process performance such as organization efficiency, process risk and error level, and further to be used for dynamic analyzing and optimizing the process.

2 Product Development Process Simulation Based on Multi-agent Modeling

According to multi-agent modeling theory, the product development process in this paper is described as a process in which designer agent continuously changing the state of the design environment until achieve the goal of product development project through autonomy behavior and organization behavior. So, the model of product development process based on multi-agent can be constructed by design agent and design environment. Agent represents designer and environment represents the object treated by designers. According to the work content of agents in product development project, the design environment objects include design task, product information, and design resource, as shown in Fig.1. The agent's behavior process is simulated by performing design tasks and collaborating with other agents under the limitation of organization constrains. When the status of all tasks is "finished" and the status of all product information is "known", the simulation is ended, and the accumulative simulation time is just the time needed to complete the project.

Based on the above principle, the behavior characters of designers can be sufficiently represented in the product development process. Based on the analysis of the product development process, three behavior layers of design agents are established: reactive layer, deliberative layer, and collaborative layer. Reactive layer includes error behavior and disturbance behaviors [9]. Deliberative layer includes task scheduling behavior and resource selection behavior. Collaborative layer includes collaborative behavior and report behavior. Collaborative behavior means that design agent needs assistance from other members to accomplish the task. In this course, the design agent may execute the collaborative task together, or, the design agent just waits for the collaborative agent to accomplish the task. Report behavior means that the designer asks for the superior agent when exception happens during the task execution and can't be treated. When collaboration and report happen, temporary tasks will be generated in the simulation course, which are assigned to corresponding agent to accomplish. In simulation course, agent's behaviors occur in preset probabilities. And then, corresponding behaviors are executed according to the behavior rules in agent's knowledge base.

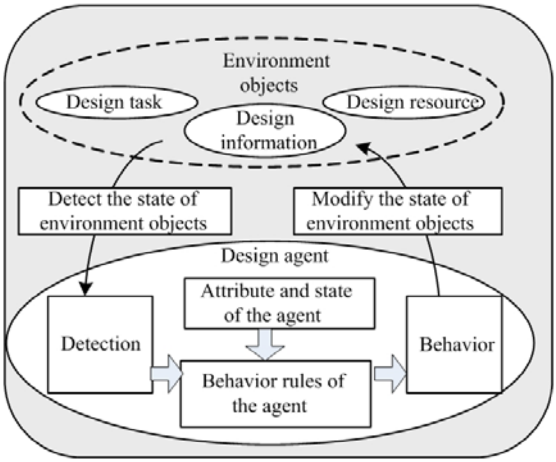


Fig. 1. Multi-agent simulation model of PDP

Because each designer's behavior in the product development process can be simulated, the process simulating data can support dynamic process evaluating of the product development project. From this starting point, this paper studies process evaluation indices and the corresponding algorithm, and how to analyze and optimize the process performance of the product development project based on these indices.

3 Evaluation Indices and Algorithms

3.1 Deviation Rate of the Plan

The first index is the deviation rate of the plan, which can be defined as follows:

Definition 1. The planning deviation rate η means the different degree between the simulated completion time of the project and the project's planning time. This evaluation index reflects the whole efficiency of development team, and can be expressed as follows:

$$\eta = (T_p - T_r) / T_p \tag{1}$$

Here, T_p is the planning time of the project; T_r is the simulated accomplish time of the project. If $T_p = T_r$, then $\eta = 0$, and it means that the project will be accomplished exactly in the schedule. If $T_p > T_r$, then $\eta > 0$, and it means that the project will be accomplished in advance. Meanwhile, the bigger η is, the higher the team's work efficiency is. If $T_p < T_r$, then $\eta < 0$, and it means that the project will be delayed. In this case, the bigger η is, the lower the work efficiency of the team is.

The simulated accomplish time of the project (T_r) in the formula (1) is the accumulative total time in a simulation cycle. And it is composed as follows:

$$T_r = \sum_{i=1}^{n} NT_i + TEP + WAIT \tag{2}$$

Here, NT_i is the normal design time of the normal task *i*; *TEP* is the total time of temporary tasks; *WAIT* is the free or waiting time during the process, which can be counted from the simulation process; n is the total number of normal tasks.

In formula (2), temporary tasks can be divided into collaboration tasks and report tasks. So the total time of temporary task TEP can be expressed as follows:

$$TEP = \sum_{j=1}^{l} TEP_j = \sum_{j=1}^{p} CO_j + \sum_{j=1}^{l-p} RE_j \tag{3}$$

Here, $\sum_{j=1}^{p} CO_j$ is the summation time of all collaborative tasks; $\sum_{j=1}^{l-p} RE_j$ is the summation time of all report tasks; l is the total number of temporary tasks; p is the total number of collaboration tasks.

3.2 Process Risk Level

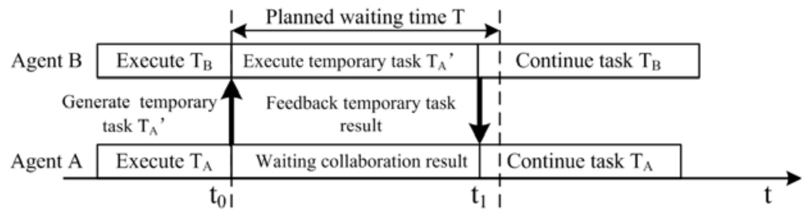
As a tightly collaborative process, risks of product development process can be generated by poor collaboration. Because the agent's behavior process is simulated, the process risk caused by poor collaboration can be evaluated based on multi-agent simulation process. As Fig.2 (a) shows, design agent A proposes a collaborative request to agent B at t_0 time when he executing task TA. Then agent B deals with the temporary collaborative task in time, and accomplishes this temporary task in A's planned waiting time (T). In this case, the collaboration is successful, and there is no process hidden risk. However, if agent B has prior tasks to do, the collaborative request will not be treated immediately. As Fig.2 (b) shows, if agent B does not treat the temporary collaborative task in agent A's planned waiting time (T), agent A will not wait anymore, and will cancel the collaboration request and continue executing task TA at t_2 time. In this case, without expected collaborative information, executing TA would cause hidden troubles to the process quality as well as product quality. The report circumstances are same as the situation above. The agent will treat the task by himself if the report is not treated by superior agent in time, and this also can increase design risk.

According to the above analysis, process risk level (R) can be defined as follows:

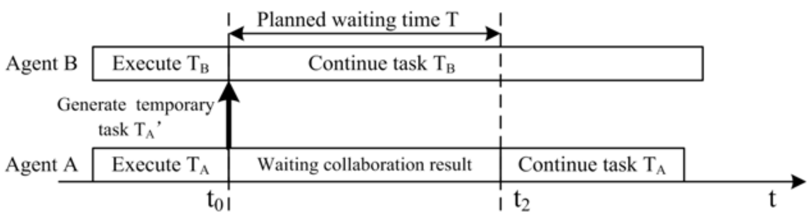
Definition 2. Process risk level (R) means the hidden quality troubles of the process caused by temporary tasks such as collaboration and report. It can be expressed as a percentage of untreated time on collaborative and report tasks on the total time of temporary tasks.

$$R = (\sum_{j=1}^{p} CO\_FAIL_j + \sum_{j=1}^{l-p} RE\_FAIL_j) / TEP \tag{4}$$

Here, $\sum_{j=1}^{p} CO\_FAIL_j$ is the summation time of all untreated collaborative tasks; $\sum_{j=1}^{l-p} RE\_FAIL$ expresses the summation time of all untreated report tasks; p is the total number of untreated collaboration tasks; *TEP* is the summation time of all temporary tasks, and can be calculated by formula (3).



(a) The temporary task's disposing process without risk



(b) The temporary task's disposing process with risk

Fig. 2. Formulation process of process risk

3.3 Error Level

Human design error has important impact on time and quality of product development process, and reflects the human resource quality of the design team. To describe it, the design agent's error behavior rules are established in the multi-agent simulation model. If design agent occurring a design error at t_1, and then rework immediately. However, due to learning effect, the time to rework the executed part will be shortened, so, the learning factor (s) is introduced. Then, the time of reworking the executed part can be expressed as $\Delta t = s(t_1 - t_0)$. Compared with the task time without error, the task time with one error has increased by Δt.

According to the above error behavior rule, error level can be defined as follows:

Definition 3. Error level E means the loss of design time caused by designer's error behavior, and can be expressed as the ratio of error time on normal time of the task.

According to the definition, the error level can be divided into individual error level and organization error level. The individual error level can be calculated as follows:

$$E_j = \sum_{i=1}^{q} \Delta t_i / \sum_{i=1}^{q} NT_i \tag{5}$$

Here, E_j is the error level of agent j; q is the total task number of agent j; Δt_i is the delayed time of task *i* caused by agent *j*'s error behavior.

Similarly, organization error level can be calculated as follows:

$$E_o = \sum_{i=1}^{n} \Delta t_i / \sum_{i=1}^{n} NT_i \tag{6}$$

Here, E_o is the organization error level; n is the total number of planned design tasks.

4 Process Analysis and Optimization

Based on the multi-agent process simulation, above evaluation indices are applied to analyze the plan of a real design project. First, in the multi-agent simulation platform, a simulation model is established according to the project plan. There are totally 5 persons working in the project. The workflow of the project is shown in Figure 3. Then, model parameters are input, including project planning time, normal time of planned tasks, temporary task time, happening probabilities of agent's behaviors, learning factor, initial status of environment objects, and task's allocation scenario.

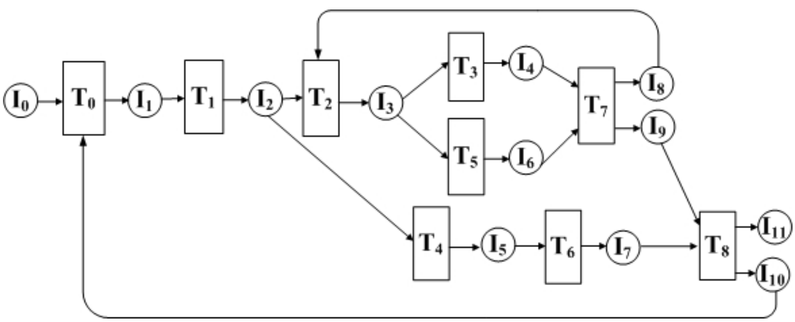


Fig. 3. Workflow of the simulation case study

Table 1 shows the simulation result. Here, each evaluation index is the statistic average value of 200 simulation runs. The project's simulated accomplish time is 47.45 days, and according to the actual finish time (52 days), the simulation error is 8.75%, which means the simulation model can effectively reflect the reality of the product development process. According to the simulation result, the plan deviation rate η is -5.44%, the process risk level is 19.0%, and organization error level is 7.2%.

The next optimization step is to find out how to shorten the project duration as well as to lower process risk and error rate. According to the effecting factors of each

Table 1. Simulation results of evaluation indices

Project duration (day)		47.45
Plan deviation rate η		-5.44%
Process risk level		19.0%
Error level	Individual error level E_i	$E_0=0,E_1=0.047,E_2=0,E_3=0.070,E_4=0.143,E_5=0.051$
	Organization error level E_0	7.2%

evaluation index, optimization and improvement of the project plan can be made from the following aspects:

Task flow: divide the task which has long execution time into concurrent shorter tasks to accelerate the schedule and eliminate design error impacts.

Human resource distribution: according to the changed workflow, rearrange human resource distribution scenario.

Organization structure: change the interaction relationship by improving the organization structure to decrease process risk level.

According to the consideration above, an improved simulation model is formulated. In this model, the organization structure is changed from the original two-level structure to flat organization structure, in order to accelerate information communication between the members. As to workflow, task T0 and task T4 are divided into some shorter concurrent tasks.

Table 2 shows simulation results of the optimized model. Compared with table 1, the project cycle time is obviously shortened after optimizing, which means that the improved design organization and workflow can accomplish the project more efficiently. The process risk level after optimization is decreased by 6.8%. The main reason for this is that the temporary collaboration task can be responded sufficiently, and the request task can be treated in time. Finally, the organization error level is decreased by 4.1%. The reason is that tasks which have long durations are reduced; as a result, the error occurring times are reduced as well. Additionally, the simulation result is accordant with the actual situation, which indicates that the evaluation indices can reflect the actual process performance of the project.

Table 2. Evaluation indices after optimization

Project duration (day)		33.6
Plan deviation rate η		25.3%
Process risk level		12.2%
Error level	Individual error level E_i	$E_0=0,E_1=0.034’E_2=0.011,E_3=0.052,E_4=0.026,E_5=0.023$
	Organization error level E_0	3.1%

5 Conclusion

This paper proposes a new process evaluation method of product development process based on multi-agent simulation. According to the agent behaviors, process evaluation indices and corresponding algorithms are studied. The multi-agent simulation and process evaluation indices can be used to analyze and optimize the plan of product development projects. The simulation case study shows that, the evaluation indices based on multi-agent simulation can effectively reflect the process performance, which provides a dynamic and quantitative decision-making method to evaluate product development project. The method also supports optimization analysis of organization structure, workflow, human resource allocation, and other individual factors of the product development team. Future work will focus on the practical application of the simulation-based optimization, and continuous improvement of the reliability and compatibility of the simulation.

Acknowledgements

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A Design of Product Collaborative Online Configuration Model

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Abstract. According to the actual needs of mass customization, the personalization of product and its collaborative design, the paper analyzes and studies the working mechanism of modular-based product configuration technology and puts forward an information model of modular product family. Combined with case-based reasoning techniques (CBR) and the constraint satisfaction problem solving techniques (CSP), we design and study the algorithm for product configuration, and analyze its time complexity. A car chassis is made as the application object, we provide a prototype system of online configuration. Taking advantage of this system, designers can make appropriate changes on the existing programs in accordance with the demand. This will accelerate all aspects of product development and shorten the product cycle. Also the system will provide a strong technical support for enterprises to improve their market competitiveness.

Keywords: Product configuration; collaborative configuration; case-based reasoning; information platform.

1 Introduction

Mass Customization(MC) [1][2][3] has now become an inevitable trend for the industry as well as an important means for enterprise competition because it embodies the advantages of both large-scale production and multi-species production, and is able to achieve the purposes of low-cost products and products diversity simultaneously(is able to lower the cost and diverse the products). Based on the special needs of each user, it completes the production of customized products according to the effective of large-scale production, so that it can realize integration of large-scale production and user's personalization. Product configuration or product design has become an important technology to address this problem, which is even called as enabler for mass customization in some papers [4][5]. The effective integration of Network technology and advanced manufacturing technology formed a new production model, called networked manufacturing technology [7][8]. In recent years, the greatest impact on the manufacturing industry is the technology based on Web and related businesses, it makes network-based product development become the main research topics for networked manufacturing in the near future. Mitchrll M. Tseng and Jianxin Jiao [9] proposed a

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design ideology based on the evolution of cases to meet the needs of MC, which chose the previous product family platform and completed customization diversification through the reuse and change of the original information .At the same time, they discussed selection and correction method of product cases and platform. Alexander Felfernig and Gerhard Friedrich [10] studied knowledge-based configuration environment system, set up a concept model of a product configuration and an automatic construction model of knowledge. By adopting model-based diagnostic techniques, they determined the knowledge base in the fields of its effectiveness, requirements of unreasonable configuration and the reasonableness of old configurations and that will support the re-configuration process. At last, they discussed how to use a standard design language to model and manage configuration of knowledge.

2 The Configuration Model of Product Structure

2.1 Configuration Process

Product structure and product configuration work as a form of the organization and management of product data. Product structure is a hierarchical structure model, it describes the formation of the parts, parts set, spare parts, spare parts set of the product, and their inter-relationship ,while the product configuration means a process of forming a product on the base of a pre-defined product structure. The product configuration is a process model including multi-user participation, dynamic, and decision-making, on the contrary, the product structure model is relatively static. Therefore, it can be said that product configuration technology [12] is defined as a product that can cover one or a number of product structure models of product categories, realizing the match between the properties of components and users' requirements that is according to certain established allocation rules as well as customers' demands for customized products and finally the production is completed. Its process is defining the product structure and parameters of features in accordance with the model of this product category, and then we can get the instantiated product structure and information of parameters. Therefore, the product configuration process is regarded as transformation from a product category model to product cases of BOM. In the configuration process, we need to provide certain configuration rules, ways and means to describe the product structure. Product configuration process model is shown in Fig. 1.

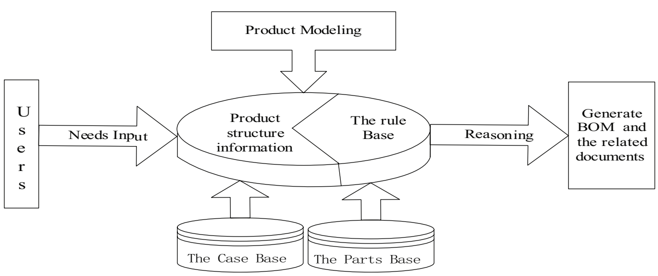

Fig. 1. Product configuration processing model

2.2 The Composition of Configuration Model

In the model of mass customization, the product always changes based on customer demands. Enterprise products are one or more product family composed of many similar products and with same structure models in it. Each specific product components may have the same function or different performance and specifications. Different from traditional design and development, the collaborative ones based on modular technology is to take full account of contacts among the products which take on same function with different performance and different specifications. By means of online designing collaboratively, it will result in many modified products with the combination and match of different modules [13].

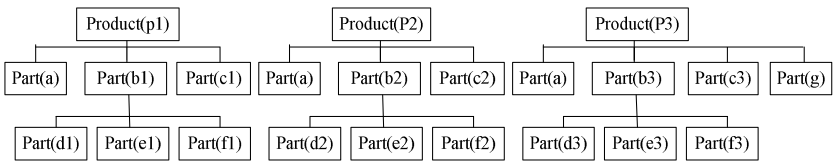

Fig. 2. BOM Structure of Product

As shown in Fig. 2, there are three different product structures P1, P2, P3 in product family P. P1 is identical to P2 and P3 is similar to P1 and P2, except that P3 is with extra components g. On applying the ideas of modular design and methods for modeling product family, these different parts are to be combined into one collection called module which can also be composed of sub-modules. For example, there are module B={b1,b2,b3}, module C={c1,c2,c3}, sub-module D={d1,d2,d3}, sub-module E={e1,e2,e3}, sub-module F={f1,f2,f3}, and we combine these products P1,P2,P3 who are of similar functions and different structures into a product P={P1,P2,P3} known as product family.

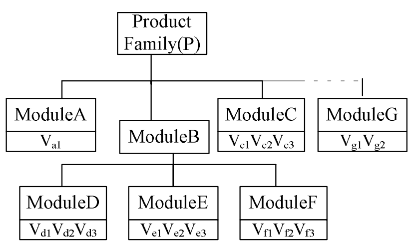

Fig. 3. Modular product family module model

Modular product family structure can be expressed as Fig. 3(V_i expresses the property variable of module model).Shown as Fig. 3, we can see that cases of each module have similar property and structure, same external interface and a different property value only if these modules are parts of modules of the same type. In order to maintain consistency of the research, the basic components of the product family is also be regarded as a module, but the module contains only one case. Look at the Fig. 3, dashed border indicates that the module is an optional module composing the product family. Module model can be expressed in many properties. When the module has more than one value of certain property, we can regard these properties as variables, namely, property variable of model modules.

3 Algorithm of Configuration Model

The process of product configuration is the same as instantiation of product structure model. It can be regarded as a process of configuration solution from the view of problem-solving process. There is a natural contradiction in the applications of large-scale users' personalized configuration, which is users' pursuit of personalization and their lack of knowledge about product technology. To solve this problem, we propose case-based reasoning (CBR) and the constraint satisfaction problem (CSP) general algorithm, to meet the needs for personalization and reduce error rate of orders.

The above algorithm includes three phases:

1. From product structure tree and the demand, generate a form for users to input.
2. Search cases in case base and find the closest one to users' demands.
3. Modify cases in accordance with constraint condition to satisfy users to the greatest extent.

3.1 The Composition of Configuration Model

When we search the cases, they need to compute the similarity in order to extract similar cases. Here we introduce it as follows:

R: means q demand variables. In the expression of $R=\{r_1,r_2,\ldots,r_j,\ldots,r_q\}$, r_j means the j demand variables. The expression $S=\{S_1,S_2,\ldots,S_i,\ldots,S_p\}$ means p cases, and S_i means the product case i. $Si=\{S_{i1},S_{i2},\ldots,S_{ij},\ldots S_{iq}\}$, means the variable q of product case i.

d（x,y）=x-y: means the distance between x and y. We standardize x-y into the range[0,1] in order to satisfy the condition d（x,y）=x-y.

$W=\{W1,W2,\ldots,Wj,\ldots,Wq\}$:means the weight of variable j, $0\leq Wj\leq 1$.

The expression of Similarity, $SIM(S_i,R)$ is as follows:

$$\mathrm{SIM}(S_i,R)=\sum_{j=1}^{q}W_i(1-d(s_{ij},r_j))/\sum_{j=1}^{q}W_i(i=1,2,\ldots,p) \tag{1}$$

$$0\leq \mathrm{SIM}(S_i,R)\leq 1(i=1,2,\ldots,p) \tag{2}$$

3.2 The Modifications of Cases

When the search of cases is finished, the case that is the most consistent with the users' needs will come up. If the value of S-SIM (S, R) for this case equals 1, it means this case meets all the user's needs and then the algorithm ends. Otherwise, it requires modifying the last picked case according to user's selected configuration items. Upon completion of this modification, check the case whether it observes constraints conditions. If it doesn't, another modification will be needed until all the constraints conditions are met and the algorithm ends. We will adopt local search algorithm to modify the cases.

In our problem models, the quantity of reverse constraints is far less than the positive ones. To improve the efficiency of algorithm, we just record mutually exclusive constraints and inclusive constraints instead of adopting the traditional method. The definition of constraints is as follows: C1 (P1, P2, F) means components P1 and P2 are mutually exclusive which also means that these two components can't simultaneously exist in the configuration. C2 (P1, P2, T) means components P1 and P2 have containing relations, which is, two elements must exist simultaneously. To improve the efficiency of algorithm, containing constraints expressed by the way of transitivity is not allowed. When the expressions of C3 (P1, P2, T) and C4 (P2, P3, T) come up, they should be modified into C3 (P1, P2, T) and C4 (P1, P3, T). The modification caused by containing constraints will not result in the breach of mutually exclusive constraints; it means that if there are C1 (P1, P2, T) and C2 (P2, P3, F), C3 (P1, P3, F) must exist.

3.3 Description of Configuration Algorithm

To sum up, the algorithm for product configuration is as follows:

1. Check users' configurations according to constraints, if it isn't satisfying, users are given feedbacks to modify it until it meets the demands.
2. Search the cases and sort them according to their similarities, the result is S (s1,s2,s3,s4,s5).
3. Choose S1 as the target case and modify the case according to users' configuration. By the definition of similarity, the revised S1 satisfies the condition of SIM (S1, R) = 1.
4. Do modifications on S1 in line with all the containing constraints.
5. Conduct mutually exclusive constraints check by the weight of configuration items from high to low, if it violates the constraints conditions,
   5.1. Replace them with the most similar alternative options.
   5.2. Check whether the modified cases are backtracking.

5.3. If they are backtracking, replace them with the second similar alternative options and turn to 5.2. If it can't find that, it proves that the problem has no solution, continue to select Si+1as the target case and go back to step 2. If they all meet with the conditions and it is the last configuration item, the algorithm ends, else turn to step 5.

6. Set the new replacing item as the new configuration item and set the weight to 0.

6.1. Check the new replacing one whether it meets with containing constraints, if no, modify it according to containing constraints, or go back to step 5.

6.2. Check if the modified item is backtracking, if it isn't, go back to step 5, or it proves that there is no solution to this problem, keep selecting Si+1 as the target case and go back to step 2.

3.4 Algorithm for Complexity Analysis

To analyze the complexity of algorithm, we provide the definition of parameters shown as Table 1.

Table 1. Definition of Parameters

Description	Symbol
Size of case base	C
The number of user configuration	U
Total number of configuration	T
The number of containing constraint	I
The number of exclusive constraint	M

The analysis of algorithm complexity is as follows:

Step 1: Check whether each configuration item configured manually by users satisfies containing constraints, and its complexity is $U * \log I$; then check if each configuration item satisfies inclusive constraints which estimate between every two configuration items and its complexity is $U^2 * \log M$. Furthermore, these two steps are independent so the time complexity of step 1 is $U * \log I + U^2 * \log M$.

Step 2: Compute the similarity of cases according to the input configuration items. The weight could be 1; it means the configuration of cases must be exactly same as the configuration items set by users. So, no more similarity of cases is needed. Here we set the number of cases whose similarity we need is $\alpha * C \ (0 < \alpha \le 1)$ and the time complexity of step 2 is $\alpha * C * U \ (0 < \alpha \le 1)$.

Step 3: Choose the target case S_i which is the most similar to that of users' requirements in the case base and its complexity is 1.

Step 4: According to users' configuration items, search the containing constraints if it contains any users' configuration items. If yes, it requires finding the configuration item having relations in containing constraint with the corresponding items, and modifying it. So, its time complexity is $U * \log I * \log T$.

Step 5: Search for inclusive constraints according to configuration items. Adopting binary search if the constraints condition is in order, and its complexity is $\log M$.

Step 6: Search for containing constraints according to configuration items. Adopting binary search if the constraints condition is in order, and its complexity is $\log I$.

In both the step 5 and step 6, according to their weights, search configuration items from high to low and new configuration items will be added in continuously, so the number of configuration items is $\beta U \ (\beta \ge 1)$ in total and the time complexity of step 5 and step 6 is $\beta U \ (\log M + \log I)(\beta \ge 1)$.

To sum up, the time complexity of configuration algorithm is:

$$U*\log I+U^2*\log M+\alpha*C*U+1+U*\log I*\log T+\beta U(\log M+\log I)(0<\alpha\le 1,\beta\ge 1) \quad (3)$$

4 Case of Product Collaborative Configuration

The components management interface of prototype system is shown in Fig. 5.

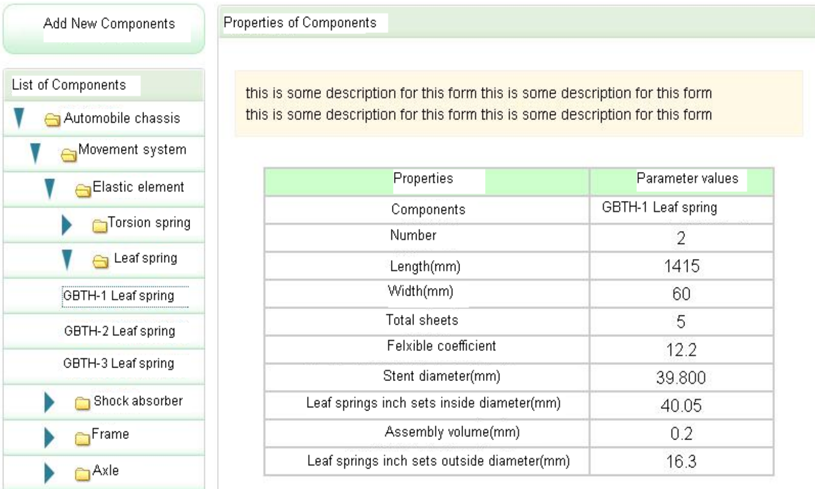

Fig. 5. Components Information Searching Interface

In this system, we can easily view and add the components. In prototype system, we can add and modify product structure tree conveniently and store product structure tree in the form of XML Schema. The system can generate configuration automatically according to the structure of product structure tree, so that users can facilitate product configuration.

Product configuration management module is the core of the entire prototype system. The system can automatically generate configuration form which is based on product structure tree model, and facilitate users to configure product. Configuration interface is shown in Fig. 6.

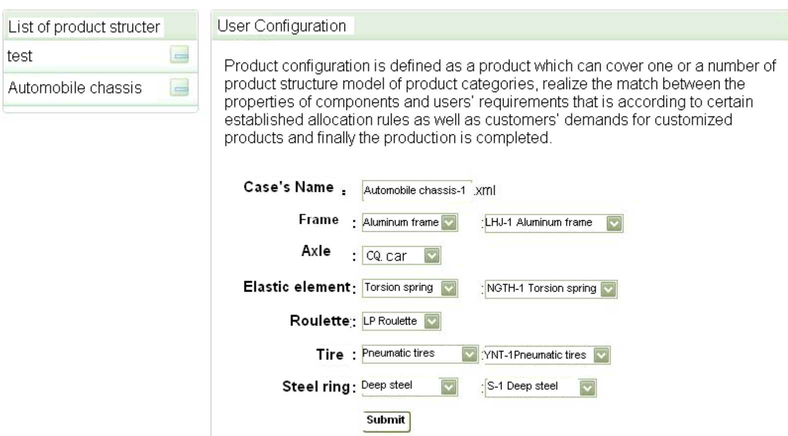

Fig. 6. Components Information Managing Interface

5 Conclusion

We propose and implement the prototype system of online product configuration and do an in-depth research in both web-based product structure and online configuration. We provide a new algorithm combining CBR and CSP, and it can make up for CSP and CBR's shortage of solving the problem of product configuration. To some extents, this system meets users' demands for large-scale and personalized customization and it does a beneficial exploration in the fields of designing series product by online collaboration based on the existing models.

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Project-Based Collaborative Engineering Design and Manufacturing Learning with PLM Tools

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Abstract. In this work we present an educational experience that is focused on teaching collaborative practices for product design. The paper compares two different approaches for engineering education. In the first one each team has to develop a product by collaborating in each product lifecycle stage. The second approach involves collaboration and competition between teams since they participate in different stages of each product's development.

Keywords: Project-based learning, collaborative engineering, product lifecycle management tools, design for manufacturing.

1 Introduction

Nowadays, a product development process is completely run with computer aided applications. According to the stage of the product development, different CAx tools are used by engineers or specialists. In engineering education many of these CAx tools are taught separately and there is no integrated vision of real product process development. For example, it is common to find courses to teach CAE fundamentals, others to teach CAD fundamentals, and so on. In general, the lack of an integrated vision in the basic engineering curriculum overlooks the necessity of teaching valuable skills in the areas of: (1) team management and workgroup management in cross-functional distributed teams; (2) identification and resolution of manufacturing problems due to inefficient designs; (3) efficient collaboration between designers and manufacturers; and (4) lifecycle management and workflow management for product development.

Some efforts to overcome these curriculum limitations have been made and reported in published work. For example, Lee et al. developed a collaborative learning environment for designing and prototyping a working toy using CAD and web-based learning software [1]. Dankwort et al. analyzed the phases of product design (creative, conceptual and engineering) and suggested some best practices for CAx education considering the relevance of Information Technology knowledge [2]. Tomovic and Wisma described a PLM experience in a senior design course where the students work on all aspects of the product design cycle, from concept design to product

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optimization and manufacturability [3]. Buchal developed a training strategy for working with a PDM tool and managing shared CAD data. He presented a case study in which the students designed an aeroplane assisted by commercial PDM and CAD software [4]. Dennis and Fulton described a real distributed collaborative product development experience conducted by mechanical engineering students from Georgia Tech and the University of Maryland College Park [5]. In general, the project experiences presented in published work claim that in the future, engineering education must integrate IT into the classroom to foster multidisciplinary distributed collaborative product development [6]. Furthermore, the advantages of learning by "doing" and "experiencing" are also clear, as is the students' interest in these product development experiences.

In this paper, two practical PLM experiences conducted in computer integrated manufacturing courses to teach fundamentals of CAD, CAE, CAM and PLM systems in a collaborative way are presented and discussed. The main idea is to present a framework for teaching collaborative design and manufacturing concepts using the PLM software. In these experiences, the students learn by practicing through activities such as 3D design, drawings, plastic injection analysis, cutting-tool and fixture selection, cutting parameter selection and CNC simulation.

2 Project-Based Collaborative Education

The Computer Integrated Manufacturing (CIM) course is given in the last semester of a Master of Science degree at Jaume I University (Spain). A collaborative project is conducted so that students learn the fundamentals of collaborative design, planning and manufacturing. The goal of the project course is to simulate the collaborative product development of a geographically dispersed enterprise where different working teams for designing, manufacturing and planning are defined. Basically, the collaborative project is divided into four main activities: (1) CAD activities to design a new product based on familiarity with an old model version provided by the teacher; (2) activities to analyze the plastic injection of the product components and design a single mould to manufacture the designed plastic component; (3) activities to prepare the manufacturing process plan through CAM operations; and (4) Activities to manufacture the designed products by rapid prototyping and to manufacture the best mould design in a machining centre.

In the first approach, a product life-cycle with four stages is defined to manage the different phases of the product components throughout product development. Therefore, the product components are based on a life-cycle with four possible phases: 1) *Design*, 2) *Reviewed*, 3) *Process Planning*, and 4) *Manufacturing*. To promote from one phase to another, a phase promotion request (stage-gate) is required and the new phase is not set up until the design or manufacturing manager reviews the component and accepts or rejects the request. The "*Design*" phase is defined as when the component is being designed or re-designed. The "*Reviewed*" phase is reached when the component design has been approved by the design manager. The "*Process Planning*" phase is defined as when the manufacturing files are created to start the process planning tasks. Finally when the process planning is approved the "*Manufacturing*" phase is reached. In order to create a real product development environment, four main roles are defined: (1) designers; (2) process planners; (3) design managers; and (4) manufacturing manager.

With the help of the PLM system, a workflow is defined to manage the information flow and the activities of each role during the collaborative product development according to the product development phases. The workflow created for the project is shown in Fig. 1, and; it relies on the collaboration of the roles defined previously. When a new product is created (for this project a toy car), its initial phase is "*Design*" according to the life-cycle defined above. During this phase, the designers of this new product are in charge of the new design. When the design is finished, the designers request a promotion to the next phase called "*Reviewed*". At this moment, the new car design is ready to be evaluated by the design manager, who is being asked to approve the design in order to start the collaboration with the manufacturing department. The design manager reports his decision, and makes the necessary comments and annotations to improve the current design. These annotations are done through a CAD visualization tool (*ProductView*). If the promotion is rejected, the designers receive an e-mail notification to modify their design according to the annotations and comments provided. Otherwise, the promotion is approved and the component is now set up for the "Reviewed" phase.

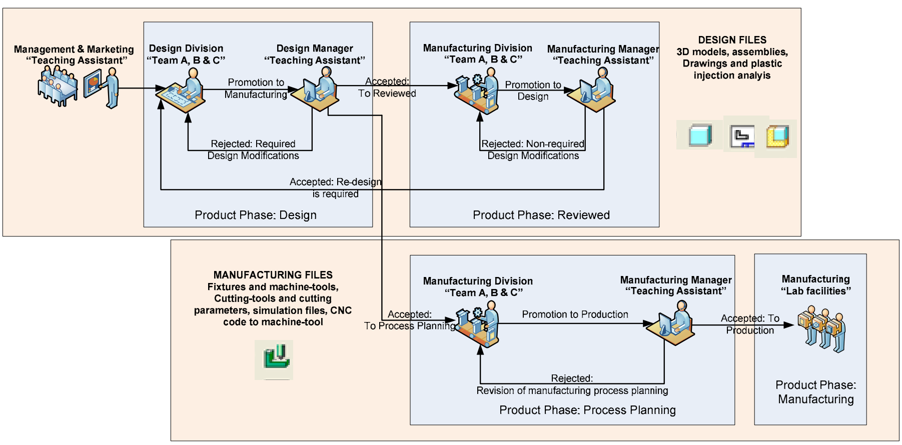

Fig. 1. First approach in collaborative education

When the component is promoted to the "*Reviewed*" phase, the process planners have read-only access to the new design components, and new manufacturing files for process planning are created by the design manager with the product phase "*Process Planning*". If design modifications are required during the process planning, a request is made for the design components within the "*Reviewed*" phase to be promoted to the product phase "*Design*". The design changes requested are provided by comments and annotations with "*ProductView*". If the requested re-design is required, the promotion is approved, and the components are set up again for the "*Design*" phase, and designers have to incorporate the changes. If the requested re-design is not required, the promotion is rejected and the process planner has to modify the process planning with the comments or advice provided by the manufacturing manager. When the manufacturing process planning is finished, the process planner asks for a new promotion to change the manufacturing component phase from "*Process planning*" to "*Manufacturing*". If the process planning is correct, the manufacturing manager approves the promotion, and the collaborative product development is finished. Otherwise, the promotion is rejected and comments and annotations are provided to improve the current process planning.

For the second approach, the project has a different concept of collaboration. The product is structured in different subassemblies and each team has to design a different subassembly. The life-cycle (Fig. 2) has three main activities with five possible phases: 1) *Design*, 2) *Reviewed*, 3) *Mould Design* 4) *Process Planning* and 5) *Manufacturing*. In this project each team participates in every activity but they have different roles for different products (designer, mould designers and process planners). In this case they are competing while they also have to collaborate.

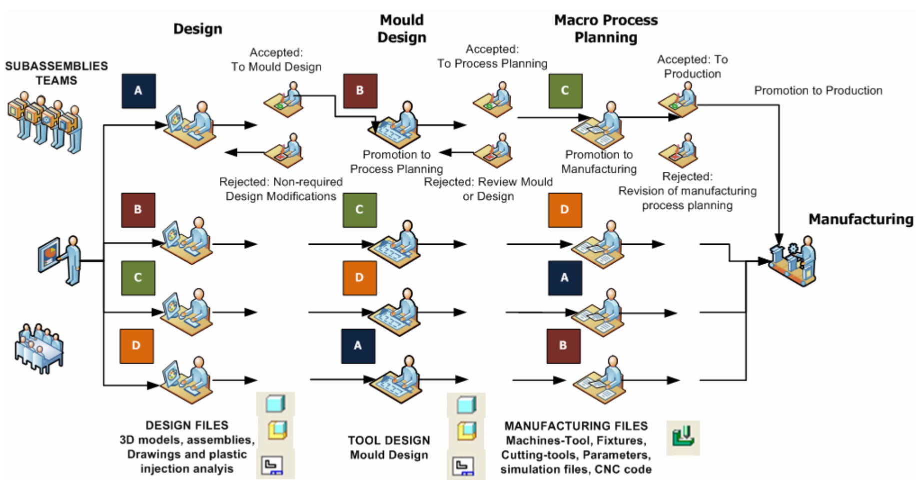

Fig. 2. Second approach in collaborative engineering education

3 Results and Discussion

The learning results obtained in these projects have enormously enriched the students' knowledge of the main problems that arise during collaborative product development. In the first experience the use of CAx tools within a PLM system was a barrier but especially when reviewing and promoting products during the lifecycle. Students were able to understand the philosophy of collaboration within a single team.

The second experience provided a new challenge: to collaborate and compete in product engineering. Product development relies on several teams because once your task has finished, the next phase involves a new team that has to continue developing the mould or, in the third phase, planning how to manufacture it. Figure 3 shows the results of both projects. The second approach generates better results and more complex products in the same lecturing time.

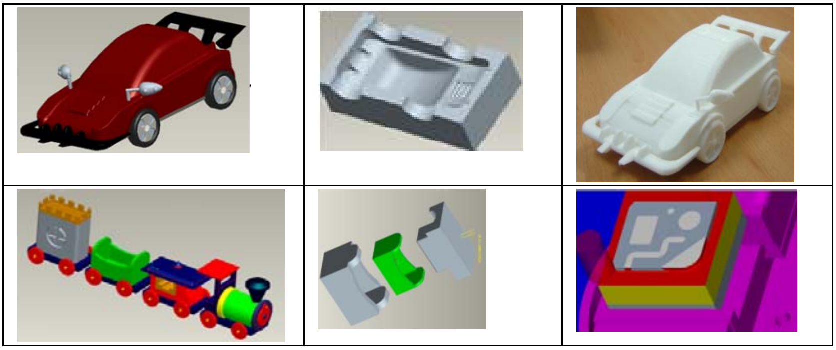

Fig. 3. Results of collaboration across the product lifecycle

4 Conclusions

A great many efforts have been made by the industry to apply PLM functionalities but there is still a lack of teaching and practice of concepts related to collaborative engineering in graduate engineering curriculums. Previous work corroborates that educational efforts are required to educate future engineers with skills that could be applied in this area. This work tries to overcome these limitations through product development experiences in a senior Computer Integrated Manufacturing course where students were introduced to modern CAD/CAE/CAM and PLM software tools in a collaborative way. The two approaches have demonstrated that collaboration and suitable training can improve the product development process.

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A Proposed Collaborative Framework for Prefabricated Housing Construction Using RFID Technology

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Abstract. Despite the popularity of prefabricated housing construction in Thailand and many other countries, due to the lack of collaboration in current practice, undesired low productivity and a number of mistakes are identified. This research proposes a framework to raise the collaborative level for improving productivity and reducing mistake occurrences at sites. In this framework, RFID system bridges the gap between the real situation and the design, and the proposed system can cope with the unexpected construction conditions by generating proper alternatives. This system is composed of PDAs, RFID readers, laptop PCs, and a desktop PC. Six main modules and a database system are implemented in laptop PCs for recording actual site conditions, generating working alternatives, providing related information, and evaluating the work.

Keywords: collaboration, prefabricated housing, RFID.

1 Introduction

Prefabricated housing has been becoming increasingly popular in housing projects in Thailand and many other countries because of shorter, cheaper, and more efficient construction compared to traditional methods [1]. A typical prefabricated housing construction project consists of about hundreds of housing units and lasts about several years. Although the construction project organization depends on the project, it usually consists of a developer and a contractor and may include sub contractors. The related personnel can be divided into the following parties by their functions: design, manufacturing, management, supervision, construction, inspection, and support. At a construction site of prefabricated housing, there are personnel such as a project manager, a project engineer, site engineers, foremen, mobile crane operators, workers, and inspectors.

Prefabricated technology has significantly changed housing construction from the handmade manner to semi-manufacturing manner. Thus, despite its potential efficiency and effectiveness, it has also caused some problems such as needs of more

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skilled and experienced foremen and workers, more collaboration among participants, thoroughly worked-out construction sequences, and treatment suited to the occasion. For example, wrong prefabricated panel installation sequence at site may cause additional structural temporary support, more time and workers to set a panel between existing panels, redoing of installation, or damage to panels such as cracks, holes.

On the basis of our observation and analysis, many of the problems are due to the lack of collaboration, which is closely related to the lack of information storing, sharing, and management among different types of personnel at the site and other personnel at the main and branch offices. Therefore, this research proposes a framework for improving the information flow by Radio Frequency Identification (RFID) technology [2,3,4], storing information and knowledge, and re-using knowledge for future work and problem solving.

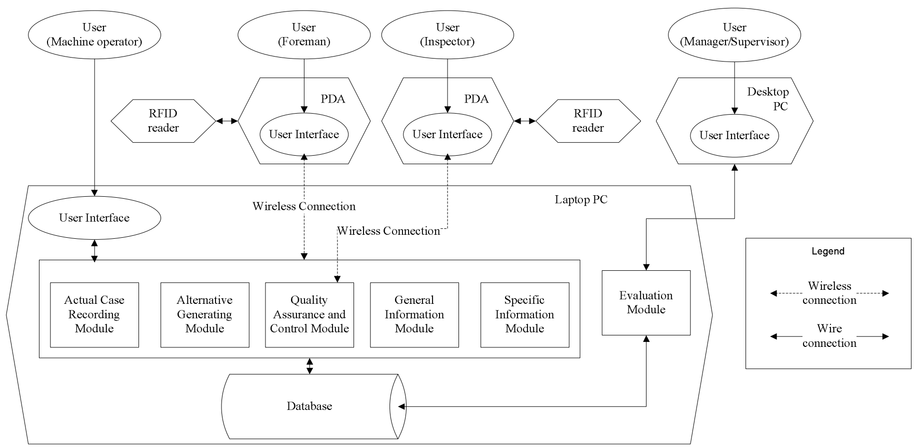

Fig. 1. System architecture

2 Proposed System Architecture

RFID technology and cooperative engineering with knowledge management are deployed for the proposed system. This system is composed of Personal Digital Assistants (PDAs) with RFID readers, laptop PCs at a site office, and a desktop PC at a main office. Users of the system are foremen, machine operators, inspectors, and managers. System architecture is shown in Fig. 1. The laptop PC at a site has six modules and one database system. The six modules are: (1) actual case recording module, which is used for recording actual conditions such as resources, space, work locations, work sequence, date and time, (2) alternative generating module, which generates several alternatives from actual conditions and general information, providing expected result, pros and cons of each alternative, (3) quality assurance and control module, which collects quality result, and provides checklists, usage and maintenance data for tools and machines for quality assurance and control processes, (4) general information module, which provides general information such as project information, organization chart, assignment, drawings, schedules, planned sequences, resource specification, space requirement, etc. to the user, (5) specific information module, which provides information specific to construction condition and sequence, showing in a graphical format and step-by-step manner, (6) evaluation module, which analyzes and evaluates works, using the data in the database coming from the actual case recording module and quality assurance and control module.

Although four main users are specified in the system architecture, other personnel such as designers are expected to collaborate in developing and maintaining the database by providing knowledge to the alternative generating module, general information module, and specific information module. Quality assurance and control module is developed from inspectors' information. Evaluation module is used at the organization management level.

3 Application and Expected Benefits

The main applications of the system cover erection, jointing, inspection, and evaluation in prefabricated member installation process by a mobile crane operator, a foreman, an inspector, a supervisor, and a manager. In this system, RFID tags are attached to all personnel (supervisors, managers, machine operators, foremen, workers, and inspectors), prefabricated members, tools (base plates, props, drillers, hooks, cables, and wrenches), and mobile cranes. Each user has to scan his/her tag to obtain proper authorization and to record the user.

Before installation process, the foreman uses RFID reader attached to his/her PDA to read ID of each component, while the machine operator inputs the inaccessible areas. Then, actual conditions are captured and possible alternatives are generated by the system from the different actual conditions, which are affected by construction resource, space, and time. Without this system, the foreman needs to cooperate with the planner, designer, or supervisor to generate proper alternatives. Otherwise, the foreman must have skill and experience to generate proper alternatives and anticipate the result of each alternative. After getting the alternatives, expected results, pros and cons, the foreman has to make a decision whether to suspend the work or to continue with an alternative.

While panels are being installed, the foreman and the machine operator obtain the information and checklists from the system and they have to input the quality result into the system. This scheme induces the workgroup to do their work right at the first time. After that, the inspector executes the crosscheck inspection on the important parts or the random inspection. This part improves the cooperation between the workgroup and the inspector and reduces inspector's workload. Not only the collaborations between foreman, machine operator, and inspector are improved, the collaboration between foreman and machine operator is also improved. In order to wait and get the signal from the foreman, this system boosts up the role of machine operators by support the work information. Then, the machine operator knows the destination of lifting panel and the next working sequence from this system in advance. Thus, the collaboration between foreman and machine operator, and productivity rate will be improved. By scanning component tags, each operation is recorded in terms of what, when, where, who, and how as actual case. Moreover, the foreman and the machine operator can request the general information from the general information module anytime.

When the supervision or management group wants to evaluate the works, the works can be evaluated from the data in the database using the evaluation module. After that, the evaluation result can be transferred and cooperated with the organization management level.

The main expected benefits by using this system are the improvement of collaboration and productivity and the decrease of mistakes. Moreover, the skilled and experienced personnel requirements especially for foreman, who plays the leading role in prefabricated member installation process, can be relaxed because of the efficient information flow and support by providing expertise.

4 Conclusion

The proposed system aims to raise the collaboration in prefabricated housing construction process using RFID technology and computer hardware with six main modules and a database system. The collaboration in this research is not limited to the personnel within the workgroup or project level but can be expanded to the organization level by developing the system, maintaining the database, and transferring the information.

Since this research is in the on-going process, we will implement the system based on the proposed framework and apply it to a real construction site for evaluation, improvement, and validation.

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Cooperative Supply Chain Re-scheduling: The Case of an Engine Supply Chain

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Abstract. One of the main issues on task planning of the enterprises with several production sites is how they can reassign tasks when a part of the supply chain is stopped. In this case, a good re-schedule, involving parts from supply chains from other sites, could imply to reduce overall costs. In this paper, we propose a cooperative system to re-schedule a network chain. The algorithm proposed is described and analyzed analytically in detail. The re-schedule decision is taken based on the time and the cost reduction. In order to test its performance and the success of our proposal, we have simulated a stylized system based on an engine network chain using the Anylogic TM simulator. Our proposal allows cooperative multisite re-scheduling by selecting the type of transport for sending components from one site to another based on the costs and the deadline to assemble the final product.

Keywords: Re-scheduling, Cooperative decision making, Supply chain, cooperative-group-based model.

1 Introduction

A basic component of the planning activities of a manufacturing firm is the efficient design and operation of its supply chain logistics network. A supply chain is a network of suppliers, manufacturing plants, and warehouses organized to acquire raw materials, convert those raw materials to finished goods, and distribute those goods to customers. These decisions can be classified into three categories according to the length of the planning horizon that has to be considered. First, choices regarding the location, capacity and technology of plants and warehouses are generally with a planning horizon of several years. Second, supplier selections, product range assignment as well as distribution channel and transportation mode selection belong to the tactical level. These decisions can be revised every few months. Finally, raw material, semi-finished and finished product flows in the network are operational decisions that are easily modified in the short term, even changing decisions that have been taken on the previous level, such as transportation mode [1].

When a major change happens on the supply chain (either a major breakdown or a supply fault) the third level decisions will have to change tactical level decisions. In

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the moment that such an unexpected event happens, the client has to decide the best way to get the supply without changing too much the usual activities, since stability is basic to perform lean activities. Such a rescheduling activity has to take into account the situations of many agents on the network chain. The coordination of operations on a short-term horizon can be referred to as collaborative production planning [2].

An internal combustion engine is a complex assembly product with a variety of components that are manufactured and assembled in a network chain [3]. The most relevant components are cylinder blocks, cylinder heads, crankshafts connecting rod and camshafts (so called 5C) although there are many others not so relevant such as the screws that are also assembled in the final product. Each one of the five main components is transformed through a complex and high precision process that is generally close to an engine assembly line. The modular design concept is used, so the degree of commonality is high. The engine supply chain is a quite connected system where 5C lines tend to specialize on some component derivatives. Usually the engine plant is close to its main client (a car assembly line) but not necessarily. Therefore engines have to travel to its clients sites (either assembly lines, either Part Spare Warehouses) using a variety of transport systems that range from short distance trucks to planes, passing through planes, rail cargoes, and ships.

In this work, we propose a cooperative supply chain re-scheduling system to reduce costs and the time production in an engine supply chain. The simulations given in this paper demonstrates the benefits that will be provided to an engine manufacturer with 3 production plants.

The rest of the paper is structured as follows. Section 2 gives some related works about supply chain and resilient and cooperative supply chain management. The problem that is wanted to be solved is explained in section 3. Section 4 explains the proposed algorithm in detail. The simulations used to validate our proposal are shown in section 5. Section 6 gives our conclusions and future works.

2 Related Work

2.1 Supply Chain Management

Supply Chain might be defined as a "network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer" [4]. Supply Chain Management is the task of integrating organizational units along a supply chain and coordinating material, information and financial flows in order to fulfil (ultimate) customer demands with the aim of improving the competitiveness of a supply chain as a whole [5].

Traditional production planning methods, such as material requirement planning (MRP), consider only the availability of materials when organizing demands, and totally ignore such factors as capacity limits and supply chain configurations. For this reason, MRP cannot provide feasible production plans, since such plans require that capacity limits and multiple objectives be taken into account. To cope with these challenges, advance planning and scheduling (APS) methods were developed [6].

2.2 Resilient and Cooperative Supply Chain Management

Supply-chain management is the integration of key business processes from end-users through original suppliers that provide products, services, and information and add value for customers and other stakeholders [7]. It involves balancing reliable customer delivery with manufacturing and inventory costs. It is evolved around a customer-focused corporate vision, which drives changes throughout a firm's internal and external linkages and then captures the synergy of inter-functional, inter-organizational integration and coordination [8], Owing to the inherent complexity, it is a challenge to coordinate the actions of entities across organizational boundaries so that they perform in a coherent manner.

Demand is estimated for each stage, and the inventory between stages is used for protecting against fluctuations in supply and demand throughout the whole network. Owing to the decentralized control of Supply Chain, coordination between entities in performing their tasks is required. With the increase in the number of participants in the supply chain, the problem of coordination has reached another dimension [8].

According to [9] there are four basic strategies that should be followed depending on the demand and supply uncertainty. If demand and supply have low uncertainty the contingent strategy is the so called efficient supply chain, but if the uncertainty is high on the supply, then risk hedging supply chain is the adequate strategy (see figure 1).

		SUPPLY UNCERTAINTY	
DEMAND UNCERTAINTY		Stable Process (Low)	Evolving Process (High)
	Functional Products (Low)	*Efficient supply chains*	*Risk–hedging supply chains*
	Innovatite Products (High)	*Responsive supply chains*	*Agile supply chains*

Fig. 1. Strategies for Supply Chain according to uncertainty levels [9]

The strategy for High Uncertainty on Supply and functional products (Risk-Hedging supply chain) has become to be called Resilient Supply Chain [10].

Thus, a Resilient Supply Chain is able to cope with major disruptions, without affecting the overall performance. It first seems that resilience should be designed in. Second, nodes on the supply chain need to be highly collaborative. Third, resilience implies agility and finally resilience will only be possible if the organisation holds a risk management culture [11].

When a major change happens on the supply chain (either a major breakdown or a supply fault) the third level decisions will have to change tactical level decisions. In the moment that such an unexpected event happens, the client has to decide the best way to get the supply without changing too much the usual activities, since stability is basic to perform lean activities. Such a rescheduling activity has to take into account the situations of many agents on the network chain. The coordination of operations on a short-term horizon can be referred to as collaborative production planning [3] or cooperative rescheduling [12].

Challenges involved in managing supply chain disruptions arise from the fact that: (1) supply chain entities are dynamic, disparate, and distributed; and (2) they are tightly linked at intra- and inter-enterprise levels and critically affect the performance of one another. These make the detection of disruptions and their root causes difficult. Furthermore, complex rectification strategies are needed to partially or completely overcome a disruption. More often than not, rectification will involve rescheduling of operations. The focus is on the coordination of short-term production planning decisions, as it is more relevant to our problem.

The most common coordination heuristics can be described as 'hierarchical'. And it is not only on practice but also in literature. In this approach there is a sequence (naturally defined or specified in the business agreement) specifying an order in which must the partners plan their operations.

These coordination heuristics are widely used in industry for the following reasons. First of all, the exchanged data are standard and the mechanism corresponds to traditional ways of doing business. Secondly, privacy and autonomy are respected (each agent plans its own activities). And last but not least, these methods are well supported by current decision support technologies: each agent still continues to use specialized planning tools to plan its activities.

The drawback is that these heuristics produce only one global solution that may not be optimal from the supply chain point of view or may not be acceptable for the external customer.

3 Problem Description

An engine assembly network has many engine plants connected with different ways of transport (different costs and times). Engine plants tend to be close to assembly lines, but not necessarily (e.g. diesel or gasoline engines).

Backlog penalties depend on the client, the product and the quantity. If you are serving to an assembly line, backlog penalties are very high. If you are serving to a Part Spare warehouses, delays are not that expensive.

Engines or components are "delicate" products so their transportation is always expensive, since their have to be transported in special racks with special treatments over them. Transporting from South Europe to North Russia might take one week using a truck that will cost 5000 Euros, but 4 weeks a ship that will cost 2000 Euros. There are cheaper ways of transport like railway cargoes, although their very low speed will require having a too large lead time, in the other hand transporting a rack of engines by plane is seen as unaffordable.

Generally, engine supply chains are able to mount many types of engine models. Any product can be mounted at any time if the types of pieces necessary to build the engine are available. However, the mechanization lines are multimodel lines that work in batches, with high setup costs. So, a supplier can be serving multiple assembly lines and an assembly line is supplied by one or several suppliers.

The minimum transportation cost is obtained when the factory is being auto-fed but even in such case there is a limited WIP capacity.

The main customers of an engine supply chain are the car assemblers that use the final product for their cars. But there are also other customers such as spare parts distribution systems and the car development departments. Engines, or any one of its most relevant components, can be sold to them.

A car manufacturer use to have several engine factories that assembly similar engines and have many pieces and components that can be interchangeable.

The production planning process has three different levels: long term (decide who manufactures what component or assemblies what engine to which client), medium term (decide the capacity –mainly working days and production rate), and short term (produce and ship). But, in some cases, a major breakdown can make that strategic decisions should be changed since it is terribly difficult to change the capacity of the line.

With the today's unstable market, the system tends to run into excess of capacity on some of the elements but not in all. Apparent small variations on final product demand might result (due to a sort of Bullwhip effect) on large variations on components. If a single component runs out of stock, the demand for some other components will rise and eventually will runt out of stock. This process has a positive feedback until production is stopped (either due to a forecast interruption such as a weekend or a non forecasted interruption like a breakdown).

4 Cooperative Multisite Re-scheduling Algorithm

Let us suppose an engine manufacturer with several production plants placed in different countries. Each plant has several supply chains to produce the components needed to manufacture the engine. All these plans are able to assemble any engine model. Any of the components made by the supply chains can be sold externally through part spare warehouses, other manufacturers, etc., but they are mainly used by the engine assembly supply chain to produce the final product. On the other hand, each component is made of a list of materials, but a few materials could be used by different components. We can express these statements analytically as follows. Let $M=(P,E,S)$ be a manufacturer, where P is set of plants of the manufacturer $P=\{P_1,P_2,\ldots,P_n)$, being $n=|P|$ the number of plants, E is the set of engine models that the manufacturer is able to fabricate, $E=\{E_1, E_2,\ldots, E_g\}$, being $g=|E|$ the number of engine models and S is the set of Supply Chains to manufacture the engines, so $S=\{S_1,S_2,\ldots,S_r\}$. For simplicity purposes, we will assume that all engines need the same number of supply chains $r=|S|$, and every supply chain makes one of the components of the engine. So, we will denote the component made in supply chain r as S_r. All components will be used to manufacture the engine. Let $F=(A, B, C, D, E)$ be the set of feedstock to make the components. We suppose that all of them could be of several types, so $A=\{A_1,\ldots,A_h\}$, $B=\{B_1,\ldots,B_i\}$, $C=\{C_1,\ldots,C_j\}$, $D=\{D_1,\ldots,D_k\}$, $E=\{E_1,\ldots,E_l\}$.

Figure 2 shows an example with 4 engine plants and 5 supply chains inside each one of them. Engines are sent to car manufacturers mainly, but any component can be provided to a client such as part spare warehouses, other manufacturers, etc. There is a unique material provider that is able to provide all types of materials for simplicity.

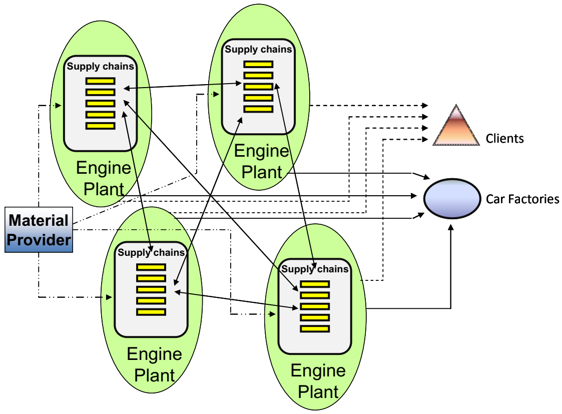

Fig. 2. Engine multisite production example

The time needed to produce each component in a supply chain *r* depends on the time needed to assemble every material of the component as it is shown in equation 1.

$$T(S_r) = \Delta T_{A_h} + \Delta T_{B_i} + \Delta T_{C_j} + \Delta T_{D_k} + \Delta T_{E_l} \tag{1}$$

The cost for each component can be calculated as it is shown in equation 2.

$$Cost(S_r) = \sum Cost_F + Operation\_Costs \tag{2}$$

Where there are two main parts: the sum of the costs of all materials denoted as $\sum Cost_F$ plus the operation costs. Labour, energy, depreciation of machine and so on are included in the operation costs. Every customer has different costs. The shortage in a car assembler plant has higher costs than the shortage in the engine plant and the last one has higher costs than the shortage in the spare parts system. Although they could be added, we are going to consider all of them equal for simplicity purposes.

Using the expression given by the same authors of this paper in reference [12], the capacity of a supply chain can be estimated as it is shown in expression 3.

$$Capacity\,(S_r) = \frac{production\,(S_r)\cdot FTT \cdot Ava\_Links}{\sum Cost_F \cdot Max\_Links \cdot (Saturation + 1)^2} \tag{3}$$

Where the *production* (S_r) is the capacity to produce a component in the supply chain *r*. *FTT* is the quality of the product (percentage of units that finish the production process and satisfy the quality rules). *Ava_links* depends on the availability of supply chains from other plants that are able to make the same component, *Max_Links* is the number of supply chains able to make the same component and *Saturation* is the grade of saturation of the supply chain and is calculated every new incoming order for that supply chain. If the *Capacity* is equal to 0, the component can't be provided.

If a plant is not able to supply its demand (engines or components), because one of its supply chains is broken, there is not one of the materials or produce components in a lower speed that is required, any supply chain from other plants, that produce the same component, could be cooperate by supplying the required component. In order to perform this action, some considerations must be taken into account because the costs and the production time will be incremented. Shipments by plane, by train, by lorry and by ship give different values, so these costs and delivery times should be included in the cooperative re-scheduling system. On one hand, the system complexity will be higher and, on the other hand, it could overload the supply chain selected to provide the required component, so the cost and the time production of the supplier will be higher. The time needed to produce the Engine when a component is provided externally is given by expression 4.

$$T(E_g) = \sum T(S_r) + Shipment\_Time \quad (4)$$

The Cost of an Engine when a component is provided externally is given by eq. 5.

$$Cost(E_g) = \sum Cost(S_r) + Shipment\_Costs \quad (5)$$

The algorithm is as follows. If a supply chain can't provide the required component to manufacture an engine, the system looks for all supply chains with capacity parameter higher than 0. If there is not any supply chain in this condition, the component can't be obtained externally. Otherwise, given a set of supply chains with capacity parameter higher than 0, the decision is taken based on the balance between the delivery time and cost. So, for all components we define a parameter α which depends on the *Cost*, the *Time* needed to produce a component and the *Capacity* of the supply chain involved in the component production: $\alpha(S_r)=(Capacity,T,Cost)$. Now, the schedule planner can use α parameter to find a balance between the time to produce the engine and its final cost. An example is shown in the simulations section.

5 System Simulation

To evaluate the capability of our system a test bed based on a real supply chain has been developed. The model has been created using Anylogic ™ as an agent based simulator. The system has four types of agents: (a) PureClients that control the external demand, either for engines or for its components. (b) PureSuppliers that only supply materials from the external market, they supply what asked (if available), and their delivery is always on time. (c) InterSupplier asks to or receives demand from other InterSuppliers. (d) Transportation agent holds the product from the ship date until the delivery date. All agents (except transportation agents) are located in places. Distances, times of transportation and transportation cost between them are known.

Each client generates a demand for each supplier with a given horizon, and using that is cheaper able to manufacture the component of the engine. Demand is indicated with a due date and a ship date.

Figure 3 shows the simulation of a plant of an engine manufacturer with 3 production plants. The "always supplied" graph shows the production when a material supplier can always supply what asked and the delivery is always on time. The "support from plant 1" graph shows what happens when a supply chain can't make one component the 10th day of the month and another plant provides this component by sending it by truck 1 week later (cost=5000 Euro). The "support from plant 2" graph shows what happens when the components are served by ship 2 weeks later (cost=2000 Euro). Figure 3 makes the manufacturer to decide between receiving materials one week later and having a price of 1589 Euro/engine or receiving materials two weeks later and having a price of 1577 Euro/engine.

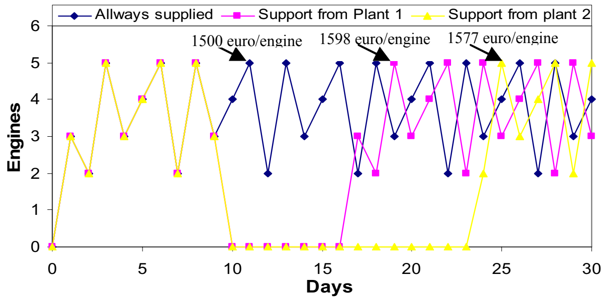

Fig. 3. System simulation

6 Conclusions

We have proposed a cooperative system for re-scheduling engine supply chain plants. It has been described and analyzed analytically. The simulation shows the execution of the delivery dates, the costs savings, the schedule performance and the time to solve a problem in the system. In future works, tests of the overload and the delay produced in the other plants, when they are supporting a plant, will be added.

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Cooperative Secure Data Aggregation in Sensor Networks Using Elliptic Curve Based Cryptosystems

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Abstract. Remote sensing infrastructures are now in widespread use to acquire detected information. Since the deployed nodes are separated, they need to cooperatively communicate sensed data to the base station, as shown in Fig.1. Additionally, the carried information probably contains confidential data. However, the properties of wireless communications are vulnerable to an exposed environment. Hence, secure data transmissions for cooperative information integration in sensor networks are essential. In general, wireless sensor nodes have limited resources, and they cannot provide sufficient CPU, memory and bandwidth to address complex operations. The proposed scheme depends on Discrete Logarithm Problem (DLP) of Elliptic Curve Cryptography (ECC), and exploits a smaller key size to achieve comparable security levels than Rivest Shamir Adleman (RSA) and Diffie-Hellman (DH) cryptosystems. Consequently, this paper exploits Elliptic Curve Diffie-Hellman (ECDH) based security methods to achieve cooperative secure information integration.

Keywords: Cooperative, WSNs, DLP, RSA, DH.

1 Introduction

Although, the Public Key Infrastructure (PKI) provides sufficient security levels for secure data transmissions. However, sensor nodes cannot provide sufficient CPU, memory and bandwidth to address complex operations. Therefore, this study adopts Elliptic Curve Diffie-Hellman (ECDH) key agreement protocol that allows two parties to establish a shared secret key (session key) over an insecure channel. ECDH with 160-bit key lengths provides the same security level to Rivest Shamir Adleman (RSA) and Diffie-Hellman with 1024-bit cryptosystems [1] [2], as shown in Table 1, which requires high CPU and memory capabilities to perform exponential operations. However, ECDH replaces exponent operations with point multiplications. Therefore, ECDH are quite suited for sensor nodes with insufficient power and limited resources.

The ECDH key agreement protocol uses elliptic curve cryptography that allows two parties to establish a shared secret key (session key) over an insecure channel. Two parties exploit this key to encrypt subsequent communications using a symmetric key scheme. Consider the case in ECDH, where sensor node *A* wants to establish a shared key with node *B*, as shown in Fig.2. The public parameters (a prime *p*, a base

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point P as a generator in Diffe-Hellman, coefficients a and b, and elliptic curve $y^2=x^3+ax+b$) must first be set. Additionally, each party must have an appropriate key pair for elliptic curve cryptography, comprising a ECC private key K (a randomly selected integer) and a public key Q (where $Q = KP$). Let a node key pair of A denote (K_A, Q_A), and a node key pair of B denote (K_B, Q_B). Each party must have the other party's public key. Node A calculates $Q_A = K_AP$, while node B calculates $Q_B= K_BP$. Both parties calculate the shared key R as $R = K_AQ_B = K_AK_B\mathrm{P} = K_BK_A\mathrm{P} = K_BQ_A$. The protocol is secure because it reveals nothing (except public keys, which are not secret), and because no party can calculate the private key of the other unless it can solve the Diffie Helman Problem (DHP) [3][4].

This paper takes the advantage of ECDH to perform cooperative secure data routing and aggregations. The rest of this study is structured as follows. Section 2 introduces the cooperative secure information aggregation using ECDH key agreement. Section 3 presents the security analyses. Conclusions and future work are finally drawn in Section 4.

Table 1. Comparison of key length for ECC and RSA

Security Level	Symmetric Key Length (bits)	ECC Key Length (bits)	RSA/DH/DSA Key Length (bits)	ECC/RSA Key Size Ratio	MIPS Years Time to break key
2^{80}	80	160	1024	1/6	10^{12}
2^{112}	112	224	2048	1/9	10^{24}
2^{128}	128	256	3072	1/12	10^{28}
2^{192}	192	384	7680	1/20	10^{47}
2^{256}	256	512	15360	1/30	10^{66}

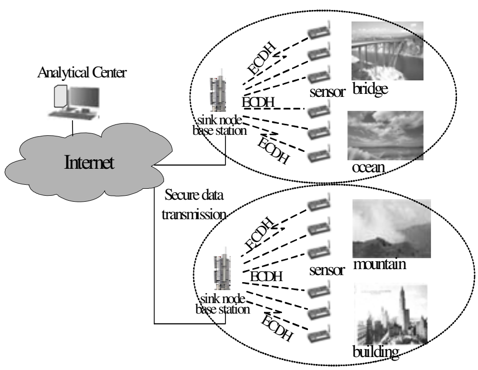

Fig. 1. A remote sensing framework

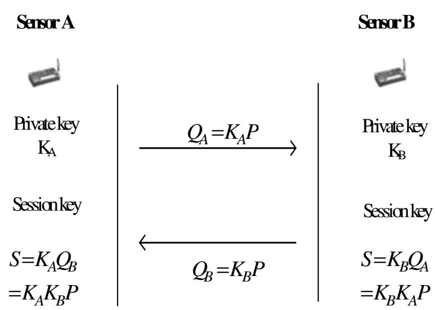

Fig. 2. ECDH key agreement protocol

2 Cooperative Secure Information Aggregation

The sensor nodes are deployed in advance on distribution locations for detecting information. After the data gathering, sensor nodes send the collected data back to the base station and analytical center for analyses. During data transmissions, each node along the routing path cooperatively integrates and secures the fragments of messages. This study proposes a cooperatively secure information integration scheme to protect the data transmission. This study presumes that twelve nodes and a sink node (base station) exist in the network as shown in Fig. 3. Nodes S_4 and S_8 sense data, and deliver them to the base station S_0. Along the transmission path, the passing through nodes are responsible for cooperatively integrating and securing the transmitted data. The secure information integration procedures are as follows.

As the node S_4 sensing data D_4, it exploits a message authentication function compute the message digest HMAC(D_4). For simplicity, this paper denotes HMAC(D_4) as H (D_4), and S_4 integrates the H(D_4) with original sensed data D_4. Besides, S_4 records the passing through node S_4 as the routing path. Eventually, S_4 encrypts all of them using the session key ($S_{7,4}$) of S_4 and S_7. Subsequently, S_4 sends the encrypted data to the next node S_7.

$S_4 \rightarrow S_7$
$EK_{S_{7,4}}[S_4 | D_4 | H(D_4)]$

As S_7 receiving the encrypted data, S_7 decrypts them using session key $S_{7,4}$, and verifies the integrity of message authentication code H(D_4). Subsequently, S_7 aggregates the sensed data D_7 with D_4; computes $H(D_7 || D_4)$; records the routing path (S_7, S_4), and encrypts all of them. Eventually, S_7 send the encrypted data to the next node S_{10}.

$S_7 \rightarrow S_{10}$
$EK_{S_{10,7}}[(S_7,S_4)|(D_7||D_4)|H(D_7||D_4)]$

After S_{10} receiving the data, S_{10} repeats the same procedures, and delivers the encrypted data to the following node S_9.

$S_{10} \rightarrow S_9$
$EK_{S_{9,10}}[(S_{10},S_7,S_4)|(D_{10}||D_7||D_4)|H(D_{10}||D_7||D_4)]$

S_9 performs the similar procedures, and transmits the encrypted data to the sink node (base station) S_0.

$S_9 \rightarrow S_0$
$EK_{S_{0,9}}[(S_9,S_{10},S_7,S_4)|(D_9||D_{10}||D_7||D_4)|H(D_9||D_{10}||D_7||D_4)]$

When the base station S_0 receives the data, then decrypts them using session key $S_{0,9}$. Subsequently, S_0 verifies the integrity of received data, taking the $(D_9||D_{10}||D_7||D_4)$ as input, and computes the message authentication code $H(D_9||D_{10}||D_7||D_4)$. If the result matches the received HMAC, then the integrated data are complete. Otherwise, the base station identifies the modification during the transmission.

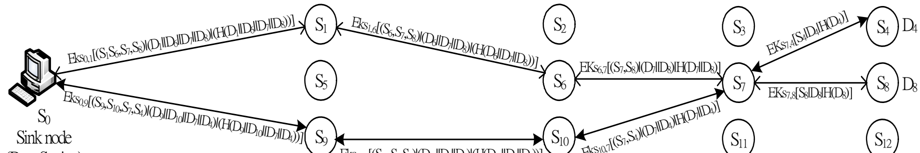

Fig. 3. Cooperative secure data routing and aggregations

3 Security Analyses

This section provides several security analyses for the proposed scheme, and evaluates the performance of the scheme.

(1) Confidentiality and authentication
During data transmission, each sensor node employs a session key to encrypt transmitted data. Only the node with the same session key can decrypt the encrypted data. The other nodes are not aware of the session key, and therefore the system can assure the confidentiality of transmitted data.
(2) Data accuracy and integrity
This study exploits HMAC to ensure the accuracy and integrity of the transmitted data. During the transmission, the sender computes HMAC using the session key. Thus, the system avoids that malicious nodes exploit a spoofing key to pass through the verification of HMAC. As the receiver obtains the transmitted data, then takes plain messages and the session key as inputs, and then verifies the integrity of HMAC.
(3)Fault tolerance
Once the dedicated routing path collapses, a sensor node chooses other cooperative nodes to perform secure data transmissions, and the system regains normality. This method is rapid and efficient for fault-tolerant routing in peer-to-peer secure data transmissions.

4 Conclusions

The paper proposes a cooperative secure data aggregation manipulation in sensor networks using ECDH protocol, which indeed provides a significant performance of resource constrained networks for sensor networks with limited resources. ECDH employs a small key length to achieve compatible security levels on RSA or Diffee-Hellman methods. Additionally, each node cooperatively performs data routing and data aggregation. If the routing path collapses, the system can cooperatively find a spare routing path and regain normal transmissions. The proposed cooperative secure data aggregation scheme is rapid, efficient and highly suited for wireless sensor networks.

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