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Preface

Many papers in this volume reflect, to some degree, the active, rapid economic development in certain geographic areas in the world such as China, Japan, South Korea, and Eastern Europe, which demand cooperative work, particularly cooperative engineering, more than ever. New concepts and new ideas of cooperative design, visualization, and engineering have emerged to meet the higher demand resulting from the economic development in these areas. Another trend among the papers in this volume is to apply existing concepts and methods to new application areas.

The emergence of new concepts can be considered as a signal of fruitful research with its maturity in the field. This can be found in the papers of this year's conference. Cooperative design, visualization, and engineering via cloud computing is a new concept presented in a group of papers in this volume. The concept of cloud has been proposed for cooperative manufacturing, large scale cooperative simulation, and visualization, etc.

Applying existing concepts to new application areas or creating new methods based on them is a logical direction to take full advantage of the cooperative design, visualization, and engineering technology. This is no doubt the best way to widen and deepen the knowledge in the field. Typical examples in this volume include the cooperative visualization of DNA microarray data in bioinformatics, astrophysical simulations, natural disaster simulations, and cooperative risk assessment, etc.

As the volume editor, I would like to congratulate all the authors for their research and development results, raising cooperative technology to a new level. I would like to thank our program committee, organization committee, and all the reviewers for their contribution to another successful event in this series of international conferences.

September 2010

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Table of Contents

Part I: Cooperative Applications

Part II: Cooperative Design

Part III: Cooperative Visualization

Part IV: Cooperative Engineering

Part I

Cooperative Applications

5 Conclusion

Human as the operator of the design tasks, is a kind of special resource compared with technology resource. Different combination of human resource and technology resource caused different task execution time, which would influence the total duration of the project. Aiming at this character, this paper introduced designer-task-resource matching matrixes into the multi-mode resource-constrained scheduling model. Case study shows that the method can obtain the minimum project duration by allocating most suitable person and resource to the task under the constraints of task relations. In the near future, designers' collaboration matching degree should be considered in the model, especially when there are collaborative design tasks which should be executed by more than one designer.

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Using Tag Clouds to Promote Community Awareness in Research Environments

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Abstract. Tag clouds have become a popular visualisation scheme for presenting an overview of the content of document collections. We describe how we have adapted tag clouds to provide visual summaries of researchers' activities and use these to promote awareness within a research group. Each user is associated with a tag cloud that is generated automatically based on the documents that they read and write and is integrated into an ambient information system that we have implemented.

Keywords: Tag Clouds, Ambient Information, Community Awareness.

1 Introduction

Community awareness within working environments promotes knowledge sharing among members of an organisation and extends cooperation beyond formal project boundaries. Keeping a community informed about its members and their activities is becoming increasingly challenging as the sheer amount of information available to us, and directed at us, rapidly grows and our capabilities to filter and absorb relevant, but non-critical, information are reaching their limits. At the same time, there is a tendency for users to become locked into virtual communities, not only for reasons of geographical distribution, but also the time spent communicating and working within a digital world.

To address these challenges, we developed an ambient news service, AwareNews [1], that integrates information about activities within an organisation as local news items within a more general news service. By providing information published by various media services such as breaking news stories, sports results and technology news alongside local news, we aim to attract users and sustain interest. News items are automatically integrated through newsfeeds and we developed additional local newsfeeds for a range of applications including calendars and software repositories.

Recently, we decided to investigate ways in which we could extend AwareNews to improve awareness of the past and present research activities of members of a research group. Tag clouds are widely used in Web 2.0 sites to provide visual summaries of various forms of data collections[1] and have now been adopted by

[1] http://www.flickr.com, http://delicious.com, http://wordpress.com

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some research groups to summarise the topics of their research based on titles of publications and/or projects[2]. We therefore decided to experiment with the use of tag clouds to visualise the research activities of individual members of a group based on, not only the publications that they had written, but also those recently read. The visualisation schemes were carefully selected so that a single tag cloud could be used to represent the overall expertise of a researcher as well as recent areas of interest.

In Sect. 2, we discuss the background to this work before going on to present the details of our tag cloud representations in Sect. 3 and 4. We then provide an overview of the system that we have implemented in Sect. 5. Open issues and directions of future research are discussed in Sect. 6 before giving concluding remarks in Sect. 7.

2 Background

Awareness has been recognised as a key factor for increasing efficient and effective cooperation within shared workspaces [2]. Community awareness is not related to any specific task, but rather aims to make users more aware of other members of the community and their activities in order to promote interactions that may lead to ad-hoc collaboration and knowledge sharing. This must be done in a manner that places few or no demands on the users and does not distract them or disrupt their normal work practices. For this reason, secondary displays [3] or ambient displays [4] are often used to display awareness information.

In [5], a general infrastructure for communication walls is presented that enables users to post any information items (text, images, videos) of interest. Apart from the disadvantage of relying on active user participation, another problem of such a system is the fact that the public displays are generally not aesthetically pleasing and hence not attractive to potential information consumers. Some projects have therefore looked at designing aesthetically pleasing information collages [6] or adapting recognised art forms to display information [7].

The kinds of information used to promote awareness and also the sources of that information are important in determining not only what users will become more aware of, but also the level of interest and involvement of the users. One informal study related to a personal awareness system found that 80% of participants check news and financial web sites on a regular basis [8]. This suggested that integrating various forms of news information into a community awareness system could be beneficial in terms of attracting users to the system and this is what we did in our AwareNews system [1]. In AwareNews, RSS feeds developed for local applications such as calendars and software repositories are integrated with feeds from various global news services. This allows users to be informed about the activies of other users related to events that they attend and also software projects that they are working on. Further, by using Apache SubVersion to control shared access to text documents as well as software, information about activities related to the writing of documents could also be integrated into the system. AwareNews provides access to this information by means of peripheral

[2] For example using http://www.citeulike.org/groups/browse

displays installed in offices and public areas. News items are selected at random and displayed one at the time using a very simple layout and slow rate of change to minimise distraction. Details of a qualitative user study are given in [1].

Although AwareNews provides some information about the current activities of users and was shown to have a positive effect on community awareness, it is very limited in terms of raising awareness about the knowledge and interests of users and therefore stimulating knowledge exchange and ad-hoc collaborations as proposed in [9]. In the remainder of this paper, we describe how we extended the system for a university setting to provide more information about the past and present work of researchers in terms of their reading and writing activities.

3 Profiling Researchers through Tag Clouds

Tag clouds have become extremely popular in Web 2.0 applications as a means of providing visual summaries of collections of documents. Although very simple, they can be used to support search, browsing and recognition as well as forming and presenting impressions [10]. We therefore decided to investigate their use as a means of profiling researchers.

We conducted a simple user study to assess if, and to what extent, members of a research organisation would be able to identify persons using a tag cloud generated from the titles of the papers that they had authored. The tag clouds were generated using the Web application Wordle[3] with a merged list of publication titles given as the input string. We chose to generate monochrome tag clouds and the only significant variable is the size of the tags which correlates with the relative term frequency in the input string.

Since the tag cloud of an individual represents their accumulated expertise, we decided to create a second augmented version which highlights the recent work of the user in terms of the two most recent publications. This was done by copying the tag cloud and colouring the tags appearing in the last two publication titles in red. An example of an augmented tag cloud is given in Fig. 1 with the monochrome tags shown in grey and the red coloured tags shown in black.

For the study, we chose three research groups[4] within our department. From each of these groups, we selected six PhD students with at least five publications, three of them to be *test persons* and three of them to be *represented persons*. The nine test persons were asked to identify nine represented persons, each represented by a basic and an augmented version of their tag cloud. We first showed the basic tag cloud and asked the test person to identify the research group. Second, we asked the test person to identify the represented person. Third, we showed the augmented tag cloud. If the test person named a person before, we asked whether they had changed their mind. If they were unable to name someone before, we asked if they could do so now. Finally, we presented the tested person with their own tag cloud and asked whether they liked it.

[3] www.wordle.net/create

[4] A group is either a research group associated with a single Chair or an Institute composed of multiple Chairs all working in the same area of research.

Fig. 1. Tag cloud of an individual researcher

The main results of the study are summarised in Table 1. In the first row, the number of correct identifications are given as a percentage of all attempts with the standard deviations written in brackets. In the second row, we provide the percentage of incorrect identifications. The remaining cases are those where the user was not able to name a group or individual.

The first two columns give the percentages for the cases where represented persons were members of the same group as the test persons or different groups, respectively. In the former case, they were able to identify the research group in 92.6% of all attempts and the represented person in 74.1%. In the latter case, the ability to identify the group decreased to 46.3% and the identification of the represented person to 7.4%. In both cases, the identification of groups was more successful than that of individual persons and this difference was even more prominent when the test person and represented person were members of different groups. The fault rates were higher when represented persons were members of different groups. We note that test persons were more cautious when identifying persons as opposed to identifying groups.

The last two columns indicate the effect of augmented tag clouds overall. With basic tag clouds, research groups were identified in 56.8% of cases while represented persons were identified in 25.9% of cases. The presentation of the augmented tag cloud increased these numbers to 61.7% and 29.6%, respectively. The fault rates decreased when identifying persons rather than groups, however, in both cases the fault rates increased when presenting the augmented tag clouds.

Table 1. Identification rates, fault rates and standard deviations in brackets

	Same Group		**Different Group**		**Basic Cloud**		**Augmtd. Cloud**	
	Identify		**Identify**		**Identify**		**Identify**	
	Group	**Person**	**Group**	**Person**	**Group**	**Person**	**Group**	**Person**
+	92.6 (0.4)	74.1 (1.1)	46.3 (1.6)	7.4 (0.5)	56.8 (1.4)	25.9 (1.0)	61.7 (1.7)	29.6 (0.9)
−	11.1 (0.7)	11.1 (0.7)	40.7 (1.6)	25.9 (1.6)	24.7 (1.2)	14.8 (1.4)	30.9 (1.6)	21.0 (1.5)

In summary, the study indicates that test persons had a good recognition rate for members of their own research group based on tag clouds. Generally, they were better at identifying groups than individual persons with the ability to represent individuals outside their own group being relatively low. It was interesting to note that many cases of false identification of both groups and individuals resulted from overlaps in research areas that reflected general hot topics in research such as mobile computing. Finally, seven out of nine test persons revealed a positive attitude toward their own tag cloud.

4 Using Tag Clouds for Awareness

We decided to integrate researchers' tag clouds into the AwareNews system as a means of raising the awareness of members of a research group about the past and current interests of other members of the group. In addition to providing a visualisation of topics of papers authored by a researcher, we also wanted to integrate information about the topics that they were currently reading about. Further, in line with the general goals of AwareNews, we wanted to be able to capture this information and generate the tag clouds automatically without requiring a change in work practices.

Since it is common nowadays for researchers to use some kind of tool for managing bibliographies of papers read as well as papers written[5], we decided to use this as our information source. When a user creates a new bibliography item, a simple check is made to determine whether or not the user is an author of that paper. If so, then the title of the paper is added to profile data of that user under *authored-papers*. If the user is not an author, then the title is added to the profile data under *read-papers*. The only change to work practices that we are considering is to have researchers create a bibliography entry for papers as soon as they start working on them as a technical report in order to ensure that the tag clouds reflect current work and not just work that is already published. We note that some research groups already enforce such a practice.

The tag clouds used in our study were based on only authored publications and we created an augmented version with the tags in red to highlight topics of recent papers. Our study has shown that this simple mechanism is also effective in helping to identify researchers within a group. To represent recently read publications, we incorporate the tags appearing in the titles of the last two papers read into the tag cloud and then highlight these terms in blue. If a tag appears in both *authored-papers* and *read-papers*, then it will be coloured red since writing about a topic is considered to subsume reading about it. Note that there are issues about how many papers should be taken into account in representing recent activities and also whether tags should be weighted in some way so that the size of tags of recent topics would be larger relatively and hence more easily noticed. A disadvantage of giving more weight to recent activities is that this may have a negative effect on raising awareness of past experience if these tags would become very small. For the moment, we have therefore chosen to experiment

[5] http://www.endnote.com, http://www.mendeley.com, http://www.connotea.org

with two versions of the tag clouds—one where no weighting is applied and one where tags are weighted according to recency. In the case of publications authored, recency is determined by the year entry of the bibliography item, whereas in the case of publications read, it is determined by the date that it was entered in the bibliography.

An issue of importance in all awareness systems that use shared displays and especially displays in public areas is that of privacy. Here the results from our study also indicate some of the benefits of tag clouds. On the one hand, they are an abstract representation of researchers' activities and for people outside of the group they would tend to simply see the tag clouds as visually pleasing representations of the activities of a group. On the other hand, within a research group, users can easily identify individual researchers and their current activities. This enables them to recognise if other members of the group have worked, or are working on, topics that are of interest to them.

5 Architecture and Implementation

The AwareNews system consists of several secondary and wall-mounted public screens driven by small computers which are connected to a context-aware data aggregation engine responsible for acquiring local and global news sources. News sources are RSS feeds where feed items are pushed to the displays on a regular basis. Therefore, additional news sources can be integrated by implementing an RSS feed generator. To support the work presented in this paper, we have implemented such a generator that produces feeds containing tag clouds.

Figure 2 gives an overview of the system architecture and highlights the processes involved in generating and displaying tag clouds. To the left, we show the users of AwareNews who are exposed to the ambient displays shown in the middle, while the software system is outlined on the right. The screens display tag clouds which *aggregate* the titles of those documents which the *represented* users have either *written* or *read* as exemplified by the grey circles and diamond-shaped relationships.

While Wordle was used to manually generate tag clouds for our study, we had to develop our own *tag cloud generator* for the AwareNews system which is shown in the top right. The tag cloud generator accesses the *bibliography*

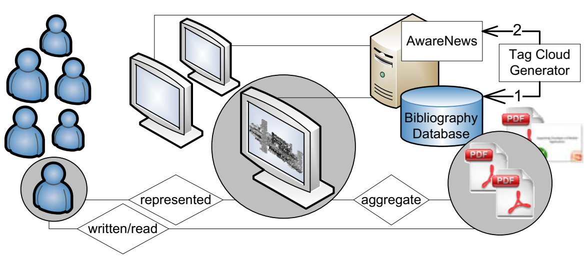

Fig. 2. System architecture

database (1) which is in charge of managing the bibliographies of all users and includes items for the documents authored by the users as well as for those that they have read. Whenever a document authored by a user is entered into the system, a deferred task is spawned that refreshes the tag clouds affected by the current addition. For each author of the new document, the tag cloud generator queries the database in order to retrieve the titles of all documents written or read by the author. Similarly, a user's tag cloud will be updated if they add a new document to the bibliography database that was not authored by any members of the group, but in this case it will be added to the set of read documents.

In order to obtain more useful clouds, some basic natural language processing is performed on the accumulated titles, such as filtering insignificant words and removing certain inflections. In a last step, a tag cloud algorithm determines the sizes of the tags according to their frequencies and places them spatially according to a layout strategy. Based on this layout and additional aesthetic options such as font type, font size and colouring, the tag cloud is directly rendered to an image and stored in the file system. The whole process is concluded by updating a single RSS feed with a URL pointing to the newly created image (2). Consequently, the next time the AwareNews system polls this feed, the images are retrieved from the file system and displayed.

6 Discussion

Following our study, we have a first implementation of the system and are experimenting with different visual representations. As mentioned previously, one of the issues is to investigate possible weighting schemes to reflect the recency of tags and whether this could be beneficial. One of the factors that has to be taken into account is the size of the tag cloud in terms of the number of tags. If one considers the tag cloud of a professor who has been publishing over many years, then clearly the characteristics of their tag cloud is quite different from that of a new PhD student and it is easier for individual tags to get lost within the cloud if they are recent but infrequent. Therefore, it may be that we require a weighting scheme that is even dependent on the size of the tag cloud. However, we note that the ability to recognise more senior researchers from junior researchers through the size of the tag cloud can be seen as another benefit of using tag clouds as profiles of individual researchers. We also want to experiment with the number of publications considered as defining recent activities. At the moment, we are using the two most recently written and read publications, but this is mainly because our study focussed on PhD students who tend to have a relatively small publication record.

One of the features of the existing AwareNews system is that it also displays information about the presence of members of a group based on their MSN status. We are experimenting with different ways of capturing and visualising presence and status information and plan to include the tag cloud profiles as one possible visualisation. This means that a researcher's tag cloud would only be displayed when they are actually present and it could be visually augmented to indicate the status.

AwareNews is currently an ambient information service that involves no user interaction. However, it could be useful for users to be able to interact with the tag clouds to find out more information about the publications or even the projects related to them. We have also considered the possibility of allowing users to send a message to the researcher associated with a tag cloud as a first means of opening up discussions. As future work, we therefore plan to extend the system to support such forms of interaction.

7 Conclusions

We have proposed the use of tag clouds as a means of visualising researchers' past and present activities and described how we integrated this concept into an ambient information service designed to promote community awareness. We note that tag clouds can play a double role in such a setting since they provide an attractive display for visitors that provides them with an overview of the group, while, at the same time, being used by members of the group to identify researchers and keep them informed about their activities.

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A Proposal for Model-Based Design and Development of Group Work Tasks in a Shared Context

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Abstract. The design and development of groupware systems is a difficult task, especially due to their multidisciplinary nature and the technical complexity of these kinds of systems (e.g. distribution, data sharing, multi-user interfaces). A model-driven development approach could help to deal with this research problem. This paper presents an approach to tackling the design and development of groupware applications. This approach is part of a framework for the model-based user interface development of collaborative applications (called CIAF; *Collaborative Interactive Application Framework*), which includes issues of particular relevance based on the use of several models and notations for representing the collaborative and interactive aspects of this kind of systems.

Keywords: groupware design, model-based design, groupware production.

1 Introduction

In order to speed up and facilitate the development of groupware applications by the developers of such systems, the goal is to automate, as far as possible, the creation of groupware, in such a way that the developer can handle models and higher levels of abstraction, and thus obtaining quality collaborative applications.

Molina et al. [1] presented a review of the main notations and approaches for the analysis and modeling of the interaction and collaboration within groupware systems. Also, a review of current literature relating to the model-based design and development of applications providing support to group work [2-8] has been undertaken. None of these works tackle the development of groupware applications via models that are capable of generating both the user interface and the functionality of the application. CIAF (Collaborative Interactive Application Framework)[9] is established in this line of work. CIAF proposes a model-based methodological approach to the development of the user interfaces of collaborative applications. CIAF proposes the integration of the specified information by means of a notation known as CIAN (Collaborative Interactive Application Notation)[7], dedicated to the modeling of the interactive aspects of group work, and using information gathered from UML models. However, this proposal focuses primarily on the more interactive aspects of the application (its user interface) at a very high level of abstraction,

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leaving aside many of the more practical aspects. Also, this framework does not allow designing purely collaborative tasks in which the users access shared context simultaneously. Therefore, in our work we aim to take this framework as a starting point and to extend it to also consider these practical aspects. Therefore, our research hypothesis can be formulated as follows: "*it is possible to propose a methodological framework for the model-based design of groupware applications which is capable of generating fully functional and complete collaborative applications*". In order to validate it, our main goal is to develop a framework for designing group work tasks that supports the generation of a fully functional collaborative application from this design. Due to the lacks detected in CIAF, our first partial goal is the model-based design of work tasks in a group with a shared context. And, the second partial goal is know the collaboration mechanisms of the low-level abstraction that are involved in these subtasks, both functional and more interactive level. In this paper, we only focus on the model-based design of tasks for group work in a shared context.

This article is organized into four sections. Section 2 describes in depth how CIAF is complemented by our proposal for the design and modeling of the purely collaborative (or functional) aspects of the end user interface. Lastly, Section 3 presents the conclusions that have been reached and the future lines of research derived from this work.

2 Towards a Model-Based Framework for Design and Development of Group Work Task in a Shared Context

As a solution to the hypothesis presented above, we present an approach organized into stages and based on components for the design and generation of groupware applications. To design the most relevant aspects of an interactive system for supporting group work, already existing notation will be used or new notations will be proposed where necessary to represent certain aspects. From these models, the generation process will take place, based on the selection of those collaborative components that will eventually form the user interface of the final tool. The steps that make up this proposal are explained below, along with the selection method that our framework uses to decide upon the most appropriate components to form part of the final user interface.

CIAF allows for the modeling of individual and group-work tasks. The specification for the first type can handle different levels of abstraction, down to the most detailed levels, in which the CTT notation[10] is used to specify particular aspects of human-computer interaction. Using CTT a developer can achieve high levels of detail describing the model of interaction, and the obtaining of the final design of the user interface is facilitated. As for the modeling of the group-work tasks, CIAF makes a distinction between cooperative and collaborative tasks. This distinction is based on the definitions of the terms cooperation[1] and collaboration[2] as given by Dillenbourg[11]. CIAF proposes breaking down cooperative group-work

[1] Cooperation implies that group member pursue the same goals, but act independently in terms of their own work but in separate parts within a shared context.

[2] Collaboration implies that individual members work together within a common space of representation.

tasks into independent individual tasks because CTT only allows the modeling of cooperative tasks that are specified by a cooperative model that relates individual tasks. However, CTT cannot be used for modeling collaborative tasks and shared contexts. Obtaining the final user interface, for individual and cooperative tasks alike, presents no problem since for both types of tasks a CTT model is created, allowing the appropriate corresponding user interface to be obtained. However, obtaining the interface for collaborative tasks is somewhat more complex because they cannot be broken down into individual, independent tasks. As such, we have found that the CIAF methodological framework does not allow for the generation of user interfaces for purely collaborative tasks in which there exists a shared context and less coordinated and independent interactions between users, who access this context simultaneously. To address this problem, we propose the method described below, using the CIAF methodological framework. These phases that make up this method are: **(1)** *Modeling of the group-work tasks*, **(2)** *Modeling of the interaction of group-work tasks*, **(3)** *Relating the group-work tasks and the application domain* y **(4)** *Designing the interaction of group-work tasks*. Before explaining in detail what the steps above consist and how each stage is carried out, we explain how the selection of components for supporting the group-work tasks is made. This is necessary in order to better understand the proposed process.

2.1 Selection of Components for Supporting Group Work Tasks

This section explains how to perform the selection of components for supporting group-work tasks. This selection is critical to the design of group-work tasks and allows one to identify which components will form part of the user interface.

Firstly, we conducted a systematic review of those groupware tools already documented in current literature. From each one of these tools we identified the visual components from the graphical user interface that support group work, making a distinction between those of them without any connection with the domain of the tool providing support and those of them linked to the domain. For example, a communication component, such as a chat feature, has no connection with the application domain whereas another component, such a specific collaborative editor, does have a connection with this domain. The aforementioned review was also intended to measure the degree of coverage that each of the components had in terms of the six dimensions of the Zachman framework [12]. This taxonomy consists in a two-dimensional matrix, where the columns show different *views* of a system (*What, How, Where, Who, When, Why*) and, the rows indicate the different levels of specification or *perspectives* to take into account in its development (technological, system, and business level). As such, our next step consisted in classifying the identified components according to the cells of the Zachman taxonomy in the system's perspective, where the relevant aspects are designed according to the technology that is to be used. After analyzing the components that usually form part of end collaborative user interfaces, the next step is to define a set of *decision rules* to makes possible, from a set of parameters, to decide which component is more suitable to provide better support for some specific collaboration requirements. As decision parameters we take the views of the Zachman framework. Up to now, we focus on the views *What*, *How* and *When*. Focusing on the *How* view, we consider the various collaborative mechanisms proposed by Pinelle in [13], defined as the basic operations and interactions to be performed by the workgroup to carry out a task that must take place to get a job done within a collaborative framework. These collaborative mechanisms can be modeled using the method proposed in the phase *Relationship between the group-work tasks and the application domain* since this relationship is determined by the action carried out by the user upon the task, which will imply the way in which the data will be handled. To define the actions that can be carried out upon the found collaborative components, certain changes have been made to the table of collaboration mechanisms provided in [13]. In Table 1 below you can see the different collaboration mechanisms sorted by categories, along with the action that each performs and the symbol that is used to model it:

Table 1. Collaborative Mechanisms

Category	Symbol	Mechanism	Action
Communication		Spoken messages	Conversational. Verbal shadowing
		Written messages	Conversational. Persistent
		Video messages	Conversational
		Manifesting actions	Stylized actions
		Deitic references	Pointing conversation
Information		Visual evidence	Normal actions
Gathering		Basic awareness	Observing who is in the workspace, what they are doing and where they are working
		Feedthrough	Changes to object. Characteristics sings or sounds
Coordination		Basic coordination	Allows users to be coordinated
Shared access		Obtain resource	Physically take objects or tools. Occupy space
		Set resource	Physically set objects or tools
Transfer		Deposit	Place object and notify
		Handoff object	Physically take/give object. Verbally offer/accept object

The next parameter to consider in the designed decision system is related to the *What* view. Therefore we considered those activities in which the use of groupware components is most common. We have analyzed each component of those under review, considering the essential task for which that particular component is used. The following list of tasks has been compiled: search, share, communicate, coordinate, decide, draw, discuss, edit, report, swap, browse and plan. Last of all we must consider the *When* view. In this case we consider the type of collaboration that is to take place: whether the interaction is to occur synchronously or asynchronously. Information pertaining to these two dimensions, *What* and *When*, is added to the models created in the phase *Configuring the interaction of group-work tasks*.

After analyzing each component, along with the considered parameters, we obtain a system of decision rules which allow us to select any collaborative component out of those collected. The inference rule for the components is as follows:

What x How x When => Component

Or expressed in another way:

Activity x Collaborative mechanism x Collaboration type => Component

Thus, when modeling a group-work task, configuring the type of activity it will be used to complete, the way in which the interface information collaboration will occur, and whether this activity is synchronous or asynchronous, the most appropriate graphical component for supporting said collaboration can be generated. For example:

Edit x Set resource x Synchronous => Edit panel

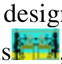
Draw x Gestural messages x Synchronous => Annotation panel

From this moment onwards, the groupware application continues to be developed following the guidelines and phases of the CIAF framework, which were explained above. To solve the identified problem, namely that the generated collaborative application must be functional and complete, all of the graphical components of the user interface are generated with their own functionality, as a *black box*. Thus, the final user interface product will be composed of fully functional components, in turn ensuring that the final product itself is also fully functional.

2.2 Stages of the User Interface Generation Process for Groupware Systems

This section explains in depth what each one of the phases that make up the proposed process covered above consist of.

Modeling of the Group Work Tasks. This phase is the starting point for our proposal The purpose of which is to increase the level of detail in the specification of group-work tasks. These tasks are broken down into individual tasks and group-work tasks of a lower level of abstraction, for which CTT[10] task diagrams will subsequently be created. These subtasks form an activity graph via which the dependencies that exist between the subtasks can be modeled. At this stage, just as proposed in CIAM [7], it will be possible to specify the tools used to support the collaborative activity (e.g. chat feature). These components will only be able to be added in group-work tasks or subtasks.

Modeling of the interaction of Group Work Tasks. The purpose of this phase is to create the interaction model associated with each of the individual and group-work subtasks to represent the computer-person interaction between the user and the interactive system. Its objective is to describe the division of the activity and its classification of interaction and implementation types according to who is responsible for leading a task. At this level, the breakdown of the subtasks is represented using CTT task models, since they are highly suitable for designing usable interfaces. This proposal adds a new kind of task to the CTT models, allowing for the modeling of those tasks that require interaction within a shared context (collaborative tasks), since CTT only allows for the modeling of individual and cooperative tasks.

Relating the Group Work Tasks and the Application Domain. This stage specifies the way in which the interactive part of the system relates to the information. Once the task model has been defined, the data manipulated by the user interface must be connected. From the point of view of the interface, the execution of a task requires a series of actions to be carried out upon the interface elements. As such, in order to select the graphical component that supports group work in a shared context, to the new task type included in the CTT we add the way in which the user interacts with the domain data. Such actions are called *collaborative mechanisms* [13].

Designing the Interaction of the Group Work Tasks. So far, the information that has been provided is not yet sufficient for the generation of the components that support group work within a shared context, since it would not be possible to clearly distinguish the components that are being designed. As a possible solution, at this stage the CTT task is configured for the modeling of the group-work tasks. This configuration uses the provided information that is necessary to clearly distinguish each component. Said information will be the *type of collaboration* to be implemented in the task and the *activity* that will be performed with the task. With this information, along with the modeling done in previous phases, the appropriate component for the support of group work can be identified. In section 3.1, this step is explained in depth.

From this point onwards, and following the CIAF methodological framework, the sequence of generating the graphical interface begins, encompassing the consecutive development of the *abstract interface*, the *concrete interface* and the end interface [14] within the activities of the *conceptual design*, the *detailed design* and the *implementation*, respectively. In order for the user interfaces generated via this proposal to be fully functional and complete, each of the components forming the final user interface will have its own functionality. Thus, all of the components that make up the tool will operate independently of each other, making the final product a complete and functional groupware tool.

2.3 Case Study

In order to provide a better explanation of this process, we use a small case study. A teacher proposes an activity, consisting in completing a writing, and their pupils carry out this activity in groups, each using their personal computer and a collaborative tool designed using our proposal. The students will have the help of a faculty advisor who will guide them in the use of the tool and clarify any doubts. This type of activity was chosen for the case study because of its clear need for collaboration between users and for interaction between each individual user and the designed application. Below we detail the steps that make up our proposal.

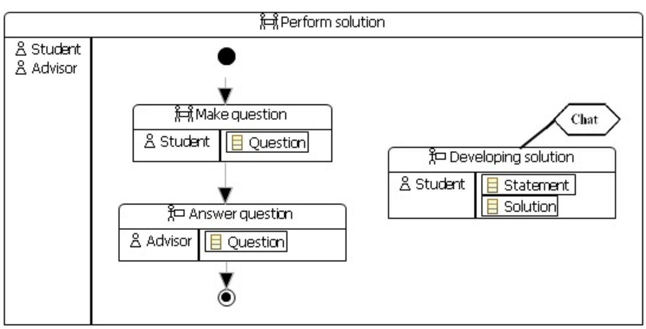


Fig. 1. Modeling group task "Perform solution”

Modeling of the Group Work Tasks. At this point, the tasks that make up our case study are broken down into individual tasks and group-work tasks of a lower level of abstraction. For example, Fig. 1 shows how the group-work task *Perform solution*, which is performed by the roles *Student* and *Adviser*, is designed. This task is broken down into three tasks: a group-work task, *Developing solution*, performed by the *Student* role, and two individual tasks forming an activity sequence, where *Make question* is made by the *Student* role and *Answer question* by the *Adviser* role. Added to the group-work task is a domain-independent collaboration component which facilitates working in groups, in this case a chat feature.

Modeling of the interaction of Group Work Tasks. To illustrate this point in terms of the case study, the *Developing solution* task is broken down into two group-work tasks: *Edit* and *Correct*. For the modeling of these tasks, the new proposed CTT task has been used, since in these tasks users will interact with the shared context, in this case a text editor.

Relationship between the Group Work Tasks and the Application Domain. The relationship between the task model and the application domain for the previous task of this case study is shown in Fig. 2a. These relationships are labeled with the new symbols which indicate the involved collaboration mechanisms. In this case, the relationship type is *Set resource*.

Configuring the Interaction of the Group Work Tasks. The configuration for group work task in a shared context of this case study is shown in Fig. 2b. In this case, the Edit Task, That is a synchronous task and use the mechanism of Collaboration *Set resource.*

With all this information, the modeling framework could generate the component *Edit Panel* for supporting collaboration in this subtask, which would have a fully and independent functionality.

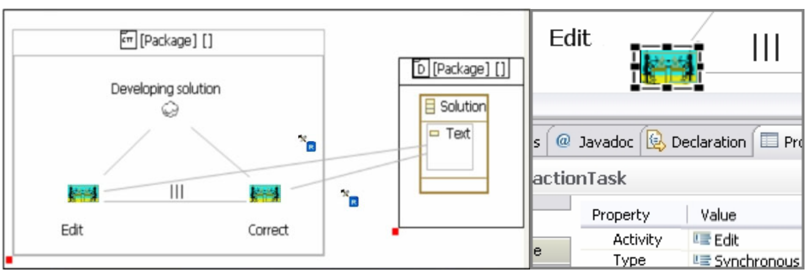


Fig. 2. a) Interaction diagram for the task *Developing solution*. b) Configuring the task *Edit.*

3 Conclusions and Future Work

In this article, we have proposed a methodological framework for the model-based design of group work tasks in a shared context, which can generate fully functional and complete collaborative applications. The framework allows a developer to can model the collaboration mechanisms that the user can use in during the collaborative tasks, and it can model the group work tasks in a shared context. Therefore, our working hypothesis is validated. Our work has taken CIAF as a starting point, integrating new notations and mechanisms for the modeling of groupware applications.

Additional work for the future is the generation of collaborative applications which, from the CIAF framework now enhanced by this proposal, have as their final product a fully functional, executable application. This will require the development of a complete toolkit of components designed with collaboration in mind.

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Fixing Collaborative Edition on Typed Documents

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Abstract. Collaborative edition is achieved by distinct sites that work independently on (a copy of) a shared document. In pure Peer to Peer collaborative editing, no centralization nor locks nor timestamps, therefore convergence, i.e. all sites have the same copy of the shared document, is the main issue. When the editing operations defined on the data structure enjoy a commutation property, efficient algorithms can be designed. The XML language provides a widely used format for documents and these documents are usually typed by DTD's or XML Schemas that are subclasses of regular tree languages. We extend a collaborative editing algorithm that relies on a notion of semantics dependence for operations and a tree data structure implementing XML documents to handle type information provided by DTD's or XML Schemas (and more generally regular tree languages). We show that the algorithm is convergent and that the final document has the required type.

Keywords: Peer to Peer Framework, CRDT, Collaborative Editing, Valid XML documents.

1 Introduction

Collaborative edition is daily used in many applications (writing article with SVN, setting appointments with doodle, Wikipedia's articles,...) and it is achieved by distinct sites that work independently on (a copy of) a shared document. In Peer to Peer systems -P2P in short- no centralization like locks (as in svn or cvs) nor timestamps is allowed and new sites may join at any time. The main issue is to ensure that all sites have the same document after the editing process is terminated. This problem is classic in distributive database and many algorithms proposed for documents modelled as word on a finite alphabet turned out to be faulty (see [3] for details) and many systems currently in use do not ensure convergence [3,2] or rely on centralization to get this property [4,6]. Commutative editing is a variant of the problem where the basic operations for *adding, removing or changing* an element commute and several propositions have been done in this framework [8,10,7]. In this setting, ensuring convergence is easier and the algorithms can be simpler.

In this paper, we consider collaborative editing of XML documents subject to type constraints that can be DTD or XML schemas or more generally regular tree languages [1]. For example, we would like to say: "All events are only one date". This extension is natural since types for XML documents are regularly used and should be considered in

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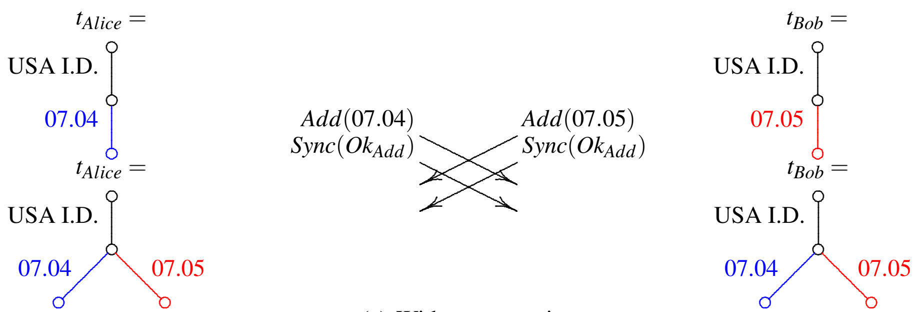
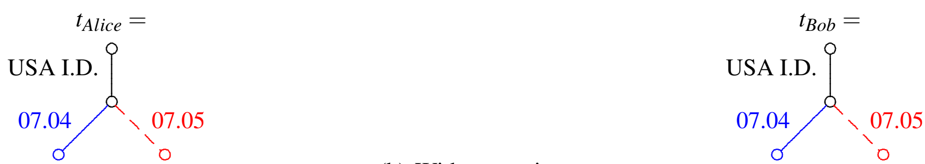
the edition system to restrict the edition process to valid documents. Up to our knowledge, the combination of collaborative edition with type information has not been considered. Our solution is an extension of a collaborative edition algorithm FCEDIT [5] that relies on a notion of semantics dependence of operations that states when operations can commute and ensure the convergence. This extension relies on a data structure that combines a *local view* and a *global view* of the document currently in progress.The local view is obtained thanks to repair algorithms (see [9]) that give a type S and a document d, compute the nearest document d'(for some editing distance) that belongs to S. When the user does an operation on *local view*, our algorithm converts it to a sequence of valid operation on *global view*. It is still convergent without history recording and ensures that the document is compliant with the required type. Since repair algorithms are efficient, our solution is tractable and can be used for real applications.

2 An Example

Let Alice and Bob edit concurrently a calendar for recording events and their date. We assume that the calendar respects a DTD that demands that an event is followed by a unique date. Assume that at some point Alice and Bod have created a document that contains the event independence day (USA I.D.). The next step is to set up a date for this event. Independently, Alice and Bob add a date to their own copy of the document using the editing operation *add* and broadcast their changes to all participants. Since each copy satisfies the DTD, Alice (resp. Bob) also sends a *sync* operation to signal that her current copy respects the DTD.



(a) Without reparation



(b) With reparation

But after each participant receives the *Add* operation from the other one, the document no longer satisfies the DTD. We solve this problem by invoking a repair algorithm that computes a new document respecting the DTD when *sync* operations are received.

Our goal is to ensure that at the end of the process, each participant agrees on a document that respects the DTD. The main point is to know when to invoke the repair algorithm: although such algorithms are polynomial, it is too costly and usually meaningless to use it after each editing operation. Waiting until the end of the editing process is also not desirable: each participant must be able to check that his copy respects the DTD at any time. Our main contribution is to adapt our previous collaborative editing algorithm by using a sophisticated data structure that allows each user to have a *local view* of the document (trees with plain lines only in figure 2) and a *global view* of the document (trees with plain and dotted lines in figure 2). A main feature of our proposition is to keep a CRDT framework that allows to get rid of history lists storing all operations performed by each participant.

3 A Data Structure for Editing XML Document

We consider the unordered unranked edge labelled trees, where the labels contain informations related to the editing process that is used to build the actual XML document represented by the tree (restoring actual XML labels and transforming unordered trees into ordered trees).

We extend the data structure given in [5] by repair informations (visibility, and copy of edge state). The main points are that a tree contains both the *global view* of the document, shared by all sites, and a *local view* of the document and that these views can diverge since repair algorithms may remove, insert and relabel edges locally.

3.1 Labelled Trees

Identifiers. Each site is identified by a unique *SiteNb* and each operation generated by this site is identified by a numbering *NbOp*. The repair algorithm of the site is identified by *RepSite* (concretely 0) and each operation generated by this algorithm is identified by a numbering *NbRep*. An identifier *id* is a pair $(SiteNb : NbOp)$ or a pair $(RepSite : NbRep)$. For instance $(2:3)$ identifies operation 3 of site number 2 called a global identifier and $(RepSite : 3)$ identifies operations 3 of the repair algorithm called a local identifier. The set of the identifier is denoted by *ID*.

Labels. The set of labels is denoted by $\mathcal{L}$. A label $L' = (id, order, l)$ in [5] become $L = (visible, id, order^{Rep}, l^{Rep}, order, l) \in \mathcal{L}$ is a complex data structure such that:

1. $visible \in \{0,1\}$ is a tag that indicates that the edge is locally visible (1) or not (0), that is used to build the local view that the current user may extract.
2. $id \in ID$ is a unique identifier of the edge, using some $id \in ID$, i.e. distinct edges have distinct labels.
3. l is XML label and *order* is a order information, with additional information to ensure the convergence. For the sake of readability, we do not to go further into detail, see [5]. In this paper we consider them as abstract object. Let $\mathcal{L}_{XML}$ for labels set and $\mathcal{L}_{Order}$ for ordering labels set.
4. $l^{Rep} \in \Sigma_L^*, order^{Rep} \in \Sigma_O^*$ are either the labels and order information of the edge in the local view, or have undefined values. Σ_L is XML label alphabet and Σ_O is an alphabet. The order information is generated like explained in research report [5].

Furthermore, if $id = (RepSite : NbRep)$ then $visible = 1$. If $id = (SiteNb : NbOp)$ then visible can be 1 or 0. This restriction states that edges created by the repair algorithm are local but that edges created by users (either the local user or other users) may or may not be in the local view.

Trees. The grammar $T \ni t ::= \{\ \} \mid \{L_1(t_1), \ldots, L_p(t_p)\}$ *with* $L_i \in \mathcal{L}, t_i \in T$ and each L_i occurs once in t defines the set of trees T. Label unicity will be ensured for free by the editing algorithm since identifiers are unique by constructions. A *leaf edge* is an edge which has no descendant. This tree data structure is used to provide both the global document and a local view of the global document. Since repair operations are local, a local view may contain an edge which does not belong to the global document.

3.2 Local and Global Views

The local view $loc(t)$ of a tree t is defined by:

$$loc(\{\ \}) = \{\ \} \text{ and } loc(\{L_1(t_1), \ldots, L_p(t_p)\ \}) = \{L_{i_1}(loc(t_{i_1}), \ldots, L_{i_l}(loc(t_{i_l}))\}$$

where $L_{i_1}, \ldots, L_{i_l}$ are labels such that $visible = 1$ (and not $visible = 0$)

The global view $glob(t)$ of a tree t is defined by:

$$glob(\{\ \}) = \{\ \} \text{ and } glob\{L_1(t_1), \ldots, L_p(t_p)\ \}) = \{L_{i_1}(glob(t_{i_1}), \ldots, L_{i_l}(glob(t_{i_l}))\}$$

where $L_{i_1}, \ldots, L_{i_l}$ is the set of labels such that their identifier is some $(SiteNb : NbOp)$ (and $SiteNb \neq RepSite$)

The XML document d associated to $t' = loc(t)$ is defined by $d = \varepsilon$ if $t' = \{\ \}$ and $d = l^{loc}_{i_1}(d_{i_1}), \ldots, l^{loc}_{i_p}(d_{i_p})$ if $t' = \{L_1(t_1) \ldots, L_p(t_p)\}$ where $L_{i_j} = (1, j, l^{Rep}_i, ord_i, l_i)$, d_i is the document associated to t_i for $i = 1, \ldots, p$ and $l^{loc}_{i_j} = \begin{cases} l^{Rep}_i & \text{if } l^{Rep} \text{ is not null} \\ l_i & \text{else} \end{cases}$

An XML document is associated to $glob(t)$ in the same way (ignore local view informations).

4 Operations on Trees

4.1 Basic Editing Operations and Dependence Relation

The basics edition operations on trees given in article [5] modified to work on extended data structure. Actually, since we consider edge labelled trees instead of node labelled trees, insertion and deletion are performed on edges instead of nodes.

Adding an edge. The operation $Add(id_p, id)$ with $id_p \neq id$ adds an edge labelled by $(1, id, order^{\perp}, l_{\perp}, order^{\perp}, l_{\perp})$ under edge labelled $(\ldots, id_p, \ldots)$ where $order^{\perp}, l_{\perp}$ are default values. When id_p does not occur, the tree is not modified.

Deleting a subtree. The operation $Del(id)$ deletes the whole subtree corresponding to the unique edge labelled by $(\ldots, id)$ (including this edge). When id does not occur, the tree is not modified.

Changing a label. $ChLab(id_e, l')$ with $id_e \in ID$ and $l' \in \mathcal{L}_{XML}$ replaces the label $(visible_e, id_e, order^{Rep}, l^{Rep}, order, l)$ of the edge by $(visible_e, id_e, order^{Rep}, l^{Rep}, order, l')$ depending on some relations on dependencies. When no edge with the identifier id_e exists, the tree is left unchanged.

Changing the ordering. $ChOrder(id_e, order')$ with $id_e \in ID$ and $order \in \mathcal{L}_{Order}$. This operation is similar to ChLabel but it changes the order field.

Causal dependencies. The relation $\succ_s$ is a partial order on Op which expresses causal dependencies in the editing process: $op_1 \succ_s op_2$ iff op_2 depends from op_1 (for instance op_1 creates an edge and op_2 relabels this edge). In our model the set $OpDep$ defined by $OpDep = \{op \in Op, \forall op' \in Op | op \succ_s op'\}$ is a bounded set. We write $op_1 \parallel_s op_2$ iff $op_1 \not\succ_s op_2$ and $op_2 \not\succ_s op_1$. A sequence $[op_1; \ldots; op_n]$ is valid iff it is linearization of the partial order $\succ_s$.

- $Add(id_p, id) \succ_s Del(id)$: an edge can be deleted only if it has been created.
- $Add(id', id_p) \succ_s Add(id_p, id)$: adding edge id under edge id_p requires that edge id_p has been created.
- $Add(id_p, id) \succ_s ChLab(id, l)$: changing the labeling of edge id requires that edge id has been created.
- $Add(id_p, id) \succ_s ChOrder(id, order)$: changing the labeling of edge id requires that edge id has been created.

Lemma 1. *The set $(Op, \succ_s)$ is an independent set of operations. Let $[op_1, \ldots, op_n]$ be a valid sequence of operations in Op and let σ be a substitution compliant with $\succ_s$. Then $[op_1, \ldots, op_n](s) = [op_{\sigma(1)}, \ldots, op_{\sigma(n)}](s)$*

4.2 Synchronizing on a Type

The set Op is extended by a synchronization operation $sync(Dep)$ that is used by a site s to signal that, at some time, the local view of the document belongs to S. Since there is no clock to define time, we use instead a set Dep of operations those are the minimal operations for the ordering $\succ_s$ executed by the site s when the *sync* operation is issued (hence $op \parallel op'$ for each pair $op, op' \in Dep$). The application of *sync* is defined by $sync(Dep)(t) = t$ and the partial order $\succ_s$ is extended by setting $op \succ_s sync(Dep)$ for each $op \in Dep$. Note that a synchronization $sync(Dep)$ can refer to other synchronization since Dep may contain sync operations.

Locally the *sync* operation does not change t, but the FCEDIT algorithm will invoke the repair algorithm (fix function) when it receives a *sync* operation issued by other sites provided all operations in Dep have been executed.

4.3 Type Related Operations

Since labels of a tree t contain ordering information, each label of $glob(t)$ corresponds to a unique position p.

We invoke a repair algorithm. For instance, given a DTD S and a term d, the set of terms and the corresponding sequences of operations realizing the minimal distance of d to S can be computed in $0(|S|^2|d|)$, see [9]. We assume that all sites share the same deterministic version of a repair algorithm.

The Fix operation. The *fix* operation is an internal operation which is not broadcasted to other sites, but invokes the repair algorithm on the tree $glob(t)$ and applies the operations returned by the algorithm to t resulting in a local view $loc(t)$ such that $loc(t) : S$. The repair algorithm is invoked on the document d associated to $glob(t)$ and returns a sequence of operations of $remove(p)$ (remove an edge at position p), $insert(p,i,l)$ (insert an new edge as i^{th} son with label l under the edge at position p), $rename(p,l)$, $reorder(p,i)$. We describe how these operations modify the data structure t corresponding to d.

1. Set $t = glob(t)$ i.e. erase all edges generated by previous reparations and set all visibility flag to 1.
2. Apply each operation generated by the repair algorithm as follows. This operations is similar of definition of 4 but they change only reparation part on data structure.

5 The Collaborative Editing Algorithm for DTD

The editing operation is derived from [5], but is more complex since it must combine the local view and the global view as well as the local operations and the global operations. Each site performs concurrently editing operations on its local view and broadcasts these operations to the other sites. It also receives operations from other sites and executes them.

Local Variables. Each site s has a local counter *OpCount* that is used for numbering operations generated by this site. It has a local counter *OpCount* that is used for numbering operations generated by a *fix* operation. It has a vector *SReceived* of counters that remember for each other site s', what is the numbering of the last operation of the site s' that has been executed by s. This vector is used to compute dependencies on operations, assuming a stricter precedence relation that states that an operation generated by a site depends from all operations generated previously by the same site. Each site stores operations received from other sites in *WaitingList*. The local variable t stores the structures containing both the local and the global view.

The SendOp Operation. Given an operation *op* generated by site s on a local view of t, the *SendOp(op)* operation computes and sends the sequence of operations to perform to ensure that *op* can be done as an operation on the global view. In many cases $SendOp(op)$ simply returns *op*. When *op* depends of an edge which has been created by a local repair algorithm, i.e. does not exist in the other sites, the *SendOp* computes and sends a sequence of operations (computed recursively with $GenerateRequest(op)$) needed to create this edge on all sites. Therefore, *op* is modified since the operation numbering of its identifier field must be updated.

See appendix for a complete description.

6 The Convergence Property

The convergence of our algorithm relies on the convergence of the collaborative editing algorithm FCEDIT presented in [5].

Theorem 1. *Assume that each site performs a sequence of operations ending in a sync operation. Then after all operations have been processed by all sites, each site has the same local copy* $loc(t)$ *of the document and* $loc(t) : S$.

7 Conclusion

We have presented a distributed algorithm for P2P collaborative edition of typed XML documents that relies on commutative operations via semantics dependence, the repair algorithms to ensure type compliance and does not require to store any history information. Since the invocation of repair algorithm is left to the user and has a low complexity, the algorithm is expected to be as efficient as FCEDIT. We aim at extending our current prototype with these new features to get experimental results.

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Appendix

Algorithm. Let $getFather : ID \longmapsto ID$ be the function such that $getFather(id) = id_p$ iff id_p is the identifier of the edge which is the father of the edge with identifier id.

```
GENOPFIX(id): begin
    return Add(getFather(id), id_a)
    // with id_a is identifier generated by algorithm in GenerateRequest
end
```

Fig. 1. GenOpFix

```
SENDOP(op):        // Check and repair all
   dependance of local identifier
begin
    forall id ∈ dependanceOf(op) do
        if id = (RepSite : NbRep) then
            Let OpFix = GenOpFix(id)
            Let r = GenerateRequest(OpFix)
            Let (op, #Site : #Op) = r
            op = op[id := #Site : #Op]
    return op
end

GENERATEREQUEST(op):          // User emit
operation
begin
    op = SendOp(op)           // Can generate
       recursive call via SendOp
    Let r = (op, SiteId : OpCount)
    OpCount = OpCount + 1
    t = op(t)                 // Apply operation
    broadCast r to other participant.
    return r
end

RECEIVE(r):    // This function is executed
   when a request is received
begin
    WaitingList = WaitingList ∪ r
    forall r ∈ WaitingList | isExecutable(r) do
        r = (op, #Site : #Op)
        StateReceived[#Site] = #Op    // Update
           state vector
        Execute(r)
        WaitingList = WaitingList / r    // remove
           r from waiting list
end

INITIALIZE():
begin
    ∀i, SReceived[i] = 0      // State Vector of
       received operations
    (SiteId, t, OpCount, WaitingList) = (n, o, 1, {})
end

ISEXECUTABLE(r):   // Check that request r
   is executable
begin
    Let r = (op, #Site : #Op)
    // Check that the previous operation
       on same site has been executed
    if #Site ≠ SiteId ∧ SReceived[#Site] ≠ #Op − 1
    then
        return false
    // Check all dependencies was
       executed
    for (nSite : cSite) ∈ dependancesOf(r) do
        if SReceived[nSite] < cSite then
            return false
    return true
end

EXECUTE(r):           // Execute a request r
begin
    r = (op, #Site : #Op)
    if op = Sync(dep) then
        t = fix(t)                // Fix the tree
    else
        t = op(t)           // Apply operation
end
```

Fig. 2. The Concurrent Editing Algorithm

Towards the Construction of a Knowledge Building Environment

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Abstract. Nowadays, we can find a variety of Knowledge-Building Environments (KBEs). A proposal of KBE for communities interested in generating a common corpus of quality knowledge is presented in this work. This innovative KBE combines in an integrated and complementary way the functionalities of two tested and validated Knowledge Management Web-based systems: Sofia and KnowCat. On the one hand, the Sofia system provides the ability to externalize tacit knowledge, through the group storytelling approach. On the other hand, the KnowCat system provides the crystallization of collective explicit knowledge thanks of its Knowledge Crystallization mechanism.

Keywords: Knowledge-Building Environment, Knowledge Management, Groupware, CSCW, Collaborative Learning Practices.

1 Introduction

There is a wide selection of collaborative, knowledge-building software systems available today. Some of these systems support collaborative process among a group of users engaging in the research and discussion of their common interests. Furthermore, the works of Minna et.al. [1] and Scardamalia and Bereiter [2] offers a good perspective on how knowledge-centered activities in education and work contexts facilitate successfully collaborative learning practices.

Gerry Stahl, in [3], refers to these groupware systems as Knowledge-Building Environments (KBEs). The author synthesizes the ability to support collaborative learning with Web-based environments in seven issues: i) constructing perspective on knowledge from threaded discussions, ii) distinguishing learning tasks, iii) representing collaborative perspectives, iv) converging ideas, v) negotiating agreement, vi) encouraging system use and vii) scaffolding learning practices.

With this in mind, we aim to provide the possibility to work with KBE, where communities interested in generating a common corpus of quality knowledge, will be able to take advantage of this new environment and gain from it in both a personal and professional context. The KBE proposed is composed of two tested and validated Knowledge Management (KM) Web-based systems. In this manner, communities benefit from the services that each system offers which complement each

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other–without the need to develop a new ad-hoc KBE. The KM systems integrated in this proposal are: Sofia, which facilitates the externalization of tacit knowledge [4][5]; and KnowCat, which facilitates the crystallization of explicit knowledge [6][7].

The paper is organized as follows. Section 2 shows the characteristics and contributions of the mentioned KM systems Sofia and KnowCat. Section 3 presents the proposed integration of these systems into a KBE. Section 4 presents some case studies were the approach could be applied. Finally, Section 5 concludes the paper.

2 The Integrated KBE: Sofia and KnowCat Systems

Sofia is a Group Storytelling system which has been developed at Federal University of Rio de Janeiro (UFRJ, Brazil) as an evolution of the original TellStory approach [4]. The technique of group storytelling can be applied to different contexts. Knowledge Management area is a good one, due to the benefices of this mentioned collaborative technique can be used in order to provide the externalization of the tacit knowledge of its communities of users [5].

Sofia supports the aforementioned Stahl's issues. Its main contributions are in the line of facilitating the representation of collaborative perspectives, the possibility of converging ideas and the option of negotiating agreement.

KnowCat (acronym for "Knowledge Catalyser") is a fully consolidated, tested and validated collaborative Knowledge Management system developed at the University Autónoma of Madrid (UAM, Spain), where it has been in active use since 1998. The system is based on a mechanism called "Knowledge Crystallisation" which gives us evidence about what the best contributions are according to user opinion, through their interaction with the system. Users can contribute with documents (organised in a topics' taxonomy) and express their opinion about any document in the system through votes and annotations [6][7].

KnowCat supports the mentioned Stahl's issues; however its main contributions are facilitating the construction of perspectives on knowledge from threaded discussions through its annotations service, the representation of collaborative perspectives by means of alternative documents and the scaffolding of learning practices.

3 The proposed integration between Sofia and KnowCat

The desired result of an integration effort would allow both systems to access each other's core logic as services, as well as leverage knowledge resources seamlessly. Given the nature of these systems, and the locations of each R&D team, adopting a Web Services[1] (WS) model has been deemed as the more scalable and manageable approach towards integration. Both KM systems must design a robust and easy to use API that can be provided as a service to third party consumers. We have already outlined the initial drafts of an API that fulfills these requirements, as well as proof-of-concept examples. The expectation is that integration will continue to be a joint effort, so the lighter WS model, REST[2] is being adopted.

[1] http://www.w3schools.com/webservices/ ws_intro.asp
[2] http://java.sun.com/developer/technicalArticles/WebServices/restful/

For Sofia, the implementation of a WS model requires only that authentication and authorization mechanisms be put into place. The Sofia system already makes its business logic available as services for deployed Sofia instance, so the making of an API already exist –needing only to fill gaps as needed by KnowCat. Today, most of the API have already been implemented, and can be integrated as RESTful calls from KnowCat.

KnowCat on the other hand, was not initially designed as a service provider. Developing an API that can be consumed as RESTful services will require a larger investment. Because of the size of this effort, a piecewise approach towards integration was chosen, and is currently underway. As more features are completed, more of the API is exposed and KnowCat moves closer to full RESTful compliance.

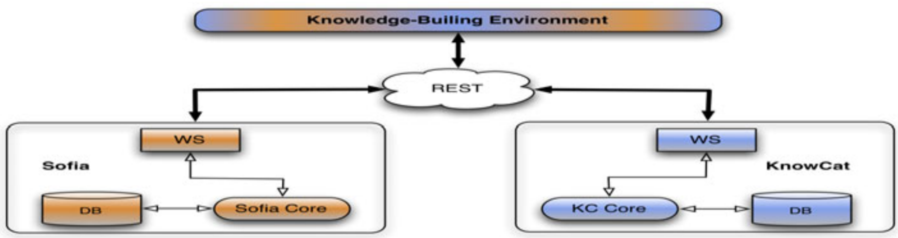

Fig. 1. The proposed integration between Sofia and KnowCat

4 Case Studies

We propose two case studies focused on knowledge management. Both cases were developed in the area of Emergency Planning and revolve around scenarios from the Fire Department of the city of Rio de Janeiro, and as participants the firefighters and the office staff.

To perform tacit knowledge management, every event or incident lived within the station is stored as a story in Sofia. These stories are created through the narration of fragments by firefighters and office staff who have been involved directly or indirectly selected events –often an emergency call. Each person can add one or more fragments within a story and these can be commented by the other partners involved in the story. Once everyone has introduced all his experiences in Sofia, the administrator will compile the final story.

Explicit knowledge management can be performed using KnowCat. To do so, technical manuals of operation and prevention of risks in case of fire, based on experiences registered in Sofia are used. There are several groups of people who are commissioned to write these manuals. Each group provides a KnowCat Web document, which receives endorsements and votes of quality from the other groups. Each group then votes on a limited number of documents. After the voting process is complete, the document list is reordered according to their social acceptance, which is provided by the KnowCat Knowledge Crystallization mechanism. New versions of these documents are drafted based on feedback received through annotations. The result is a consolidation of the document with the highest level of crystallization as the “Technical manual of operation and prevention of risks in case of fire”. Due to the generation of the mentioned manual is a result of the collaborative work of the implicated users, the user satisfaction is guaranteed.

5 Conclusions and Future Work

A proposal for a KBE aimed at communities interested in generating a common corpus of quality knowledge is presented in this work. This innovative KBE combines in an integrated and complementary way the functionalities of two tested and validated Knowledge Management Web-based systems: Sofia and KnowCat. The Sofia system allows tacit knowledge to be externalized through the group storytelling approach. The KnowCat system on the other hand, makes crystallization of explicit knowledge possible thanks of its Knowledge Crystallization mechanism. This work concludes with some details of the integration between the mentioned KM systems and some examples of case studies where to apply the proposed approach.

We plan to test the integrated KBE with the fire department of the city of Rio de Janeiro. Besides, we are starting to test the proposed approach with communities of students of the respective Master Studies at UFRJ and UAM.

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Applying Situation Awareness Approach to Cooperative Play in Interactive Installation Storytelling System

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Abstract. Owing to its character of virtual reality situation, Interactive Installation Storytelling System with Cooperative Play (IISSCP) provides children an immersive environment and situation awareness (SA) to interact with digital content more directly, intuitively, psychically and mentally. SA improves the interactivity between children and digital content. Through the interaction of play, children participate in learning willingly, give feedback quickly and enjoy peer learning. By integrating virtual computer vision applications with stage props as physical user interface, this system aims to create a natural immersive situation to attain four setting goals which are memory training, imagination of shape, music creation and training of physical strength and reaction. The target users are children aged 8 to 12. However, the cognitive differences of peers cause some problems during cooperative play. Based on findings from this research, we discuss the problems causing cooperation failure during play which are: (1) the cognitive differences when using icons of user interface corresponding to physical user interface, (2) the situation design affects role play during integrating the virtual and physical user interface into a mental gestalt and (3) the interaction complexity and difficulty affect children ability of situation awareness.

Keywords: Situation Awareness, Interactive Installation Storytelling System, Cooperative Play, Immersive Situation, Physical User Interface.

1 Introduction

Cognitive psychologist Hung [1] mentioned that playing with peers will help children's neurons to connect with one another in complex networks and develop and train their brains naturally. In addition, psychologist Jean Piaget saw play as an

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important role of children's cognitive development. It helps children's imagination and intelligence development.

It's also the sprit of Nine-Year Curriculum Education in Taiwan focuses on creative thinking, problem solving and active learning. Through the cooperative play, children can learn from peers and develop their own group-oriented strategies to discover the contents and solve problems together. In multiple users' system, the overlap of individual goal from team members develops into a team goal. Situation Awareness (SA) design approach is to design an environment to maximize children's ability to perceive their needed information [2]. In this study, we integrate virtual computer vision applications and physical device with stage props to create a SA storytelling playground Clock Exit. The virtual and physical user interface coheres all information into a mental gestalt. The environment presents level 2 information directly and helps children to comprehend the information. It also provides assistance for level 3 SA projections [2]. Children intuitively immerse in a story situation of role-playing and imagination of narrative, physically and mentally. Moreover, this empirical study focuses on exploring the problems which disrupt SA during the cooperative play and suggestions included.

2 Literature Review

Interactive installation technology provides users a virtual reality environment and intuitive interaction with computer. It can be applied to alternative fields such as arts, education, entertainment and so on. Beyond Pages, a virtual book is projected on the desk and participants are able to interact with virtual book by using a real pen [3]. Interactive Playbook project combines computer technology and traditional pop-up book to enhance physical dynamics of children's game playing [4].

Through the concept of constructivism, learners construct, reconstruct and organize their knowledge by actively utilizing their own cognitive schema to meaning formation, conceptualizing and integrating their experiences to be a new knowledge. Scenario-based design encourages users to involve in system and to share information, knowledge and uncertain future tasks [5]. Social constructivism emphasizes children actively involve in the learning process is important. During the learning process, children are able to cooperate in task or discussion to share understanding [6]. Through peer learning, children become active participators. Based on the collective criteria of knowledge construction, the learners who are collaborative learning orientated gain more success than less collaborative ones [7]. Besides, children learn social interaction and reconstruct their knowledge through discussion and develop their own strategies during playing process. Realistic constructivism claimed that environment constructed with situation, peers gained more fun of reality through interaction [8].

SA provides users with an environment in different levels of perception which are '*the perception of the elements in the environment, comprehension of the meaning and projection of future status*' [2]. Interactive installation technology mixes virtual and real elements to provide children a humanized user interface to build a situation to bridge the content and users' imagination. In the interactive storytelling system, children have changed from story listeners to participants. Integrating virtual and physical user interface, we intend to shape a story immersive environment with SA as a playground. Through symbolic metaphors, a situation awareness environment provides users a context of situation. During the metaphor mapping to user's cognition, visual perception helps users quick to link the all information to construct the user's conceptual model.

3 Method

Clock Exit is constructed by three parts which are environment of story situation, applications and physical device.

3.1 System Design

3.1.1 Design of Story Situation Environment

Fig.1 presents the system design.

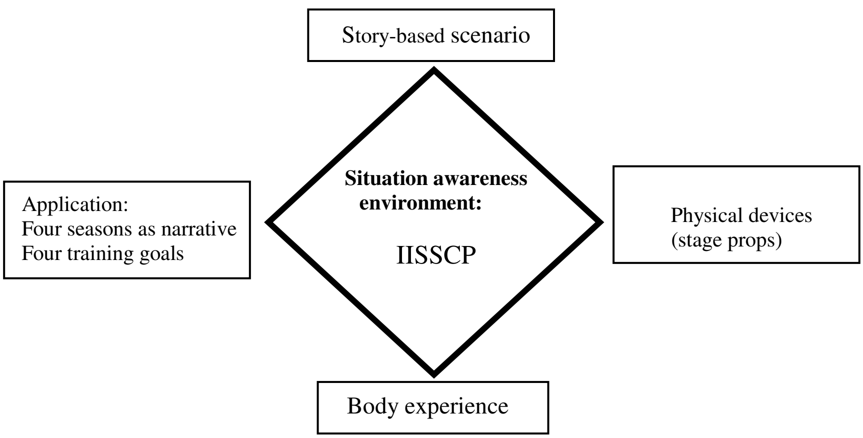


Fig. 1. The concept structure of Clock Exit for constructing a SA environment

3.1.2 Application Design

Four season games are design to create scenarios and situations, and also four training goals embed as well. Spring is a memory training game, summer as a shape imagination game, fall as a music creation game and winter as a physical strength training and reaction game. The graphical user interfaces are 2D environment. Trying to link the story context, we designed main character Puppet Dino and four characters to bring out the introduction. Table 1 and 2 illustrate the design settings including scenario, physical devices and play method for each game.

Table 1. Scenario

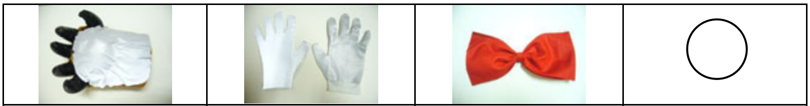
Seasons	Scenario
Introduction Movie	Main character Puppet Dino brings children into the story.
Spring	**Fun with touching stars** 1. Children need to discover two same icons hidden under the stars and to remember the positions. They can also interact with the worms, butterfly hidden in the environment. 2. After the stage completed, the scene becomes flourishing and main character comes out.
Summer	**Where is number?** 1. Children need to find the shapes of objects associating with numbers. If the answers are correct, the numbers of the graphic show out. For example, two bubbles together are shaped like 8. 2. After the stage completed, main character comes out and dances.
Fall	**Conducting the concert** 1. Children waves hands with gloves to avoid pine cones hitting animals to keep background music to be continued as a conductor. However, every animal symbolizes a music instrument. Random animals are hit by pine cones just like specific concerto. 2. After the stage completed, main character comes out to conduct the concert.
Winter	**Rolling ball** 1. Children needs to help main character to hit the snowmen until they disappear to keep the space for building gingerbread house. 2. After the stage completed, main character comes out to join the party in gingerbread house.

Table 2. Physical devices and play method

Seasons	Physical devices	Play Method
Spring	Gloves (bear paw glove or hand shape glove options) and bow (microphone)	Using gloves (bear paw glove or hand shape glove options) to select the answer and bow (microphone hidded) to activate it
Summer	Gloves (bear paw glove or hand shape glove options) and bow (microphone)	Using gloves (bear paw glove or hand shape glove options) to select the answer and bow (microphone hidded) to activate it
Fall	Gloves (bear paw glove or hand shape glove options)	Using gloves (bear paw glove or hand shape glove options) to wipe pine cone
Winter	Physical balls	Using physical ball to hit snowman.

3.1.3 Physical Device Design

Since traditional form of play is easy to link to our play experience, we design physical devices as stage props and also tangible user interfaces to help system to create a cinema atmosphere. It is also to increase active cooperative possibility [8]. Through interactive technology, bear paw glove and hand shape glove with reflective fabric have the same function to interact with webcam to select the answer; bow is a microphone to activate function; physical ball is to hit the screen with micro switch hidden to interact with the application. Fig.2 shows physical devices.



Bear paw glove	Hand shape glove	Bow	Physical ball

Fig. 2. Physical device design

3.2 Usability Evaluation

A questionnaire was designed in three section questions. The first part is for evaluating general satisfaction to the system design, the second part is open-ended questions for understanding children's favorite game, and the third part is for finding children's favorite physical device. The children participants for this study were recruited from different child care education institutes in 2008. 56 children are aged 8 to 12 including 31 male and 25 female. We grouped two children into a team to experience Clock Exit and gave a peer to peer interview to understand the answer.

4 Discussion and Conclusion

4.1 Questionnaire of Satisfaction Analysis

For the first section, respondents were asked for general satisfaction of system design. Q1, Q2and Q3 are for understanding if content is suitable for cooperative and if it helps children active cooperation. Q4 is for understanding the complexity of operation

Table 3. General satisfaction of system design

Q	Question	Average
1	Do you think application provides the possibility of discussion or communication with peers through cooperation with two or more people to complete the stage during play?	4.08
2	Do you think it has more fun through two or more people with cooperative play?	3.78
3	Do you think it will accelerate the speed of complete stage through two or more people cooperation?	3.58
4	Do you think it is easy to get confusion during operating Clock Exit system?	3.42
5	Do you think the graphical user interface for story situation is easy to understand?	3.6
6	Do you think the icons in graphical user interface of this system are easy to understand?	3.25
7	Do you think the usability of navigation aid for graphical user interface is friendly?	3.3
8	Do you think the integration of application and physical device is easy to learn how to use?	3.46
9	Do you think the interaction design of application is interesting?	4
10	Do you think this system immerse you into the storytelling situation?	3.64

for physical devices. Q5, Q6 and Q7 are for understanding if the user interface for application is easy to understand. Q8 is for understanding if the visual perception of user interface in application is easy mapping to physical devices. Q9 and Q10 are for understanding if the integrating virtual application and physical devices successfully immerse children into SA environment. Of the 56 users' test for the system, question 1 gets the highest satisfaction rate (4.08), followed by question 9 rated (4), question 2 rated (3.78). Table 3 shows the findings for general satisfaction of system design.

This section is an open-ended questionnaire for understanding children's favorite game in Clock Exit. The question is "*Which season game do you think has more enjoyment for multiple users in cooperative play? Why?*" The result shows 32 children like winter game and it gets 57%, the highest percent, followed by spring game 14 children (25%); summer game, 7 children (13%); fall game, 3 children (5%). Table 4 shows the finding.

Table 4. Open-ended questionnaire for four season game

Season game	Answer	Number of users	Percent
Spring	1. Through cooperative play, we are able to discuss and help each other to remeber the position of two same icons to complete stage easier. 2. We need to coordinate well to take our responsibility for our own charging region during cooperative play. Otherwise, we will easily get confusion about the situation.	14	25%
Summer	1. Through discussing together, children decide which shape symbolizes what number. Then one child uses glove, and the other one uses microphone to activate the answer. We cooperate to complete the stage together. 2. The cursor icon is different from the real glove; therefore, we cannot find the position of cursor sometimes. 3. The operation is a little complex through glove and microphone together.	7	13%
Fall	1. It is like a conductor conducting the concert. The animals are hit randomly by pine cones to produce random composition. 2. It is suitable for one player.	3	5%
Winter	1. Using real ball is easy to operate. Besides, it is able to be played by a lot of people and we can discuss our strategies together to complete the stage. 2. The operation is intuitive. In addition, during the play, we get more interaction from each other.	32	57%

For understanding children's favorite physical device, the question is "*Which one is your favorite physical device? Why?*" The result shows 20 children like Bear paw glove and it gets 36% the highest percent, followed by Physical ball, 17 children (30%). Bow, 13 children (23%); Hand shape glove, 6 children (11%). Table 5 shows the finding.

Table 5. Open-ended questionnaire for physical devices

Season game	Answer	Number of users	Percent
Bear paw glove	It looks cute and easy to inspire participants involved in story, and the interaction is more intuitive.	20	36%
Hand shape glove	The interaction is quite intuitive, however, it provides less story immersive situation.	6	11%
Bow	To wear the bow is cool and just like to play the role as main character in the story.	13	23%
Physical ball	Taking real ball to throw snowmen is interesting, and interaction is intuitive and convenient.	17	30%

4.2 Discussion and Conclusion

The cognitive differences when using icons of user interface corresponding to physical user interface

The Fig.4 cannot correspond with Fig.3 during using glove to interact with application. Therefore, users sometimes cannot find their cursor position. (Table 4, spring and summer game) The interactivity is not intuitive, and the glove becomes function oriented instead of situation awareness.

Fig. 3. Icon of cursor

Fig. 4. Bear glove as stage props

The situation design affects role play during integrating the virtual and physical user interface into a mental gestalt

The design of bow with microphone instead of mouse click is to activate the function. (Table 4, spring and summer game). In fall game, we design a platform to provide player to stand on it as conducting the concert. One player experiences the application is like to conduct concert. However, two or more players will just like to hit pine cones (Table 4, fall game). Therefore, the multiple players playing together will get less immersion than single player (Table 4, fall).

The interaction complexity and difficulty affect children ability of situation awareness

In spring and summer game, children use gloves to select the answers and use microphone to activate the function cause the operation complex (Table 4, summer). In winter game, the times for hitting snowmen to complete stage should be reduced from five times to three times. Otherwise, participants will get frustrated and tired. It will interrupt the immersion. Through cooperative play, children construct their shared SA to be a team SA. However, peers' cognition differences during icons of user interface mapping to physical user interface, the situation design affects role play during integrating the virtual and physical user interface into a mental gestalt, and the interaction complexity and difficulty affect children ability of situation awareness. will disrupt

SA. For children, the icon metaphor corresponding to physical device should be more intuitive. Besides, the operation should be simple and navigation depth is better to have no more than one level for cooperative play in Interactive Installation Storytelling System.

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Argumentation Tools in a Collaborative Development Environment

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Abstract. In the field of Computer Supported Collaborative Work several studies have explored the possibility to improve the collaboration in software development teams by integrating into IDEs tools to support the coordination and sharing of common resources. Similar studies have emphasized the need of integrating into IDEs collaboration and communication functionalities to improve the building of a shared knowledge. In this paper we describe how we enhanced Rational Team Concert (an IBM CDVE built on Eclipse and Jazz) with structured communication tools by integrating a collaborative platform named CoFFEE, that was developed for structured argumentation and discussion in an educational setting.

Keywords: Collaborative IDE, CSCW, structured communication tools.

1 Introduction

The increased availability and accessibility of network resources and the research of specific competences around the globe are crucial motivations that are pushing the increase of software development teams distributed around the world. In spite of plentiful technological means to communicate, to exchange information/documents and, in general, to share resources, there is still a wide margin of improvement in the collaboration software development, as both the academic and industrial research shows [1,2,3,4].

As described in [5], most of the existing Collaborative Development Environments aims to support mainly the collaboration in the *coordination* and *control* activities[1] such as Sourceforge, GForge and TRAC. Another research direction is exploring the best way to integrate *communication* tools within the development environments [7], and the main examples are CollabVS and Rational Team Concert, development environments which integrate also communication functionalities in the development process.

CollabVS [8] is a Microsoft research project providing a Visual Studio extension that augments the user experience with functionalities aimed at collaborative, distributed development. CollabVS is an effort to introduce collaboration and multiparty, distributed software development enhancements into Visual Studio. Real-time Presence information compensates for the team members not being in the same room, to see what's going on by creating a virtual environment. Communication tools compensate for the team members not being in the same room to talk to each other (an instant messaging session, an audio/video session, or a shared whiteboard).

[1] See [6] for the definition of coordination, control and communication.

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Rational Team Concert [9] is an IBM product providing a development environment built on Eclipse and Jazz (an extensible platform providing services to support collaboration) integrating advanced control and coordination collaborative functionalities. The choice of leveraging RTC on open source projects (Eclipse and Jazz) allows and stimulates the creation of extensions and research projects based or integrated with it (see, for examples, the list in [10], FriendFeed [11,12] and Ensemble [13]).

In this paper we present the integration of synchronous communication tools to support structured *argumentation* within Rational Team Concert. The collaborative argumentation tools come from the CoFFEE suite [14,15], developed for the European-funded project LEAD [16]. Tools to support communication and collaboration in IDEs are indicated by Booch and Brown [17] among the features that a *Collaborative IDE* should provide to reduce the friction between the work activities and the communication tools.The motivation to our work was the consideration of evidence of lack of support for synchronous and structured collaboration in CDVEs. In fact, the synchronous communication available today is often represented either by simple tools (chat) or by shared audio/video/whiteboard communication tools. As an example, RTC is a team collaborative development environment that provides wide support to the teams, by integrating tasks across the software lifecycle. What is missing, currently, is the ability for the team to (first) discuss[2] and debate (with advanced synchronous tools) during the development process by using the platform, and (second) to be able to include the discussions into the project repository in such a way that it builds into the team knowledge. In a way, the development process in RTC is enriched, with our extension, by the interactions among team members, that are, indeed, part of the process, but rarely stored/used. The advantage is that one can re-use previous successful solutions (as design patterns) by accessing also the process (the discussion) that led to design, adopt, and deploy the solution.

2 CoFFEE and Rational Team Concert

CoFFEE (Collaborative Face-to-Face Educational Environment) is a face-2-face cooperative environment composed of several applications supporting each phase of the collaborative learning process. CoFFEE is a suite of applications (see Fig. 1): the Class Editor, the Session Editor, the Lesson Planner, the CoFFEE Controller and the CoFFEE Discusser. The CoFFEE Controller (launched by the teacher) and the CoFFEE Discussers (launched by learners) are the applications developed to support the face to face collaboration in the classroom, which provides access to a predefined set of collaborative tools (possibly organized in pre-assembled sessions). Several tools are available and we focus on the Threaded Discussion tool and the Graphical Discussion tool. They may help learners to represent the problem space or to organize their interactions. This kind of support is expected by the possibility to connect related contributions so that the discussion can be organized in a logical order that reflects learners' reasoning. The **Threaded Discussion** tool allows synchronous messaging between the users, structuring the contributions in threads to improve improving the organization of debates

[2] RTC offers limited support for communication, since only simple instant messaging, interfaced with existing Lotus SameTime or Jabber server, is available.

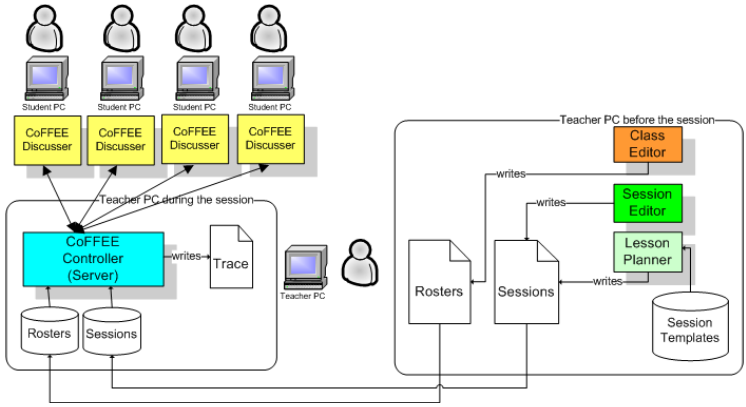

Fig. 1. The applications of the CoFFEE suite and the relationships among them

going beyond the temporal sequence and highlighting the relationships among related arguments. The **Graphical Discussion** tool allows synchronous messaging among the users, representing the contributions as boxes in a graphical space, eventually linked by several kinds of arrows. This tool is designed to support brainstorming processes and conceptual maps creation, but it is enough generic and malleable to satisfy other usage scenarios. However, CoFFEE has been designed also to allow the integration of new tools, to evolve following new needs and expectations and currently offers several other collaborative tools providing a variety of collaborative functionalities. Each tool offers a set of configuration options which make possible the tool customization to address several usage scenarios and to pursue several aims. Many more details can be obtained by the project website (`http://sourceforge.net/projects/coffee-soft`) and by the literature available in [14,15,18].

Rational Team Concert is a team collaborative development environment that provides wide support to manage software projects by integrating tools to improve the exchange information and tools to support management activities and collaboration (like teams managements, projects areas, work planning, source control, integrated reporting, process support). RTC provides users with several interfaces: an Eclipse-based client, a Microsoft Visual Studio client and a Web interface. The client interfaces provide developers with a rich, integrated development environment for building and delivering artifacts. The Web interface is well suited for server and project administration and allows users to access project areas, browse repository information, update tasks, or read about recent events. RTC is the delivered on the Jazz technology platform. Jazz is a scalable, extensible team-collaboration platform that integrates tasks across the software lifecycle. The platform also provides useful building blocks and frameworks that facilitate the development of new products and tools. Jazz includes an extensible **repository** that provides a central location for tool-specific information. Data is stored in the repository in terms of top-level objects called items. The repository includes auditable item types, which maintain a history of an item's creation and subsequent modification for audit purposes. The audit trail includes a record of past states of the item, the user who saved the item, and the time of the change. For item types which do not require audit history, the repository retains only the latest state of the item.

The **project area** is the representation of a software project. The project area defines the project deliverables, team structure, process and schedule. A project area is stored as a top-level or root item in the repository. A project area references project artifacts and stores the relationships between these artifacts. Access to a project area and its artifacts is controlled by permissions. A project can be quite simple or complex in terms of its committed product deliverables, process, and schedules. An established project can have multiple active lines of development, known as timelines. A timeline represents an area of activity within a project that typically has its own schedule, deliverables, teams, and process. For example, a project with both new product release development and current product maintenance might define these two efforts in separate timelines because they have different delivery schedules, teams, and processes.The structure of the project teams is defined by one or more team areas. Complex projects can have a hierarchy of team areas. Typically, one or more teams are assigned to each line of development. Users might have multiple assignments that require them to work on more than one team. Team areas are optional. A simple project with a small number of users might not need separate team areas.

Project process is the collection of roles, practices, rules, and guidelines used to organize and control the flow of work. The project process is defined in a project area and can be further customized in a team area. In Jazz, you use process to define user roles and their permissions for performing operations within the tool, such as changing the state of a work item. RTC includes process templates that you can adopt and customize. Process templates provide a starting point and guide for a project area process configuration and iteration structure. Your team can begin with a simple process and evolve it as the project progresses.

3 Argumentation Tools into Jazz RTC

The integration of RTC with CoFFEE grants the possibility of having a strong support to synchronous discussions, involving two or more users, taking advantage of the variety of CoFFEE collaboration tools, and to save the discussion to the Jazz repository. The latter functionality is very important, because it allows to re-analyze the discussion which led to a decision, and also to re-open an old discussion keeping memory of everything was said before. Furthermore, different users might want to access other people's discussions about a problem they are facing, and this could be done with a simple repository search.

Architecture. We have created an eclipse plug-in which allows to use the CoFFEE tools within eclipse. Adding it to RTC, which is an eclipse-based application, is straightforward, but we had to modify our generic CoFFEE plug-in to load/save the discussion from/to the Jazz repository. To allow the interaction between the CoFFEE plug-in and the Jazz repository, we have implemented a Jazz component, which consists of a service and a client library which communicate to each other via SOAP/XML. Finally, we had to create a new Jazz *artifact*, to render the CoFFEE discussions in the Team Artifacts view and to allow some common operation such as adding to the Favorites folder and creating references from Work Items.

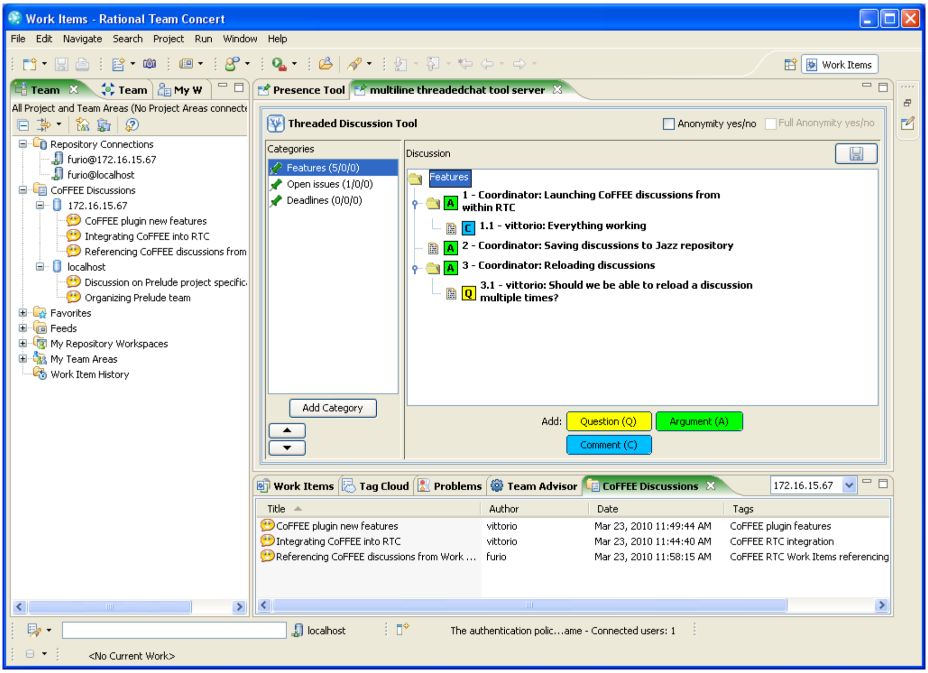

Fig. 2. Discussion with the Threaded Discussion Tool. The CoFFEE Discussions view is also shown at the bottom and discussions are also shown in the Team Artifacts tree at left.

User Interface. A CoFFEE toolbar has been added to the RTC toolbar to allow the launch of a CoFFEE discussion from within RTC. The CoFFEE tools run inside the user interface of the RTC application. The discussions are saved to the Jazz repository and represented as artifacts: they are visible in the Team Artifacts view in a tree format, grouped by repository, and in a dedicated view, in a list format, where further details are shown (author, creation date, and tags, in addiction to the title). Like other artifacts, saved discussions can be added to the Favorites folder, and organized in sub-folders by the user. Other operations allowed on the saved discussions are loading, deleting, and saving to the file system. This allows to create, execute and manage CoFFEE discussions all inside Rational Team Concert. Artifacts can be referenced from inside the RTC Work Items, but an easy support to this feature for CoFFEE discussions is currently under development.

A CoFFEE discussion inside RTC. Let us show a small example of a discussion in a work team using CoFFEE within RTC.

The user Furio wants to start a discussion, so he clicks the CoFFEE toolbar menu and chooses ‘Tools List’; now he can choose to use a dedicated Eclipse perspective for the discussion, or to visualize the CoFFEE tools inside the currently active perspective. Then he fills a small form in which he indicates the argument (“Next Jazz-CoFFEE release”), and the discussion starts with Furio as coordinator. He selects the Threaded Discussion Tool as first CoFFEE tool to use, editing or loading the desired configuration for the tool (a default configuration is available as well). In our case, he decides that

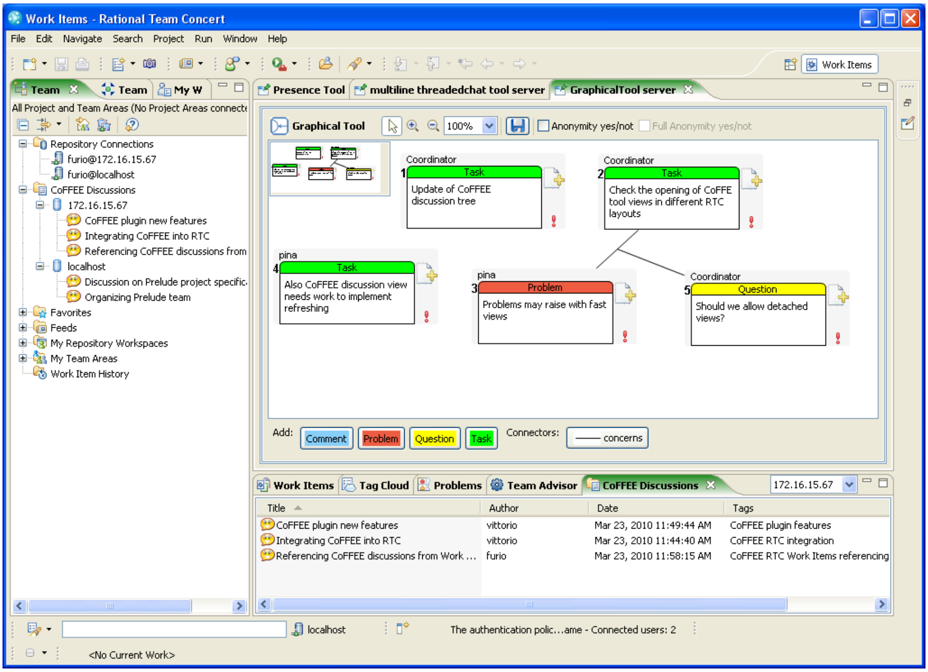

Fig. 3. Discussion with Graphical Tool

contributions can be tagged as *Question*, *Argument* or *Comment*. Other users, Vittorio and Pina, join the discussion by clicking the 'Client Start' command, and choosing the discussion among the available ones (from a list with the coordinator's name and the title for each active discussion). They receive all the tools launched by the coordinator, with all their contents. Now they can interact with the discussion. If the coordinator launches other tools, they will appear on the clients' UI.

The coordinator adds the main discussion topics with 'Add Category' button (in our example: 'Features', 'Open issues', 'Deadlines'), each of which has its own discussion tree. The threaded discussion allows to organize the contributions in the correct logical way, so that every contribution can be appended to the one it refers to. Furthermore, the tags on the contributions give an immediate idea of the contribution intents.

After this preliminary discussion, the coordinator starts a new tool, the Graphical tool, editing the configuration so that the contribution can be tagged as *Task*, *Question*, *Problem*, *Comment*, and with a single type of connector which means *concerns*. In this tool, the discussion can be organized as a concept map. In the example, the team members use the tool to organize the tasks, underlining the possible problems and adding their comments (Figure 3). At the end, the coordinator starts the 'Co-Writer' tool (a shared editor with turn-taking mechanism) to write down (the draft of) a final document on what to do for the next release.

Finally, the coordinator closes the discussion by clicking the 'Server Stop' command. The discussion is closed, the CoFFEE tools disappear from the coordinator's user interface and from the clients' UI too. Now the coordinator is prompted for saving the discussion: he specifies a title for the discussion (e.g "Release 1.1"), some tags useful for a successive search, and the repository to save the discussion to.

4 Conclusions and Future Works

In general terms, the integration into IDEs of tools to support communication and collaboration improves the building of a shared knowledge about the common aims. Moreover, an integrated Collaborative IDE reduces the costs related to the context switch between communication tools and the development environment. Furthermore it allows to keep all the information within the environment, where users can quickly achieve desired information related to a specific task.

Our solution is a significant improvement over the synchronized communication tools currently available in RTC: not only we offer a wide variety of tools, with support to elaborated and structured interactions, but we also do not rely on external servers, as (on the contrary) even the simple chat available in RTC does (since it needs a Jabber or Lotus Sametime server which the clients connect to). But our work offers also a simple platform to develop and include new collaboration tools in RTC: any new CoFFEE tool can be easily included in RTC and simple Eclipse wizards exist (available on CoFFEE Sourceforge website) to support the development of new CoFFEE tools. Indeed, there are several tools in CoFFEE that can help the development, besides the discussion tools. For example, the synchronized WWW browser can be used to access public documentation site or support forums, during the discussion, the Shared (programmer) Editor [19] supports collaborative editing and the Positionometer supports voting (also with anonymity included).

Our work has been conducted not without some difficulties: as stated by a group of IBM researchers [20] (from Watson, Haifa and China IBM Research Centers, with experiences also in developing Enseble [13]), the lack of well structured and complete documentation is among the difficulties in extending RTC. It has been sometime very complex and time consuming to identify correct patterns for extending some functionalities in RTC, often solved only by "educated guessing", supported by some experience on the Eclipse platform and a bit of intuition. Work currently under development includes linking directly from work items toward CoFFEE discussions, so that tracing the process where actions on the projects were planned is more immediate. Successively, future works will include experimentations to evaluate the effectiveness of the integration of the collaboration tools in the IDE.

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Cooperative Learning by Replay Files in Real-Time Strategy Game

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Abstract. In real-time strategy game, the game artificial intelligence is not smart enough. That makes people feel boring. In this paper, we suggest a novel method about a cooperative learning of build-order improving the artificial intelligence in real-time strategy game in order to make games funny. We use the huge game replay file for it.

Keywords: Game A.I., Real-time strategy game, Build-order, Cooperative Learning, Replay file.

1 Introduction

The game industry grows rapidly. Because of the influence of beginning the game conferences, people play game for money as well as for fun. Blizzard, who develops games, has patched last10 years for the balance among the tribes in the Starcraft, real-time strategy game, but the artificial intelligence is not enough smart [1].

In the real-time strategy game, there are tremendous cases, so that the traditional artificial intelligence technology cannot deal with it as human does. In the real-time strategy game, it is very hard the artificial intelligence beats human who is good at it [2]. This causes people feel a repugnance to the game.

Most of the real-time strategy game, such as Starcraft, offers the replay files. Players can analyze the game for knowing a cause of defeat, see as interests, or hold in common the replay files. There is already a program that allows computer can play along the replay which is played by human. However the simple imitation of the game replay is not concerned about artificial intelligence. Every game replay uses their own build-order for the other party.

In this paper, we suggest an automatic learning of build-order to improve the artificial intelligence in real-time strategy game. We analyze a lot of game replay, so that the computer artificial intelligence can compose build-order dynamically to win the game. We can provide some rules for corresponding the human's build-order.

The rest of the paper is organized as follows. Section 2 presents the related work. Section 3 explains how to do an automatic learning of build-order and shows some brief rules for the idea. Finally we conclude with section 4.

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2 Related Work

There are some researches in improving the build-order in real-time strategy games. Kovarsky proposed the build-order optimization problem for real-time strategy games. This work aimed to minimize the time of making specific units or buildings. However, human's actions are needed for defining build-orders [3]. Lee proposed the A.I. improvement method in the Starcraft. He improved the A.I. for the efficiency of the build-order and the production of units. However human should code statically [4]. Buro presented about real-time strategy which is a new A.I. research challenge [5]. Weber suggested a case-based reasoning for build-order in real-time strategy games [6]. In the existing studies, unfortunately, human should make up the build-orders manually. Because of this, when it comes a new strategy, human work is also needed. In this paper, we suggest an automatic learning of build-order to improve the artificial intelligence in real-time strategy game.

3 Automatic Learning of Build-Order

In strategy computer games, a build-order is a linear pattern of production, research, and resource management aimed at achieving a specific and specialized goal. For example, attacking the enemies fast or gathering the resources a lot. Especially in the real-time strategy game, player starts the game with incompleteness information. In general, play can recognize the map as much as he occupied with his units or buildings. This means that it is hard to estimate other player's build-order. Because of this characteristic, it is very important to use build-order method in real-time strategy game. There are some relationships among build-orders. One player produces works to gather resource a lot. The other player produces attack units to attack fast as possible. In this case, the player who produces attack units will win the game. If the game A.I. can aware the build-orders and the relations among build-orders, the game A.I. can play more effectively against human player.

3.1 Game Replay Files

As increases sharing of player replay files in online communities, the programs which analyze the player's actions using replay files were created. BWChart which is for Starcraft and W3Chart which is for Warcraft 3 are representative replay file analyzer [3]. There is some information of game such as players' ID, date, time, game result, unit productions, building construction, unit/building selection, upgrade-information and so on. Fig. 1 shows the examples of player's action information in replay files using BWChart.

3.2 Extracting and Clustering the Player Behavior

We make a line the player's action by time ordering because replay file has records of player's action at each time. In the player's action information, there are build-orders and player's corresponding for each situation. Each build-order takes different

Time	Player	Action	Parameters	Units ID
15000	SW)Lois	Move	(1952,800),0,228,0	0
15000	MgZ)nookie	Move	(717,644),0,228,0	0
15000	MgZ)nookie	Move	(717,644),0,228,0	0
15005	MgZ)nookie	Move	(708,649),0,228,0	0
15010	SW)Lois	Attack Move	(768,1024),0,228,	0
15025	SW)Lois	Attack	(514,1218),Nexus,228,	3552
15025	MgZ)nookie	Build	Warp,(20,19),Pylon	
15030	SW)Lois	Move	(534,1218),0,228,0	0
15030	MgZ)nookie	Hotkey	Select,1	
15035	SW)Lois	Move	(547,1215),0,228,0	0
15035	SW)Lois	Move	(547,1215),0,228,0	0
15035	MgZ)nookie	Hotkey	Select,1	
15045	SW)Lois	Shift Deselect	Siege Tank	3533
15050	MgZ)nookie	Select	Probe,3468	3535,3468
15055	SW)Lois	Select	3473	3473
15055	MgZ)nookie	Move	(460,172),3735,228,0	3735

Fig. 1. The examples of player's action information in replay files using BWChart

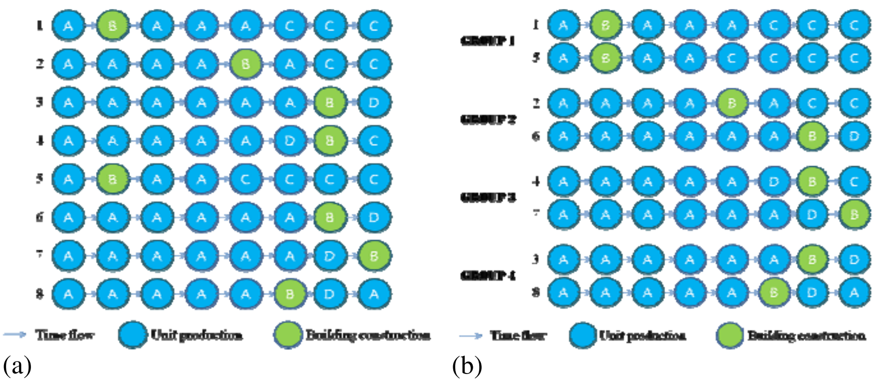

Fig. 2. (a) Extracting the player behavior (b) Clustering the player behavior

time. If it is to attack enemy fast, the build-order should make units in 3 minutes. On the other hand, if it is to gather resource a lot, the build-order could make units after 5 minutes. In the former case, player attacks enemy's base first and then he corresponds the next situation by the enemy's build-order or unit production. In the latter case, player gathers resources up to 5 minute and then he deals with the next situations.

To get the knowledge of relationship between build-order A and build-order B, we should figure out how many times the build-order A won against build-order B and how many times the build-order A lost against build-order B. In order to group the build-orders by player's action information, there exists two ways. One is that experts group the build-order by themselves. The other is that machine does it by some intelligent methods such as rule-based method or comparing similarities between action information of players.

In case of exports group the build-order by themselves, it could make the most exact results but it could take very huge time. Fig. 2(a) shows that the rules are defined by each build-order using LordMartin Replay Browser. As Fig. 2(a) shows, it is the build-order of terran race named "Fast siege tank drop". This build-order is defined as the player upgrades the technique named "siege tank" and build control tower in five minutes. Clustering based on replay build-order has a merit on speed. However there is a weak point that human should decide the build-order. The rule is defined by the start time of building construction or the upgrade time of building but it is influenced by the enemy's status due to the nature of the real-time strategy game. So, it is very hard and it might be no use of improving game A.I.

In this paper, we use the similarity measure which has a purpose to categorize the build-order. To achieve this goal, we extract the information about unit production, building construction, upgrade order from replay files. Through this information, we measure the action similarity of players. Fig. 2(b) shows the clustering result of the player's action information which is shown by Fig. 2(a).

3.3 Generating the Relation Table and the If-Then Rule

To understanding the relation among build-orders, we generate build-order relation tables. To make a build-order table, we use the player's outcome of the game and the player's build-order. Table 1 shows the example of the build-order relation table.

Table 1. The example of the build-order relation table

	Build-order1	Build-order2	Build-order3	Build-order4
Build-order1		5-win / 3-loss	6-win / 2-loss	0-win / 5-loss
Build-order2	3-win / 5-loss		2-win / 3-loss	6-win / 2-loss
Build-order3	2-win / 6-loss	3-win / 2-loss		3-win / 5-loss
Build-order4	5-win / 0-loss	2-win / 6-loss	3-win / 4-loss	

To increase the ability of the computer A.I., we generate the rule. When we select the suitable build-order to win the game, we should know about enemy's build-order choices at that time. Fig. 3 shows the result of preprocessing of build-orders which are shown at Fig. 2(b). We unite the build-orders as a tree and then apply time.

If player's state is E, he can choose build-order 3 or 4. At that time enemy's build-order must be one of the three cases those are state C, D, or E. If enemy's state is D, he can choose the build-order 2. The build-order 3 has 60% winning ratio if it corresponds the build-order 2. The build-order 4 has 25% winning ratio if it corresponds the build-order 3. Therefore, if player want to win the game, he should choose the

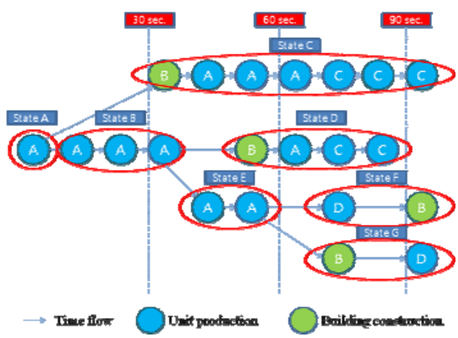

Fig. 3. The result of preprocessing of the build-orders which are shown as Fig. 2(b)

build-order 3. Though this mechanism, we can show the example of the If-Then rule like this.

```
If status = b and opponent_status = c then select e
If status = e and opponent_status = c then select g
If status = e and opponent_status = d then select f
If status = e and opponent_status = e then select f
```

We can apply these If-Then rules to the computer A.I. in order to improve its ability.

4 Conclusion

In real-time strategy game, the ability of player increases more and more, however the ability of game artificial intelligence does not. This is because of the difficulty of the learning for artificial intelligence. Because the level of players overwhelms that of game artificial intelligence, the interests of the game decreases. In this paper, we suggest a novel method about a cooperative learning of build-order to improve the A.I. in real-time strategy game. We use the huge game replay file for it.

Acknowledgment

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Cooperative eLearning to Enhance Knowledge Creation

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Abstract. The introduced approach aims at teaching hands-on knowledge management (KM) in the context of electronic business and allows students of business administration and students of communication research to experience the value of cooperation and the value of knowledge creation. Additional synergetic effects are an interwoven research and teaching setting that will allow collecting empirical data for further research issues on cooperative learning and KM.

Keywords: cooperative learning, knowledge management, online marketing, innovative teaching.

1 Introduction

Though learning processes are supported by blended learning and e-learning tools, university students in traditional environments are still afflicted with exclusiveness in subjects and in classes. Usually, blended learning and e-learning tools in university courses would support predefined groups of students per class mostly on a time basis of one or two terms; they are considered as separate, isolated entities.

The approach introduced in this paper brings together students of different disciplines and fosters their cooperation skills and abilities. Furthermore, it dynamically involves students of subsequent terms in a cooperative learning approach that aims at teaching hands-on knowledge management (KM) in the context of electronic business and allows students of business administration and students of communication research to experience the value of knowledge creation, exchange, and adaption in particular. The knowledge transfer to subsequent classes is based on classic (web) community mechanisms where users contribute to an "anonymous" public (e.g. [4]). Additional synergetic effects are an interwoven research and teaching setting that will allow collecting empirical data for further cooperative research issues, as well as bridging gaps between detached fields of studies and students and lowering barriers between academia and SMEs.

Researchers have developed different models for proposing a possible implementation of KM in organizations, whereby the transfer of already existing, tacit knowledge into explicit knowledge constitutes one of the major challenges. Explicit knowledge is coded knowledge that can be transferred via spoken or written language, and may therefore be available for everybody. Per contrast, tacit knowledge is

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personal, context specific and therefore difficult to communicate and to describe [3]. Examples for this tacit knowledge would be experience, rules of thumb, feelings or attitudes [5]. The sharing of implicit knowledge "among multiple individuals with different backgrounds, perspectives, and motivations becomes the critical step for organizational knowledge creation to take place" [1]. According to Nonaka's Knowledge Spiral, new knowledge can be created by the conversion of tacit into explicit knowledge. The transfer of already existing, tacit knowledge into explicit knowledge (externalization) constitutes one of the major challenges in KM. This transformation can be seen as the central part of the Nonaka and Takeuchi model. Nonaka's main conclusion was that a knowledge based organization can generate innovative knowledge if and only if it identifies the problematic transfer from tacit to explicit knowledge and displays it through processes that foster the dissemination of individual knowledge [3].

2 Research Framework

In this contribution, the framework for knowledge creation is based on the Nonaka and Takeuchi knowledge spiral [3]. We focus on the externalization phase and try to capture innovative student knowledge. Specifically, we apply this model in our interdisciplinary university course where students are trained on the use of an online marketing tool (e.g., AdWords[1]). We try to capture the tacit knowledge students acquire by applying that tool and transfer it into explicit knowledge; as a result, future students may profit from these insights, and, in turn, enrich those insights with their own experiences as they undergo the same process and apply the same tool in the subsequent semester. This way, a constantly growing knowledge base will be built up that that may (i) raise the awareness among students of the importance of knowledge sharing, and (ii) result in a knowledge base of student generation's experiences with this specific online marketing tool and the respective knowledge extraction technique (semi-structured interviews).

The research framework is based on an interdisciplinary cooperation in two different courses of the University of Vienna: a master course of international business administration and an undergraduate course of communication research. The students in the master course are being trained on the online marketing tool AdWords and take over an expert role by the end of the term, whereas the undergraduate students take over the researcher role and try to extract tacit knowledge from the experts by using an interview technique with iterations.

Specifically, student groups in the master course take part in the Google Online Marketing Challenge, a global challenge of university student teams. Therefore, Google provides a 200 Dollar budget for each team for the use of their online advertising tool (AdWords). Student teams cooperate with local SMEs, for whom they develop an online marketing strategy, and run a three weeks online marketing campaign for them with AdWords. Besides an obvious effort by Google to increase their tool's familiarity and customer base, this challenge offers various advantages for

[1] Google AdWords is an online keyword advertising tool where short ads are displayed alongside the search result of user queries [2].

students as they have the possibility to apply their theoretical knowledge in an industrial context.

In our graduate course "Applications of eBusiness and eLogistics", we took part in the challenge in 2008 and 2009 where we gained various experiences that motivated the development of this paper's framework:

(i) Students turn into AdWords "experts" after the three weeks challenge. During that time they observe key values (e.g., prices, structure, and keywords) and improve them by strategic online moves and activities. As a consequence, they develop an intuition based competence for the input-output effects. These experiences (i.e., tacit knowledge) would be lost from one year to the next, due to a lack of KM- adequate documentation.

(ii) Students may become demotivated due to the enormous time effort they have to invest in order to fully understand AdWords procedures and the full range of functionalities. They may profit from previous experiences and therefore perform better in the challenge.

(iii) A mere theoretical explanation of the KM concept has less sustainable impact than its application in a real life context. The willingness to share one's knowledge without immediate benefit and the attraction to contribute to a bigger whole is also in line with the Web 2.0 intention.

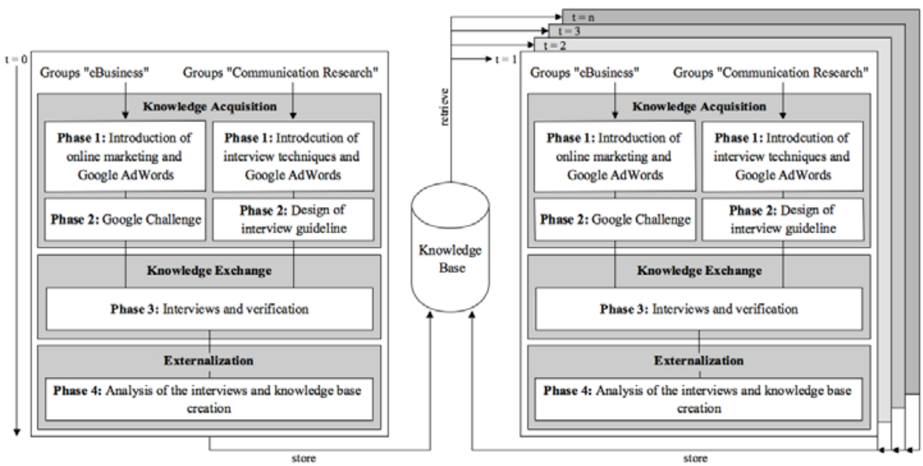

Fig. 1. Framework and timeline

In our framework, this tacit knowledge will be recorded, verified, analyzed and passed on to subsequent classes with the objective to increase performance (Figure 1). The research framework is divided into two stages: the initiation and the iteration stage, each consisting of four phases. In the initiation stage, phases one and two reflect knowledge acquisition phases for both student groups. The e-business students are introduced to online marketing tools with a focus on Google AdWords, and set up their campaigns together with SMEs in phase one, whereas the communication students are briefly introduced to the Google AdWords tool and to knowledge management theory. In phase two, tacit knowledge is created for both student groups. The e-business students conduct the Google Challenge, while the communication students prepare their interview techniques. In phase three, knowledge exchange happens as experts in interview techniques meet experts in AdWords whose knowledge is extracted by means of in-depth interviews. After transcription, verification and analysis, findings (e.g., documents, drawings, diagrams) are collected in a knowledge pool. The loop stage consists of identical phases but starts in the subsequent term (time t+1) where students of both courses may retrieve knowledge from the knowledge pool, adapt it for their purposes and, in the end, enrich the existing knowledge with their experiences that are, again, being externalized and stored in the knowledge pool.

3 Benefits and Results

This contribution is focused on the development of a research framework for interdisciplinary cooperation on teaching in academia and creates benefits for various players:

(i) Students: knowledge acquisition and subsequent application takes place in the areas of online marketing and communication research. Moreover, the interdisciplinary nature of this framework enables a knowledge exchange between students of different departments and between students and SMEs.

(ii) University: this best practice approach may be transferable to other university courses; it incorporates cooperative research-based teaching and fosters industry cooperation with University.

(iii) SMEs get an online marketing strategy developed by student teams and free online marketing via AdWords. Barriers for SMEs to cooperate with academia are lowered.

(iv) Google: research studies about the AdWords tool and propositions for an improvement of its application may help Google to improve their AdWords support materials. In addition, a raise of awareness and an increase of AdWords users may entail an increase in Google's customer base.

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Memory and Creativity in Cooperative vs. Non-cooperative Spatial Planning and Architecture*

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Abstract. Meanings and roles of memories and creativity in spatial organizations are raising increasing attention among scholars and professionals. Creativity in cognition-oriented spatial studies is gradually seen as a normal feature of an organization. This thesis is supported, e.g., by the evidences on the role of memory in the most creative parts of the activity of architects, combined with exceptional association abilities representing the real bulk of creativity.
The present paper addresses the discussion of such issues, by analysing case studies of single-agent and multi-agent spatial organization under two levels of spatial navigation and space design. The paper explores possible modelling approaches and system architectures supporting cognition-oriented activities in spatial organizations.

Keywords: Spatial creativity, Multi-agent planning, Spatial memory, Urban architecture, Spatial organizations.

1 Introduction

There are many human abilities that deal with space mastering, whose ontology can be useful in building intelligent machines in which space conceptualization plays a fundamental role. Space understanding and space organizing are two important categories of spatial human abilities, in which sensorial and mental abilities intriguingly interact. As usual, the analysis of human intelligent abilities in this functional perspective helps in illuminating aspects of them, whose explanation could be otherwise erroneously given for granted. Human agents conceptualize, design and organize spaces for human organizations, for example in architectural design, by using numerous routine and non-routine cognitive processes that deserve attention [1]. Also in this case automated reasoning and design agents, from the precursors to the current protagonists, still provide only bad copies of human performances [2].

Creativity is postulated as a non-routine sophisticated human cognitive function, a conscious and intentional process for redefining agents' situations in the world in new ways. Even if the concept of creativity remains controversial, an increasing number of

* The present study was carried out by authors as a joint research work. Nonetheless, D.Borri wrote chapter 1, D.Camarda wrote chapter 2.1 and 3, R.Stufano wrote chapter 2.2.

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cognitive scientists considers creativity as a specific part of the ordinary cognitive equipment of the human agent, to be used in certain situations, not confined to a limited set of exceptional human agents [3][4].

We assume that it is worthwhile adding spatial domain to the other domains of creativity studied in cognitive science. We also assume that space understanding and space organizing can be fruitfully analyzed and modelled by paying attention to both routine and non-routine (creative) cognitive functions. To show that assumption we have analyzed two cases: the consideration of spatial elements during a wayfinding task in a real world environment (space understanding), and a very curious case of creative interaction among architects in a game-based situation (space organization).

Space understanding provides a lot of hints in cognition analysis. In their development stages, humans use space forms and relations (apparent boundaries, objects, geologic features, star movements, etc.) to rapidly reach that understanding and locate themselves in space [5]. They use simplified spatial representations – mainly dealing with space forms and relations – to facilitate this understanding performance. Experience is a powerful multiplier of spatial understanding abilities, education is a way to make experience more meaningful or to substitute or differ direct experience. Unnatural space forms (labyrinths) can irreparably hamper spatial understanding abilities by impeding both sensorial and mental mechanisms.

Individual space-understanding abilities have to be integrated with social space-understanding abilities. However, the social vs. individual learning trade-offs of spatial agents involved in space understanding and wayfinding are poorly addressed by literature [6][7][8]. Experiments in cognitive research show that human abilities are always under the risk of failing because of numerous factors. Some of them are ambiguous environmental forms and/or geometries, uncertainties in space perceptions due to alteration of normal perception, illogical loops between concepts and actions [9][10] [11][12].

Recent research in spatial wayfinding show that the dualistic conception of fundamental landmarks (final beacons, intermediate features) is inadequate to model real human behaviours [13]. Our experiments, for example, highlight the importance of emotion and sensibility and the discrepancies in temporal operations Sense of space, aesthetics, imagination, space ornaments entering the scene without hampering, are drivers of space understanding and wayfinding [14].

Civil architecture is a relevant domain of spatial knowledge and action and of course of spatial organization. In it, aesthetics and art, based on creativity mechanisms, play an important role. Studies on architectural creativity based on self-biographies by leading architects (who usually motivate their designs with memories of other designs or spaces, or architectures, experienced by them in the past) prove that spatial memory has primary importance on creativity [15]. But architecture is also technique, therefore its spatial memories can be analyzed under the concept of technological memory, apparently useful in conceptualizing technological change in between tradition and innovation [16].

Our experiments-simulations are based on a sort of chess game among architectural design agents lacking any other substantial goal but playing (with exhibitionistic and competitive behaviours). Chess moves are substituted by graphic design moves and subsequently analyzed by multimedia recording. Therefore, an extraction of ontologies and procedures from relevant move snapshots (experiments resembling Veloso's CAMEO approach [17]) confirm that creativity is based on memory and on a merge of specific and domain-dependent expert knowledge and of generic knowledge [2]. Routine moves apparently depend on the restraints of other characters of the emerging designed space (in terms of reactive-adaptive routines). Instead, non-routine (creative) moves apparently depend on the activation of memories and expert abilities belonging to the ability patrimony of the agent.

Interestingly, the dialectics between the two agents can become a coral dialectics with the entrance in scene of a third agent, just in terms of an orchestra performance. This situation resembles the creative jazz jam session with no other objective but group fun, suggested by Schon to show cooperative knowledge-in-action planning [1].

Within this theoretical framework, the present paper is structured as follows. After the present introduction, the next section compares two case-studies on space understanding for wayfinding and space organizing for architectural design, discussing methodological approaches as well essential results. Some outcomes raised by the two experiments in terms of spatial-cognition creativity mechanisms are drawn out as brief concluding remarks in the third section.

2 Analyzing and Modeling Spatial Creativity: One or Two Issues?

2.1 Spatial Features and Primitives of a Navigated Environment

For the second time, a questionnaire survey was carried out to start the experimentation, and the layout of questions was organized as shown in figure 1.

Situation 'A': You are in Bari, at the crossroads between via Sparano and via Nicolai, and decide to go north, to a shop in via Sparano, crossing the space in between.

Question A1: Find out the shop you want to go and declare the reasons for your visit.

Question A2: Describe the actions you carry out to reach the shop of your interest

Question A3: Describe in detail the "substantial elements" of the space in which you move, being of help or obstacle in your reaching the shop 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 shop 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 in Bari, at the crossroads between via Sparano and via Nicolai, and decide to go north, to the Art Desco bar in via Sparano, crossing the space in between.

Question B1: Describe the actions you carry out to reach Art Desco bar.

Question B2: Describe in detail the "substantial elements" of the space in which you move, being of help or obstacle in your reaching Art Desco bar.

Question B3: Describe in detail the "ornamental elements" of the space in which you move, conditioning the actions in your reaching Art Desco bar.

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 survey

The questionnaire was answered by 117 out of 150 students of a Town planning course program in the Technical University of Bari through an institutional Internet homepage. The survey followed a similar one carried out in the preceding course program, focused on a university corridor [18].

It tried to find out information on spatial representation and ontology in navigating spatial environments, focusing on a walking corridor of downtown Bari, Italy [19][20][21]. Again, a mono-dimensional space was chosen, in order to attain a highly structured environment and facilitate the agents' navigation and analysis. In comparison with the indoor corridor, the outdoor streetscape shows increasing complexities and diverse problems [22], whose allegedly richer impact on navigation features' significance has been explored by this study.

Checking previous literature findings [18][23] a statistical analysis was carried out on answer protocols, aiming at singling out some features of the navigated environment, particularly 'essences' and 'ornaments' They were further cross-analyzed with the categories of 'landmark' and 'beacon' [9], for significant clues. Ad-hoc text-mining software (particularly TLAB 4.1 and SPSS Text Analysis for Surveys 1.5) was used for statistical analysis, basically focusing on text keywords. A factor analysis tried to reduce the huge number of variables collected by using SPSS 13.0.

The approach aimed at understanding the agents' interpretations of spatial elements in navigating a simple urban environment. The environment is a typical pedestrian streetscape of a lively Italian city, dating back to 1800 but heavily rebuilt along centuries. It is about 1km long and 20m wide, full of people all day, with several stylish shops, shaded benches along the streed and many driveway crossings. Pedestrians have a large variety of shop selections, but in responses to question A1 our navigating agents clustered basically on libraries (44%) and clothing stores (38%). Yet, the actions described by the respondents in reaching their objectives do not show a clear propensity to watch shops, but rather focus on target-oriented movements.

More particularly, responses to questions A3 and B2 (essence), as well as A4 and B3 (ornament) were analysed and statistically described, highlighting a list of keywords, as reported in figure 2.

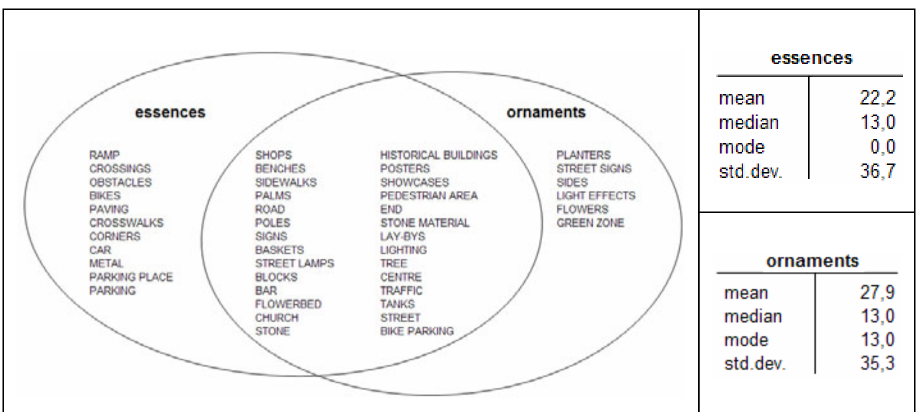

Fig. 2. Essences and ornaments occurring in protocols (high-rank excerpts)

The figure shows that some elements that are basically common to the two feature groups, similarly to what happened in a previous experimentation [18].

An analysis carried out on protocols suggests that the differences between essences and ornaments are significantly tributary to different cognition and perception attitudes. In particular, sensorial perceptions seem to be important in representing both essences and ornaments during the navigation task. Yet, the representation of ornaments is significantly integrated by non-sensorial perceptions, such as the emotional ones. For example, the navigation is facilitated and made more pleasant by window lightings, tree shadings and the possibility of collecting ideas on benches. This occurrence is not evident in a previous indoor experimentation [18]: however, it seems to confirm some interpretative trends in spatial cognition literature, particularly in urban environment spaces [24].

In finding correlations among keywords characterizing both features, factor analysis was carried out, 5 variables explained about 80% of the total variance:

1. Structural features	2. Ornamental features
Buildings and service areas	Physical elements at urban scale
Elements of position and directions	Phys. elements at architectural scale
Shopping-related elements	Elements of shopping and leisure
Moving aids and supports	Elements of street furnishing
Elements of parking & vehicular mobility	Tourist-oriented elements

The two lists show areas of logical intersections, as expected [25]. Yet, among the top, the most statistically significant features of the lists, exclusive clusters can be found, such as position/direction elements (essences) and architectural elements (ornaments). Non-intersecting areas are more evident than in the previous indoor experiment [18].

Another analysis concerns the possibility that (perceived) spatial elements can be somehow considered either 'landmark' or 'beacon' features within a navigation activity [9]. In the survey, we can consider situation 'A' more suitable when looking for possible beacons for the navigation target, and situation 'B' more suitable for the identification of navigation landmarks, being the target mostly unknown to agents and being therefore signs and indications critical for its reaching [18]. A list of keywords was analysed and statistically described, and factor analysis found out 5 aggregate components, explaining about 80% of the total variance. They are listed below:

1. Beacon condition	2. Landmark condition
Services and facilities	Characters of rest areas for pedestrians
Physical characters of pedestrian areas	Historical and leisure elements
Elements of the mobility system	Architectural elements
Elements identifying the path	Elements of residential facilities
Elements identifying the target	Green elements

As occurred previously [18], it is not easy to characterize each set logically, because of a non-empty intersection, paralleled by exclusive members that are themselves not antonymic nor mutually exclusive. Goodman's skepticism [23] about the mere transposition of the distinction between essences and ornaments (today typical in robotics) would seem confirmed. Yet, in a real urban context, the elements tend to consolidate in specific ontologies and coherent aggregations. Even beacon/landmark conditions categories look comprehensible and helpful to build decision support systems in navigation tasks.

Admittedly, an urban street is not so close to a mono-dimensional situation as the previous corridor experience. Here, the agents cross the environment in a variety of directions, times and multi-dimensional distractions, and the space shows a low structuring degree [26]. Yet there is a structuring degree, induced by the intentional action of navigating agents and confirmed by the path facilitation and features of a pedestrian street, as shown by the above analyses. However, considering this agents' intentionality as a critical element to guarantee a sufficient degree of space structuring, the extent to which s/he is able to single out and associate space features becomes itself critical to synthesize the essential aspects of, and to support the navigation in, an environment that would be otherwise unintelligible [27]. From this viewpoint, the creative attitudes of single agents should be decisive in this effort, and the low degree of categorization of feature results should represent the price to pay for that creativity.

On the contrary, there is a significant aggregation of results, as shown before. This may be partly tributary to a process approach that is rather hybrid and multi-agent, owing to the fact that some students strolled around the urban area in groups, and many of them delivered pretty similar responses to the survey. The database built on the responses can be itself considered a multi-agent-generated knowledge base, because of its multiple-source acquisition approach [28]. Given this substantially MAS-based layout, the aggregation of results cannot but be considered, therefore, a sort of fortunate accident of a cognitive process that –as a matter of fact- is still far from being fully understood and deserves further consideration in future research.

2.2 Creativity in Spatial Design[1]

Usually we consider creativity as an innate ability, appearing "out of norms" through original creations giving rise to novel entities. Yet creativity can be considered as a process of transformation, re-combination of something already existent in a different form.

In architectural composition, creativity is an original beginning for a transformation proceeding according to a quasi-musical sequence. It is a particular attitude toward an unconventional transformation of reality that is represented in form of memory. It depends on contexts, environments, maestros, key points, lifestyles. Spatial creativity is a ground on which it is difficult to establish an objective, a frame of reference from which to interpret artistic or architectural creation. It leads to an interplay of resemblances and reminiscences, to the drawing on the memories of other artists and architects.

With reference to design, the exploration focuses on the management and filing of memories, images, reference schemes, metageometries detecting spatial references on a (apparently) blank space. The blank space can be a sheet before a drawing that makes it 'dirty' by putting shapes, geometries or constraints on the physical and mental page, around which to develop the drawing itself.

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[1] The authors would like to thank Vincenzo D'Alba, as well as Modern Architecture Art Gallery in Rome, with professor Francesco Moschini and Francesco Maggiore.

In the present experimentation we observe the approach to a blank sheet by two expert agents. In this case, there is not a case of a design problem to solve, but simply the beginning and sharing of a drawing game, by starting from scratch.

In a series of meetings organized at the AAM art Gallery in Rome, we look at a series of pencil duels/duets among architects, titled ‘Chess games’. Here, a ‘gaming’ process is in fact a real approach process observed and studied in the drawing space, a process with primary protagonists of contemporary architecture. From such ‘chess games’ we can observe some interesting and peculiar cooperation dynamics, concerning the mutual positions of the objects and the agents, as well as the cognitive actions performed by the agents in the spatial contexts, with evolutionary outcomes.

All meetings are documented by clip movies. The following lines report on the meeting among Vincenzo d’Alba, young architect and design virtuoso, and the international architect Alvaro Silva. The finality of the meeting and the drawing is particular in this case. It is not sharing a project, but sharing an experience, a design space, organizing and signing it, starting from an initial cue. Therefore, there is not an objective, but a cooperative ‘dialogue game’.
We think this material is extremely interesting with reference to some important questions, such as the behaviour of an expert agent in cooperatively moving in a ‘paper space’.

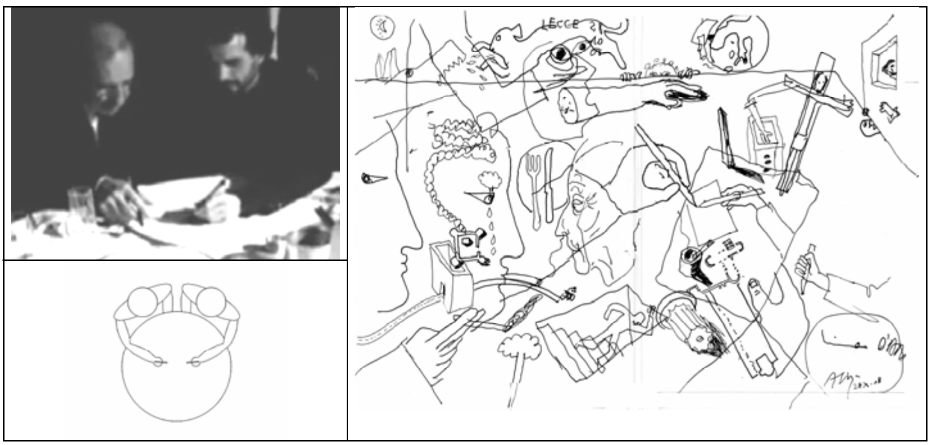

Fig. 3. Agents interaction, their position at the table and the output drawing

In the expert agent, spatial memories are combined with the received education: the richer the reference memory, the more the images of what is produced. But memories are created also from inside, and new images of old memories are created, whereas new memories can stimulate old images according to a continuous and iterative intersection of elaborations.

In the design process, it is evident the theme of context-related constraints on memories and on new combinations of geometrical primitive or derived forms. Creativity is not a purely rational process, but is a concept coupled with the intentionality concept. Making an image is comparable to drawing lines by moving a 'cursor' (as in computer drawings), related to our attention focus: an actual 'mental design' [29][30][31]. Mental images, memory objects that make the expert agent's reference, multiple places of the memory are all a database in continuous evolution where themes and memories distant in time are indispensable parts of its cognitive structure [32]. According to Zumthor, the precious instants of inspiration are produced in a patient work, following a sudden manifestation of an interior image or a realization of a new piece of design, the whole project structure seems to change and reform in a fraction of seconds [15].

The experience of the cooperative work on a blank sheet seems to confirm such reflections, when the first expert's work develops in an intricate and intriguing interweaving with her/his memory and with the memory of the second expert. Architects look mutually at their drawing advancements and complete the creative spatial work when one of them stops. Then they resume and organize their process again. It seems evident how cooperation revives autochthonous memories and stimulates new elaborations and associations, in an evolutionarily creative path.

Other 'chess games' take place in AAM Gallery, with two or more agents, toward a general framework confirming such reflections, even within a plurality of aspects and suggestions. More contextual aspects of the cooperative process remain to be defined, to clarify the extent to which the outcome of the creative effort is augmented or penalized by the cooperative process in comparison to hypothetical paths of individual spatial creativity. This and other kinds of issues will then represent interesting study elements for future research perspectives.

3 Some Final Remarks

Today most of cognitive science scholars converge on conceiving creativity an ordinary specific cognition function. It is patrimony of all living agents, casually or intentionally activated in certain situations, challenging the old conception of creativity as exceptional endowment of talented cognitive agents [3][4][33]. But the idea remains of a largely unexplored set of cognitive mechanisms and abilities, hardly repeatable by computer programs. That occurs because of the evident human (biotic) features of divergence from routine reasoning and calculus, use of intuition and other intriguing biotic generic cognitive behaviours (introducing analogies, abstractions, relations, boundaries, equalities, consistencies, and beauties into the expert and domain-dependent reasoning) [2].

In this framework, we have assumed that the creativity studied in the domains of space understanding and space organizing can be modelled by addressing both routine and non-routine (creative) cognitive functions. The experimentation carried out in the two above domains has provided interesting results in that context.

Creativity in space understanding (wayfinding) proves to be critical, in that it allows agents to associate space features, synthesize essential parts of the environment making it intelligible and navigable. In design-based space organizing, creativity makes memories raise form cognitive databases and stimulate new elaborations and associations, toward the final artwork. Both activities are boosted in case of cooperative multi-agent tasks, even if in that case creativity is not always separable and recognizable as a single-agent feature [1][17][34].

In both experiments, creativity has emerged as a rather ordinary activity of cooperative and non-cooperative agents, whose main ability is to operate intentional associations on knowledge bases. In this sense, it seems to confirm some basic assumptions of our work.

Because of such findings, the quest for models of wayfinding and/or architectural composition can be a reasonable target to be aimed at, in order to support and enhance planning and architectural creative efforts.

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An Embedded Road Crack Detection System in a Cooperative Platform

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Abstract. A cooperative platform is studied for improving the efficiency of road crack detection. The platform is mainly divided into a mobile terminal with an embedded road crack detection system, which detects pavement surface cracks, and a control center which analyses the crack information and makes further decisions. The experimental results indicate that this real time platform is more efficient than classical road detection systems. Also a sample case of the platform is given to show the road crack detection results and output. The application of the road crack edge detection was realized in embedded Linux system in the cooperative platform. The evaluation report will be output in real time and sent to the central database from the embedded mobile terminal, including the corresponding position information in the GIS of the cooperative platform.

Keywords: Pavement crack detection; Embedded Linux system; Real-time collaboration; Cooperative platform.

1 Introduction

With the growth in highway development, the workload for road crack detection is increasing rapidly. It requires the detection equipments to have higher performance, to be more cost-effective, and with real-time processing capability. However, traditional image processing methods are not very effective in pavement cracks detection in real-time because of their isolation without a central cooperative platform. In the past, the road crack detection system usually uses a video camera to capture the road image including pictures or video streams [1]. After the work of road image collection, the image files will be transferred to a personal computer from the location to be analyzed, processed, and the result can then be obtained. The terminal's handling capacity is often insufficient to support the real-time performance. Another problem is that it is hard to associate the crack information with the location of the road.

In order to solve these problems, a real-time collaborative scheme is proposed and discussed here. We use an embedded mobile terminal to capture the images of the roads by its video probe. The images are then recognized and analyzed in the image capturing location. The images and the resulting reports are sent to the central cooperative platform by 3G network real time. They are then saved into the database which is indexed using the correspondent roads in GIS. This scheme has greatly

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improved the efficiency of the crack detection and therefore the traffic network maintenance and management.

The embedded road crack detection system uses 32-bit embedded ARM development board as the terminals, combined with the open-source embedded Linux system Qt/E to complete the development of graphical interfaces. It can process images in real time, send crack information and location information to the cooperative platform via GPS, GPRS, etc. This unifies the GIS with image processing, analysis and storage; transmits dispatching commands through the browser. The system has the advantage of lower cost, less demanding on the hardware devices. In addition, it has strong scalability and reusability for different application cases.

2 Design of the Cooperative Platform Structure

2.1 Architecture of the Platform

Our platform includes the embedded mobile terminal in vehicle and software system in cooperative platform, integrated GPS, GPRS (CDMA), and Internet (Intranet) network. The embedded mobile terminal acquires the road images and performs the real-time detecting. It sends the road images, the GPS information and the detecting result to the central cooperative platform, which will backup the information in its database and make further processing if necessary. All the process is continuous through the WAN integrated in the GPRS (CDMA) and Internet (Intranet) network. The results will be directly displayed on the electronic map based on the degree of road damage. The detail can be seen in Fig.1.

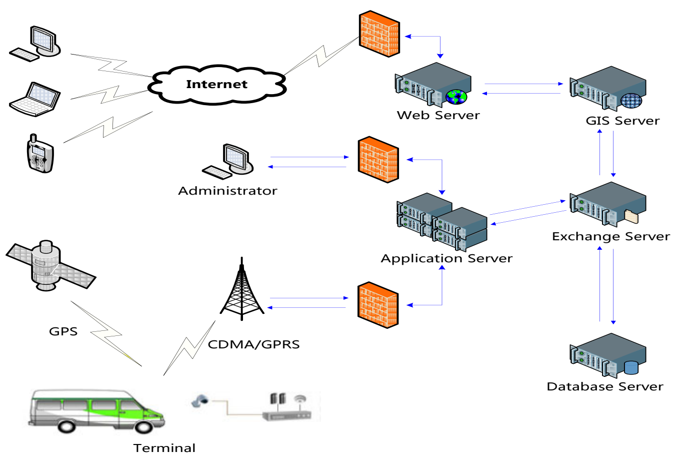

Fig. 1. The platform architecture

2.2 The Architecture of the System

We adopted a multiple layer structure for our cooperative system which includes the physics memory level, business logic level, network level and application level. The details can be seen in Fig.2. The physics memory level stores the crack information and GIS information through database interfaces. The business logic level accomplishes the crack classifying and counting. It also connects the crack information with pavement information using Web GIS, so that each crack can match its road location. The information will be further analyzed by the assistant decision module and the information service module. The network layer manages several kinds of network signals such as GPRS (CDMA), Internet (Intranet), and helps to send, receive and transmit these signals. The application layer is made to interface with the users directly so that the terminal users can get real-time pavement crack information and transmit dispatching commands through the browser.

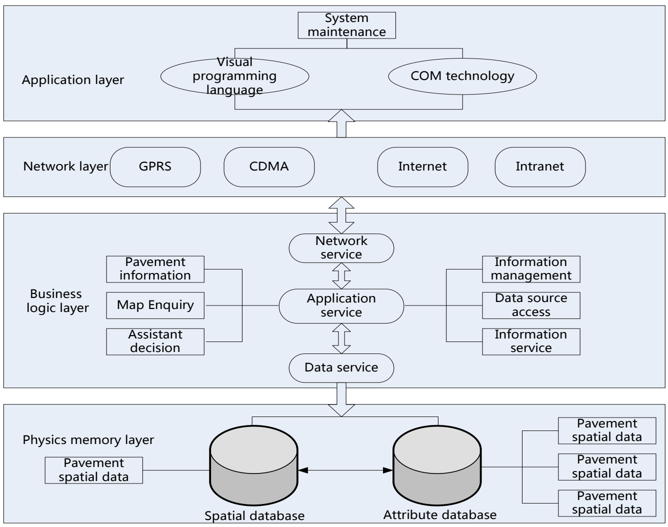

Fig. 2. System Architecture

3 The Realization of the Cooperative Platform

3.1 Application Layer

The application layer is the core of crack detection embedded mobile terminal. We choose a crack detection method based on multilevel model and an improved Canny algorithm to improve the detection efficiency [2].

The embedded mobile terminal gathers the road information through an in-car camera, and calculates the crack information using the algorithms presented in [2]. After the crack information has been obtained about 1 second, the embedded mobile terminal packs the information and sends it to the network layer.

3.2 Network Layer

Some network modules for cooperative platform have been studied in the past, such as relay network presented in [3], but the capacity of the single-relay channel has not been solved. Some new network has been built recently, which integrated 3G, Internet and Intranet [4] [5]. We adopted this new cooperative network in our platform.

Our network layer is the bridge between the application layer and the business logic layer. It is also the bridge between the control center and the mobile terminal. Here we provide the GPRS, CDMA, Internet and Intranet interfaces for the users to choose them to transmit the network packets according to the requirement.

3.3 Business Logic Layer

Business logic layer is the core of our system. Most functions of the control center of the platform are based on this layer, such as Map Enquiry (ME), Information Management (IM), Data Access (DA), Assistant Analysis and Decision (AAD) and Information Service (IS).The interaction of the modules can be seen in Fig.3.

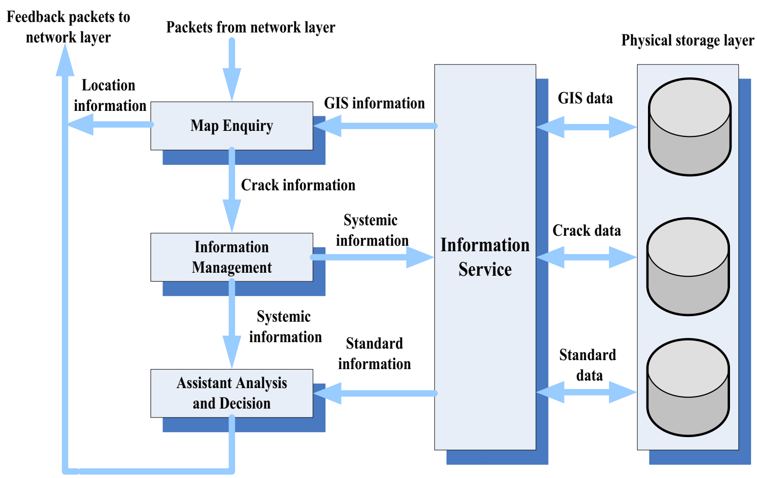

Fig. 3. The business logic layer

Map enquiry is the first process after the information packet arrives at the central cooperative platform via the network layer. This module separates GIS information from the packet, and locates the packet sender with the GIS.

After that, the information management module will classify the crack information from the packet and send the information to the assistant analysis module and the decision module. The information management module will then deliver the information to the physical storage layer through the data service interface.

The assistant analysis and the decision module play a role of a decision maker. It analyses the crack information and compares it with the road maintenance standard and road manage information which is provided by the information service module. If the result of technical analysis recommends that the road needs maintenance, the information service module will immediately remind the municipal council and road maintenance team, together with the location and detailed crack information of the road.

3.4 Physical Storage Layer

This layer mainly stores all kinds of data for the whole system. The spatial database is developed as an application in order to get geographic and spatial data flexibly and conveniently. There are two implementation modes: integrated mode and blended mode. The integrated mode stores the spatial data in the file system and other data in relational database, while the latter stores both data in the database. Here we choose Oracle Spatial for our GIS.

4 Implementation Result of the Embedded Road Crack Detection System

The embedded road crack detection system has good performance during the test. A sample case is presented here. Fig.4 (a) and Fig.4 (b) show the simulated effect on a personal computer, Fig.4(c) and Fig. 4(d) show a snapshot of the embedded mobile terminal which is detecting the cracks on a road.

The communication protocol utilizes the XML data file stream between the embedded road crack detection system and the central cooperative platform. The details of a protocol data package can be seen in the following.

```
<?xml version="1.0" encoding="UTF-8"?>
<ROOT>
 <HEAD>
  <PROTCOL />
   <IP />
   </HEAD>
   <ERROR>
    <ISERROR>false<ISERROR>
    <ERRORMESSAGE />
    <ERRORTYPE />
   </ERROR>
   <DATA>
    <INTERVAL>6</INTERVAL>
       <TYPE>纵向裂缝(comment: virtical crack) </TYPE>
       <LENGTH>1995</LENGTH>
       <WIDTH>133</ WIDTH >
       <AREA>265335</ AREA >
     </DATA> …
</ROOT>
```

The communication between the embedded terminal and platform is in real time. The platform control center receives and processes the messages sent from the terminals in real time. We can obtain the information about the surface damage condition of the road visually from the platform in real time as well. Fig. 5 shows the result in the control center of cooperative platform, in which we can get the location and crack information of the road. The images and resulting report will be saved to the central database, and indexed by the road number in GIS of the cooperative platform.

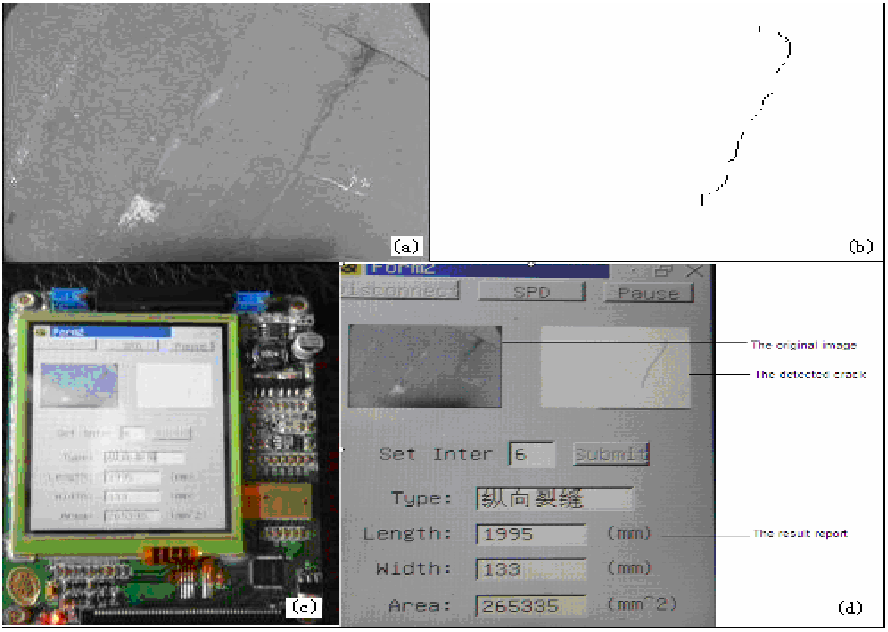

Fig. 4. (a) Original Image acquired by the terminal (b) The crack after image detecting (c) The embedded system terminal (d) Result of the crack detection by our embedded software

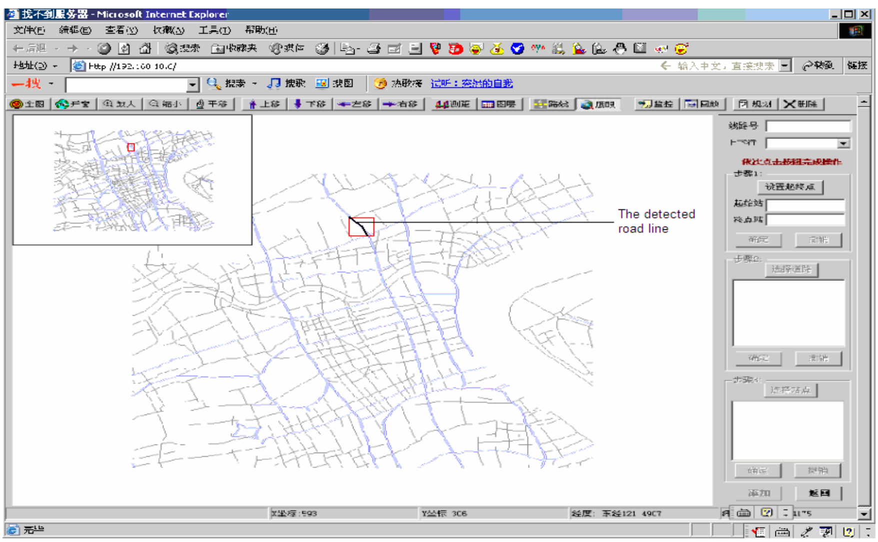

Fig. 5. The IE browser of the GIS software in the cooperative platform

5 Conclusion

The experimental data shows that our real-time road detection system works well thanks to the close cooperation of the crack detecting system with the cooperative platform. The embedded mobile terminal in vehicle is able to capture and process the images, send the results to the cooperative platform in real time. The central cooperative platform can collect the data and the cracks information effectively. The cracks can accurately match the road position by using the GIS system. The information can be stored in the database for further analysis. Users can obtain the road crack information in real-time and transmit the dispatching commands through the browser. However, there are some problems on the platform during the work, which can be the focus for our future research. These problems include how to synchronize the data to ensure high response and parallelism of concurrency control, conflict detection and coordination, load balancing on the cooperative platform etc.

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Saving Energy with Cooperative Group-Based Wireless Sensor Networks

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Abstract. Wireless Sensor Networks (WSNs) can be used in many applications, but it is most used in environmental monitoring. The energy consumption of each node should be as low as possible, and the collaborative methods can improve their performance. In this work, we compare the energy consumption of a regular WSN with a WSN in which the nodes are organized in cooperative groups. We demonstrate that cooperative group-based WSNs have fewer transmissions than regular WSNs. Because higher energy consumption occurs in the transmitting and receiving process of packages, collaborative group-based WSNs can have lower global consumption.

Keywords: Collaborative system, group-based WSNs, energy saving.

1 Introduction and Related Work

A Wireless Sensor Network (WSN) can be defined as a network of small embedded devices located strategically in a physical environment that are capable of gathering information and send the information to the base station, which is a kind of system with high process capacity. A WSN may consist of many nodes without any grouping hierarchy. Nodes can communicate using any wireless technology such as Bluetooth, ZigBee or IEEE 802.11 a/b/g/n.

There have been studies to compare the energy consumption in sensor networks. They are mostly based on the routing protocol and the wireless technology. In [1], we can see a comparative study between Bluetooth (IEEE 802.15) and IEEE 802.11 technology. This article presents a comprehensive analysis of the main features of both technologies. As we can see in this paper, each wireless technology has been created for specific applications (indoor and outdoor) and therefore their consumption depends on their usage. In [2], L. M. Feeney and M. Nilsson made a study on the Lucent WaveLAN IEEE 802.11 device, working in ad-hoc mode. They modeled the energy consumption by a set of linear equations, where data is sent and received point to point, with packages of different sizes. Their results suggest that the energy consumption of a device and the bandwidth are not directly related, only the transmission, reception, packet drop, amount of traffic and the protocol are important. In [3], the authors propose a new protocol called HEED (Hybrid Energy-Efficient Distributed clustering) for saving energy in WSNs. The protocol periodically selects key nodes in

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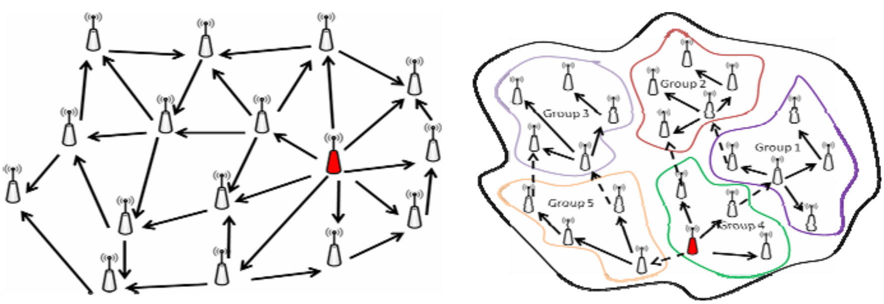
the cluster according to a number of parameters, such as residual energy and other parameters. In [4], the same authors of this paper propose a cooperative sensor network based on the group-based idea. The cooperation between groups could change the direction and level of the alert.

The rest of this paper is organized as follows. In section 2 the main differences between regular WSNs and cooperative group-based WSNs are described. Section 3 demonstrates why cooperative group-based networks consume less energy. Finally, Section 5 shows the conclusion and future works.

2 Regular WSNs versus Cooperative Group-Based WSNs

In a regular WSN, when a node registers an alarm (node in red in Fig.1), it transmits the alarm to all its neighbors, these neighbors transmits the alarm to their neighbors and so on. It spreads the warning to the entire WSN without control. In this case, a node could receive the alarm packet several times from different neighbors (see Figure 1 a). This situation leads to excessive energy consumption.

A collaborative group-based WSN has a group of sensors and is built based on defined areas or as a function of the nodes' features [5]. Moreover, each group is formed by nodes that interact to share resources or to acquire data to produce joint results [4]. When a sensor detects a new event, this sensor sends the information to all the members of the group and, depending on the case, the groups could share this information in order to reach all sensors of the WSN or just some groups. Only the closest sensors to the edge of the group will transmit the information to the sensors of other groups (see Figure 1 b). This considerably avoids raising the global energy consumption of the WSN, which is very important to prolong the lifetime of theWSN.



(a) (b)

Fig. 1. a) Regular WSN b) Collaborative group-based WSN

3 Energy Analysis

In this section we analyze the energy needed to transmit packets in a cooperative group-based WSNs architecture and compare it with a regular WSN architecture.

The notation used in our analysis and its definition is shown in table 1. φ_{11}, φ_{12} and φ_2 are constant radio parameters, typical values are φ_{11}=50 nJ/bit, φ_{12}= 50 nJ/bit, φ_2 = 10 pJ/bit/m^2 (when n = 2) or 0.0013 pJ/bit/m^4 (when n = 4).

Table 1. Notation and definition

Parameter	Definition	Parameter	Definition
φ_{11}	Power to run the transmitter	r	bits per second
φ_{12}	Power to run the receiver	S	# of sensor in the sensor network
φ_1	$\varphi_{11} + \varphi_{12}$	R	Average area radius of a WSN
φ_2	Power for the transmission	S_i	Number of sensors in the group$_i$
d	Distance between 2 communicating nodes	R_i	Average area radius of the group$_i$
d_{opt}	Optimum distance between 2 nodes	m	Average # of cooperative groups
n	Path loss exponent (typical values: 2 or 4)		

We follow the model presented in [6]. The energy consumed by a sensor to transmit and receive a data packet between two nodes is given by (1).

$$P = (\varphi_{11} + \varphi_{12})\cdot r + \varphi_2 \cdot (d^n) \cdot r \quad (1)$$

Where d is the distance between both nodes.

3.1 Analysis of a Cooperative Group-Based Sensor Network

Let D be the distance between the sending node of a group and the closest node from other group. Thus, $P(D) \geq P^{opt}(D)$, being $P^{opt}(D)$ the minimum power to transmit a data packet from the node to the other group. $P^{opt}(D)$ is equal to (2) if and only if D is multiple integer of $d_{opt} = \sqrt[n]{\frac{\varphi_1}{\varphi_2 \cdot (n-1)}}$, as we can see in [7].

$$P^{opt}(D) = \left(\varphi_1 \cdot \frac{n}{n-1} \cdot \frac{D}{d_{opt}} - \varphi_{12}\right) \cdot r \quad (2)$$

$P^{opt}(D)$ is the lower bound of energy consumption in the flat scheme without data aggregation, which indicates an ideal case where the per-hop distance for transmission is d_{opt} meters. According to the energy model in [6] and the previous assumptions, the expected energy consumption per second of a group is given by (3).

$$P = \sum_{m=1}^{N_i - 1} \left(\varphi_1 + \varphi_2 \cdot \frac{2 \cdot R_i^n}{n+2}\right) \cdot r + (\varphi_{11} + \varphi_2 \cdot D^n) r \quad (3)$$

We assume that there are J groups in the network and each regular node only needs to transmit its data packet to the central node or to the border node of its group. The average radius of each m group can be regarded as $R/\sqrt{J}_m$, and the expected energy consumption per second in all regular nodes will be given by (4).

$$P_{rn} = (S - J_m) \cdot \left[\varphi_{11} + \varphi_2 \cdot \frac{2}{n+2} \cdot \left(\frac{R}{\sqrt{J}}\right)^n\right] \cdot r \quad (4)$$

The energy consumption for all border nodes is given by (5).

$$P_{bor} = (S - J_m) \cdot \varphi_{12} \cdot r + J_m \cdot \left[\varphi_{11} + \varphi_2 \cdot \left(\frac{R}{\sqrt{J}}\right)^n\right] \cdot r \quad (5)$$

The final energy consumption in a cooperative network would be $P_T = P_m + P_{bor}$

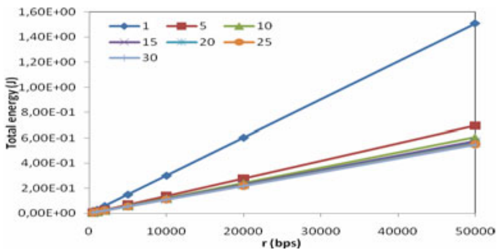


Fig. 2. Total energy consumption for different number of groups

3.2 Analysis for Regular WSNs

In order to evaluate the energy consumed in a network without cooperative groups, we consider (4) and (5) for a single group (J=1) and where there is only one sink node. Then, we can obtain the equations (6) and (7) respectively.

$$P_{rn} = S \cdot \left[\varphi_{11} + \varphi_2 \cdot \frac{2}{n+2} \cdot (R)^n \right] \cdot r \tag{6}$$

$$P_{bor} = \left[S \cdot \varphi_{12} + \varphi_{11} + \varphi_2 \cdot R^n \right] r \tag{7}$$

Where the total energy consumption of the network is $P_T = P_m + P_{bor}$

Figure 2 shows the energy consumption for different values of J. When J=1 the energy consumption is higher than for any cooperative group-based WSN. When J increases, the energy consumption decreases, but each time their difference is lower.

3 Conclusion and Future Works

This paper demonstrates that cooperative group-based WSNs have higher energy-savings than the regular WSNs. We hope that this work can encourage the researchers to create collaborative group-based WSNs.

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Enhancing Collaboration in Vehicular Networks

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Abstract. A VANET (Vehicular Ad-hoc NETwork) is an ad-hoc network that allows providing communications among nearby vehicles and between vehicles and nearby fixed roadside equipment. In these networks, warning messages affect decisions taken by drivers, so it is necessary the existence of a scheme to determine whether the road traffic information available to the driver is trustful or not. Besides, the quality of communications in VANETs is degraded when the number of non cooperative vehicles is very large. For this reason, cooperative groups are proposed as a solution to the spread of false traffic warning messages, and reputation lists are presented to stimulate cooperation among selfish nodes.

Keywords: Cooperation, Reputation List, Reactive Group Formation.

1 Introduction

There are many possible situations where communications among vehicles would help to prevent accidents and to avoid collapses. A VANET is a wireless networks spontaneously formed by vehicles in movement. VANETs have no central infrastructure and present unique challenges such as high node mobility, real-time constraints, scalability, gradual deployment and privacy. This paper deals with the topic of cooperation in VANETs, which has been addressed just in a few papers such as [1] and [2]. In our proposal the considered network consists of a collection of Road-Side Units (RSUs), which are fixed equipment located on the road and connected to a high speed backbone, and a collection of On-Board Units (OBUs), which are vehicles on the road. Communication between OBUs and RSUs is based on authentication system[CCMH] and wireless technology such that it is not necessary an end-to-end session, so routing is not required.

In this work we will define a scheme for the use of cooperative groups, which will ensure that vehicles generate trustworthy warnings. Other forms of groups of vehicles have been proposed for VANETs in [3], but with several differences with respect to our proposal. In order to stimulate cooperation in packet forwarding, our scheme associates trust to nodes through reputation lists. A new

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node in the neighbourhood is a node with undetermined trustworthiness. However, an untrustworthy node is a misbehaving node that should be avoided and deprived of network services. Every node keeps two reputation lists. One of these reputation lists is individual, updated based only on direct observation, and not distributed. The other list contains a global reputation value and is shared with the other nodes in the network and the RSU.

2 Individual Reputation List

An essential element when implementing vehicular networks is the cooperation between vehicles in relaying packets of their neighbouring nodes. In this paper we address this problem and propose a solution based on Individual Reputation Lists (IRLs). Unlike other proposals, these lists will store personal experience of every node with respect to other vehicles during its life on the network.

Misbehaving node detection is performed based on ACKnowledgment (ACKs) packets, which allow nodes to take decisions on whether to cooperate with other nodes or not. When a node A wants to send a packet to B, first it splits it into two parts. The purpose of this division is to ensure that node A receives at least an ACK as proof that it is cooperating before B receives the complete information. So, when B receives the first part of the packet, it sends the ACK signed, $PK_B(ACK)$. If B decides not to give back the packet, it does not receive the full information so it cannot get any benefit from the network. Besides, in such a case B is introduced in A's IRL so in the future it will not receive network information from A. If B cooperates, A sends the second part of the information so that B can recover the content of the packet. Finally, B sends the final ACK to node A. If B does not give back the second ACK, it is introduced in A's IRL, but in this case at least A has one ACK to prove its cooperation in the network.

If node A has some traffic information, before providing it to node B, it will ask it about B's cooperation in the network. The node B will answer with the last ACK it has received. If the date of such ACK exceeds a limit m, defined by the protocol in terms of the network size, node A does not send the packet to B. Thus, the nodes will be motivated to cooperate in order to upgrade their ACKs to be able to receive traffic information.

3 Reactive Cooperative Groups

This paper proposes a novelty in the groups to provide real-time and trustful information. In particular, the establishment of cooperative groups in a self-organized way is presented because no technical infrastructure is available to coordinate car groups, so groups are only formed when they are necessary. Hence we call them reactive groups.

Vehicles can generate messages about road condition to warn vehicles about potential hazards, increasing the safety of driving. However, message trustworthiness must be guaranteed because this type of warning messages affects decisions taken by drivers so that any wrong message could lead to loss of drivers' time, high money expenditure on fuel, and in the worst-case scenario, traffic accidents. Therefore, a warning message can be considered valid if it has been endorsed by at least n different vehicles.

When a car detects a hazard, it forms a cooperative group Fig 1 with other cars within its one-hop communication range, and such a car is the leader of the group . If a vehicle detects a hazard, all vehicles within its range can view and confirm the existence of such danger. Thus, the leader of the group will be in charge of constructing the warning message. The leader will sign the message and send it to all the members of the group. When the vehicles of the group receive the message, they will be able to validate the warning. If they agree with the information, they will sign the message and send it back to the leader. The leader will aggregate all the signatures to generate an aggregated warning message as described in [5]. Finally, the leader will select relaying nodes in the group and send the aggregated message.

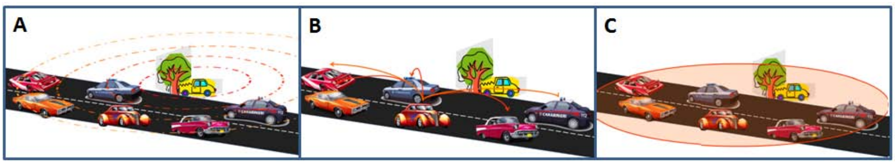

Fig. 1. Cooperative Group

In cooperative groups we can identify some attacks that have to be detected in order to insert the malicious node in the IRL. An attacker may forge a message that does not correspond to its real environment information. If the nodes of the group do not detect the same problem that is specified in the message they will insert the node in the IRL and reject the message. Another attack could consist in creating aggregated messages with arbitrary data and injecting them into the network. The attack can take place through the use of signatures from other opponents. However, when a vehicle has no direct contact with the information contained in a message, it will check the group signatures and the timestamps. The public key can be verified using its digital certificate. The timestamp shows the moment when the packet was generated so that if it was generated long time ago, the packet will be discarded, and the attacker will be inserted in the IRL.

4 General Reputation List

In our proposal each node has an individual vision about cooperation in the network but it also needs an overview of the cooperation within the network. To solve this problem we propose the use of RSUs. Hybrid VANETs consist of a collection of RSUs interconnected through a high speed line and a collection of vehicles, where communication between vehicles and RSU is based on wireless technology while communication between RSUs is wired. When vehicles go along a RSU, they download their IRL, so that if they meet another RSU later and have no new entry in their IRL, they do not download the IRL again. The RSU maintains a common organized data structure to store information received from all the nodes. When a node has a bad behaviour and it is detected, its neighbours report it so that the structure will have more than one registration about this misbehaving vehicle. RSUs are continuously collecting vehicle information to generate and update the data structure, where each record contains the misbehaving node and the date of the complaint. Hence, the RSU will know the number of complaints that has received a certain node and the date of the last complaint. Depending on the size of the network a minimum of complaints will be required before introducing a particular node in the General Reputation List (GRL). The nodes may request this list each time they pass near a RSU, in order to update their GRLs. This will allow them to detect and exclude those nodes that have a bad behaviour with other nodes in the network. Furthermore, nodes are removed from the lists when the time records become obsolete. In this way nodes that had been excluded from the network can become part of it again, what implies that the new proposed scheme has certain flexibility.

5 Conclusion

In this paper we have presented several new ideas and two different tools for cooperation mechanisms in VANETs. On the one hand, the reactive group approach allows aggregating warnings in a fast and efficient way and such that it guarantees trustworthiness. On the other hand, the proposed solution based on node reputation uses the two concepts of IRLs for individual detection and GRLs for global detection of misbehaviour. These new mechanisms ensure that the information is not lost within the network, foster cooperation in VANETs and contribute to data correctness in a cooperative way. This work is still to be fully developed in practice. In future versions complete simulations using the simulator of traffic SUMO and the networks simulator NS-2 will be described.

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Initial Risk Assessment of Emergency Events in Cooperative Operating Control

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Abstract. It is often encountered some cases in the industrial control systems, where emergency situations require a vital, irreversible, and relatively quick decision, concerning further operations of the controlled process. The outcome of the decision can be optimal if it is taken cooperatively by a group of experts after careful assessing the risk of future hazards, taking into account the depletion of resources caused by taken actions. For taking such decision, an integrated environment is needed; in which geographically dispersed experts could cooperatively test various control scenarios. In this paper the example of a vital process is presented, i.e. an industrial wastewater treatment plant, where a sudden increase in the content of toxic substances in the inlet flow is the considered hazard. The proposed solution for the cooperative environment is an agent-based framework, which supports the full integration of the JADE environment with the numerical data acquired by OPC from industry-grade instrumentation.

Keywords: risk assessment, emergency management, distributed expertise, wastewater treatment, cooperative operating control.

1 Introduction

In a broad class of the control systems there are emergency situations in which a decision is required, concerning further operation of the controlled industrial process. These vital decisions are irreversible. Before they are implemented, all the options should be carefully examined in order to assess the risks associated with each of them. However, the risk assessment process itself often requires the expert knowledge, which is dispersed in various fields of science and life. Experts in these fields, who understand the specifics of the considered controlled process, can be, at the moment of sudden unexpected emergency situation, physically dispersed and located remotely. It is therefore desirable to have a mechanism allowing the experts to cooperatively explore the possible options, evaluate the consequences of each option, and apply the final consensus decision to the system.

In this paper a proposal of such a mechanism is described. We present an environment in which experts can cooperatively experiment and examine the impact of the decision on the subsequent behaviour of the system, to assess the associated risks. The environment is heavily based on the multi-agent framework for hardware integration of the industrial control systems. The framework is currently under active development, it

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already provided very promising results. It contains software agents that are able to acquire live data from the industrial control systems. The ontology describing the nature of these numerical data was specifically developed for the task. Since the software environment is based on the JADE according to the FIPA requirements, it is open and allows the users to add new agents to the pool in a unified way [1]. The agents are proposed for the experts, which support the experts in the collaborative process of taking decisions according to the results of the accelerated process simulations embedded in the framework. The agent-based approach is the further development of the original idea presented in [2]. The eventual consensus can be put to life by applying the resulting settings directly to the industrial instrumentation connected to the controlled process by means of specifically developed interface agents.

The framework is described using an application of an industrial wastewater treatment plant. The wastewater treatment process is at risk by many hazards, of which the threat of destroying the activated sludge is the most dangerous. Many experts must cooperate in order to assess the risks posed by this unpredictable hazard, and the process of their cooperation is the basis for presenting the solutions introduced in the framework.

2 Problem Statement

Risk management aims to provide decision makers with a systematic approach to coping with risk and uncertainty [3]. The task of risk assessment is one of the stages of the risk management and consists of identifying the hazards and evaluating the scale of potential losses. The typical approach to the risk assessment involves passing through a few steps at the stage of the enterprises design or during the periodical reviews, when the risk factors are identified, prioritised and managed [4-7].

An industrial wastewater treatment plant is presented as the example of a vital process. In the plant, a sudden increase in the content of toxic substances at the inlet flow is the considered hazard. Hazard prevention is strictly related to the risk management. In the presented case of a wastewater treatment plant the risk management process is difficult to be performed fully at the stage of design, due to unpredictability of possible hazards. Well-known methods of managing the risks, such as tolerating, terminating and transferring, are also inadequate or unacceptable in this case. Potential hazards are the integral part of the wastewater treatment process, so ceasing the activity posing the risk would equal terminating of all the activity. The risk connected to the hazards cannot be tolerated because occurrence of the hazard entails a complete breakdown of the plant. Transferring the risk is also no option because, due to the severe consequences of hazard occurrence, there is no party willing to accept it. The only method left is treating the risk and developing the way of dealing with the hazards. Because the occurrence of toxins in the wastewater is unpredictable, risk treatment at the stage of the plant design consist of securing countermeasures, which can be later used when emergency situation arises. However, each of the emergency situations is specific and response to each of them has to be worked out individually.

The hazard, which is considered below, is the sudden and unexpected increase of the cyanides concentration in the inlet flow of the plant, located before the primary (i.e. mechanical) treatment process. A small concentration of the toxins is acceptable

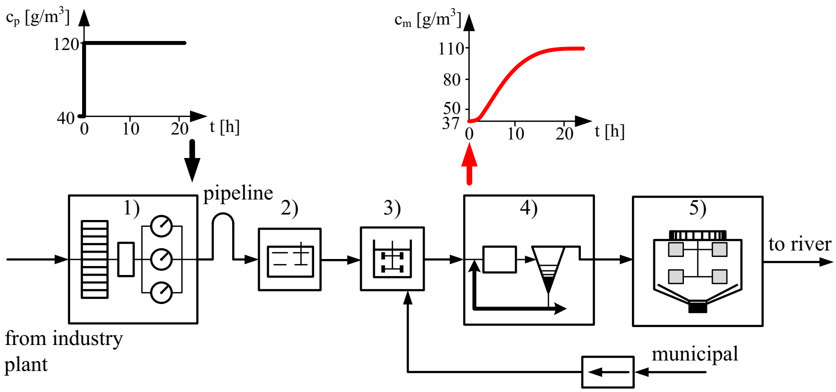

Fig. 1. Typical emergency event requiring the risk assessment (graph on the left: cyanide concentr. at the main inlet; graph on the right: cyanide concent. at the inlet of biological treatment; 1: initial mechanical treatment; 2, 3: chemical treatment; 4: biological treatment; 5: additional treatment).

in the normal regime of work, because small amounts of the cyanides are treatable by the activated sludge (see [7]). Typically, in the wastewater treatment plant inlet volume flow rate is of about 400m^3/h. The concentration of the cyanides below 40g/m^3 in this flow is acceptable, and without any special actions is reduced by the secondary treatment (biological with activated sludge) to about 10g/m^3. Concentrations of the cyanides in the inlet flow higher than 50g/m^3 are still treatable but should be closely monitored and considered as warning; the concentration of 80g/m^3 is critical. Concentrations higher than this, when they get to the secondary treatment, will kill the living organisms of the sludge, destroying the ability of the treatment plant to function properly, in effect forcing the plant to be restarted, which is time-consuming and expensive. The response of the cyanide concentration at the inlet of biological treatment, which is located after the primary treatment is presented in the Fig. 1. Due to the dynamics of the wastewater treatment plant (resulting from the flows and canal capacities), there is about 8 more hours, after the dangerous concentration of toxic substances occurred at the inlet, before the contaminated wastewater reaches the activated sludge in the biological treatment. This time should be utilised by experts to fully consider all the options available to respond to the situation.

Decision on how to proceed in a given state of the system, must be taken cooperatively by a group of experts. The first group of experts consists of the professionals in the field, i.e. an experienced process technologist who is able to estimate allowed values of parameters, and the installation technicians located at the site, who knows the current status of process. Their role is to present the available solutions of the situation to the second group, which is formed by a lawyer, a public relations expert, and an accountant. Their task is to choose one of the proposed solutions with respect to the law, company image, and projected costs.

To provide the means for dealing with the hazard, the plant is equipped with a parallel system of reservoirs. The contaminated wastes can be diluted with non-contaminated wastewater stored in the reservoirs, or the reservoirs may serve as the storage for contaminated wastewater so they can be treated later by being gradually added to the normal inlet flow. To improve possibilities of operator actions, the second system of retention reservoirs, dedicated for storage of clear water from rainfalls (normally used as water resource for other purposes) can be considered as an additional resource of clear water for dilution of the contaminated wastewater.

The number of reservoirs and their exact configuration (a-e in the Fig. 2) is fixed at the stage of plant design, and depends on the results of initial risk assessment. The initial risk assessment should be ideally performed by the same team of experts, which will be managing the emergency situations. The reservoirs and their connections are the only resources available for use during the emergency. The elemental actions available include storing the contaminated wastewater in the reservoirs to be processed later; or diluting the contaminated wastewater with any of the following: previously stored non-contaminated wastewater, processed clean water, or with the

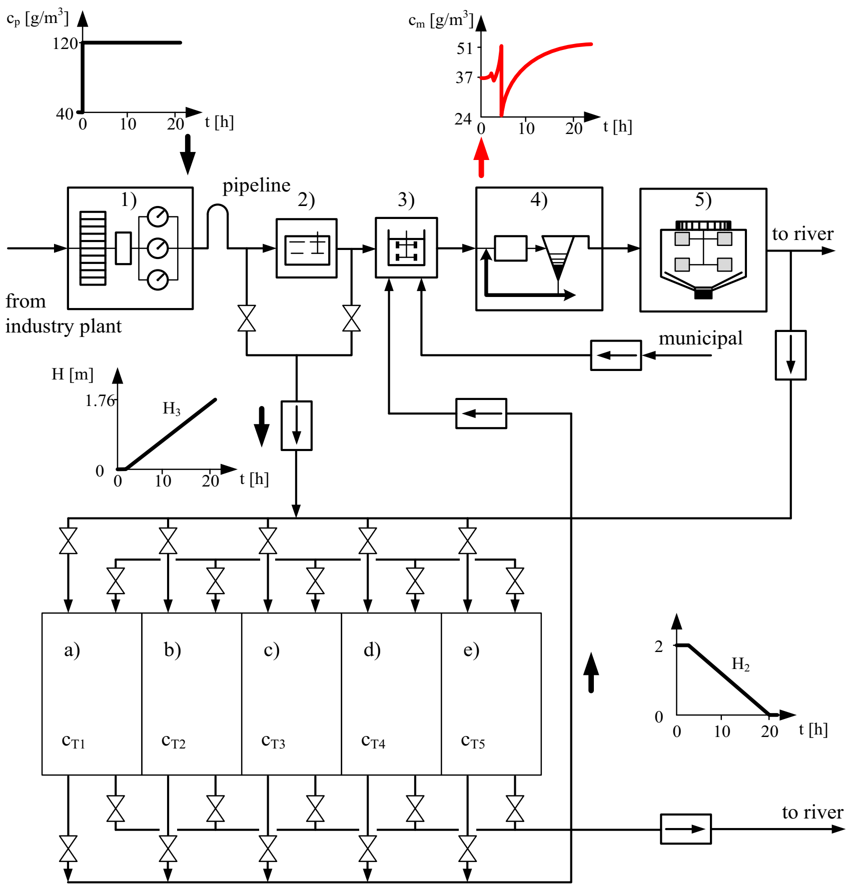

Fig. 2. Properly managed emergency situation (graph on the left: cyanide concentr. at the main inlet; graph on the right: cyanide concent. at the inlet of biological treatment; a-e: retention basins).

water stored from the rainfalls. The decision on actions to take should take into account the state of the reservoirs at the moment of emergency situation. It should be noted that the response to the hazard situation poses risk itself. The new risk is caused by depleting the resources i.e. limiting the possibilities of future operations, because the response to the hazard consists of filling some reservoirs with the contaminated wastes and/or using the clean water from other reservoirs. The problem is important when another hazard situation occurs before the process fully recovers from the current situation. Thus, in dealing with the hazard, the risk of future events should be assessed, taking into account the depletion of resources by taking actions. This risk assessment process is crucial as the decision on the current actions depend on the predicted future – in the same current conditions, recommended actions may differ, depending on the predictions for the nearest future. In case of serious danger, when there are no views for improvement of conditions, the ultimate solution, used to protect the living organisms of the activated sludge, consists of redirecting the toxic wastewater directly to the plant outlet, without any treating, which in turn has serious consequences in terms of pollution of natural waters.

An example of an emergency situation dispatched by the experts by ordering proper sewage flows is shown in the Fig. 2. In this case some of tanks were used to store part of the contaminated wastewater for later treatment, and the wastewater which was treated immediately was diluted with the rainwater from the reservoirs. As it is seen, issuing proper commands results in keeping the concentration of cyanides in the range acceptable for the biological part of the plant.

3 Proposed Framework

To properly assess the scale of the risk imposed by the hazard and to work out a proper strategy, the experts need the full knowledge of the current status of the installation. What's more, the strategy should be chosen in respect to the risk it poses itself, because of the resource depletion. An integrated environment is therefore needed, in which experts can cooperatively test the various scenarios of intervention with respect to both the current state of resources and predicated need for the resources in the future. Ideally, the environment should support the remote collaboration, because it is highly probable that the experts will be geographically dispersed at the time of the emergency situation, while the timing is critical.

The proposed solution for the cooperative environment is agent-based. The framework is currently still under development in the Institute of Automatic Control (Gliwice, Poland). At the current stage of progress it already supports full integration of the software agent-based environment with the numerical data acquired from industry-grade instrumentation. The software part is based on the JADE environment implementing the FIPA compliant software agents [1], which connect to the industrial instrumentation using the OPC interface [11] through the Java Native Interface. An ontology has been developed which describes the nature of industrial numerical data, so the software agents understand the specifics of the operating control data, which enables them to incorporate the data in their internal communication.

Remote experts connect to the framework by means of predesigned software agents supporting the functionalities required by specific expert groups. These remote connections are supported directly by the JADE platform, as it is distributed by its

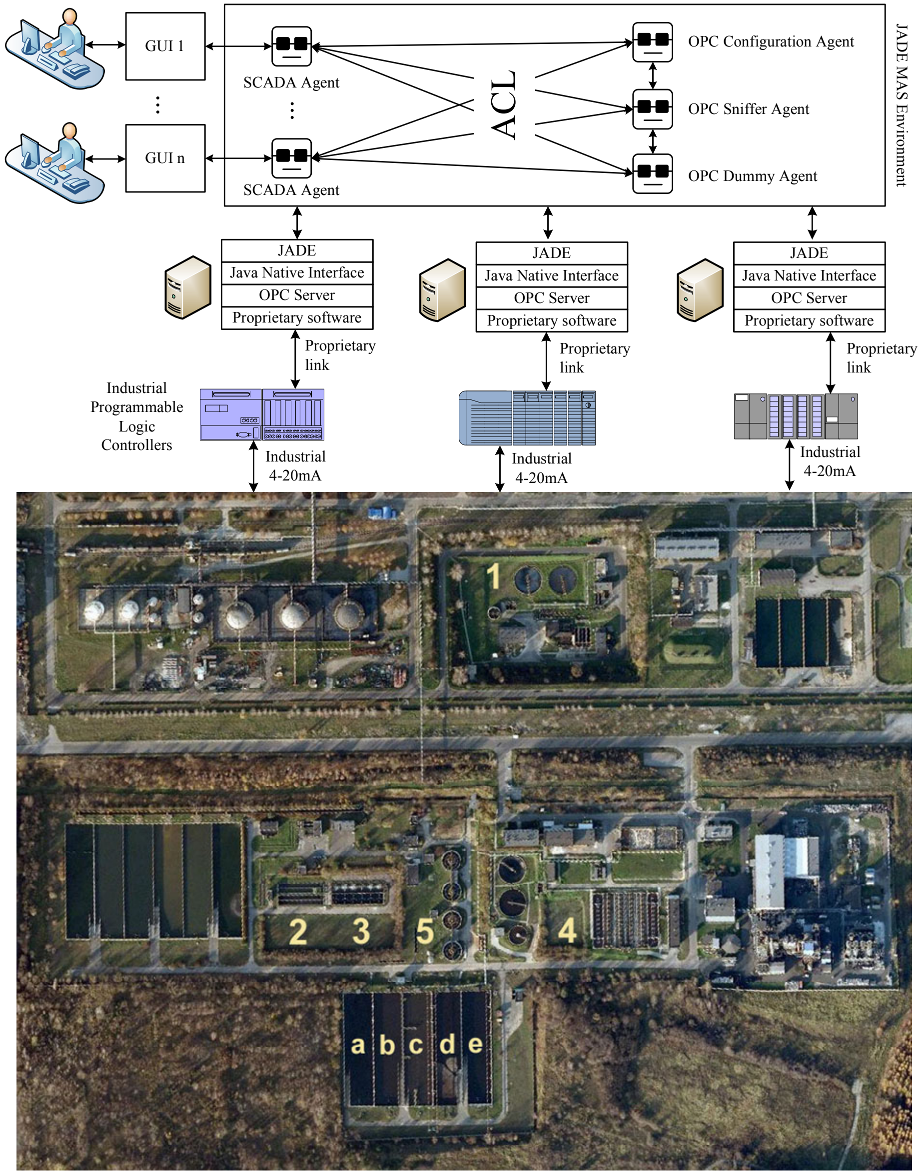

Fig. 3. The structure of the cooperative environment and an example of wastewater treatment plant layout (1: initial mechanical treatment; 2, 3: chemical treatment; 4: biological part of the WWTP; 5: additional treatment; a-e: retention basins)

nature. The expert agents embed the graphical user interfaces which present industrial process data to the experts and allow them to input desired strategy of hazard prevention. For a discussion on customizing the user interface to suit the user's expertise and taste see [12]. The outcome of the strategies proposed by all the experts is determined by performing an accelerated simulation of the plant performance with the mathematical model [13]-[15]. The mathematical model is a separate application, which takes input commands in the form of proposed strategy (as in [16]) and responds immediately with the graph of expected cyanide concentration in the biological treatment and resource depletion in the form of resulting contents of reservoirs. The experts may discuss and correct the parameters of the simulation and rate the results according to their own criteria. The choice of the final strategy to be applied is done when the experts reach the consensus by discussion. As soon as the consensus is reached, the corresponding strategy may be immediately applied by writing the required commands to the industrial instrumentation by means of OPC agents. This process is overseen by the plant technicians, which continuously monitor the state of the plant and track the process of cooperative hazard management.

4 Conclusions and Future Work

The framework is still under development, but even at the current state it provides very interesting results. The components, which are already implemented i.e. the interface between the JADE platform and the industrial instrumentation, and the OPC agents integrating both the environments at the logical level, perform very well. The work currently focuses on the implementation of the agent-based interfaces for the experts, with the emphasis on their customised graphical interfaces. The mathematical model of the plant is currently implemented as a separate application, and requires conversion to the JADE-compliant agent, which in order will require modifications to the already developed ontology. However, as soon as this work is finished the framework will be considered complete. It is expected that the tool will be applicable in many other industrial plants requiring cooperative assessment and planning, the only requirement for the plant will be that its mathematical model is implementable in the framework.

An interesting issue that requires careful considerations is automation of reaching the consensus by the experts. Currently, the consensus is reached by experts during the discussion in natural language through the separate communication channel, and the effect of the discussion depends on the negotiation skills of specific experts. Because of this, introduction of the separate auction mechanism is considered, through which the experts could withdraw from some aspects of their strategies in exchange for similar tradeoffs from other experts, until the consensus is reached. The other mechanism is also considered, in which the final strategy will be determined as a weighted average of the strategies proposed and rated by experts.

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The Sensitivity Analysis for Cooperative Decision by TOPSIS Method

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Abstract. Quantitative multiattribute decision making methods are handy for making cooperative decisions, because the decision makers are interested in finding a common solution; even some times they have diverse goals. The initial data for cooperative decision making depend on the decision makers' own views, therefore the input data may be inconsistent. An important step in cooperative decision making is to perform a sensitivity analysis for the cooperative decision.

In this paper we perform a sensitivity analysis for the cooperative decision with respect to the values of attributes and the values of the attribute significances. The judgements of the expert group are used for generating the values of attributes significances. Monte Carlo simulation is used for the generation of the attribute values. We propose to represent the final decision together with the results of sensitivity analysis and confidence level of the decision. We believe that this can help to increase the reliability of the cooperative decision making.

Keywords: cooperative decision making, diverse goals, sensitivity analysis, multiple criteria decision, TOPSIS method.

1 Introduction

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 some problems in the investment of construction or monetary civil suits (suing for damages). It is clear that the implementation has a different level of agreement required from the experts. [2]

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. [8]

In this paper, we use a set of quantitative multiple attribute decision making methods for cooperative decision making. The block diagram of these methods is described in our prior article. [7]

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Group evaluation may be considered to be reliable only if the estimates elicited from 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. [8]

Often data in multiple attribute decision making (MADM) problems are imprecise and changeable. The significance of quantitative attribute is usually determined with some errors. If measurements are not accurate, the result obtained is not accurate either. [2] Therefore, an important step in many applications of MADM is to perform a sensitivity analysis for a final decision in respect of the input data.

"A possible definition of sensitivity analysis (SA) is the following: The study of how uncertainty in the output of a model (numerical or otherwise) can be apportioned to different sources of uncertainty in the model input" [5].

In this paper we analyze the cooperative decision by quantitative multiple attribute decision making method TOPSIS and its sensitivity on the initial data - the values of attributes and the values of attributes significances. Monte Carlo method is applied for the generation of the attribute values. The judgments of experts are used for generating the values of attribute significances.

2 Related Works

The significance of quantitative attribute 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. [3]

In [9], the authors presented a set of quantitative multicriteria decision methods facilitating multicriteria decision making. However, the analysis of the initial data (the values of attributes x_{ij}) is not made, and the confidence level of the final decision is not clear. A number of essential disadvantages of the attributes were given in the paper [9]. These are: a definition of the attributes significances is complicated and in some cases, their relationship with the efficiency parameters is weak; the small size of one parameter is compensated by a superfluous size of another; the average success criterion sensitivity of the made decision to the changes of the size of separate efficiency parameters is low, especially, if the attribute number is great. The authors gave sensitivity analysis of a SAW method in point of the values of the attributes significances. They used two methods of normalization. [9]

In [6], the authors presented the strategic decision process for oil exploration, where they used MAUT model and the high dimension sensitivity algorithm. The authors proposed three simulations procedures for high-dimensional sensitivity analysis: randomly generate weights, random weights preserving a rank-order of importance, and random weights from a response distribution. Based on that, an algorithm was constructed using routines for three simulations procedures [6].

In [9], the authors stated that the data in MCDM problems are difficult to quantify, or they are easily changeable. Therefore, the decision maker often assesses the data with a certain degree of accuracy. And therefore it needs to perform sensitivity analysis of a MCDM problem [9].

After analysis of the related work, we found that there were no specific measurements of the multiple attribute decision's sensitivity depending on values of attributes and values of attributes' significance.

3 Proposed Approach

We propose an evaluation scheme for the sensitivity of cooperative decision by TOPSIS. We can prove it by using the diagram MCDM-1, part-1 [8]. We perform a modification of this diagram by appending some diagram items. This modification allows the cooperative decision making group to participate in the cooperative decision making process (see Fig 2).

Suppose that *k* experts participate in decision process. The experts fill the pairwise matrixes, which are used to calculate the subjective significance (weights) of the attributes. Each expert gives the opinion about the values of attributes. We have *k* vectors of subjective significances of attributes, and *k* decision matrixes with values of attributes - these are the initial data.

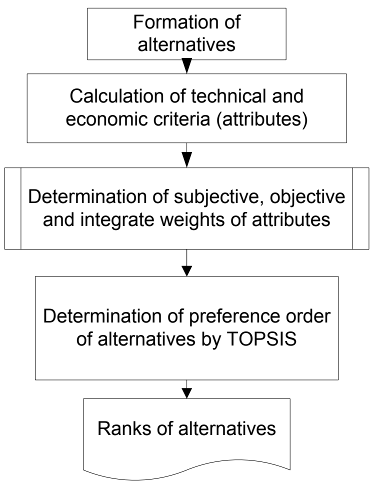

Fig. 1. Modified primary diagram MCDM-1, part 1

We will propose an approach designed for an evaluation of the sensitivity of cooperative decision from the point of the initial data (the subjective significance of attributes and the values of attributes). For this purpose, a series of operations will be performed in accordance with the modified diagram (see Fig 2)

Stage 1. A group of experts are chosen. The alternatives A_i $(i = 1, ..., m)$ and the attributes X_j $(j=1,..., n)$ are chosen.

Stage 2. Based on the judgement of each expert and applying the modified method complex MCDM-1, part 1, the values of subjective significances of attributes are

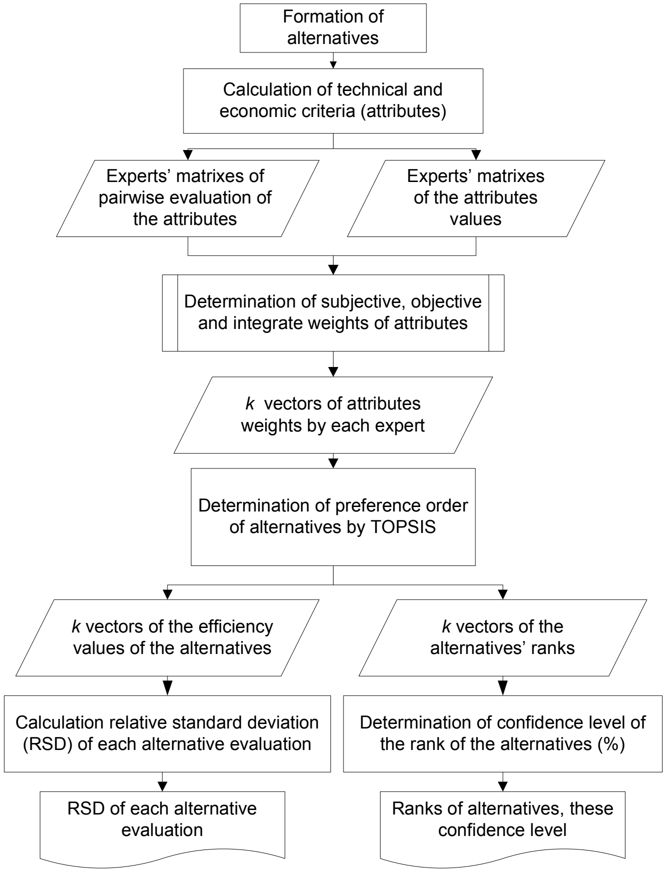

Fig. 2. Sensitivity analysis is incorporated into the MCDM-1, part 1 diagram

determined, i.e. the significance of each attribute X_j will have k values q_{j1}, q_{j2}, ..., q_{jk}, where $j=1, ..., n$.

Stage 3. Group evaluation may be considered to be reliable only if the estimates elicited from various experts are consistent. Therefore, when the data provided by experts is statistically processed, the consistence of the expert estimate should be assessed and the causes of the information ambiguity should be identified. For this purpose, an enhanced method of pairwise comparison should be used [8]. The degree of agreement of experts' estimate can be determined by using W. Kendall's concordance coefficient which is calculated by the formula:

$$\chi^2 = \frac{12S}{rn(n+1) - \frac{1}{n-1}\sum_{i=1}^{r} T_i} \tag{1}$$

If χ^2 values obtained from formula (1) are above the normal χ^2_{lent} value, depending on the degrees of freedom and level of significance, the estimates of the experts are considered to be consistent (in agreement). Otherwise, when $\chi^2 < \chi^2_{lent}$, the estimates elicited from experts are considered to be inconsistent and varying to a considerable extent.

Stage 4. Based on the values of subjective significances of attributes, the efficiency of the alternatives A_i is determined using the method TOPSIS (see Fig 2), i.e. each alternative will have k estimates a_{il}, where $l = 1, ..., k$. This method is known as TOPSIS – *Technique for Order Preference by Similarity to Ideal Solution.*

A relative distance of any i-th alternative from an ideal one is obtained:

$$K_i = \frac{L_i^-}{L_i^+ + L_i^-}, i = \overline{1, m} \text{ , where } K_i \ [0, 1], \tag{2}$$

where L_i^+ is a distance between the compared i–th alternative and the ideal one; L_i^- – a distance between the compared i–th alternative and negatively ideal option. The nearer to one is K_i value, the closer is the i–th alternative to a^+, i.e. the optimal alternative is the one which has the highest value of K_i [4].

Stage 5. We have k vectors of efficiency of the alternatives A_i. The cooperative decision's sensitivity is determining in point of the values of subjective significances of attributes by calculating relative standard deviation. The relative standard deviation (RSD) is often times more convenient. It is expressed in percent and is obtained by multiplying the standard deviation (s) by 100 and dividing this product by the average ($\overline{x}$).

$$RSD = \frac{s}{\overline{x}} \cdot 100 \tag{3}$$

Stage 6. The reliability of rank determination is calculated by the formula:

$$p(A_i) = \frac{n(l)}{r} \cdot 100\% \tag{4}$$

where $p(A_i)$ 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. [7]

With the intention of our proposed approach, we use Monte Carlo simulation for initial data generation. We generate Normal distributed n random values of attributes. The values of the attributes represent the values of average; the standard deviation represents *10%* from the attribute value. We carry out the alternatives evaluation by TOPSIS with these generated initial data. We get n decisions and calculate relative standard deviations to each alternative's efficiency evaluation.

We provide the final decision alongside the results of sensitivity analysis, with relative standard deviation, and the confidence level. The main approach is presented, compared and demonstrated by means of analytical and practical examples.

4 Case Study

To illustrate our proposed approach, some alternatives of purchasing an office building for a company are considered. Suppose that the clients (the decision makers) need to purchase office premises. There are four variants $(A_1 – A_4)$ of office location. Four attributes are considered: X_1 – price *(10,000 $)*; X_2 – office area (m^2); X_3 – distance from home to work (km); X_4 – office location (in points). The attributes X_2 and X_4 are maximized, while X_1 and X_3 are minimized. Suppose that we have 20 experts, which gave the diverse values of these attributes (*20* decision matrixes). The values of attributes vary by *10%* from their average. The first expert's data concerning office purchasing is presented in Table 1. And we have four experts, which fill pairwise matrixes for determination of the values of attributes significances.

Table 1. The values of attributes on office purchasing by first expert (Decision matrix -1)

Attribute / ***Alternative***	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

Step 1. Primarily, we must calculate the subjective significance values of the attributes. This calculation is based on pairwise comparison matrix, using four experts' data. After the calculations, we got four variants of subjective significance values of the attributes. They are presented in Table 2.

Table 2. Subjective values of attributes significances received using four experts' data

Attribute / ***Expert***	X_1	X_2	X_3	X_4
Expert 1	0.092	0.264	0.184	0.460
Expert 2	0.088	0.218	0.143	0.551
Expert 3	0.110	0.231	0.127	0.532
Expert 4	0.109	0.141	0.172	0.578
Average	0.09975	0.2135	0.1565	0.53025
Stand. deviation	0.011383	0.052067	0.026134	0.050493
RSD	11.412	24.38748	16.69921	9.522565

We calculate the average of each attribute significance and relative standard deviation (RSD), which indicates how many percents subjective values of attribute significances of each expert differ from their averages. We got, that the values of attribute significances differ from their averages by *15.51%.* We estimate the alternatives by TOPSIS method using each expert's values of attributes significances and the decision matrix – 1. We got four variants of alternatives' efficiency. The data obtained by calculating the efficiency of the alternatives with respect to the values of attribute significances by four experts, represented in the table 3.

Conclusion 1. When the subjective values of attributes significances vary by *15.51%*, the efficiency of the alternatives varies by 7.8*%.*

Step 2. We have 20 decision matrixes. The values of attributes vary by *10%* from their average. We calculate the efficiency of alternatives by TOPSIS, using these

Table 3. The efficiency of the alternatives by TOPSIS

Expert \ Alternatives	A_1	A_2	A_3	A_4
Expert 1	0.514	0.391	0.583	0.638
Expert 2	0.444	0.298	0.678	0.649
Expert 3	0.443	0.286	0.684	0.646
Expert 4	0.440	0.316	0.676	0.660
RSD%	**7.79**	**14.61**	**7.37**	**1.40**

Table 4. The twenty results of efficiency and ranks of alternatives by TOPSIS

Number of data generation	Estimates of alternatives' efficiency				Ranks of alternatives			
	A_1	A_2	A_3	A_4	A_1	A_2	A_3	A_4
1	0.4784	0.3771	0.5651	0.5385	3	4	**1**	2
2	0.6844	0.4346	0.3668	0.7176	2	3	4	**1**
3	0.4498	0.3807	0.5723	0.609	3	4	2	**1**
4	0.4693	0.3013	0.6723	0.4808	3	4	**1**	2
5	0.6894	0.4452	0.5516	0.6386	**1**	4	3	2
6	0.4965	0.3122	0.6781	0.727	3	4	2	**1**
7	0.5502	0.398	0.5602	0.7117	3	4	2	**1**
8	0.5517	0.4099	0.585	0.6504	3	4	2	**1**
9	0.527	0.4131	0.4962	0.5644	2	4	3	**1**
10	0.5048	0.3684	0.5869	0.7138	3	4	2	**1**
11	0.368	0.365	0.6125	0.4399	3	4	**1**	2
12	0.4347	0.3223	0.6224	0.6132	3	4	**1**	2
13	0.563	0.4515	0.4977	0.7645	2	4	3	**1**
14	0.5901	0.4442	0.5005	0.6491	2	4	3	**1**
15	0.6205	0.4567	0.5456	0.6424	2	4	3	**1**
16	0.5057	0.3318	0.6389	0.6155	3	4	**1**	2
17	0.5603	0.3759	0.5906	0.7084	3	4	2	**1**
18	0.4767	0.3233	0.6289	0.3546	2	4	**1**	3
19	0.5511	0.3879	0.5591	0.7471	3	4	2	**1**
20	0.6069	0.3903	0.5967	0.7564	2	4	3	**1**
RSD	15.087	12.584	12.343	17.536				

Table 5. The reliability evaluation of the rank of alternatives

	A_1	A_2	A_3	A_4
Value of rank	3	4	2	**1**
Frequency of rank value	12	19	7	**13**
Percentage of frequency	60%	95%	35%	**65%**

decision matrixes and the averages of each attributes significance (see Table 2). We get 20 evaluation of alternatives' efficiency. These results are present in table 4.

Finally, we calculate the relative standard deviations of the alternatives' efficiency (Table 5) and made the conclusions about a variation of final decision.

Conclusion 2. The efficiency of the alternatives varies by *14.4%* when the attributes' values vary by *10%.* The most effective alternative is A_4, its rank is ***1***, and a confidence level of its proposition is *65%.*

5 Conclusions

In this paper we analyzed the cooperative decision by quantitative multiple attribute decision making method TOPSIS and its sensitivity on the initial data - the values of attributes and the values of subjective significances of attributes. The performed sensitivity analysis of cooperative decision allowed the authors to draw the following conclusions:

1. Suggested method doesn't identify which alternative is the best in one hundred percent. This method allows estimating a variation of cooperative decision, if the initial data are uncertain.
2. The relative standard deviation is suitable to represent results of cooperative decision's sensitivity analysis.
3. The authors offer to use this method for cooperative decision making, when quantitative multiple attribute decision making methods are used for decision making.

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A Freshness Based Persistent Assurance Scheme for Secure Scalable Media Distribution

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Abstract. Unlike a single-layer based media, maintaining data integrity of a scalable media (*SVC-encoded media*) constructed as multiple layers is more difficult to achieve due to a retransformation property of the scalable media. Moreover, media redistribution among heterogeneous devices makes this issue more critical. To provide consistency in data management, we newly define an extended concept of data integrity as *freshness* in the standpoints of currency and reuse of data. In this paper we propose how to generate freshness information from the scalable media and describe a freshness-based persistent control of verifying currency and reusability for reliably coping with media retransformation and redistribution problems, respectively.

Keywords: Data Freshness, Persistent Control, Scalable Video Coding.

1 Persistent Control Issues in Scalable Media Distribution

Unlike a conventional transcoding scheme applied in the single-layer based video coding algorithms such as MPEG and H.264, the scalable (multi-layer) media encoded by SVC (Scalable Video Coding) [1] can be freely retransformed in terms of spatial, temporal, and quality scalabilities in order to satisfy devices' capabilities and users' requirements. Moreover, media redistribution between multiple devices can be frequently occurred over CDNs (content delivery networks) such as IPTV, P2P, and Multicasting as depicted in Fig. 1. Due to difficulty of constantly controlling data usage patterns in aspects of various retransformation and free redistribution, devices participating in the interactive CDNs do not guarantee if received data is illegally modified or compromised in an unauthorized manner. Furthermore, they cannot trace when media is originally generated and retransformed and how many times data is retransformed and redistributed. Unfortunately, few studies on persistent assurance of secure scalable media have been proposed.

Intuitively, generating message digest using a hash function or MAC (Message Authentication Code) is the simplest method for verifying scalable media against the undefined access and the unlawful usage. Moreover, encrypting media can be an alternative for concealing original meanings of media; however, entire media protection means that all data should be controlled according to the highest level requirement for individual media. However, these approaches which are based on traditional

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data integrity and encryption are not appropriate to ensure the secure retransformation and redistribution of the scalable media.

Therefore, we newly define an extended version of data integrity as freshness which consists of two security assurance concepts with respect to currency and reuse of data. More specifically, assuring data currency of some layers means that receiving layers belong to a valid full-scale media and execution time of creation, extraction, and other modifications are correctly identified. Furthermore, assurance of data reusability guarantees that particular layers are not compromised during any media processing such as encoding, extracting, and decoding. In this paper, we propose a freshness-based persistent assurance scheme of the scalable media for verifying secure retransformation and redistribution.

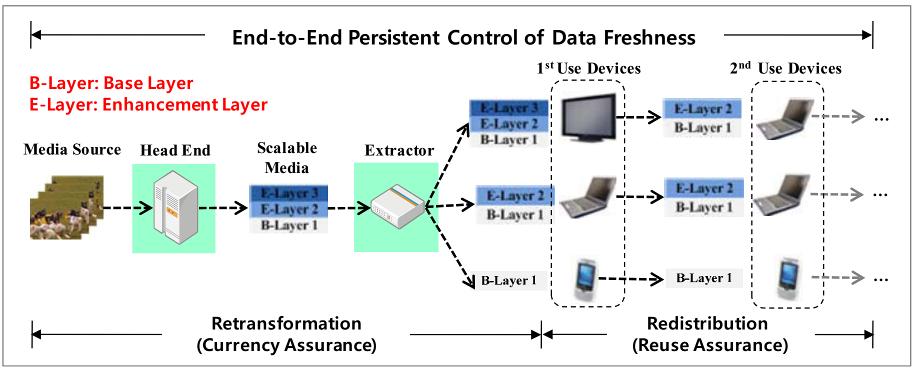

Fig. 1. Scalable Media Distribution with the Freshness Based Persistent Control

2 Freshness Based Persistent Control

In this section, we describe how to extract features and to create layer and scalable media freshness information. Then we show a whole procedure of data verification in aspects of currency and reusability for supporting secure media retransformation and redistribution, respectively. Here, we assume that media is protected by the selective encryption scheme [2] and key related processes are managed by a secure directory.

2.1 A Freshness Creation Algorithm for the Media Layers

In our proposed scheme, the feature presents uniqueness of a single layer so that extracting the feature of each layer is the first step before creating layer freshness information as follows:

$$f_i = \begin{cases} 1, if\ |DC| \geq \alpha \\ 0, otherwise \end{cases} \rightarrow f_i = \{1011000111\cdots\} \tag{1}$$

In Eq. (1), $|DC|$ means an absolute value of DC (Direct Current) component of macroblock which is generated from DCT (Discrete Cosine Transform) in the scalable media and α is a pre-defined threshold value. Hence, feature extraction speed depends on the number of DCs to be examined. For this reason, randomly choosing some DCs among macroblocks can be considered as a solution for overhead reduction.

As the second step, our assurance scheme gathers each layer's feature (f_i), layer's scalability indicator of scalable media (si_i) and metadata such as user identity (*uid*), content identity (*cid*), creation time of the original media (*crt*), latest time of extraction (*ext*), and the total number of extraction (*exn*). These metadata are used for guaranteeing global uniqueness of the layer's freshness; on the other hand, other parameters can be added according to application requirements. Next, the proposed method encrypts the collected metadata by using *LEX* which is a lightweight version of AES (Advanced Encryption Standard) designed for reducing encryption overhead and then concatenates this encrypted metadata with f_i and si_i as an input of unkeyed hash function (H). Finally, freshness information of *i-th* layer (LF_i) is generated by hashing the concatenated data set as described in Eq. (2).

$$\begin{aligned} LF_i = H(f_i \mid si_i \mid LEX_{sk_i}(uid) \mid LEX_{sk_i}(cid) \mid \\ LEX_{sk_i}(crt_i) \mid LEX_{sk_i}(ext_i) \mid LEX_{sk_i}(exn_i)...) \\ where\ si = (S, T, Q) \end{aligned} \tag{2}$$

where S, T, and Q in scalability indicator (*si*) denote resolution, frame rate, and signal-to-noise ratio, respectively.

Thirdly, the freshness information of scalable media (*MF*) can be generated by applying a one-way accumulator (*H'*) iteratively to individual layer freshness as shown in Eq. (3). This is because *H'* produces an identical result regardless of the order of the input data. In addition, a set of metadata is encrypted by a receiver's public key and is then transferred to the receipt for freshness verification.

$$MF = H^{'}(H^{'}(LF_i, LF_{i+1}), LF_{i+2}) \tag{3}$$

2.2 Currency and Reusability Verification of Scalable Media

Fig. 2 describes a procedure of freshness verification in a form of sequential function chart. There are four representative entities participating in the scalable media distribution networks: a secure directory, a transmitter, a receiver, and a reuse device. In particular, the secure directory plays roles of key manager, freshness repository, and media database. In the currency verification, first the receiver obtains layer/media freshness information, metadata, and scalable media itself and then calculates new layer freshness (i.e., LF'_1 and LF'_2) by using Eq. (2). Next, currency of data is assured by comparing the received layer freshness with newly created layer freshness. After finishing this procedure without a verification failure, the receiver as the first media consuming device needs to redistribute the scalable media if there are reuse requests from the others. For the secure reuse, the reuse device has to completely verify reusability of scalable media by using Eq. (4). Furthermore, these two assurance processes can be done in a single device.

$$MF = MF^{'} \Leftrightarrow H^{'}(H^{'}(LF_1, LF_2), LF_3) = H^{'}(H^{'}(LF_1, LF_3), LF_2) \tag{4}$$

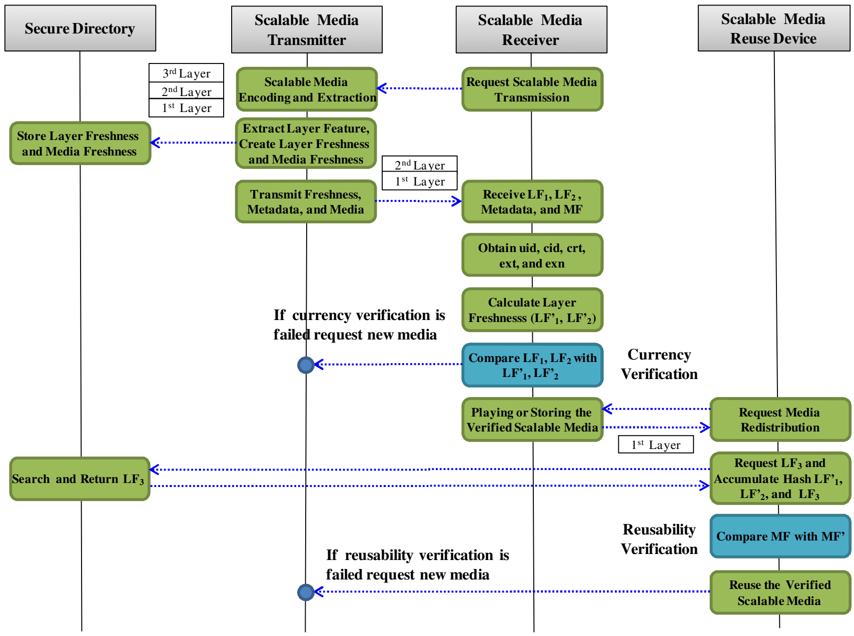

Fig. 2. A Procedure of Verifying Currency and Reuse in Scalable Media Distribution

3 Feasibility Discussion

The proposed persistent assurance scheme is designed for constantly tracing the status of data usages and for ensuring that a particular media is not compromised. By simply comparing layer and media freshness between devices, each user can verify the history record of scalable media in terms of currency assurance and can examine if there are illegal access or modification according to reusability assurance during retransformation as well as redistribution. A general encoding process is performed in high-capable hardware and the feature extraction is possibly completed during encoding process as a sub-processing. Furthermore, sampling some DCs and using LEX are helpful in reducing creation time of the freshness information. Accordingly, this scheme can be feasibly deployed to a practical streaming service (i.e., real-time IPTV).

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Cooperative Decision Making for Evaluating Ports' Reception Facilities

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Abstract. This paper illustrates how to perform a cooperative decision making employing rough sets theory. Programs for effective management of ship-generated waste in a port are considered and a conclusion is obtained via an approximate reasoning scheme.

Keywords: cooperation, rough sets, approximation schemes.

1 Introduction

Establishment and operation of reception facilities for ship-generated waste is very important regarding protection of the external environment. The reception facilities can be fixed, floating and mobile units. Examples of ship-generated waste include oily waste, sewage, cargo residues and garbage.

Reception facilities are often ranked according to availability of the pre-treatment equipment and processes, methods of recording actual use of the port reception facilities, methods of recording amounts of received and disposed ship-generated waste and cargo residues. Actual use of reception facilities is sometimes stimulated by the so-called "no-special-fee" system, [2].

Rough sets theory is applied for evaluating a port's programs for provision of facilities for effective management and disposal of ship-generated waste.

The rest of the paper is organized as follows. Related work and supporting theory may be found in Section 2. The model of the proposed system is presented in Section 3. The paper ends with a conclusion in Section 4.

2 Related Work

In the rough set theory [5], objects are described by either physical observations or measurements. Consider an information system $\mathcal{A} = (U, A)$ where information about an object $x \in U$ is given by means of some attributes from A, i.e., an object x can be identified with the so-called signature of $x : Inf(x) = a(x) : a \in A$.

Approximate reasoning schemes (AR schemes) [6] are employed for approximation of specific properties of structured (complex) objects. The schemes are often presented in a tree structure where the root illustrates the satisfiability

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degree of a feature of a complex object and leaves show the satisfiability degrees of different features of the so called primitive objects. Every part of a structured object is connected to concepts describing its properties. A structured object is usually related to several ontologies of concepts [9] since concepts form a hierarchical structure.

Labelled approximate rules, called productions are used for constructing an AR scheme. They can be obtained from data using domain knowledge. Productions are also defined as parametrised implications with premises and conclusions built from patterns sufficiently included in the approximated concept. Concepts approximations are presented in [7] and [8]. It is assumed that it is possible to change some of the objects' properties by various actions. An action can be either defined by a set of attributes, or by training data describing objects before and after actions execution.

Quantitative approaches to decision-making are discussed in [1]. Interesting approaches to automated planning can be found in [3] and [10].

3 The Decision Process

Plans and programs of port authorities for effective management and disposal of ship-generated waste are evaluated based on their responses to a Web-based questionnaire. A port is evaluated with respect to the provision of facilities to receive, treat, and safely dispose of ship-generated waste. Three experts, denoted as Expert 1, Expert 2, and Expert 3 respectively, participate in a cooperative decision making process. A degree to which a port's program satisfies the corresponding international rules known as Marpol 73/78 Convention [4] is taking one of the values - low, medium or high. The experts are asked to consider provision of facilities related to - oils, denoted as concept C_1; harmful substances, denoted as concept C_2; and solid waste, denoted as concept C_3.

Production for concepts $C_i, i = 1, 2, 3$ is formed as a collection of simpler rules, called production rules, and is approximated by linearly ordered layers.

The presented case can be read as follows - if inclusion degree to a concept C_1 is at least low, to a concept C_2 at least low and to concept C_3 is at least medium then the inclusion degree to a concept C_4 is at least low; if inclusion degree to a concept C_1 is at least low, to a concept C_2 at least medium and to concept C_3 is at least high then the inclusion degree to a concept C_4 is at least medium; if inclusion degree to a concept C_1 is at least low, to a concept C_2 at least medium and to concept $C3$ is at least medium then the inclusion degree to a concept C_4 is at least medium. The concept from the highest level of production is called the target concept of production, whilst the concepts from the lowest level of production are called the source concepts of production. For example, in the case of production from evaluations made by Expert 1 with respect to receiving ship-generated waste in Fig 1, C_4 is the target concept and C_1, C_2, and C_3 are the source concepts.

The production rule for provision of facilities to receive ship-generated waste is illustrated in Fig 1 and denoted as 'Receive'. The production rule for provision

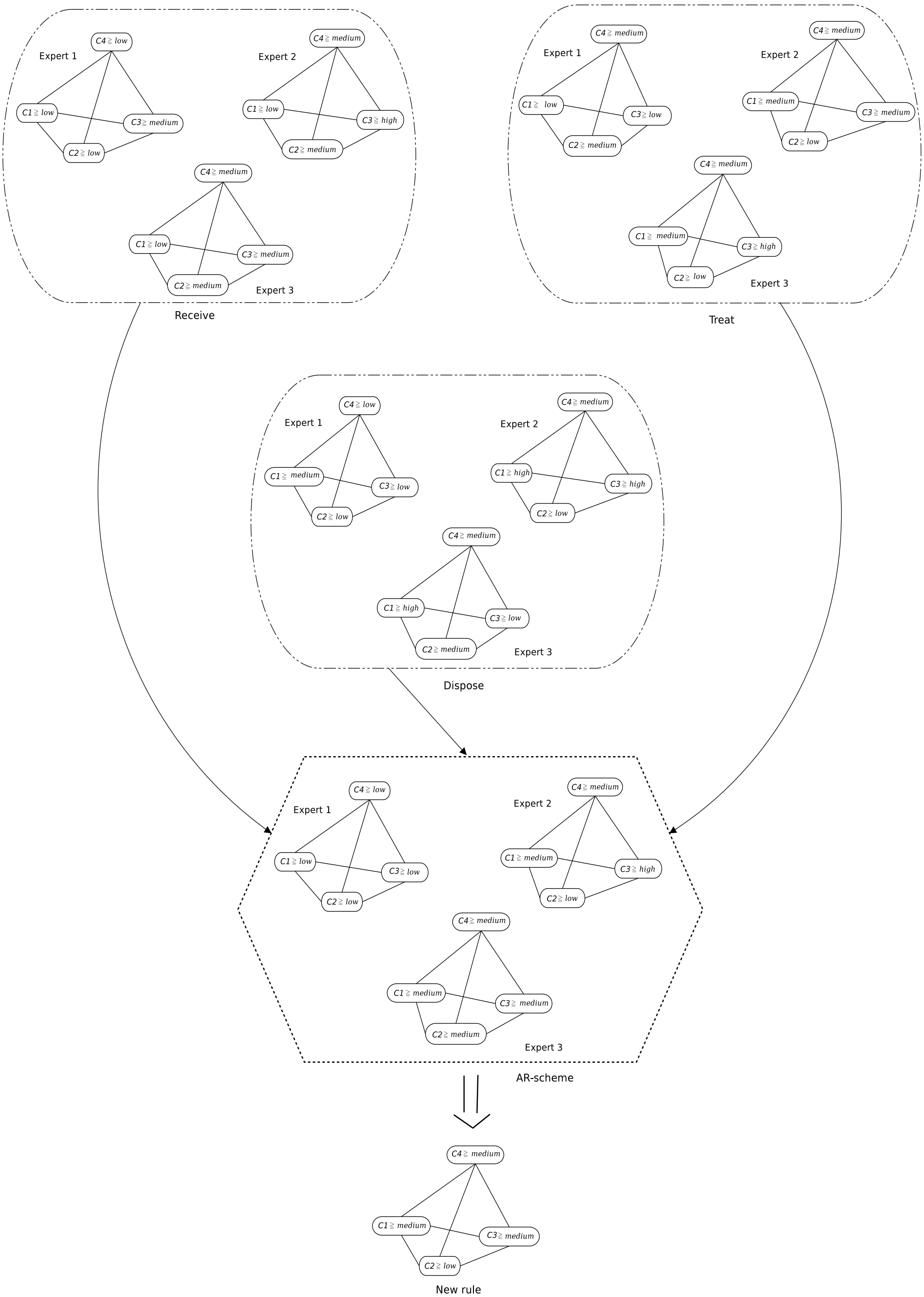

Fig. 1. Approximate reasoning scheme

of facilities to treat ship-generated waste is illustrated in Fig 1 and denoted as 'Treat'. The production rule for provision of facilities to dispose ship-generated waste is illustrated in Fig 1 and denoted as 'Dispose'. The outcomes resulted from the evaluation of each expert are summarized in an AR-scheme. The final conclusion is presented as a new production rule. In this particular case it says that if $C_1 \geq$ 'medium', $C_2 \geq$ 'low' and $C_3 \geq$ 'medium', then $C_4 \geq$ 'medium', i.e. the degree to which this port's programs satisfy certain rules in Marpol 73/78 Convention is medium. Further actions have to be taken for providing better facilities to receive, treat, and safely dispose of ship-generated waste.

It is worth mentioning that approximation of actions can be executed on several levels of generalisation since the AR schemes used for approximation are hierarchical structures.

4 Conclusion

In this work we have composed AR schemes into hierarchical and multi-level structures using productions constructed for various concepts. This approach can be applied for automation of various cooperative decision making processes where actions can be taken for improving properties of the investigated objects.

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Group Formation through Cooperating Node in VANETs

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Abstract. Vehicular Ad Hoc Networks (VANETs) will play a vital role in the future road safety and comfort. The lack of centralized infrastructure and high node mobility and number of vehicles generate problems such as interrupting connections, difficult routing, security of communications and scalability. Groups are here proposed as a solution to avoid data collisions by decreasing the number of connections exchanged among vehicles. To reach this goal, nodes should cooperate with each other. They should form groups or join a group depending on their state. This paper provides a global vision of the life cycle of cooperative nodes who form groups and a description of how to deal with the information within a group. Simulation results show that the proposed scheme reduces the number of communications, avoiding data loss due to collisions.

Keywords: cooperation, group, simulation.

1 Introduction

Cooperation between nodes is essential to create a communication network that would help to prevent accidents and to avoid traffic jams, which would save time, money, environment contamination and consumption of fuel reserves. The topology of the roads tend to create traffic jams, which produce the so-called hidden station problem that causes data loss due to collisions. The often used RTS/CTS mechanism is no longer feasible in road scenarios. In addition to this, reliability and not-delay are crucial for the efficiency of warning systems. Analysis show that the throughput of the WLAN broadcast scheme degrades rapidly with an increasing number of nodes. The use of groups allows optimizing communication in dense traffic situations.

Several general characteristics can be considered in wireless networks: authenticity, privacy, anonymity, cooperation, low delay, stability of communications, scalability, etc. [1] [3]. There are a few bibliographic references that propose the use of groups in VANETs. [2] describes clusters where the leader is the node in

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the middle with the lowest identifier. To maximize the advance of the relayed information and to avoid interferences [4] proposes clusters . None of these works define in detail the total life cycle of groups and present no reliable results that demonstrate the behavior of groups, which is the main objective of this work.

2 Group Stages

We distinguish among several stages in group management, corresponding to different situations of vehicles, depending on the route and on their status in each moment. The stages are: Detection, Election, Creation, Membership and Life of a group. There are a large number of highly volatile connections between vehicles in VANETs. For this reason it is necessary to define in detail the way in which vehicles must cooperate. The total life cycle of groups proposed in this paper is as follows. Initially all cooperating nodes start in the Group Detection stage. After this, each node can enter the Creation or the Election stage, depending on the circumstances. After Group Creation, one node will be the group leader, while after Group Election, the node would proceed to Group Membership stage.

Group Detection: This is the first stage, where vehicles do not belong to any group. The node who starts the stage checks the number of neighbors and the number of leaders among them from time to time. If there is at least one neighbor who is leader of a group, the node proceeds to the Election stage, otherwise to the Creation stage. This stage does not generate any traffic of control due to the fact that all the necessary information is contained in the generated beacons.

Group Election: This stage starts when the vehicle has found, among its neighbors, at least one node that is leader of some group. If there is only one neighbor who is a group leader, the choice is automatic. Otherwise, if there are several leaders, the vehicle has to choose one of them to join it. $groupValue$ is a value that denotes a quantity used for the choice and $groupLeader(j)$ represents the j-th neighbor of the node that is leader of a group. If there are several leaders among its neighbors, the vehicle chooses one according to the $groupValue$ that depends on *Density* $A(j)$ of vehicles, *average quality of signal* $B(j)$ within the vehicles and *Time* $C(j)$ during which it has been *connected* to the leader. The analysis of simulations have determined that 8 is the best value for threshold of group formation, when there are 20 nodes in a close area, the number of lost packets grows up fast. The quality of signal in 100 meters is over 7/10. The time connected to the leader depends on the kind of road where the vehicle circulates. In simulations we used highways with 3 lines for each direction.

Group Creation: In this stage the vehicle is not close to any leader. It should check whether within their neighbors there are at least X nodes that do not belong to any group, plus a variable Y that indicates the number of vehicles that can turn off, separate or not join the new group that is being created. If the number of neighbors without group is lower than the minimum threshold required for group creation, the vehicle waits a period $time1$ and starts the Group Detection stage. Otherwise, if the number of neighbors is greater than the threshold $X+Y$, the vehicle begins a new Group Creation process. In order to do it, it multicasts a group creation request towards all neighbors with distance equal to 1. Nodes that receive this request respond accepting or rejecting the invitation. If the number of neighbors that accept the invitation is greater than the minimum threshold X, the new group leader sends to each node the secret key of the group encrypted with the public keys of each node. In this moment the new group is formed. Otherwise, the number Y of estimated vehicles is increased by adding the number of vehicles that did not accept the invitation.

Group Membership: Once the group is formed, the leader must periodically validate that the group continues being useful. Otherwise, it would be necessary to change the leader or to end the group. When the node loses any contact with the leader of the group for certain time, the node stops to belong to its group and begins the Group Detection stage.

Group Life: The leader of a group periodically checks that the group is still useful. If group size falls below a certain threshold, the leader checks whether it has a number of neighbors greater or equal to D (group formation threshold) and waits for $time2$ instead of ending the group in order to avoid introducing group management traffic when the vehicle is in a dense traffic situation. If the leader is not in a dense traffic situation, it begins a leader change or a group ending process. First, the leader asks about the neighborhood density in order to know if the number of neighbors of the same group or without any group near is bigger than X. It also finds out which of its neighbors has more neighbors. After this, it sends a leader change signal to all its neighbors. The new leader will begin a Group Creation stage. In the absence of any neighbor exceeding the threshold, the leader sends a multicast group ending signal to all its neighbors.

3 Simulation Analysis

In order to make a comparative study, NS-2 simulations of node cooperation network that and without groups formation using the same topology has been implemented. The parameters used for the simulation of the shown results are the following: Total number of vehicles: 80, number of vehicles with OBUs: 80, number of lanes for each direction: 3 and 3, simulation time: 100 seconds, moment when retransmissions begins: 40 seconds, retransmission period: 10 seconds, distance relay nodes: 75 meters, routing protocol: DSDV, distance traveled before the traffic jam happens: 800 meters.

Thanks to the analysis of the output files of the NS-2 simulations, we can obtain information about the number of packets generated or lost in the whole network, the number of formed groups, which nodes are the leaders of the groups, which nodes generate packets and which nodes forward them, etc. A complete comparative study among the models was done. Fig. 1 show measures obtained respectively in networks with groups and without them. The conclusion we got is that the number of generated packages is always inferior when groups are used, what shows that groups and cooperation imply an improvement of the original schemes without groups. Therefore, cooperation and group tools, suppose a

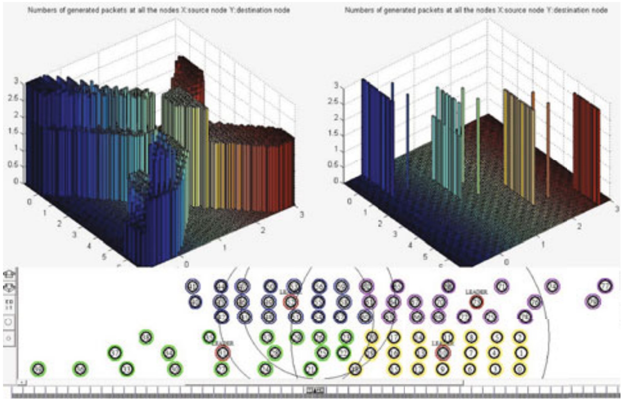

Fig. 1. Number of generated packets

useful defence for the problem of overhead and collisions that can present the network during the node lifetime.

4 Conclusions

In this paper the use of cooperating nodes which form groups has been proposed as a solution to decrease the number of communications in VANETs under dense traffic conditions when the overhead of transmitted data causes a considerable drop in communication quality. In particular, a complete description of the total lyfe cycle for group management in VANETs is provided, which includes differentiation among possible vehicle states: from the initial state when it does not belong to any group, to the choice of an existent group to join it, the creation of a new group, and the end of a group. This paper also shows how to proceed with group communications. A complete analysis have been done through simulations using the open source traffic simulator SUMO and network simulator NS-2. Such simulations allow the analysis of the operations at each stage, of the reduction in communications, and of the optimal threshold values. A more detailed analysis of the schemes is not displayed for lack of space.

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Scrum in Research

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Abstract. The article is focused on research management and cooperation within the research team and between the research team and enterprise (industrial or commercial) partners. It is a kind of meta-research (research on a research method). Roots of some problems of the current scientific research can be seen in a lot of isolation that still endures – both personal isolation of the individual scientists, and isolation of the academic world from the industrial/commercial one and vice versa that makes the scientific research applied practically impossible –, and in bad time and/or resource management. A lot of research activities are conducted by researchers itself who are excellent professionals in the area of investigation, however the communication skills or leadership is often lacking. It makes conducting research as cooperation of a team at least inefficient or unmanageable. The article focuses on Scrum method that is popular as a product oriented management method in software development. It comments Scrum – strictly team based activity, rigid but informal – as suitable candidate for management of some types of scientific research. A special attention is devoted to the aspect of iterative incremental deliveries that enable an operative planning of suitable ratio between scientific and practical tasks for each iteration (usually from 2 to 4 weeks) allowing monitoring and controlling milestones, industrial or commercial needs together with actual state of the research. A positive side effect is that the potentially idle workers can share task of the 'opposite world', and thus the experience of the scientist can be enriched by the real industrial task cognition, and vice versa. The paper describes a Scrum implementation in the scientific research, and shows some practical findings. A community web site *www.scruminresearch.org* loosely grouping people and teams applying Scrum in research is proposed as a conclusion. Such web site can help with sharing information, tips and tricks and could allow collaboration of research teams on tuning Scrum in research.

Keywords: Scrum, Scrum in research, research methods, applied research, *www.scruminresearch.org*.

1 Introduction

First impulse for initiating *Scrum in Research* activity was brought by an internal analysis of research activities of the author, focused on research methods and organization with goal to be able to widen academic–enterprise cooperation. Result of the

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analysis has pointed out vague research management that disheartens enterprise partners to deepen cooperation with academic sector.

Discussions with enterprise partners confirmed that having evidence that each research activity is able to deliver mutually agreed outputs in defined limits (typically on time and within an approved budget) would significantly help to increase the number of academic–enterprise cooperative activities.

Proposal to organize research combined with an enterprise activity as a *project* was the outcome. It allows introducing project management for controlling such cooperation, which can be based on a firm project charter, with project plan and underlying triple-constraint principle and controlled change management. I.e. project cost, timing and scope are under a control. This kind of contractual relationship and transparent control makes cooperation with academic institution more trustable for the enterprise partners. In order to have not only controlled cooperation, but even compatible with the enterprise, one of the standard project management methods seems to be the natural choice. For that reason, next step after finding bottleneck of cooperation, were two feasibility studies analyzing an employment of PRINCE 2 [1] and PMI [2] methods. Both analyses indicate high probability of significant problems during project preparation and planning. Research is a discipline working with a lot of unknowns, and lot of hardly predictable or unpredictable factors, that limit use of classical project management. Last, but not least argument against such steering is psychological – researchers, scientists and visionaries needs to feel some freedom, to be relaxed to be able to fully concentrate and explore all possible corners of researched space, and all alternative approaches potentially leading to a coveted result.

These opposing needs were discussed across the workplaces, academic and enterprise ones, together and separately. These discussions led to move the focus on agile methods. Together with the enterprise partners, Scrum [3] has been chosen as a suitable approach for steering the academic-enterprise cooperation. It allows having a charter with agreement on vision, timing and budgeting and brings a transparent way of research progress monitoring and steering. There were two main reasons for selecting Scrum from all agile approaches. It is (i) exact and very strict process of steering, providing freedom for doing the research. On one hand, researchers can use appropriate research methods and approaches, according to their needs, and they are not bothered by superfluous administration or bureaucracy. On the other hand, the process strictness helps also, because project leaders and team members do not form the planning and preparatory processes, do not look for its optimal time boxes, etc, as being simply defined by Scrum. The second reason is again (ii) a compatibility with the enterprise environment. Scum, step by step, has penetrated the enterprise environment and is used for conducting of some kind of projects or product developments.

Described activity is not first use of an agile approach [4] or Scrum for research management [5, 6], but this initiative is distinctive in focus on cross-institutional cooperation. One of long-term goals of the author is helping to bridge the gaps between academic and enterprise (industrial, commercial, ...) worlds. *Scrum in Research* shows how to improve and professionalize this kind of cooperation. Two highlighted side-effects of using Scrum are better management of expectations leading to better satisfaction of both sides, and significantly better sharing the academic and enterprise problem domains.

2 Scrum and Story Points

What is Scrum? Scrum is a method of product development management and work organization. It can be seen as a project management method. Scrum is definitely suitable for conducting a team developing a product. It is a way of continual interaction with requestor during *his/her* product development, and a way of communication in the team. Scrum is a tool for continuous improvement of used methods. It is exactly and strictly determined process.

What is not Scrum? It is not development method, nor software development method. Scrum does not reject professionalism like modelling, creating documentation, etc. It is not a modifiable process framework. Scrum in not an anarchy.

What are Scrum characteristics? It is heavily oriented on business (requestor) and product. Team activity is monitored and coordinated on daily base (requestor can, team members have to). Scrum is iterative. The iteration is called *sprint*, and has fixed time-box (usually 2–4 weeks). Each sprint delivers a product increment that is *done*, i.e. in production quality, and accepted by the requestor. Scrum is agile, i.e. disciplined, focused on heart of the matter, not doing useless things. Everything in Scrum is time-boxed.

Scrum describes vision, fixes a frame (usually budget and time) and delivers the vision step-by-step, from the most important parts toward the less important ones. It declares *change* as a welcomed event, but has strict change management affecting team only at the beginning of each sprint (typically one day per two weeks). It woks with prioritized lists, called backlogs, that can be seen as lists of requirements and/or tasks. Fig. 1 depicts basis of the Scrum process in UML [7]. It is not standard Scrum description, and has been used for meta-research of *Scrum in Research*. Since lot of materials is available, e.g. [3], you – the kind reader – could refer details there.

User stories [8] are often used as a form of product backlog items. It is recommended below not using them violently for research items however. Using relative tory points and planning Poker – a method for estimating size of user stories – is however recommendable even for estimating research activities. It works for free-from items mentioned below as well. Planning Poker uses playing cards with modified Fibonacci numbers. Team select one product backlog item with known size as a reference and assign one of the numbers to this reference. Then each team member votes for relative size of each product backlog item related to the reference. An agreement is found across the team by a defined process (that provokes analytical thinking in case of initial disagreement). The backlog is then relatively sized (estimated) and each team member participates on the estimation. Relative estimation is more natural for human thinking than absolute one. Team velocity is measured during sprinting (relative story points per sprint). It brings clear picture about feasibility of delivering selected product backlog within defined limits.

Scrum is a management process, and use of the research (or development) methods is not limited. The methods should be defined for each sprint in Sprint Planning 2. This activity assigns tasks for each selected product backlog item, leading towards completing the item. It brings the desired freedom for researchers. The requestor can modify the ratio between research and engineering, according to his plan, deadlines and actual needs. It helps to manage expectations and prevents unwanted surprises.

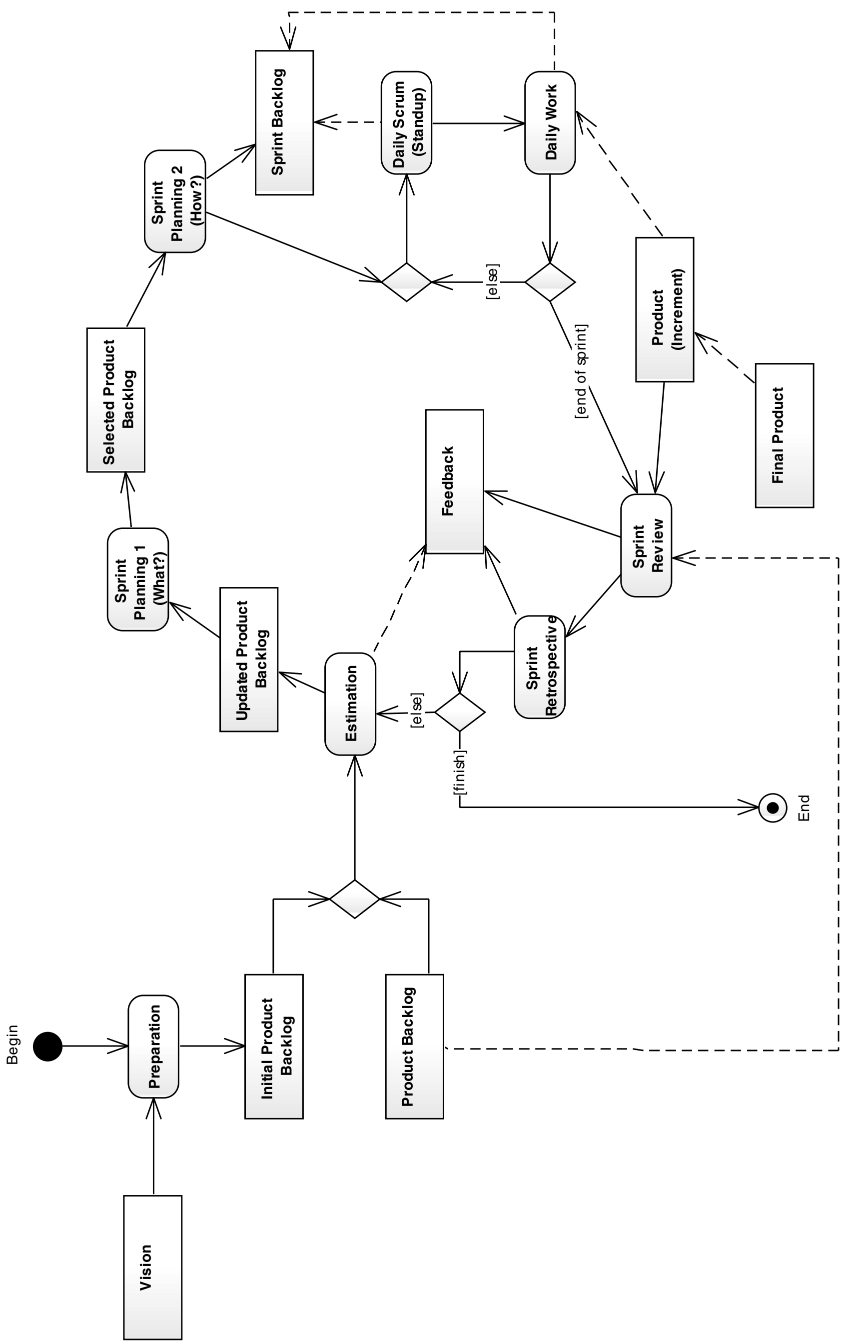

Fig. 1. Scrum process

If for example the research of some part rounds in circles, the requestor (sponsor) see it in right time and can decide whether to continue with the same goals in subsequent sprint, or can accept a workaround for this part of the vision, reprioritize or modify the backlog and focus on less risky parts. This iterative approach and Scrum change management was one of arguments for selecting Scrum for managing such kind of collaboration.

3 Case Study

First possible project allowing a practical use of the outcomes of the aforementioned investigation has been a research-application project focusing on improving quality of addresses' data quality in a large enterprise CRM (Customer Relationship Management) system. The business goals of the project were simple: (i) exclude management of customer addresses from current systems (around twenty), build one centralized module with database and user interface, and modify the environment to be an integrated whole; and (ii) improve data quality by using of an external register of addresses owned and maintained by a state controlled authority. The original databases and archives containing addresses were business critical, and under a strict legal restrictions. Therefore a lot of problems with testing, data anonymization, time-boxes for data migration, etc have emerged. Moreover, it was necessary to design appropriate business processes for maintaining existing addresses (e.g. reaction on introduction of street names in an existing village). It was decided to perform some activities connected to the project by a research team, and the research part of the project was extended by meta-research focused on piloting new cooperation model based on Scrum. The approach, mainly issues and recommendations of this pilot project are commented in the following paragraph. The pilot project has been evaluated as successful case improving quality of academic-enterprise cooperation.

4 Pilot Project Approach – Issues and Recommendations

First issue to be solved was contracting. As a solution, the principles of standard project management and Scrum were combined. The cooperation was confirmed by project charter defining standard conditions, project budget and timing. Instead of precise scope definition, the vision was described, including high level definition of outputs. This was enriched by description of Scrum driven work. This contract for research team involvement was called *vision statement* to differentiate form standard project charters. **Recommendations**: do it, with maximal focus on pithy description of the vision. This initiating activity helps among others with putting both sides in a same mood for reaching the *same* goal.

The output of research team was a part of feasibility study in this project. It is not typical Scrum product however a research report or article is common output of research. The project faced two challenges regarding output type. How to slice the task into product and sprint backlogs, and how to measure the outputs (Is it *done*? Is it in *production* quality?) The problem can be sliced according to feasibility study structure (e.g. static model, dynamic model, rules, ...), or according to logical areas (per affected systems, business domains, migration steps, etc). The research team tried to slice product backlog items according to feasibility study structure, and tasks in sprint backlog – for each product backlog item – according to the logical areas. This decomposition model naturally does not work – it is not possible to e.g. finish static model of a problem, and postpone dynamic model as a whole to a subsequent iteration. The team twisted the 'cutting axles' from next sprint: slice product backlog according to logical areas, and take study structure into consideration in product backlog item decomposing into sprint backlog tasks. It worked better, but was not good for e.g. research report parts 'Introduction' or 'Conclusion'. **Recommendations**: do not use user-stories, use-cases or other formal structures common in software development for describing research items, at least where it is not natural. Listen to your feelings. Free-form 'notes' (e.g. nodes of PBS – product breakdown structure) work well. Use mixed model of slicing. Basic approach is: use logical groups' axis for product backlog items, and output structure axis for sprint backlog tasks. In case of decomposing logically coherent parts of research report, you should consider twist the 'cutting axles'. In case of doubts, use the basic approach, which usually works well. Important rule: product and sprint backlogs are only temporary structures helping organize you and your colleagues. It is important to have a clear and appropriately grained list, accepted by whole team, and all other rules can be broken indeed (pragma above dogma). The project has not found any automated control of production quality issue, and has recommended having a reviewer on-site internally deciding done / not done. The outputs then should be shared with requestor ahead of review meeting schedule (immediately at the best), to give him/her time to read the materials and think of the content.

It can be complicated to match research and engineering task sizes for estimation and measuring team velocity. **Recommendations**: Avoid of violent matching, use two references and two-dimensional vector for velocity. After three or four sprints, where team velocity should stabilize, the coefficient for unifying velocity into scalar value can be found. It is not accurate (velocity never fully stabilize, and the ratio between research and engineering tasks usually varies), but for research management it is acceptable – at least it was acceptable in the pilot project.

An open issue of *Scrum in research*, but probably Scrum in general, is waiting for inputs. If there is a product backlog item in a two week long sprint, and solving of its sprint backlog task requires an external input which delivery exceeds two weeks (i.e. sprint duration), it causes problem. In case of one or two tasks, it is manageable, but in case of higher number, the sprint is endangered. This issue was not fully solved by the project. **Recommendations**: use prototyping and/or tasks with preliminary studies of researched areas, and think somehow beforehand about dependencies and external inputs. Proofs of concept – called *spikes* in Scrum – help. Be aware of risk of not identifying the inputs in time. Focus on this issue during contracting, mention it in project charter / vision statement, as a part of expectations management.

Scrum has three roles – Product Owner (can be seen as sponsor), Scrum Master (can be seen as project manager or leader, process guard and process coach), and Team Member. **Recommendations**: Any person cannot be in more than one of these roles. Invest in training of Product Owners and Scrum Masters to have real professionals. It helps. Subjective impression: Product Owner must be from the enterprise, and Scrum Master should be from the enterprise as well, or it can be neutral third party professional Scrum Master.

5 www.scruminresearch.org

People involved in *Scrum in Research* activity (many thanks to them!) have recommended building a community web site loosely grouping people and teams applying Scrum in research. It can help with sharing information, tips and tricks and could allow collaboration of research teams on tuning Scrum in research, or deriving a modified Scrum for research. One of the conclusions is therefore a proposal to build *www.scruminresearch.org*.

6 Outcomes and Contributions

Contributions of the presented meta-research activity can be summarized in the following list of outcomes:

1. A bottleneck in research management frequently discouraging academic-enterprise cooperation has been recognized.
2. Need of project management has been identified, however the standard project management approaches have been found as not fully suitable.
3. Scrum has been selected as a mutually agreed approach by both academic and enterprise representatives. It is suitable for some kinds of projects combining academic/scientific research and applied engineering within a product development.
4. The pilot enterprise project including academic research, conducted according to Scrum, has verified theoretical outcomes and has confirmed that *Scrum in Research* makes the academic-enterprise cooperation more trustable, controlled and thus attractive for enterprises.
5. Scrum introduces different communication between academic and enterprise parts of team that results in better sharing the academic and enterprise problem domains. The positive side effect is that the potentially idle workers can share task of the 'opposite world', and thus the experience of the scientist is enriched by the real industrial task cognition, and vice versa.
6. The pilot project has shown possibility of velocity measurement by a two-dimensional vector measuring academic and enterprise velocities. It helps to avoid of violent matching of research and engineering task sizes at the project start.
7. *www.scruminresearch.org*

7 Conclusion

The *Scrum in Research* has shown how to make academic-enterprise cooperation more attractive for enterprises by introducing a transparent way of research management.

Scrum is suitable method for steering some kinds of projects combining academic/scientific research and applied engineering within a product development. Besides the controlled research organization, it brings better management of expectations leading to better satisfaction of both academic and enterprise sides, and significantly better sharing the academic and enterprise problem domains.

Simultaneously to publishing this article, a community web site *www.scruminresearch.org* is being built. Goal of this site is loosely group people and teams applying Scrum in research.

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Towards a Framework for the Development of CSCW Systems

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Abstract. This paper proposes a conceptual and technological framework for the improvement of the development processes and the quality of collaborative systems, starting from a previous study of the most notable lacks identified in the field of CSCW regarding implementation issues, and the analysis of all the inherent aspects of organizational contexts such as internal structures, resources management or workflow definitions.

Keywords: Groupware Applications, Reusability, Tailorability, Model-Driven Development, Service-Oriented Architecture.

1 Introduction

Although collaborative systems have increased their presence in our lives through the integration of diverse tools, such as instant messaging, shared calendars or popular Web 2.0 technologies, into many different environments [1], the ultimate goal pursued by the CSCW field of study of transforming the work carried out with computers from an individual use to a collective one, still appears as a difficult achievement in a distant future. The effort and costs involved in the development of a groupware application is still very high compared to traditional software [2, 3], although some proposals [4, 5] have provided theoretical and practical guides to simplify these development processes and improve the quality of final products, dealing with not only the technical complexity of such systems, but also the psychological and social aspects identified [6]. However, the problem is far from being completely solved.

New software development paradigms like Model-Driven Development (MDD) or architectures like Service-Oriented Architecture (SOA) provide new valuable tools in regard to the building of CSCW systems [7]. On the one hand, MDD provides a higher degree of abstraction in the development of software and different views for a system, depending on the interest of each user or participant. On the other hand, SOA architectures provide high maintainability, reusability and tailorability due to the inner nature of the Web services in which they are based on. Both technologies allow developers to simplify the development processes, and users to modify and adapt the software environments in which they are immersed when working.

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2 Framework and Case Study

The conceptual framework proposed in this paper, allows to specify any type of CSCW system for any kind of organizational environment such as universities, corporations, governments or hospitals, considering the use of high level of abstraction models and dividing a full system into three independent and complementary subsystems (Figure 1) similar to other works in literature [8, 9, 10]. The system's s*tructure* is defined in terms of *organizations*, *societies*, *groups* and *roles*. The *behaviour* is expressed through g*oals*, *activities* and *tasks*. In the *instrumentation* subsystem, g*roupware applications* and different technological r*esources* are used.

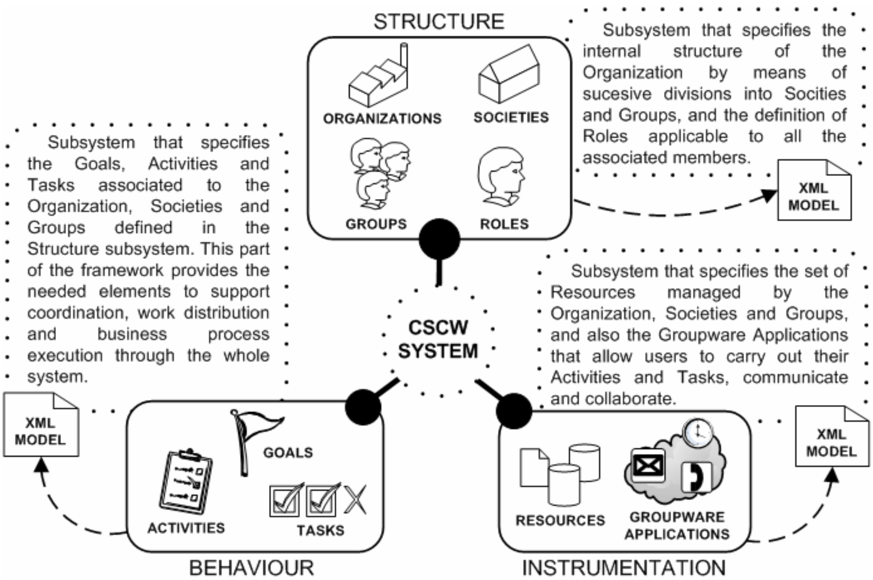

Fig. 1. CSCW Subsystems according to the proposed conceptual framework

Like other environments or specific-purpose libraries for the development of groupware applications [11, 12], our proposal also defines a technological framework that helps simplify the building processes of new CSCW systems, and to ensure high levels of reusability and tailorability in the final implementations, something specially relevant for the specific case of collaborative software, as appointed in several studies [13]. The proposed technology framework provides a Client/Server architecture in which communications between the users are carried out by exposing and invoking distributed Web Services.

The framework additionally provides on-the-fly mechanisms for the analysis, interpretation, compilation and execution of new groupware applications by means of dynamic source code generation tools and internal reflection properties that allow user interfaces and business logic to be altered in real time, just replacing or modifying the XML specification files [14] for the s*tructure*, *behaviour*, and *instrumentation* subsystems (see Figure 1).

We illustrate all these concepts in the case study of health care area. Hospitals are well-defined organizational entities with a clear overall *goal*: provide a good health care system to citizens. Additionally, a hospital can be seen as a more complex structure consisting of several *societies* dedicated to *activities* associated with the different areas of current medicine: Cardiology, Oncology, Neurology, etc. At the same time, each of these *societies* can be divided into different *groups*, composed of individuals with specific *roles* such as doctors or nurses, who perform more concrete *tasks* such as diagnosis or surgery interventions. Thus, we can realize how a common organizational environment as a hospital can be described and modeled by elements defined in the subsystems of *structure* and *behaviour* of the proposed conceptual framework.

On the other hand, the *instrumentation* subsystem provides the *resources* and *groupware* applications needed for the execution of the *tasks* assigned to each *group*. For instance, a *group* composed of three doctors involved in diagnostics *tasks*, may need to check a patient's medical history at a given moment from distant locations of a hospital. An initial *groupware* application for this simple purpose could be made up of a documentation viewer and a video-conference component, which would be appropriate enough for this kind of context. However, if one of the doctors would decide to replace the video-conference component with instant messaging due to privacy issues, he would only have to replace the *instrumentation* XML specification (see Figure 1) that he was using with a suitable one, in order to change the user interface and the functions provided by the system without altering the final functionality offered.

Figure 2 shows the explained runtime tailorability features and how all the technologies exposed are used to fulfill the usability and tailorability requirements.

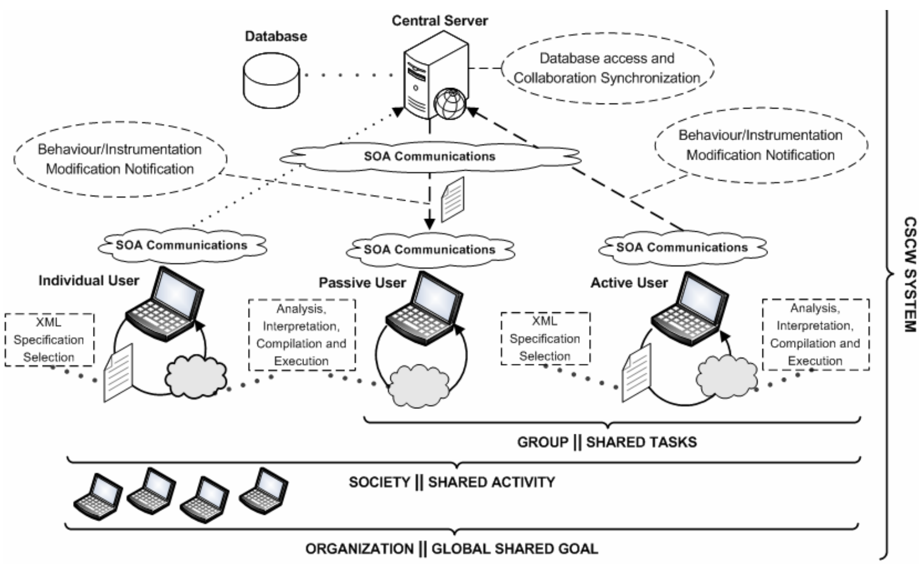

Fig. 2. Runtime tailorability features for groupware applications

3 Conclusions and Future Work

This article has established the principles of a new development framework by means of a conceptual model and a technological architecture that cover all aspects and fundamentals involved in CSCW systems development processes, including groupware applications, taking into account the characteristics of organizational internal structures or the development of business processes, and facilitating the proper levels of maintainability, reusability and tailorability for this kind of software.

The work to be performed in the immediate future will focus on formalizing the entire conceptual framework by means of ontologies and meta-models, developing a visual modeling language and devising a suitable development methodology for CSCW systems based on the exposed framework.

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Part II

Cooperative Design

An Anthropo-Based Study of Industrial Design Cooperative Practices Using "Mediating Objects"

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Abstract. This paper presents a two months in situ case study analyzing the characteristics of designers' cooperative work through the use of "mediating objects".We suggest that the consideration of real and evolutionary practices and everyday complementary work tools helps to understand the various cooperative modalities between co-workers and offers good clues for the development of cooperative support systems.

Keywords: Cooperative design analysis, study of design tools as cooperative work support, evolution of industrial design practices.

1 Introduction

Providing designers with more intuitive and user-friendly cooperative design tools, or more accurate sketching support systems to support preliminary design, are some of the challenges faced by CSCW (Computer Supported Cooperative Work) and SBIM (Sketch-based Interface for Modeling) researchers. Remote cooperative design tasks occasion several challengeswe all (researchers, designers, managers,…) try to deal with, such as multiplication of large projects introducing relocated skills, increase of exchanged information volume and need for specific competences to work together, even if there aredifferent toolsusages and operating methods.

Most scientific papers facing these difficulties share the same comparative argumentation principle. On the one hand, traditional design tools such as free-hand sketches are said to stay the most powerful support to preliminary design phases but do not easily meet the constraints of remote cooperativedesign tasks [1; 2 and 3]. On the other hand, it is often argued that CAD tools fail to support ideation [4; 5]but ease long-distance communication and documents exchanges.

We have to record that,with the exception of few innovative design studios, still exploited in specific exploratory contexts [6], designers go on using their traditional "maladjusted" tools(sketches or CAD tools) during their cooperative tasks. They rarely take advantage of alternative solutions issued from research(supposed to constitute a better support to preliminary distant design phases) and rather deal with their every-day tools' inadequacies.

To solve what appears to be a paradox, we suggest studying the cooperative design practices with another standpoint. This standpoint combines an anthropo-based

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approach of real industrial practices and the study of the "mediating objects".The hope is that the better understanding of these "basic" cooperative characteristics (that is, working *in presence* of others using *every-day*complementary tools) will lead to the definition of more coherent and effective remote cooperative support systems, closer to real practices and their current evolutions.

2 Theoretical Framework

Threetheories structure our research. First the anthropo-based approach addresses the real practices and replaces the human being at the core of the design research.We secondly focus on "mediating objects" (extending the traditional design tools to their linked external representations) through the application of the instrumental theory [7; 8]. Finally, we suggest, as third theoretical basis, to undo the common comparative approach of cooperative tasks using "sketch *or* CAD tools". We argue that this study of "mediating objects" complementarities is in benefit ofcooperative tools' improvements.

2.1 The "Anthropo-Based" Standpoint

Comprehensive Ergonomics and the activity theory (based on Leont'ev's and Vygotsky's cultural-historical psychology) provide sound methods to conduct empirical *in situ* studies adopting a multi-disciplinary point of view to understand the actors of a professional activity such as cooperative design. Without being restricted to the single and obvious "end-user" of an application, this "anthropo-based" approach broadens the study to allen closed profiles and enables researchers to definethe real and prescribed tasks, the strategies, the required competences, ...that could impact the cooperative modalities. These disciplines are on top of that well adapted to the logic of business, reliability, productivity and competition inherent to cooperative design environments [9].

These field researches are conceptually close to Case Study research but present specific characteristics. For instance,researchers selectively code data linked torelevant working situationsor professional experiences (such as every-day working tasks, tasks' repartition and cooperation inside a team, time or stress management,…). Sociological information (such as leadership, personal creativity or strategic positioning inside the team,…)is also considered as external qualitative data but stays less decisive. As proposed by many case studies' theorists, various methods can be adopted for gathering and triangulating data as well as analyzing it through coding [10]. Considering new results, Ergonomics allow these methods to evolve and to adjust during time. Research questions and hypothesis should nevertheless preferably be constructed on previous literature(conflicting and similar) and stay more flexible than in hypothetico-deductive theories.

The observations, interviews and analysis we conducted helped us to take into consideration two major elements. First the impact of new technologies: since CAD tools are unavoidable in every-day design practices, we should evaluate how designers are able to adapt their cooperative work and competences in regard to what constituted their previous habits. Respectively, it is also interesting to investigate how designers adapt their tools to the cooperative context. The introduction of new technologies can constitute a positive dynamic on condition of correct appropriation and compatibility with designer's cognitive modes [11; 12; 13]. Secondly there is a need to put forward the context [14; 15], and we would even emphasize the multiplicity of elements to be considered by putting it into the plural: working contexts, cooperating contexts, physical environments or project types.

2.2 The Focus On "Mediating Objects"

Among all the possible approaches of human cooperation, the theoretical framework of instrumental theory suggests that any type of activity (and, by extension, cooperative ones) is mediated through the use of artifacts [16].This theory, developed by Rabardel and Vérillon [7] in Piaget's theories tradition, introduces the notion of instrument as the combination of an artifact (material, symbolic, cognitive, or semiotic) and one or more associated schemes. The artifact can be commonly defined as the physical part of a tool. The scheme, on the other hand, is the result of "a construction specific to the subject, or through the appropriation of pre-existing social schemes" [17]. The example usually given is the hammering scheme, ordinarily associated with a hammer, but which could in case of necessity be adapted to a shifting spanner. Both sides of the instrumental entity (the artifact and its utilization scheme(s)) act together as mediators between the subject and the object of his activity (fig 1) [17].

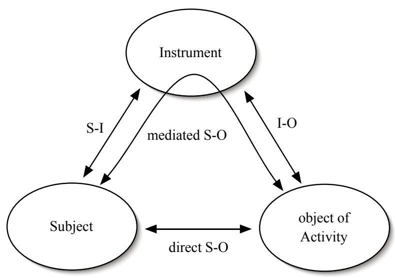

Fig. 1. The IAS Model, "Instrumented Activity Situation", and its three poles: the subject (S), the object of activity (O), and the mediating instrument (i.e. an artifact and an utilization scheme, I). The arrows represent the several ways the mediation can occur.

As our interest is to put forward the new characteristics of designers' cooperative work through the use, the sequence of use and the modifications of "objects" inputs, we will define here (i) the "object of the activity" as the "act of designing together";(ii) the "subject" as a group of actors involved into cooperative activities and (iii)the "artifact" part of an instrument as a "mediating object". Extending this way the "artifact" term, we add to the physical tool (the pen; the computer, the prototyping machine, ...)its linked external representation (respectively the free-hand sketch; the 3D model or print, the physical model, ...),in order avoid the general misunderstanding that can occur between "tool" and "external representation".

2.3 The Study of Complementarities

As we underlined before, the established digital design tools inevitably impact cooperative practices *and vice-versa*. The instruments evolved and conjointly the cooperative modalities existing between design actors. What could be seen as a paradox - the use of tools that could seem inappropriate - is rather considered here as the human capacity to adapt to a constraining environment, or to deviate the tools from their original uses.

Our hypothesis is that several schemes of objects' use co-exist, and that users deviate them when necessary, depending on the cooperative environment. As figure 2 shows, there wouldn't be two opposite profiles of designers working in dichotomous worlds and using dichotomous schemes, but alternatively a flexible mid-way profile taking advantage of the objects' diversities and complementarities (in regard to the appearing constraints and the cooperative contexts).

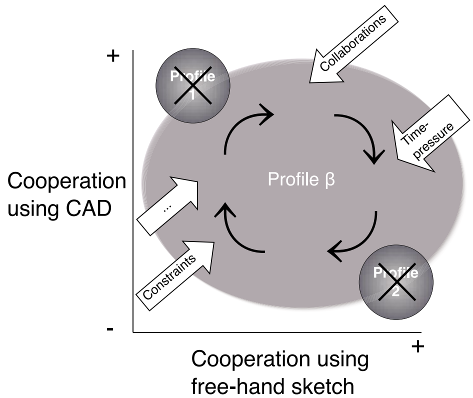

Fig. 2. The undo of the "dichotomous approach" in benefit of the study of complementarities

This three-phased proposition structures our study of cooperative design evolution inside a particular field, as presented next.

3 Case Study

A two months case study afford us to observe *in situ* a design team (6 designers, 4 draughtsmen) who was in charge of industrial projects in the field of contemporary heating devices.

3.1 Methodology

One observer was allowed to stay 8 hours a day inside the open-space office to interview the subjects and capture (recording or filming) every step of their current designs as well as the cooperative activities (inside the team, between members of the team and external members such as the CEO or prototypists).

This *in situ* intervention presents several advantages:

(i) it avoids the limitations of a non-realistic lab situation by providing the essential contextual elements;
(ii) it enables a qualitative approach of the fine-grained details of the cooperative process that would be ignored in a more quantitative study but still constitute a keystone of the whole project's rationale;

(iii) it enables a global overview of several projects presenting diverse states of progression (formal, technical and productive), providing a relatively complete view of design processes and methods without following a 2 or 3 years complete project.

On top of the interviews (based on a semi-directive and retrospective analysis protocol) we selected 5 different products as a basis of study. These projects were selected for their representativeness of the process evolution and the use of mediating objects, for their cooperative modalities and the variety of their design rationale (one project started a few days earlier; one project in design phase; another in pre-production phase; product already on the market but needing some adjustments and a new version of a pre-existing range of products).

3.2 Data Analysis

The data gained (interviews based on retrospective analysis as well as *in situ* observations) has been selectively coded, as recommended in [18]. This coding of meaningful events enable the analystto make astep-by-step “track” of cooperative context given the appearing constraints and external representations’ evolution (graphic, numeric and volumetric).The coding applies to distinct unit of designing actions. One action is defined as soon as the mediating object changes, a new type of cooperation occurs or each time a shift in design process clearly happens (shift from one support to another, one piece to another, one constraint to another,...).

This coding scheme is exploited to construct the timelines of the 5 selected projects (see fig.3)[1]. The X-axis represents the project evolution in time, and represents different time scales since the data proceed from interviews’ or observations’ coding. The Y-axis sums up the various variables of the coding scheme, which are the use of one specific kind of tool (free-hand sketch; CAD tool or prototype) in parallel with the modality of cooperation (with whom, for doing what).

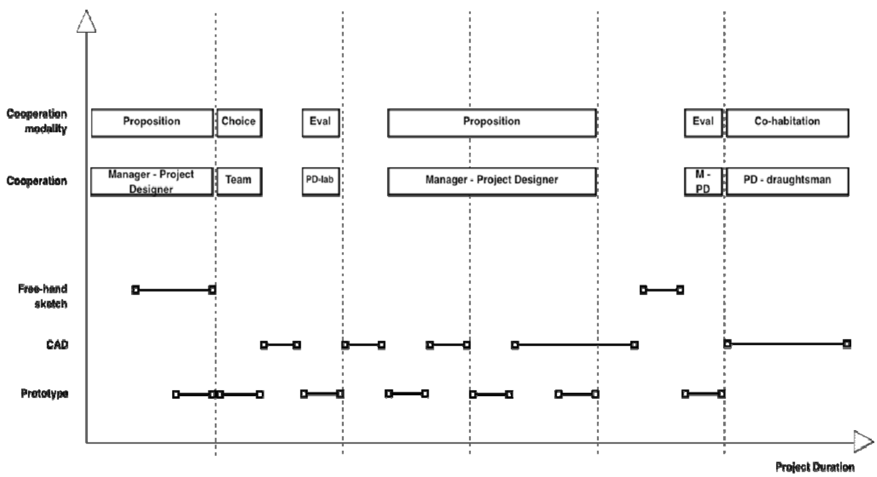

Fig. 3. An example of timeline with some variables (non exhaustive listing)

[1] This timeline’s methodology is derived and extended from Darses’ and al validated work [19].

The various stages of the design process are graphically structured so their analysis reveals (i) on a vertical axis, the occurrences of their concurrent characteristics and (ii) on an horizontal axis, their temporal importance inside the process (by means of sticks' length).

4 Results

Our results underline that

(i) the evolution of the design tools' use (new or traditional) greatly impacts the cooperative work inside or outside the team and leads to a new kind of cooperation between designers and "designers-draughtsmen"(whose activities are part and parcel of a revalued design activity);
(ii) several modalities of cooperative work co-exist and co-evolve during a single project. These modalities (co-design, co-habitation, cooperation between various professions, distributed design, ...) depend on work contexts, experience level in design or CAD field, spatial location and hierarchy.

4.1 New Practices - New Cooperation

CAD tools are nowadays completely integrated in industrial designers' practices, sometimes since preliminary design. Cooperative modalities have been greatly impacted by this shift in design tools' use.

Indeed, a new kind of cooperative work appears between designers and "designers-draughtsmen". As already underlined in [13], draughtsmen are no longer performers of blue-prints or production plans and subordinates to designers, but take part in the design process since the evolution of task distribution. Our 5 timelines moreover demonstrate that designers nowadays sometimes start designing modeling a 3D rough model instead of using traditional free-hand sketches. On the other hand, draughtsmen receiving this rough model go on with more detailed modeling, sometimes discover design errors (such as pieces'conflicts or production incompatibilities) and suggest solutions through a quick technical sketch[2]. These backs and returns between design tools, all along the design process, are symptomatic of an effective usage of the tools given their complementarities, and tend to support our "non-dichotomy" hypothesis.

On top of that, this indistinct use of design tools whatever the profession is typical of a deep share ofcompetences andreference system. The verbatim suggests that co-workers are aware of this phenomenon and fit their cooperative modalities to ease each other procedures. For instance, designers adapt their representations (in content and in aspect) to communicate with draughtsmen that, on the other hand, learn how to interpret in essence the drawings or rough 3D models they receive, presenting heating devices technological details.

[2] There is consequently a need to distinguish "rough" sketches and "rough" CAD models or representations (that stay ambiguous and support ideation), from "technical" sketches and "detailed" CAD models that focus on a more specific sub-problem. The "rough" CAD models or representations are characterized by simple 3D primitive forms very quickly created without taking care of real dimensions and proportions. As rough sketches, they support the rapid evaluation of more formal or functional ideas.

We also observed that involved partners always tend to cooperate using the external representation the closer to their shared system of reference. For instance, two designers will cooperate on a drawing (fig 4);a designer and a draughtsman will point out on a screen; designers and prototypists will work on prototypes. Finally, our observations proved that design actors sometimes transform their mediating objects to fit the cooperative situation (see in fig. 5 an example of catachresis phenomenon: the prototype is diverted from its primary goal to be used as a drawing support).

Fig. 4 and 5. An example of cooperation between two designers (fig. 4) and the catachresis phenomenon (fig 5)

4.2 Modalities of Cooperative Work

The projects' timelines and the *in situ* observations suggest that several modalities of cooperative work co-exist and evolve during a project. These modalities are impacted, in this particular situation, by geographic localization and actors' expertise levels in the design field or use of CAD tools.

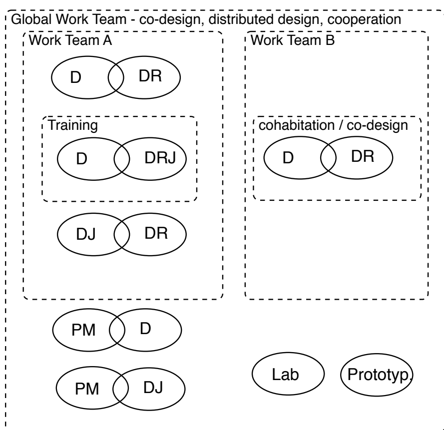

Fig. 6. Synthesis of the team's cooperative modalities. D = Senior Designer; DJ = Junior Designer; DR := senior draughtsman; DRJ = junior draughtsman and PM = Projects Manager

The figure 6 briefly presents the geographic localization of the design team, the common binomial of co-workers with their respective specificities as well as the co-operative modalities we have observed. The global team is split in two open-spaces: the first work-team (A) is composed by two senior designers; one junior designer; two senior draughtsmen and one junior, while the work-team (B), on the other hand, is composed by one senior designer and one senior draughtsman. In other offices stand the Projects Manager, the fire laboratory team and the prototypists.

Both teams cooperate everyday, and inside their cooperative work we find:

- Co-design and distributed design [as defined in 20], where two partners share the same expertise levels (respectively in heating design field and CAD tools) and effectively cooperate during the whole design process (for instance between D and DR, team A). Allocation of tasks and short briefings are enough to make them match their ideas and work in an efficient way;
- Training, where a senior design, with good competences in 3D modeling, teaches to a junior draughtsman how to deal with the specific technologies of heating devices (D and DRJ in team A);
- Training again, but in a different way, when a junior designer asks for some advices to a senior draughtsman which has become very competent in the field of heating devices' development (DJ and DR, team A);
- Co-habitation, finally, between senior designer and draughtsman that both are experts in 3D modeling and "share" a modeling task on a single file. They have to totally re-organize their way to cooperate to work together, from distant computers, on the same 3D object (D and DR, team B).

Outside the team, other types of cooperative work occur between designers/ draughtsmen and the lab team or the prototypists. They constantly have to synchronize to adapt themselves to others point of view, given their various competences. Finally, the Project Manager, himself designer, shows different ways of cooperating with a designer or a draughtsman. Being less available, he shares very quickly with the team always using the most effective cooperative interface: quick sketches with designers; more technical drawings, annotations on prints or interaction on screen (pointing, gestures) with draughtsman.

5 Conclusion and Perspectives

This research, considering its unavoidable sample's limitations, provides interesting-clues for the development of cooperative interfaces that should stay closer to real practices and their evolution.

Indeed, we could resume our findings as follow:

- First, there is a need not to only focus on "obvious" cooperative and end-user actors, but to widen our field studies to all practitioners that impact in a certain way the cooperation. There aren't dichotomous profiles but flexible ones, actors adapting their work habits to the contexts. CSCW tools should consequently stay adaptable to several users that could modify and appropriate the interface depending on their respective needs;

- Second, we should take practices' evolutions into account and constantly measure, *in situ*, the real work habits. Ergonomics provide researchers sound methods to analyze different profiles and various contexts in order to dedicate efficient specifications. The interface should stay flexible and adaptable even after integration and testing by various users;
- Third, there is a need to consider various levels of experience and expertise and to evaluate their impacts on cooperation. Even if this consideration could seem hardly exploitable for designing support tools, it still reveals the way contemporary designers nowadays deal with CAD tools, also as a cooperative support. Again, as work habits quickly evolve these decades, there is a need to constantly compound to designers' procedures;
- Finally, instead of focusing exclusively on one cooperative channel (i.e. asynchronous data exchanges; virtual communication through avatars,…), we suggest to consider all tools involved in every-day work habits and to study their complementary uses. Work actors constantly deviate and "misuse" them, adapt them to the constraints of their cooperative tasks, and enlarge the common boarders of what we usually call the "preliminary design phase" and its "traditional tools". These adaptations and the constant use of multi-modal channels could constitute good clues for effective specifications.

We believe that all these facts entertain a tremendous amount of potentialities for the development of cooperative support systems. In the field of industrial design, there is naturally an urgent need to analyze other teams and other processes before reaching this goal.

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Design for Service-Oriented Collaborative Design and Manufacturing Platform

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Abstract. With the continual improving of agile manufacturing and network manufacturing, service-oriented collaborative design and manufacturing is the manufacturing model of the 21st century. Through the scenario analysis of automobile enterprises, the architecture of service-oriented collaborative design and manufacturing system is proposed. The implementation framework based on SOA and MDA is developed. The model driven processes for the development of service-oriented collaborative design and manufacturing system are described. Finally, the simulation-based framework of performance analysis and optimization is presented which support the performance evaluation of the system in SOA environment.

Keywords: Service-oriented architecture, model driven architecture, collaborative design and manufacturing, performance evaluation.

1 Introduction

With the continual improving of information technology, Agile Manufacturing and Network Manufacturing are becoming more and more popular[1][2]. Following the producer services separates from the manufacturing and it offers the professional services to the produce enterprises, service-oriented collaborative design and manufacturing (SOCDM) is the manufacturing model in the future.

This paper discusses a collaborative design and manufacturing scene of the auto custom. The auto custom enterprise (i.e. PAutocar) needs to cooperate with the design, the manufacturing and the assemble department. Figure 1 describes the business process of PAutocar. After customers submit the order information and special requirements, three departments (financial, inventory, design) check the order. If the order is feasible, the production department and the assembly department finish the order with collaboration in execution [3] [4].

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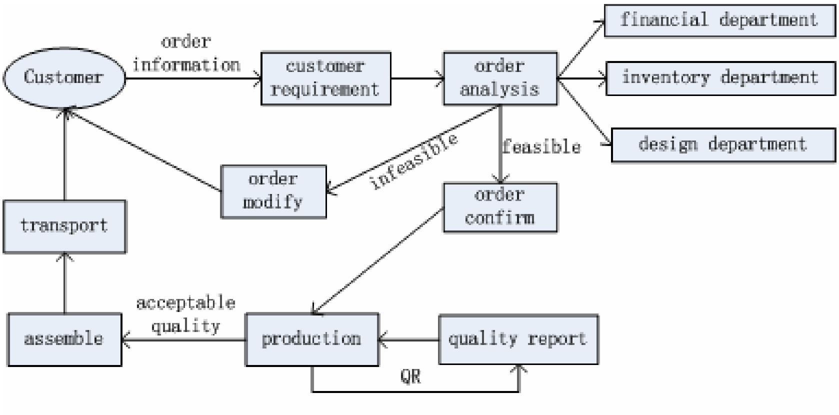

Fig. 1. Collaborative design and manufacturing scene

2 Architecture of Service-Oriented Collaborative Design and Manufacturing System

The architecture of service-oriented collaborative design and manufacturing system (SOCDMS) is shown in Fig. 2. SOCDMS is designed as a distributed system with a three-tier structure. It consists of several clients that provides interface to various users including designers and manufacturers, an application layer that performs functional services for business processes, and a resource layer that maintaining the storage of design and manufacturing data.

- *Client*: Each client has a web service client that interfaced to server side. This enables the users to access the system services to perform collaborative design and manufacturing.

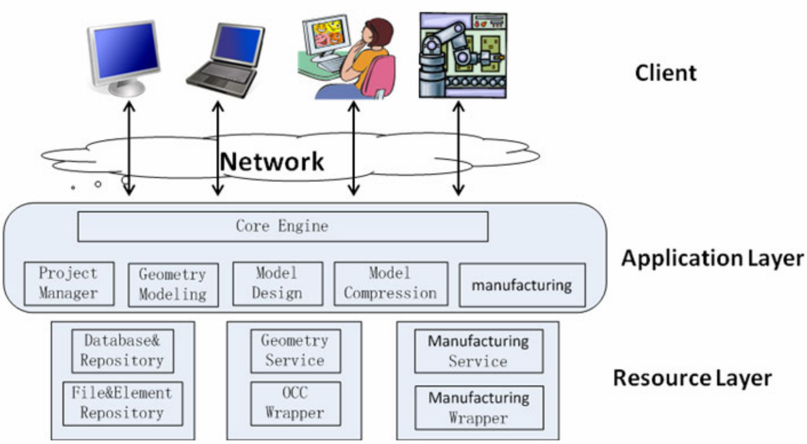

Fig. 2. Architecture of service-oriented collaborative design and manufacturing

- *Application Layer*: Functional services and business logic represent the application layer. The business modules include core engine, project manager, geometry modeling, model design, model compression and manufacturing module [5][6].
- *Resource layer* consists of the database, file repositories, geometry service and manufacturing service. The database holds user's details, projects information and management data. The geometry service module and manufacturing service module carry out the operation.

3 Service-Oriented Collaborative Design and Manufacturing Implementation Framework (SOCDM-IF)

The service-oriented collaborative design and manufacturing implementation framework (SOCDM-IF) is a development and operational architecture under service-oriented computing environment. It provides an integrated design, development and execution environment based on SOA and MDA (see Fig.3). The main components of SOCDM-IF are shown as below.

- *Enterprise Object* refers to the elements involved in collaborative design and manufacturing implementation (CDMI). All the elements defined in CDMI model can be the Enterprise Objects of SOCDM-IF, such as design systems (e.g., CAD, CAE, etc.), business processes, geometry units, or data. They must be wrapped by Service Adapters before their being integrated into SOCDM-IF.
- *Service Adapter* converts the access interface of Enterprise Object into standard service interface. An adapter works as an intermediary between service and Enterprise Object. It models data and functionality presented in Enterprise Object, and exposes a service interface from which the functionality can be accessed.
- *Service Repository* stores models and interface descriptions in a central location that is accessible to Enterprise Objects. A repository permits the searching for models and interface descriptions. It will map identifiers of abstract service with physical addresses.
- *Service Bus* is a standards-based communication layer in a service-oriented architecture (SOA) that enables services to be used across multiple communication protocols. Service Bus provides an intermediation approach which abstracts the interaction details between service consumer and service producer. It simplifies service deployment and management, and promotes service reuse in a heterogeneous environment.
- *Service Infrastructure* is a unified approach to service management that combines the capabilities of Enterprise Service Bus and business process management. Service Infrastructure creates a fabric of services for constructing and deploying new composite business applications. Main functions of Service Infrastructure include service registry, discovery, composition, orchestration, and choreography, service data management, and service lifecycle management.
- *Design and Manufacturing Model* defines the business model of integration at different aspects, i.e., the geometry, manufacturing, data, system, and service

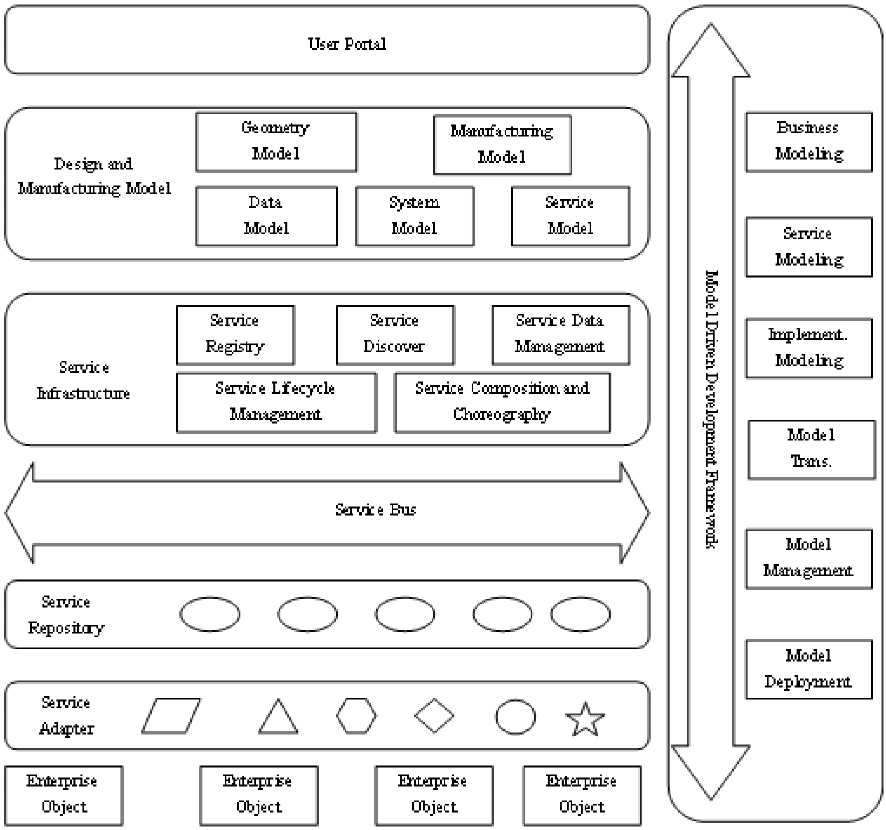

Fig. 3. Service-oriented collaborative design and manufacturing implementation framework

layers. With the integration of the different business models, the model of an actual scenario can be build with high fidelity. Eligible services can be matched, composed and executed through the mapping of Computer Independent Model (CIM) to Platform Independent Model (PIM), and PIM to Platform-Specific Model (PSM).

- *User Portal* is the front end of an integration platform, supporting dynamic workplaces and working environments tailored to a certain purpose. It generates a dynamic and configurable user interface which makes the user access platform functions and back end applications transparently and obtain right information at right time.
- *Model Driven Development Framework* crosses all the levels of SOCDM-IF and provides various MDA tools for the development of SOCDM system. It includes business modeling, service modeling, implementation modeling, and model transformation, management, and deployment.

4 Framework of Performance Analysis and Optimization for SOCDM

As far as the performance analysis approaches, there are mainly three types of methods, i.e., the methods based on model analysis [7], the methods based on data analysis [8][9], and the simulation based methods. The framework of performance analysis and optimization for SOCDM mainly has four layers as below (see Fig.4) [10].

- *Client layer*: Collaborative design and manufacturing processes/services (CDMP/S) is the core of the integration of client enterprise, relation and knowledge stratums. Enterprise stratum describes the enterprise, functions and resources. Relation stratum involves the relationships of a client with other clients which including the time, causal and coordination relationships. And knowledge stratum comprises the exception handling rules, resources scheduling rules, event handling rules, and so on
- *Collaborative design and manufacturing process/service (CDMP/S) layer* builds collaborative design and manufacturing /service model with modeling tools, and stores the models into model Data Base (DB) for process execution or simulation. CDMP/S execution are companying with the service matching and composition

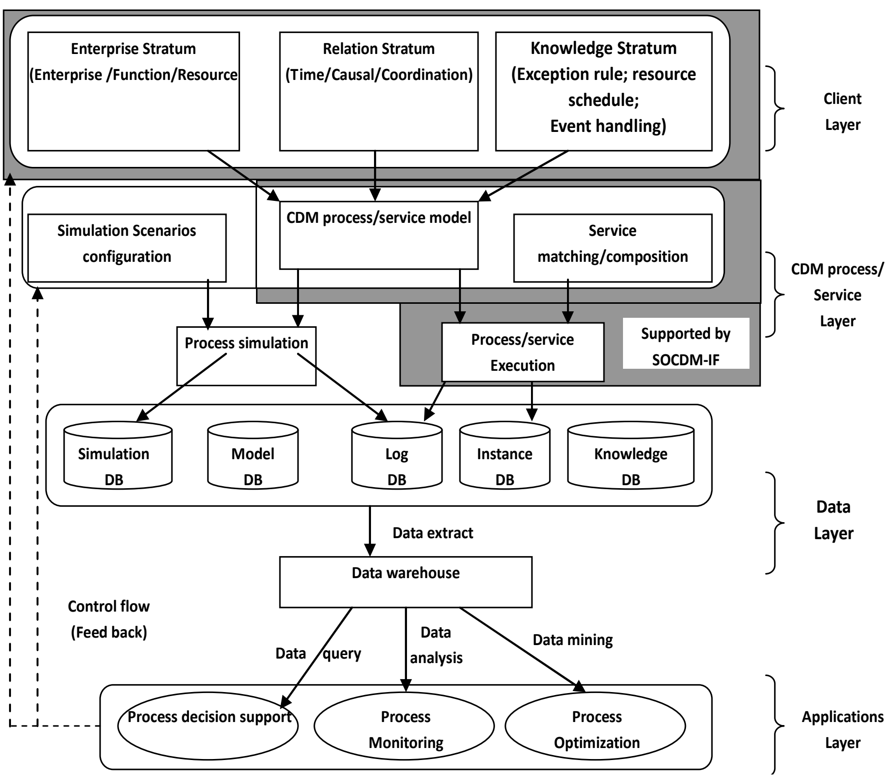

Fig. 4. Framework of performance analysis and optimization for SOCDM

which is supported by SOCDM-IF. Simulation scenarios configuration is complied with the CDMP/S decision making supported by the performance analysis applications and analysts' knowledge.

- *Data Layer* includes model DB, instance DB, log DB, simulation DB, Knowledge DB, and other DB. Execution data and log of CDMP/S generated during process/service executing are stored into the instance DB and logs DB, while simulation data and logs are stored in simulation DB and log DB. All the data are source data for data analysis and data mining. The original data can be extracted by ETL (Extract, Transform, and Load) tools, and stored into the data warehouse.
- *Performance analysis application layer* contains three application systems supporting the process performance monitoring, decision-making, and optimization. The results of the applications are fed back to the enterprise layer and CDMP/S Layer for the adjustment of the enterprise, CDMP/S models, or simulation scenarios reconfiguration.

5 Conclusion and Future Work

Information technology (IT) such as SOA and MDA have significantly influenced the IT and business collaboration of enterprises nowadays. The service-oriented collaborative design and manufacturing (SOCDM) is emerging recently. This paper proposes a MDA and SOA based framework of SOCDM first. Then a performance evaluation of SOCDM is proposed. The combination of MDA, SOA, and performance analysis and optimization (PAO) can enhance the predictability, agility, flexibility, robustness, and measurability of SOCDM and SOCDMS.

MDA gives the opportunity to bring the services definition to a higher level of abstraction. Afterwards, to have the services implemented in a specific platform, a suitable transformation is executed. Through this way, services and SOA can be created decoupled from the lower level application platforms, IT infrastructures, and implementations, opening the way to improve the enterprise integration under service-oriented computing environment.

The simulation-based PAO method with performance analysis framework of SOCDM would be studied further, which will stimulate performance analysis and optimization of SOCDM and improve the integration solution in service-oriented computing environment.

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Cluster Analysis for Classifying Similar Shared Resources in Cooperative Design

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Abstract. It is very important to classify shared resources in collaborative design by scientific method because different kinds of resources become more and more similar while resource classifying level is increased. Cluster analysis is applied for the classification of similar shared resources in this paper. An agglomerate hierarchical clustering algorithm for shared resource classification is presented. Finally a case study for classifying materials is also presented in order to illustrate the application of this method.

Keywords: collaborative design; similar shared resource; cluster analysis.

1 Introduction

With increasingly intense competition of global market, the production paradigm has changed to various-type and limited production. Product development cycles are tightened to the minimum while product and process complexities are constantly increasing. In order to shorten the R&D cycle, design actors are invited to collaborate more and more closely. Collaborative design process gathers actors, information and knowledge sharing, with a high level of activities coordination. During this process, design actors need to search and use various types of shared resources owned by different departments or even enterprises and distributed in different physical locations and heterogeneous platforms. These resources include computing resources, data and shared information (such as products, parts, etc), applications and services, equipment information, software systems, human resources and so on [1, 2]. It is very important to manage shared resources effectively in collaborative design. The scientific and effective classification of shared resources is a foundation of shared resource management and allocation.

Many scholars studied key technologies of shared resource classification [3-5]. According to the requirements of collaborative R&D, we [5] classify resources into product, personnel, equipment, auxiliary tool, design tool, design knowledge and others. These categorizations abstract the common characteristics and behaviors of the resources from various aspects, and classify resources into some collections of objects with the same attributes and operation. Because collaborative design requires for a wide range of shared resources, and different kinds of resources become more and

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more similar while resource classifying level is increased, it is more and more important to classify shared resources by scientific method, especially to implement shared resource classification. But concrete implementation methods and process are not introduced in references mentioned above. During the actual classification process, we should ignore nonessential characteristics of resource and scientifically classify similar shared resources in cooperative departments or enterprises.

Cluster analysis [6] classified the samples or variables according to the degree of closeness. It has been widely used in the areas of statistics and knowledge discovery [7]. In this paper, we are particularly interested in the implementation of shared resource classification. Cluster analysis is used to classify similar shared resources. Some conventions for cluster analysis of shared resources and an agglomerate hierarchical clustering algorithm for shared resource classification is proposed. A case study for classifying materials is presented to illustrate the application of this method.

2 Agglomerate Hierarchical Clustering Algorithm for Classifying Similar Resource Sharing in Cooperative Design

Cluster analysis describes the affinities level of shared resources with the distance and the similarity between the samples. The basic idea is to classify two types which have the smallest differences to a group in accordance with classification functions, then continue to classify groups according to the standards of classification functions until all samples are classified as relatively the most efficient collection of samples. This paper gives the following conventions of shared resource:

Convention 1 Vector of shared resource: Suppose there are n shared resource objects, each object has q real-type measurements, in which p measurements will effectively affect the resources classification. Then select these p measurements to express as a vector $x_i = (x_{i1}, x_{i2}, \cdots, x_{is}, \cdots, x_{ip}),\ 1 \le i \le n$ and name this vector as the vector of i-th shared resource, where x_{is} is s-th real-type measurement and $1 \le s \le p$.

As the similarity measure, Euclidean distance between the shared resource objects is defined as follows:

Convention 2 Suppose there are n shared resource objects, each object has p effective real-type measurements. Vectors of i-th and j-th observation objects respectively are $x_i = (x_{i1}, x_{i2}, \cdots, x_{is}, \cdots, x_{ip})$ and $x_j = (x_{j1}, x_{j2}, \cdots, x_{js}, \cdots, x_{jp})$, where $1 \le i, j \le n$. Then the Euclidean distance between i-th resource object and the j-th resource object is d (i, j), and the formula is as follows:

$$d(i,j) = \sqrt{(x_{i1}-x_{j1})^2 + (x_{i2}-x_{j2})^2 + \cdots (x_{is}-x_{js})^2 \cdots + (x_{ip}-x_{jp})^2} = \sqrt{\sum_{k=1}^{p} (x_{ik}-x_{jk})^2} \quad (1)$$

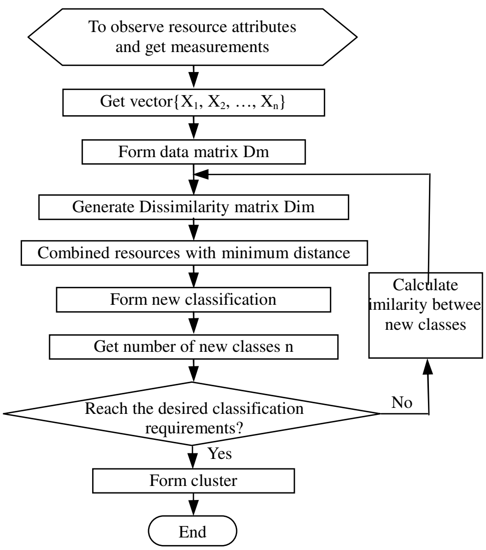
Convention 3 Data matrix of shared resource Dm: Suppose there are n shared resource objects with high similarity, each object has p effective real-type measurements. Then call the n×p-dimensional matrix constituted by the vectors of shared resources as the data matrix of shared resources. The specific matrix structure is as follows:

$$Dm = \begin{bmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1p} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{ip} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{n1} & \cdots & x_{nj} & \cdots & x_{np} \end{bmatrix}, \text{ i=1,2,}\cdots\text{n, j=1,2,}\cdots\text{p}$$

Convention 4 Dissimilarity matrix of shared resource Dim: Suppose there are n shared resources with higher similarity, then call an n×n-dimensional matrix, in which approximation among n shared resources are stored, as the dissimilarity matrix, where dissimilarity d(i, j) can be calculated by formula (1). The specific matrix structure is as follows:

$$Dim = \begin{bmatrix} 0 & & & & \\ d(2,1) & 0 & & & \\ d(3,1) & d(3,2) & 0 & & \\ \vdots & \vdots & \vdots & & \\ d(n,1) & d(n,2) & \cdots & d(n,n-1) & 0 \end{bmatrix}$$

Similar resources sharing in cooperative design are classified based on the main ideas of agglomerative hierarchical clustering [8]. Firstly clustering objects are taken as a collection, then merge objects having the biggest similarity step by step, until shared resources objects can be classified in parent class as a category. The flow of agglomerative hierarchical clustering algorithm of shared resource is shown in Fig. 1.



Step1: Observe and measure multiple related attributes of resource for cluster analysis, get vectors with p valid attribute data by convention 1:

$$x_i = (x_{i1}, x_{i2}, \cdots, x_{is}, \cdots, x_{ip}),\ 1 \le \text{i} \le \text{n}$$

while the corresponding collection is {all objects of shared resources};

Step2: By convention 3, calculate data matrix of shared resources Dm using vector group of shared resources gotten in Step1;

Step3: Calculate all similarities between resources in accordance with the formula (1) and get dissimilarity matrix in accordance with the convention 4.

Step4: Find the smallest dissimilarity in matrix of similarity gotten in the step3, that is the smallest Euclidean distance, and then merge related resources with the smallest distance, so the collection is changed to {shared resource objects not merged + objects group merged};

Step5: Keeping the similarity between other unchanged resources, re-calculate each similarity among resource objects merged and unchanged resource objects, and then according to the convention 4, form a new dissimilarity Matrix by the principle of minimum distance;

Step6: Repeat the above Step4 and Step5 until reaching the desired classification requirements.

Step7: Form the cluster of resources.

Fig. 1. Clustering arithmetic flow of shared resource

In this paper, material is taken as a case to verify the reasonability and effectiveness of cluster analysis used in the shared resource classification. Table 1 shows materials will be cluster analyzed and their attributes, where I_x is the x-axis inertia moment of the material cross-section, i_x is the x-axis gyradius of material cross-section, W_x is the curved section coefficient to the x-axis, x and y axis are respectively horizontal and vertical axes though the centroid of material cross-section.

Table 1. Some properties of material

No	Max section dimension (mm)	Section area (cm^2)	Weight (kg/m)	I_x (cm^4)	W_x (cm^3)	i_x (cm)	I_y (cm^4)	W_y (cm^3)	i_y (cm)
1	140	21.5	16.9	712	102	5.76	64.4	16.1	1.73
2	160	26.1	20.5	1130	141	6.58	93.1	21.2	1.89
3	180	30.6	24.1	1660	185	7.36	122	26	2
4	280	55.45	43.4	7114.14	508.15	11.32	345.051	56.565	2.495
5	140	18.51	14.53	536.7	80.5	5.52	53.2	13.01	1.7
6	140	21.31	16.73	609.4	87.1	5.35	61.1	14.12	1.69
7	160	25.15	19.74	934.5	116.8	6.1	83.4	17.55	1.82
8	180	29.29	22.99	1369.9	152.2	6.84	111	21.52	1.95
9	280	51.22	40.21	5496.32	392.594	10.35	267.602	40.301	2.286

By convention 3, the 9×9 data matrix of material information is:

$$\begin{bmatrix} 140 & 21.5 & 16.9 & 712 & 102 & 5.76 & 64.4 & 16.1 & 1.73 \\ 160 & 26.1 & 20.5 & 1130 & 141 & 6.58 & 93.1 & 21.2 & 1.89 \\ 180 & 30.6 & 24.1 & 1660 & 185 & 7.36 & 122 & 26 & 2 \\ 280 & 55.45 & 43.4 & 7114.14 & 508.15 & 11.32 & 345.051 & 56.565 & 2.495 \\ 140 & 18.51 & 14.53 & 536.7 & 80.5 & 5.52 & 53.2 & 13.01 & 1.7 \\ 140 & 21.31 & 16.37 & 609.4 & 87.1 & 5.35 & 61.1 & 14.12 & 1.69 \\ 160 & 25.15 & 19.74 & 934.5 & 116.8 & 6.1 & 83.4 & 17.55 & 1.82 \\ 180 & 29.29 & 22.99 & 1369.9 & 152.2 & 6.84 & 111 & 21.52 & 1.95 \\ 280 & 51.22 & 40.21 & 5496.32 & 392.594 & 10.35 & 267.602 & 40.301 & 2.286 \end{bmatrix}$$

By the Euclidean distance formula (1), the dissimilarity matrix is:

	1	2	3	4	5	6	7	8	9
1	0								
2	421.34	0							
3	954.33	533.04	0						
4	6422.95	6002.11	5469.35	0					
5	177.04	598.18	1131.14	6599.58	0				
6	103.75	524.83	1057.80	6526.32	73.52	0			
7	224.74	197.27	730.08	6198.95	401.21	327.88	0		
8	662.76	241.69	292.2	5761.09	839.38	766.06	438.21	0	
9	4799.70	4378.85	3486.11	1623.88	4976.27	4903.03	4575.61	4317.73	0

Based on the cluster analysis, the new dissimilarity matrix is as follows:

	1	2	3	4	(56)	7	8	9
1	0							
2	421.34	0						
3	954.33	533.04	0					
4	6422.95	6002.11	5469.35	0				
(56)	103.75	524.83	1057.8	6526.32	0			
7	224.74	197.27	730.08	6198.95	327.88	0		
8	662.76	241.69	292.2	5761.09	766.06	438.21	0	
9	4799.70	4378.85	3486.11	1623.88	4903.03	4575.61	4317.73	0

Repeat the above steps until all the objects are clustered to a class or the requirements of clustering are reached.

As shown in Figure 2, this clustering process is: the first step is to merge 5 and 6, the second step is to merge 1 and 56, the third step is to merge 2 and 7, the fourth step is to merge 156 and 27, the fifth step to merge 15627 and 8, the sixth step is to merge 156,278, and 3, the seventh step is to merge 4 and 9 and final step is to merge 1567283 and 49 into a broad category. If the clustering requirement is to form two categories, the cluster analysis will be stopped in the seventh step and form two categories which are 1567283 and 49.

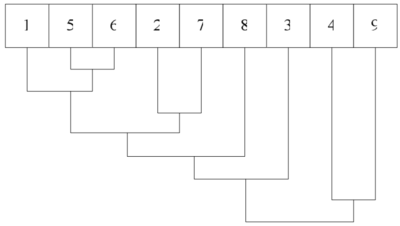


Fig. 2. Material clustering chart by the shorten distance method

3 Conclusion

Scientific and effective classification of shared resources supporting collaborative design is foundation of shared resource management and allocation. During the process of classification expansion, along with more and more detailed classification of resources, the similarity between categories is higher and higher. Agglomerative hierarchical cluster analysis method is used to classify shared resources in this paper. Using the cluster analysis method and several important properties of shared resources in shared resource classification, more effective and detailed classifying results can be received. The case study has proved that this method is simple, agile, effective and available.

Acknowledgements

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Parametric CAD Data Exchange Using Geometry-Based Neutral Macro File

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Abstract. Recently, CAD data translation without loss of design intend using commercial CAD data Translators is still impossible because these systems do not have creation history and modification history of feature. Macro parametric methodology is suggested as a solution of this problem, but critical problem still remains. The reason of this problem is that topology-based macro can cause an ambiguity in the name of feature. In this research, geometry-based neutral macro methodology is suggested as a solution of this problem.

Keywords: CAD, data exchange, macro parametric, geometry-based macro.

1 Introduction

Cooperation between companies or between departments within the same company has become increasing important in industrial sectors. Cooperation in the design step can crucially affect the time and cost in producing a product as well as the quality of the product, and is thus considered much more valuable than at any other step. In this regard, one of the most important aspects of the design step is the exchange of data of CAD systems, the main format used for design data.

Many companies share their CAD data for cooperation in the design process and for the purpose of information sharing. However, a critical problem in this process is that different companies may use different CAD systems. Consequently much money and time is wasted on exchange of CAD data.

Many commercial systems for translation of CAD data have been developed. These commercial systems translate CAD data using a direct translation method between CAD systems or by using a neutral file format such as a STEP, or IGES. Nevertheless, the design intent of the final model can be frequently missed because the neutral file exchange method only provides final result shapes based on B-rep. Furthermore, parameter change after the translation process is impossible.

For this reason, translation methodologies based on design history have been suggested. Design history based translation uses detailed records of creation, deletion, and modification of each entity in a feature-based CAD system. The main advantage of this method is that not only the final model but also the design intention can be translated.

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2 Macro Parametric Methodology

Pratt established the foundation of history-based design methodology through ISO 10303 STEP AP 203 Edition2. [1] Fig.1 shows a difference between B-rep and history-based design methodology using example of chess game. [2] Right side is a moment of chess game, and left side is a procedure for this moment. With a captured picture, we cannot know how this game was progressed and go back to some other moment and change procedure to get another game. But with a procedure, all these actions are possible.

1. d4 Nf6
2. c4 e6
3. Nc3 Bb4
4. Nf3 0-0
5. Bg5 c5
6. e3 cxd4
7. exd4 h6
8. Bh4 d5
9. Rc1 dxc4
10. Bxc4 Nc6
11. 0-0 Be7
12. Re1 b6
13. a3 Bb7
14. Bg3 Rc8
15. Ba2 Bd6
16. d5 Nxd5
17. Nxd5 Bxg3
18. hxg3 exd5
19. Bxd5 Qf6
20. Qa4 Rfd8
21. Rcd1 Rd7
22. Qg4 Rcd8

Fig. 1. A moment of chess game and its procedure

Mun suggested “a macro parametric methodology” as a way of exchanging CAD data. [3] This methodology is a practical implementation of “History-based design methodology” Pratt suggested. Macro parametric methodology uses a neutral macro file that is newly defined using a macro file extracted from a CAD system. The entire design procedure for the final model is included in the neutral macro file. Using the neutral macro file, the design intention can be translated precisely and parameter change after translation is also possible.

A neutral macro file is used in this methodology in order to meet the challenge posed by the number of translators according to the number of CAD systems. The number of translators for N different CAD systems is N(N-1) when direct translation is applied. However, when a neutral macro file is used, the number of translators is 2N. If N is larger than 3, the number of translators using the neutral macro file will be smaller than in the direct translation case, which can considerably increase translation-efficiency.

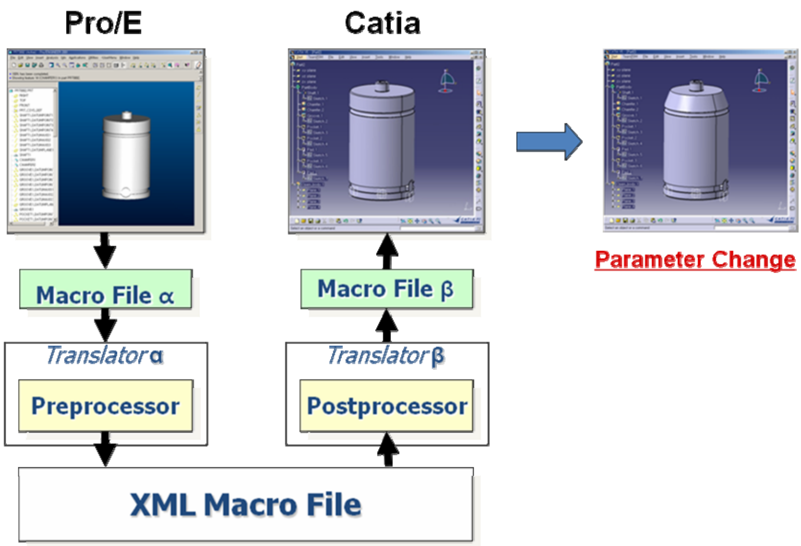

Fig. 2. Data Translation from PRO/E to CATIA using Macro Parametric Methodology

Fig.2 shows a translation process from PRO ENGENEER to CATIA. Macro file extracted from PRO ENGENEER is translated into a neutral macro file by the "Pre-processor for PRO ENGENEER". This neutral macro file again is translated into a CATIA macro file by the "Post-processor for CATIA". After translation is finished, using CATIA, the user can check whether the model is translated correctly or not. Furthermore, adding new features such as a fillet of a chamfer and changing parameters such as the radius of a circle or the depth of extrusion are also possible in CATIA.

3 Problems in Current Neutral Macro File

A core part of the macro parametric methodology is the neutral macro file. A neutral macro file has to include not only common parts of macro files from every CAD system, but also unique parts of each CAD system. With respect to expression of reference faces and edges, these CAD systems can be divided into two groups, topology-based and geometry-based systems. Among the major CAD systems, CATIA and PRO ENGENEER use topology-based macro files, and SolidWorks and UG use geometry-based macro files.

The neutral macro file suggested by Mun is a topology-based macro file, and this topology-based macro file uses the name of a reference entity. Because of this, some problems occur when a real macro file is translated. The most significant problem is that the current neutral macro file cannot reflect the changes in the name of the reference entity when a new feature is created at the entity that is linked with a reference face or edge. For this reason, translation between the neutral macro file and the CAD system`s macro file can be hindered.

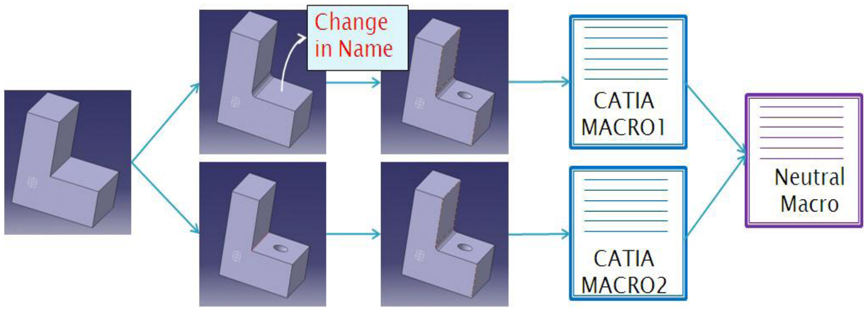

Fig. 3. Problem in Topology-based neutral macro file

As you can see in Fig.3, when a fillet is created at some edge, the names of two faces adjacent to the fillet are changed. The macro file uses these changed names as a reference. However, the current neutral macro file can not reflect this change, and thus cannot translate this process correctly.

If a geometry-based macro file is used as a neutral macro file, this problem does not occur, because only coordinate information of one point in the reference entity is required. While the geometry-based macro file has weak points when used as a neutral macro file, they are not critical compared with the problems of topology-based neutral macro files.

4 Geometry-Based Neutral Macro File

A geometry-based neutral macro file has the same format as the current neutral macro file except for an entity referencing part. In addition, geometry information is used instead of topology-based information in this part.

One of the most difficult parts in implementing a neutral macro file is the methodology of reference entity selection to create a new feature. If a face or edge that the user wishes to translate cannot be recognized in the CAD system, exact feature creation is not possible, and sometimes the CAD system can be down because of this error. Reference entity selection is divided into face selection and edge selection.

4.1 Face Selection

A new sketch plane has to be defined to create new features such as sweep, extrude, and cut-extrude on the pre-created feature. Sometimes the global coordinates system is referenced to define this sketch plane, and in many cases, pre-created features have to be referenced. In this case, face selection is essential. The following is an example of the face selection process in the current neutral macro file: [4]

```
<SELECT_Object>
<result_object_name>Reference3</result_object_name>
<type_edit>FACE</type_edit>
<entity>Extrude1,Sketch1,Line3,0,0,0,ExtrudeFeature:0,0
:0;0</entity>
</SELECT_Object>
```

In this part, the <select object> function is used for face selection. To select a reference face, first, the reference name and type are defined. The name or property of the selected entity is then defined. Because the neutral macro file is a topology-based macro file, the name of the selected entity is used. In this case, because the selected face is created by extrusion of the third line of sketch 1, which is a basic sketch, its expression is "Extrude1,Sketch1,Line3,0,0,0,ExtrudeFeature".

The only different part between the topology-based neutral macro file and the geometry-based neutral macro file is the <entity> part. The topology-based macro file uses the name of the entity, which is defined through the principle of creation, but the geometry-based macro file uses coordinate information of one point in face. The following is an example of a geometry-based neutral macro file:

```
<SELECT_Object>
<result_object_name>Reference3</result_object_name>
<type_edit>FACE</type_edit>
<picking_point>
<coordinates>70.0000000000</coordinates>
<coordinates>50.0000000000</coordinates>
<coordinates>40.0000000000</coordinates>
</picking_point>
</CONSTRAINTS_Create_3DReference_CoordSys>
```

The reference name and type definition are the same as in the topology-based neutral file, but instead of an entity name, coordinate information of a representative point is used in the geometry-based neutral macro file. Coordinate values of the representative point defined in the <picking point> function represent coordinate values of x, y, z in order. In this case, x, y values can be extracted from line3 of sketch1, and the z value can be extracted from the depth value of extrude.

In the case of the geometry-based macro file, by using coordinate values of the representative point of the face, the whole face can be selected. As seen in example, without distinction of start face or side face or end face, all faces have the same expression format and can be expressed only by the coordinate values.

4.2 Edge Selection

Edge selection is essential when new features such as a fillet or chamfer are created on the a pre-created feature. Sometimes an edge can be referenced when a new sketch plane is defined.

```
<SELECT_Object>
<result_object_name>Reference4</result_object_name>
<type_edit>EDGE</type_edit>
<entity>Extrude1,Sketch1,Line3,0,0,0,ExtrudeFeature:0,0
:0;0#Extrude1,Sketch1,Line4,0,0,0,ExtrudeFeature:0,0:0;
0</entity>
</SELECT_Object>
```

The upper shows an example of <selection object> part to select a reference edge in the current neutral macro file. As with face selection, the reference name and type have to be defined first in a neutral macro file.

In the case of a topology-based neutral file, an edge is an entity that is created by the meeting of two adjacent faces. As such, an edge can be defined using the names of these two faces. In this case, the selected edge is created by faces that are created by extrusion of line3 and line4 of sketch1. Hence, expression of this edge is "Extrude1, Sketch1,Line3,0,0,0,Extru-deFeature#Extrude1,Sketch1,Line4,0,0,0,Extrude-Feature". Notation “#” means that two entities meet.

As with face selection, coordinate values of the representative point on the reference edge is used in geometry-based neutral macro file. The following is an example of a geometry-based neutral macro file that represents the same edge in fig:

```
<SELECT_Object>
<result_object_name>Reference3</result_object_name>
<type_edit>EDGE</type_edit>
<picking_point>
<coordinates>40.0000000000</coordinates>
<coordinates>50.0000000000</coordinates>
<coordinates>40.0000000000</coordinates>
</picking_point>
</CONSTRAINTS_Create_3DReference_CoordSys>
```

Coordinate values of the representative point defined in the <picking point> function represent values of x, y, z in order. In this case, x, y values can be extracted from the intersection point of line3 and line4 of sketch1, and the z value can be extracted from the depth value of extrude.

5 Result and Conclusion

Fig.4 shows an example of translation using geometry-base neutral macro file between CATIA and SolidWorks through TransCAD.]TransCAD is a CAD system which is developed for translation of CAD data. [5] TransCAD creates target model automatically using API connected with pre-processors which translate macro file of commercial CAD system, then extracts neutral macro file from this model. TransCAD is also connected with Post-processor using API, so automatically create a macro file of commercial CAD system using neutral macro file when Post-processor is executed. [6]

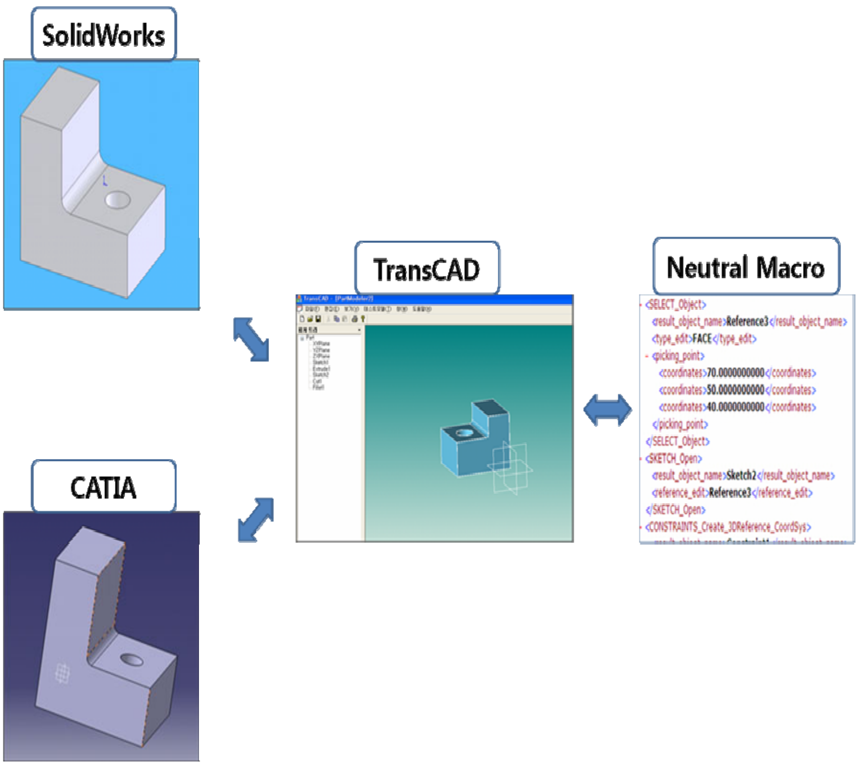

Fig. 4. Data Translation of CAD Data using TransCAD (Geometry-based macro version)

In fig.4, L-shape model is created. To create this model fillet and hole are added after extrusion. In this case, if hole is created after fillet creation, problem occurs during translation using topology-based neutral macro file as mention in chapter 3. But with geometry-based neutral no problem occurs as you can see in fig.4.

In this case, the reason why only translation of geometry-based neutral macro file is possible is that topology-based neutral macro file uses name of entity on the other hand geometry-based neutral file uses a geometry information of entity. Name of entity can be affected by order of feature creation, but geometry information is unchanged. As a result of this research, geometry-based macro file is more proper as a neutral file than topology-based macro file.

But still, translation using geometry-based macro neutral file is not perfect methodology. This methodology has its own problem, named persistent naming problem. To solve this persistent naming problem, more excellent and flexible methodology should be developed.

Acknowledgement

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Study of Collaborative Design Based on Fuzzy Theory

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Abstract. Under the Ontology-based collaborative design framework constructed by OWL and SWRL, in order to further extend the expression and reasoning abilities of domain knowledge description and to achieve the reasoning based on fuzzy theory, this paper expresses fuzzy domain knowledge by fuzzy logic and realizes the reasoning to make the design process more intelligent. First, fuzzy variables are formed by describing related fuzzy domain concepts and rules in OWL and SWRL. Fuzzy sets which are described by membership functions are then used to define fuzzy variables. At last, the fuzzy knowledge-based collaborative product design is completed by using fuzzy reasoning. A case of die selection shows the feasibility and intelligence of this approach.

Keywords: Collaborative Design, Fuzzy Logic, Fuzzy Reasoning, OWL, Intelligent design.

1 Introduction

Collaborative design supports experts or teams in the same or different fields to complete a design project together with the support of computer and network technology. Abundant knowledge is involved in it, so the description and utilization of knowledge becomes the key for collaborative design. And generally, the knowledge includes both some explicit knowledge and some fuzzy knowledge. In different areas, these two types of knowledge are often intertwined, and how to make use of the knowledge has become the key part of improving the product intelligence design.

As Ontology [1] has both good knowledge representation and reasoning abilities, it is applied to collaborative design, to contribute effectively knowledge exchange of different fields between different designers and organizations, thus, heterogeneous data sources and systems are integrated. There are many reported works on collaborative design based on ontology, and further requirements for collaborative ontology development are identified [2]. The ontology-based assembly design is addressed to support collaborative product development such that design intent could be well understood by other designers, and the applications could reason about assembly knowledge without any semantic ambiguity [3]. Recently, the use of ontology modeling in collaborative design has been proving to be a prominent approach to detect conflicts [4]. We also had constructed a collaborative design system architecture based on ontology in an earlier paper [5]. In the architecture,

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OWL was used to construct global shared ontology and local ontology; both of them are machine-interpretable. 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 which enhances the intelligence of design. However, OWL and SWRL were just be used to describe the explicit concepts and rules in domain knowledge, there is still much fuzzy knowledge not be expressed. In order to further enhance the expression and reasoning ability of the knowledge bases which will also improve the intelligence of the whole collaborative design system, we use fuzzy logic in this paper.

The rest of this paper is structured as follows: In section 2, we review the architecture of ontology-based collaborative design system and fuzzy theory. Then we discuss the expression of fuzzy concepts and rules in OWL and SWRL in section 3; Section 4 presents the implementation of the collaborative design system, in which we construct a die selection system and provide a case and its analysis. Finally, we conclude in Section 5 by summarizing our work.

2 Architecture of Ontology-Based Collaborative Design System and Fuzzy Theory

2.1 The Architecture of Ontology-Based Collaborative Design System

Ontology is a formal specification of a shared conceptualization [1]. 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. 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. The strong knowledge representation ability of description logic provides the basis for OWL to describe knowledge at semantic level.

The architecture of ontology-based collaborative design system is shown in Fig. 1. Ontology can be constructed through extracting domain knowledge and modeling by Protégé, etc. There is a global shared ontology-based knowledge base and local knowledge bases 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 and communicate with each other through communication platform on the base of global shared ontology. The inference engine such as pellet, racer etc. can be used to maintain ontology especially for large-scale ontology through satisfied test and implement rule-based reasoning.

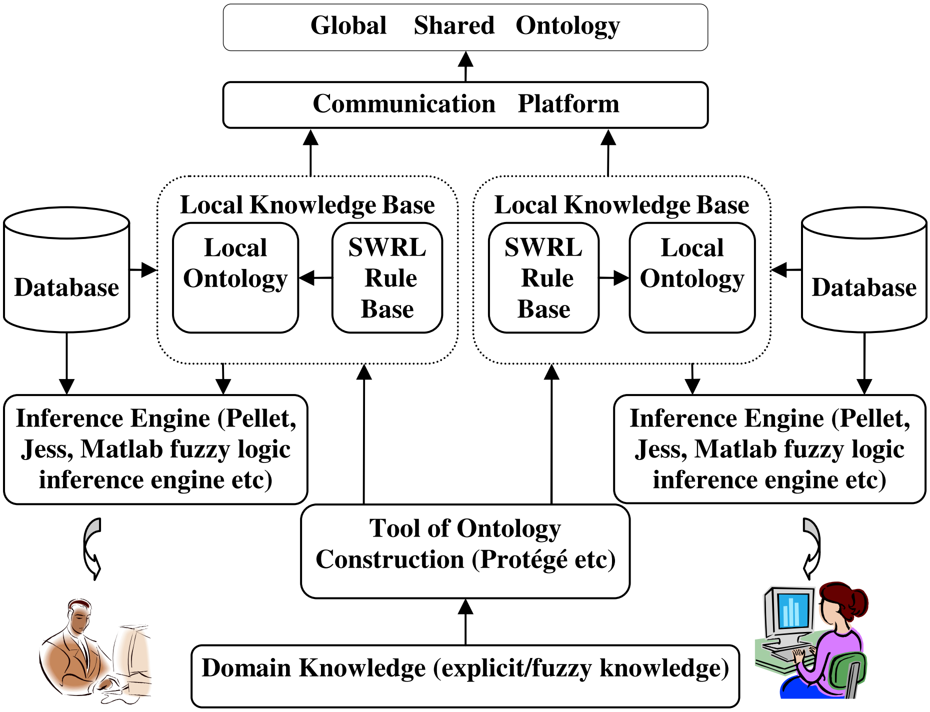

Fig. 1. The architecture of collaborative design system based on ontology

Domain knowledge includes both explicit knowledge and fuzzy knowledge, but SWRL with the rule engine only fits for describing explicit knowledge, so we first need to translate fuzzy knowledge by fuzzy theory into the form of OWL style then realize the intelligent reasoning by a fuzzy logic supported reasoner.

2.2 The Basic Knowledge of Fuzzy Theory

The important concepts of fuzzy things - membership function were first proposed in paper [7], broke the limitations of classical set theory. Membership value in fuzzy theory can be any value on the interval [0, 1] which expands the absolute subordination of general collection, so we can quantificationally describe the elements' coincident degree of concepts by using membership values. By using this approach, many challenges related fuzzy concepts in projects will be addressed.

2.2.1 Fuzzy Sets and Fuzzy Membership Function

Given a domain conclusion U, μ_A is a mapping of U on closed interval [0, 1]:

$$\mu_A : U \to [0,1]; u \to \mu_A(u)$$

It defines that A is a fuzzy subset of U, μ_A is the membership function of fuzzy set, and μ_A(u) is the membership value of u to A. Among it, the domain is a set of all objects related in discussed issues, the fuzzy subset A is described by membership function μ_A, $\mu_A(u)$ □[0,1] and its size reflects the membership degree of u to the fuzzy subset.

In the use of membership function, a fuzzy concept can be expressed from "completely not belonging" to "completely belong" There are many kinds of membership functions, and generally Gaussian-type is one of the most important and common type, so we choose it as the main membership function in the rest of this paper in die selection system, and its expression is as follows:

$$\text{gaussmf}(x,c) = e^{\frac{(x-c)^2}{2\sigma^2}} . \tag{1}$$

Thus, an element can "partly" belong to a fuzzy subset in fuzzy logic, and in the use of membership value concept can quantificationally describe the subordinate relations between elements and fuzzy subsets. Then, we can use it to achieve a quantitative description of fuzzy knowledge which is beneficial for the reasoning work.

2.2.2 Fuzzy Reasoning

Fuzzy reasoning is a process which infers fuzzy outputs in accordance with established methods of good reasoning by fuzzy inputs and rules, and its essence is a calculation process for a given input space mapped to a specific output space by fuzzy logic method.

The most commonly used fuzzy inference systems include Mamdani type and Takagi-Sugeno type. They are just different in their output membership functions, for Mamdani-type, they are fuzzy sets, while the Sugeno-type outputs a single value which makes calculation simpler and more conducive to mathematical analysis and applied in intelligent systems.

A typical 0-th-order Sugeno-type form is as follows:

```
If x is A and y is B Then z=k
```

Where x and y are the input variables, A and B are the fuzzy sets of the antecedent reasoning, z is the output variable, k is a constant. After obtaining the outputs of each rule, the system gets the total value:

$$d = \sum_{i=1}^{n} \mu_{Ai}(x)\mu_{Bi}(y)z_i / \sum_{i=1}^{n} \mu_{Ai}(x)\mu_{Bi}(y) . \tag{2}$$

In the above formula, μ_{Ai} (x) and μ_{Bi} (x) are respectively the membership values of the input variables A and B for the i-th rule, Zi is the output variable value for the i-th rule, d is the final output value of Sugeno type fuzzy inference system. Higher-order Sugeno model is seldom used because its complexity is increased but its capability is not improved.

Based on the above theory, we know that fuzzy knowledge is mainly expressed by fuzzy variables, which are defined by relevant fuzzy subsets, and then fuzzy subsets are described by membership functions. So we can get each variable' membership value and at last get a system' final output value by the formula (2).

3 The Expression of Fuzzy Concepts and Rules in OWL and SWRL

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.

The form of SWRL's 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.

Based on the theory above, we can describe fuzzy concepts and rules in OWL and SWRL as follows. Attribute value of OWL can be 'string' type, which can be used to express related fuzzy concepts, and then describe the associated rules in SWRL. A simple rule of fuzzy reasoning can be expressed as follows:

`FuzzySetA ( ?x , ″FuzzyConcepta1″) ∧ FuzzySetB ( ?y , ″FuzzyConceptb1″ ) → OutputVarZ ( ?z , FuzzySetV )`

Where `x` and `y` are input variables, `FuzzyConcepta1` and `FuzzyConceptb1` are respectively the fuzzy concepts of fuzzy sets `FuzzySetA` and `FuzzySetB`. As indicated above, we can use this approach to describe fuzzy knowledge in OWL and SWRL. But for Jess inference engine which was used in paper [5] can't infer on fuzzy knowledge stored in OWL and SWRL, so we need to use another inference engine which support fuzzy reasoning, such as Matlab fuzzy logic inference engine.

4 Implementation of the Collaborative Design System

4.1 Construction of Die Selection System

In section 2 and section 3, we described fuzzy theory and the expression of fuzzy concepts and rules in OWL and SWRL. In this section we show how the knowledge can be used in die selection system. In the selection of die, the main fuzzy variables should contain production batch, accuracy, thickness, dimensions of stamping parts and minimum thickness. According to the working procedure, the types of die include three kinds: simple die, progressie die and compound die. Take production batch as an example, one of its rules is defined as follows in SWRL:

`cuttingWorkpiece ( ?x )` ∧ productionBatch (?x ,
"smallBatch") ∧ Die (?y) → typeOfDie (?y,
"simpleDie")

Fuzzy set `productionBatch` has three kinds of fuzzy concepts: smallBatch, mediumBatch and largeBatch. Then we choose Gaussian membership function which is introduced in section 2 to describe the three fuzzy concepts, as shown in Fig.2:

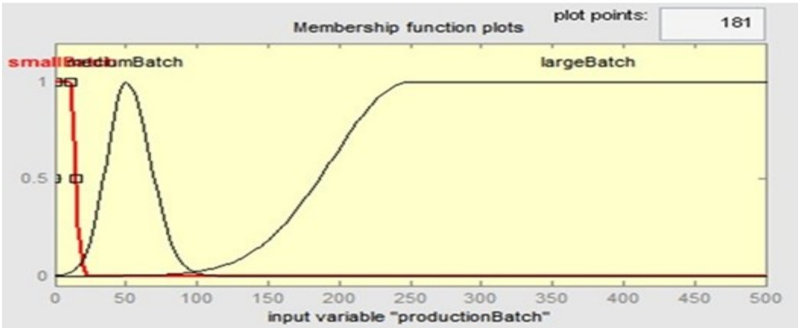

Fig. 2. Membership functions related with production batch

Similarly, we can respectively get the membership values of each element (production batch, accuracy, thickness, etc) through the membership functions of each fuzzy concept (Production quantities of smallBatch, mediumBatch, highBatch, accuracy in low, normal, higher, etc.). Then we transform the relevant fuzzy rules of die selection system, in the way described in section 3 by OWL and SWRL, to the format supported by Matlab fuzzy logic inference engine, as shown in Fig.3, finally obtain the output value of the entire system by the formula (2).

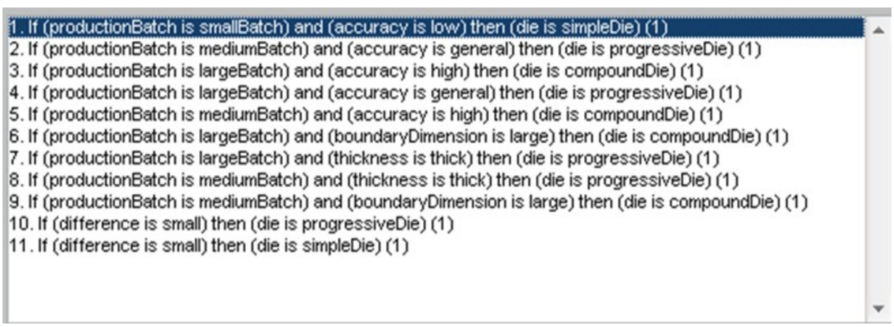

Fig. 3. Rules described in Matlab fuzzy logic inference engine

Since this reasoning system is a 0-th-order Sugeno type fuzzy inference system, so the output variable value is a constant. The value in our design inference system: a simple die is 0, progressie die is 0.5, and compound die is 1. That is when the result is less than 0.25, it should be a simple model, and when it is between 0.25 and 0.75, we should choose progressie die, and when it is greater than 0.75, compound die should be selected.

4.2 Case Study

Now we are going to choose a die type to produce a batch of stamping parts, the conditions are as follows: production batch: 8000; material: Q235-A steel; thickness:

2.5mm; maximum dimension: 250mm; grade of tolerance: IT13; the minimum wall thickness: 6.5mm.

According to the material type, we can find that the allowable minimum wall thickness of workpiece is 6.25mm, so the input variable value of "difference" (the difference between minimum thickness and the allowable minimum thickness) is 0.25mm. The translation result of known values in condition in fuzzy inference machine is shown as Fig.4:

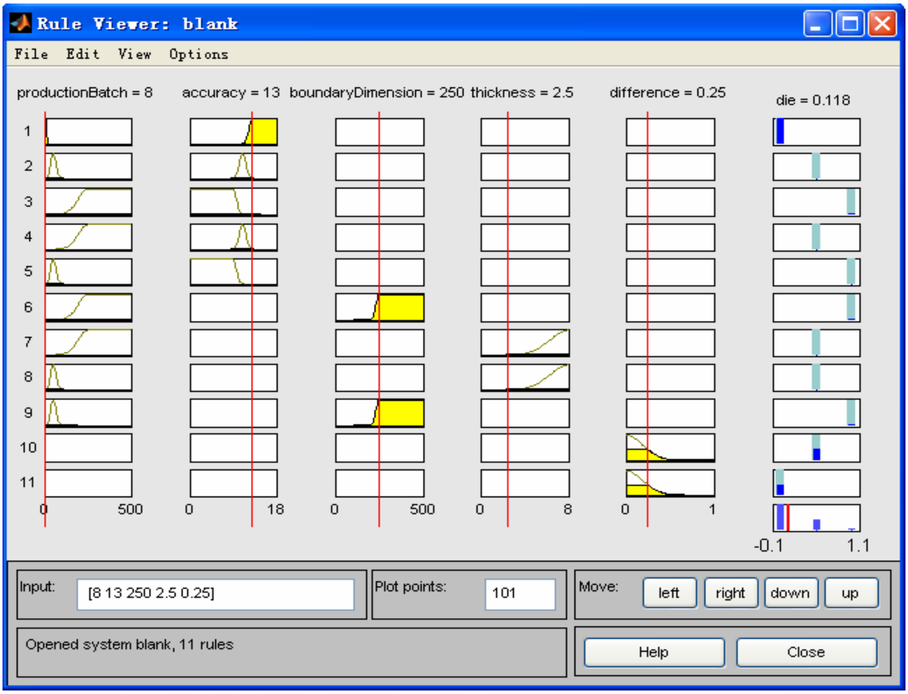

Fig. 4. The result of inference system for the case

From the above result, die value is 0.118, which indicates to choose a simple model. Then based on experience the result is coincidence with actual situation. Through the adopting of fuzzy theory to improve the expression and reasoning abilities of domain knowledge base, we can solve the problem of conflicted rules and achieve fuzzy knowledge-based design reasoning, which can not be realized by SWRL with SWRL supported reasoner.

5 Conclusion

In this paper, we have expressed fuzzy knowledge in extended OWL and SWRL which can realize fuzzy knowledge and design rules sharing in collaborative design. Then, we achieved the reasoning based on fuzzy knowledge by transforming the knowledge into the format supported by Matlab fuzzy logic inference engine which enhanced the expression and reasoning ability of the ontology-based platform. At last, we built a die selection system and demonstrated its ability by a case showing that it is feasible and intelligent to apply fuzzy theory to collaborative design.

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Technological Change: Educating for Extreme Collaboration

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Abstract. This paper considers pedagogical strategies and techniques in design for attaining sustained innovation collaboratively, in order to assist in the New Product Design process and enhance opportunities for creating truly innovative products. The authors argue that the New Product Design process demands a multidisciplinary collaborative approach in order for designers to be able to have a pro-active capacity for innovation. The central theme of this paper relates to evidence for the hypothesis that it is the design teams who should act as change agents, and that one catalyst for this is an Extreme Collaborative Working model. This requires a further re-evaluation of the benefits of teaching and working across the different disciplines of Industrial design, Design Engineering and areas outside these domains. To cope with operating in an increasing technologically turbulent context, future teaching programs need to make creative connections between diverse design issues and diverse resources.

Keywords: Technological Change, Collaborative working, Design Teams, Multidisciplinary Design, Extreme Collaboration, Design Innovation, Design Education.

1 Introduction

The pace of technological change in the world is increasing. The work of Kurzweil [1], suggest technological change is increasing exponentially. It may be argued this in turn causes turbulent societal change. Others seem to share his view in relation to technological complexity and convergence. A review of the work of Schmidt [2] reveals that much of our past has been shaped by a number of convergences that had their beginnings as separate and independent lines of inquiry. It is important to note these complex converged technologies do not exist in isolation. They exist in a social cultural context. When reviewing the work of Shavinina and Ferrari [3], they consider that all human cultural advancements are built upon remarkable technological, scientific, educational and moral achievements of the human mind.

The literature surrounding the issues of technological change suggests that it is not just the exponential growth of technologies and our growth in understanding within the sciences of which we need to be mindful. The literature argues that we need to be concerned about larger socio-cultural issues that are dynamically interrelated to

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technology and science [see: Porter, et al. [4]; Girifalco [5]; Karamchedu [6]]. The literature discussing technological change makes it clear that technological change is not just about science, technologies and patents increasing at an exponential rate, but that it is also a number of other issues advancing at a similar rate. Broadly speaking, it is argued Technological Change encompasses more than mere changes in technologies. It also includes socio-economic, cultural, legal and environmental issues. Along with the growth of technologies and our growth in understanding within the sciences, the larger socio-cultural EPISTLE issues are dynamically interrelated, and must be embedded in the design processes of our future designers. As complexity accelerates there is equally an accelerated need for complex collaborations with large and diverse groups. The implication is that the composition of these groups, working in an extremely intense environment, will be drawn from an increasingly large variety of backgrounds, expertise, and domains of knowledge. This would suggest our students will need to have tools, skills, and experiential knowledge suited to ‘extreme’ collaborative environments. In both the near and long term there is an urgent need for specific educational pedagogical strategies and techniques for attaining sustained innovation collaboratively, in order to assist in the New Product Design process, and enhance opportunities for creating truly innovative products. It is argued that the New Product Design process demands a multidisciplinary collaborative approach in order for designers to be able to have a pro-active capacity for innovation, in the context of increasing technological change.

The collaborative relationships between individual designers and design engineers within design teams, the relationships between various design teams, and the broader relationships with non designers are subject to the influences of turbulent changes. The central “umbrella” theme of this paper relates to developing evidence for the hypothesis that it is the design teams who should act as change agents, and that one catalyst for this is an Extreme Collaborative Working model. The implication is that, in the future, the role of the industrial designer and design engineer will need to adapt. The individual industrial designer/design engineer and these design teams will need to alter their thinking and working strategies as they introduce even more technological change in collaborative ways. Teaching methods need to be revised to prepare graduates for such change, requiring a further re-evaluation of the benefits of teaching and working across the different disciplines of Industrial design, Design Engineering and areas outside these domains. Industrial design/design engineering academics and researchers will not be alone in wrestling with the important issues relating to how industrial designers/design engineers, and more importantly Industrial design/design engineering students, will cope with operating in an increasing technologically turbulent context.

While the work of Kokotovich [7], proposed a way of working with and developing creative design teams, and the work of Mark [8] described a working model of what she has termed “Extreme Collaboration”, whereby she discussed a number of issues in relation to working in a “war room” like environment at the NASA Jet Propulsion Laboratory [JPL] in Pasadena California, in a technologically turbulent future the issue is how best to develop extreme collaborative teams. Additionally, how teams may need to operate in the future with respect to Industrial Design/Design engineering education is not clearly understood. This notwithstanding, in a real sense it is the design teams who act as change agents. Equally, Kokotovich &

Remington [9] has highlighted how another discipline [Project Management] could shift their creative thinking strategies in order to cope with an increasing complex future. Nonetheless, as the artifacts that designers and design teams develop, which fulfill societal wants needs and desires, become more technologically advanced and complex, there is a need to make creative connections between diverse design issues and diverse resources. From both a technical and human perspective these creative connections will clearly require an ability to work in an Extreme collaborative environment. By example, the benefits of teaching and working across the different disciplines of Industrial design and Nano-Science, may be found in Kokotovich [10]. In order to properly develop appropriate future industrial design/design engineering programs it is of benefit to investigate the alternate perspectives being debated and discussed in other Industrial Design/design engineering programmes around the world in relation to issues surrounding technological change. It makes sense to investigate these issues in a number of ways. The importance of learning to operate in a collaborative way in industry and education to cope with exponentially increasing levels of complexity within a product design environment has been highlighted and tested in a recent case study and Delphi type study as described in subsequent sections.

2 A Case for Extreme Collaboration

Describing a working model of what she has termed "Extreme collaboration", Mark [8], discusses a number of issues in relation to the working in "war room" like environment at [JPL]. However, these issues do not easily map against the technological change issues as the team she observed was not tasked to address technological changes issues. Their brief was more targeted than either our Case study or Delphi study, which more specifically determined that some Extreme Collaborative models must be explored and should be embedded in the design processes of our future designers/design students.

While the work of Mishra and Mishra [11] discusses the benefits of workspace environments, suggesting it is important for collaboration, we sought to investigate and examine educational issues by developing a case study of extreme collaboration via an academic-industry project working at the Royal College of Art. It is an example that led to "game changing" within industry partners. We wanted to highlight the benefits of placing divergent team members who have divergent perspectives and heuristics together. Further, it should be noted that when the larger technological change perspectives, discussed earlier were brought to bare on the problems, "Game changing" can and does in fact occur.

The example project that is described here took place between 2008 at the Royal College of Art in London under the direction of one of the paper's authors, Barker. They were run in the department of Innovation Design Engineering, or IDE - formerly Industrial Design Engineering. IDE is a two year double Masters graduate course, jointly run with the faculty of Engineering at Imperial College, London. The IDE course was an ideal experimental platform for investigating Extreme Collaboration for the following reasons:-

1. The course comprises students with undergraduate degrees in a diverse range of subjects: 30% engineering, 30% industrial design, and 30% other: sciences, architecture, business, marketing, and some fine art.
2. Many of the projects were run as 'real world' collaborations with industry, in that the work was intended to inform or seed commercial development programmes.
3. The project working was always undertaken in teams of various formats.
4. Projects were undertaken under very tight timescales and with demanding deliverables that were deliberately achievable only with a high degree of multidisciplinary working and lateral thinking
5. There was a great deal of input from the industrial partners in terms of technical expertise, marketing, briefing and context-setting. However, within each project the student teams had complete creative freedom.
6. As a compact college of 800 postgraduate-only students in design, applied and fine art, the college is ideal for intense multidisciplinary working

The project process described in some detail below resulted in game changing design for the industrial partners, Hutchison Whampoa / 3 Mobile. The project was titled: 'Designing the best mobile phone ever, now.' As the world's second largest conglomerate, Hutchison has invested heavily over the years in their international mobile phone division, 3 Mobile. Making heavy losses for many years, Hutchison launched as a 3G network only and struggled to attract consumers with the 3G features such as video media at a time when other networks were 2G. Over time, losses were reduced and the company changed their handset strategy with positive results. Initially offering complex multifunction phones, 3 Mobile moved towards simpler phones each with a particular selling point. The work with the Royal College of Art took place under this more rationalized approach.

3 Mobile chose to work with academia because they wanted to move away from the constraints within their existing development model. The process used by 3 Mobile was typical of most telcos: customer feedback to the marketing department along with internal consultation and brainstorming resulted in briefs for external handset designs, using modular technology. A new project involved some in-house product development, though this was predominantly at the concept and specification stage. The bulk of the design work was undertaken by engineers and industrial designers located with the handset manufacturers. The design results were heavily technology and customer driven.

The Royal College of Art undertakes many academic-industrial collaborations and looks to leverage the unique characteristics that are available within the institution. For the 3 Mobile project, the IDE department assembled multidisciplinary teams of 3-4 students that were drawn from the department – engineers, industrial designers, scientists, architects – as well as several others: industrial design, interaction design, vehicle design and textile design. The students worked together in a very compact studio space, instilling the notion of a Skunkworks (Jenkins, [12]), or an atelier format (Barker and Hall, [13]). The compact space and short timeframe encouraged the rapid development of a working network of almost polemic interpersonal dependencies (Senge, [14]). Students were also able to draw on the facilities of other departments. These other departments included: communication, printmaking, ceramics and glass, textiles and engineering (at Imperial College). 3 Mobile provided expertise in marketing, branding and technology. The students were given 3 weeks to produce revolutionary mobile phone handsets under the brief to "design the best phone ever, now."

A key aspect of the Extreme Collaboration was the way in which the design teams drew on socio-cultural factors in their research: both through personal experience, which was valid because the students were a similar demographic to 3 Mobile's target consumers, and through more formal research and investigation. In this context, the projects were heavily influenced and in some cases driven by societal trends, for example: the changing attitudes between age generations X and Y, along with upcoming indicators of generation Z – currently still at primary school. Additionally, culturally-orientated investigations shed light on aspects of technological convergence for mobile computing, mobile phone, social networking and multimedia. It became apparent that the drivers for "the best phone ever" were neither technology nor customer driven. This was diametrically opposed to the assumptions of 3 Mobile that had driven new product development previously. Additionally, the students majored on innovation by adopting a 'design from first principles' approach, jettisoning 3 Mobile's previously modular thinking – a valid innovation strategy that has been discussed by the authors (Barker & Kokotovich, [15]). The academic environment had the benefit of allowing 3 Mobile to accept failure and to be more experimental: about a third of the 15 projects resulted in design proposals that 3 Mobile considered for commercial development. As an example the winning proposals, in Figure 1 below, entitled "The Vase", is a phone which starts out as an "empty vessel" that the user fills and learns to interact with while they fill it with contents and the "Teiko phone" that is not only a communication device but also a learning aid illustrate the benefits of "extreme collaboration".

Fig. 1. The winning proposal "The Vase" sought to maximise user flexibility and a Child's phone which not helps children keep in touch but sought to encourage them to explore their surroundings

The above example notwithstanding, many others were problematic – typically because the time constraints resulted in a fragmented product or user "narrative". This was a side-effect of running a project so intensely: in 3 weeks, the students were attempting to undertake what typically took 6 months in the commercial context.

The working processes were to an extent quite chaotic, but resulted in an extraordinary number of continuous "Aha!" moments of inspiration (Gardner, [16]).

Students fused together the typically iterative stages of research, concept design, concept development, test rigs and early stage prototyping (using software simulation and/or basic electronics). In the project context, there was no time for manufacturing development. This fusion of stages also had some rationale: it compressed development time and lent a heavy emphasis to the method of "thinking by doing" and also removed the anxieties of failure since any failure was a minor setback and a major learning point. This hothousing was reminiscent of the approach taken by Thomas Edison during intense product development (Josephson, [17]), but with the process augmented by socio-cultural considerations and a broader range of disciplines.

The process described for the 3 Mobile project at the Royal College of Art has also been used successfully for a number of other industry-academic collaborations. These include: Sharp "Integrating housing with vehicles to achieve zero energy scenarios"; Unilever: "New paradigms for ice cream"; Sony "Public interaction with games devices"; and Targetti "Future of lighting". Comments from the industry partners indicate that these projects could not have been run in the same way within their organizations, and that they provided a valuable complement to the standard product development cycles. Hence, the 3 Mobile project was not a one-off experiment, but rather it is archetypal of the format for, and success of, academic-industry collaborations at the Royal College of Art. This case study serves to illustrate the benefits of developing extreme collaboration strategies within and educational context. However, as suggested earlier we are not alone in wrestling with the important issues relating to complex technological change issues now and in the future. Consequently, in order to extend our findings in the case study, it would be prudent to investigate what our colleagues around the world are thinking. The next section discusses some preliminary findings of a Delphi type study relating to technological change.

3 Delphi Study

Building upon the case study findings above, in order to identify and research alternate perspectives and heuristics in other cultures, thereby forcing a shift in our understanding of the technological change issues facing us, a number of leading Industrial Design and Design engineering programs and researchers from around the world were visited by Kokotovich and academic researchers were interviewed [i.e Technical University Eindhoven [TU/e], Technical University Delft TU/Delft, and Illinois Institute of Technology IIT etc…]. In all 55 subjects were interviewed. The central research methodology was via a Delphi type survey: The central focus of the Delphi research questions related to Exponential Technological Change and the Grand challenges for Industrial Design and Design Engineering from the present to 2015 then from 2015 to 2020. The study sought to obtain qualitative data via a three stage process. The following form the three stages of the study:

Stage 1.) Obtaining the participant's response to a few basic open ended questions while visiting Face to Face. Stage 2.) Once the open ended questions are analysed, a refined questionnaire is sent to the participants soliciting their responses in the near future. Stage 3.) Based on the themes derived from earlier responses, a tick box survey instrument soliciting responses is sent to the participants [a little further into the future]. The objective of this survey is to provide a vision of how we may be able to cope as a profession and as educators of Industrial Designers / Design Engineers with the impacts exponential growth in technological change will have. A key question is what are experts thinking as they look ahead towards the technological change issues facing our profession in the future from the present to 2020. The subjects were asked to extend their thinking beyond today's conventional wisdom. The intent is to sketch in general terms the core themes and profound changes in need of our immediate and longer term attention. Interviewees' thinking was to be expansive. However, for each question they were to limit their input to 3 to 5 most important ideas.

All of the participants were experienced researchers and in an excellent position to assist with informing this scoping exercise. The new perspectives were obtained by closely collaborating with leading industrial design educators/researchers in Europe, America and Australia. The purpose of this research is to generate a scoping study. The results of this investigation may have significant implications for altering Industrial Design and Design Engineering practice and Academia. The responses of the participants were recorded using some hardware and software called Livescribe. Basically they used a pen that has a little camera in it and a voice recorder. The pen would record what they would say in response to the questions and should they want to draw to assist in explaining their thoughts they were encouraged to do so. The six questions were broken down into the following basic themes:

[1 ***Technological Change****; 2 Corpus of Knowledge; 3 Learning Environment in the future; 4 Tools and Skills; 5 Hard systems and Soft systems; 6 Facilitator Trap; 7 Additional Thoughts].* However, of particular interest to this discussion is question one: Describe the challenges and your vision of how we as a profession and as individuals operating within that profession will cope with the ever increasing complex larger dynamically interrelated social issues, and the increasing complex detailed and dynamically interrelated technological issues facing us from the present to 2015 and then from 2015 to 2020 due to exponential growth in technology and the sciences.

Thus far only 55% of the 55 interviews have been transcribed [30 transcriptions thus far]. Consequently, the results and subsequent discussions in this paper are preliminary. Nevertheless, they are valuable as they are indicative of a pattern of responses on the part of the participants. In order to identify a pattern of responses and common threads or themes emerging from the participants, the responses to each question were grouped. That is to say, for example all the responses for question 1 were grouped for analysis.

4 Preliminary Results

In the context of the technological change issues advancing exponentially, a review of the preliminary data suggest approximately 72% of the 30 expert academics and industry participants interviewed are of the view that developing and co-evolving thinking skills and collaboration experiences will be of increasing importance in both the immediate and longer term. The central theme resonating within the transcripts was that both students and professionals must have highly developed abilities for working within intense extreme collaborative environments. There needs to be the experiential knowledge in developing skill sets for operating within extreme collaborative environments while working on a variety of design activities. Teams need to go through a large number of design / develop/ validate cycles by developing working relationships using specialised skills and tools in a consistent considered way. Additionally, design students at the start of undergraduate level need to learn from the richness of operating in these extreme collaborative environments and not in an Ad hoc manner, as it is argued that failing to offer these learning experiences would not properly prepare them for an exponentially complex future. A number of interesting perspectives were revealed which led the participants in this study to their individual conclusions. While there were many often complex and dynamically interrelated issues found within the transcripts, the following are only a few of the strategies, tools, and issues that were raised and discussed by a number of the participants. Strategies, Skills, & Tools :

1.) Visualisation Tools for cross domain and cross culture communication
2.) Strategies for collaboratively coping with inadvertent events
3.) Collaborative tools for parsing appropriate and inappropriate information
4.) Collaborative tools for coping with larger EPISTLE issues in a dynamic way
5.) Tools for linking and working with knowledge structures that are not generally related
6.) Tools for collaboratively interrogating what is not known [How does the group know what it is they do not know?]
7.) Tools for exploring dynamically interrelated issues within proposals and dynamically relating those with the larger technological change issues

In the subsequent section the authors draw upon an international case study undertaken recently, as well as their experience of teaching within several leading international design programs with a view to highlighting the benefits of working within an Extreme Collaborative model.

5 Conclusions

Through the archetypal Case study and preliminary results of a Delphi type study, the authors have examined the hypothesis that an Extreme Collaborative Working model is appropriate and necessary as a pedagogical strategy and technique in design for attaining sustained innovation collaboratively in order to assist in the New Product Design process and enhance opportunities for creating truly innovative products.

The authors have made the case that a New Product Design process demands a multidisciplinary collaborative approach in order for designers to be able to have a pro-active capacity for innovation. The authors have argued that it is the design teams who should act as change agents, and that one catalyst for this is the Extreme Collaborative Working model. The argument made has been that this in turn requires a further re-evaluation of the benefits of teaching and working across the different disciplines of Industrial design, Design Engineering and areas outside these domains.

In order to cope with operating in an increasing technologically turbulent context, future teaching programs need to make creative connections between diverse design issues and diverse resources, they need to draw on the advantages of industry-academic formats, and that changing industry demands instilled by rapid technological change are paramount to revise teaching formats. The challenge in preparing graduating students to meet these demands is significant. We need to develop the appropriate tools and skills as a matter of urgency.

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Team Organization and Web-Based Project Management for Collaborative Highway Design

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Abstract. It is difficult for highway design enterprises to manage collaborative highway design process due to its distributive and collaborative characters. Aiming at this problem, a web-based project management system for collaborative highway design was developed based on Project 2002 software. First, the organization structure of the design team is formulated, and the design process was analyzed and improved. Next, web-based project planning and controlling methods were studied. Then, the system structure and functions are proposed. Finally, a case study was illustrated to show the application of the system. The application shows that the system can effectively control the collaborative highway design process and improve the communication efficiency of the project.

Keywords: Team organization, Web-based project management, Highway design.

1 Introduction

In order to improve the engineering quality, shorten construction cycle and save cost, project management technology is widely used to manage the highway construction process [1]. Highway design project is characterized by the distributed and collaborative task structure, and the integration of process information and design information. Project design management not only consists in allocating resources, but also in stimulating collaboration among the people involved in the project, in order to increase performance of design teams [2]. However, researches on professional highway design project management are relatively short, especially in China's highway exploration and design industry [3]. Recently, collaborative design project management is developed rapidly, which benefits enterprises with its distributive and collaborative supports. For example, Jiang et al. proposed a web services and process-view combined approach for process management of collaborative product development [4]. Danilovic and Browning developed approaches of managing complex product development projects with design structure matrices and domain mapping matrices [5]. All these researches focus on product design process, while highway design process has its specialty requirements, and should be studied and developed separately.

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Starting from this point, a web-based project management system for collaborative highway design was developed in this paper.

2 Design Team Organization and Process Improvement

To manage collaborative highway design project, a design team must be organized firstly. Departments involved in the design project include design department, quality department, chief-engineering office, and customer enterprise. Then, roles in the design team can be classified into project manager, professional group leader, multi-discipline design engineer, quality engineer, and customer representative. During the project process, different role is assigned with different task and authority, and cooperate with each other in the web-based project management environment by sharing process data, design data, and design resource.

Process definition is the basic function of the project management system. However, before the process is defined and realized in the system, the collaborative highway design process must be analyzed and improved, in order to improve the process efficiency. Aiming at the characteristic of highway design process, we use ESIA (Erase, Simplify, Integrate, Automate) method to analyze and improve the process.

(1) Eliminate some unnecessary intermediate examine, quality query, and file input tasks, which create no value to the whole process.
(2) Reduce the organization controlling layers, hence to eliminate some report and feedback tasks caused by multi-layer organization structure.
(3) Simplify and re-design files and tables, cut down those re-input tasks.
(4) Integrate design information, process information, quality information into a global database, in order to simplify the data sharing and collaboration tasks.
(5) Automate the interoperation process of collecting design materials by web-based collaboration environment.

3 Dynamic Monitoring and Controlling

To support the distributive and collaborative characters of highway design project, a dynamic monitoring and controlling method is used in the system, as shown in Figure 1. Based on the web-based cooperation, the process is monitored and controlled according to the project goal by the collaborative design team. The process can be divided into the following steps.

(1) Project planning and tasks releasing. The highway design process often includes a large mount of tasks and has different task relationships according to different design requirements, which brings difficulty for process definition. However, the highway design processes can be divided into some typical classes which have common process characters. Hence, we developed several general process definition templates for each kind of process, in order to cut down the difficulty of process definition and improve the management efficiency.

(2) Web-based collaborative design of the design team. Highway design is a typical collaborative work conducted by the design team. Therefore, during the design process, the project management system should provide collaboration functions such as design data query, design models and files interoperation, group examination, design history record and query, file version management, design change management, project announcement, design confliction and negotiation, group discussion and decision making.
(3) Project data collection and analysis. Project status can be monitors by data collection and analysis. There are two kinds of data collection methods in the system. The first one is that the status data is updated by the team member in fixed time according to the management rules. The second one is that the status data is queried by the project manager who cares about some special tasks.
(4) Project plan adjustment. During the long design process, the environment and the status of the project keep changing. For example, some design engineers may find the workload has exceeded the expected workload defined in the plan, or customer has new engineering requirements to the designed highway, or design conflictions happen during different discipline groups. Therefore, the project plan must be adjusted according to these changes.

4 Development of the Highway Design Project Management System

The web-based highway design project management system is developed base on Windows, SQL Server 2000, Microsoft Project 2002 and VBA package. All the modules are developed base on the same database and the same interface style.

The system has been used in several real highway design projects. Since many plan templates have been defined in the system, project manager only needs to edit the template and input the essential items for the plan. After process definition and instantiation, checking is needed before the plan is released.

During the design process, the design engineers update the task status at 5:00 pm each day by estimating the percentage of the progress. At the same time, the project manager can ask for the progress of one special task whenever he wants. Besides project monitoring and controlling, the project manager can also assess the performance of team members according to the task progress.

When there is task collaboration, design confliction, or abnormal situation, the project team would launch team collaboration by “file sharing” function and the “question processing” functions. With the file sharing function, team members can access global process data and design data conveniently, without wasting additional time in file manual interoperation. With the question processing function, team members can upload questions and ask other members to help, and then team members can discussion technology questions by sharing design models and data.

Using the web-based highway design project management system, this project is finished in 90 days. While it often took about 100-120 days for the similar projects before the system was used. Besides, the management also benefits from high working quality, easy performance assessment, and optimized workflow.

5 Conclusion

Aiming at the features of collaborative highway design, a web-based project management system was developed and used in a China highway exploration and design company. The system supports team organizing and cooperating, web-based planning and controlling, and information integration of the project. The application shows that the system can effectively control the collaborative highway design process and improve the communication efficiency of the project. However, with the introduction of the system, changes of organization structure, business process, and management rules should be done at the same time, in order to cooperate with the system, and this is undoubtedly a great challenge for the company management.

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Taking the Customer into Account in Collaborative Design

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Abstract. This article describes the improvement of a model of collaborative design for the ceramic industry. A new stakeholder playing a crucial role is now included in the design process, i.e. the customer. Specifically, we present a pilot validation study for the framework that aims to analyse how the environment, experiences and reference criteria of different types of the customers (commercial dealers, final users, architects and interior designers, etc.) can affect their preferences. Information about these customer preferences could be very useful for designers during the early stages of product development. A multidisciplinary approach to the problem can introduce substantial improvements in defining a truly collaborative design chain.

Keywords: Collaborative Design, Customer, Subjective Impressions in Design.

1 Introduction

New requirements in the management of new product development favour cooperation between the different players in the design system and, as a result, design management has evolved towards enterprise networks and collaborative environments [1]. Yet, although collaborations between manufacturers and suppliers are becoming increasingly more usual, it is still far from common for the customer to be considered as a fundamental participant in the collaborative design chain. The different types of customers (those that 'filter' the product throughout its life cycle) are stakeholders in the process and their preferences should be taken into account from the very earliest design stages. Therefore to include the customer in the product development is another step forward in collaborative design.

This article describes a model of collaborative design for the ceramic industry. It is the result of merging the interests of two research lines related to the design and development of new products, although they are dealt from complementary perspectives, namely improving collaborative processes and taking into account the customers' impressions on the products. Previous work in this area considers these two types of methodologies independently. We believe that a multidisciplinary approach can introduce substantial improvements into the new product design. By incorporating the customer as a new key element we can make advances towards the definition of a truly collaborative design chain. This work is based on a model that

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was developed previously which focused on the management of the relationships among the different participants in the ceramic design chain [2,3,4]. The aim of our work here is to enrich the model by taking into account the subjective impressions of different types of customers during the design process. Such observations would be a key factor to design more innovative products that meet the customer expectations better in today's changing and highly competitive markets.

2 The Conceptual Framework

To enrich the previous model with the customer collaboration, a new conceptual framework was developed [5] which establishes the relationships between the subjective impressions elicited in human-product interaction and the designer's work. The main purpose of this framework is to serve as a base for developing a practical tool that can be used by designers to take into account the subjective impressions of different types of customers. The work in this paper is to further develop the framework and make the pilot study on it. Fig. 1 shows the framework and the focus of the work presented in this paper.

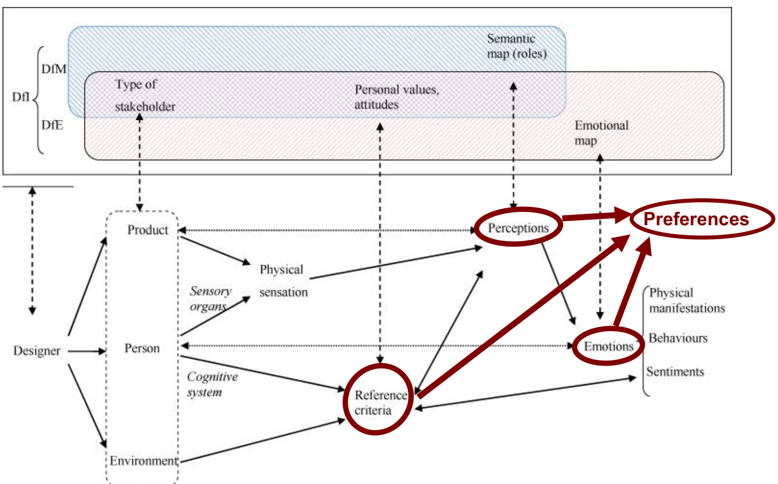

Fig. 1. Taking the customers' impression into the collaborative design

A number of interesting aspects were taken from relevant works [6,7,8]. Our proposal considers the design process as a key moment for the study of customers' impression. It also considers the existence of different types of people who decide or inspect the product design, such as the architects, interior designers, commercial dealers, final users, etc. who may generate similar impressions inside a particular group, depending on their environment or reference criteria. Particularly, the pilot study focuses on the analysis of the perceptions that are most relevant to the product and the relationship of these perceptions with customer preferences (marked in red at Fig. 1). The relationship between perceptions and reference criteria is also suggested.

3 Pilot Study for Validation

The validation of the conceptual framework is carried out through a pilot study in which several representative groups of ceramic industry customers participate. Nineteen different ceramic tiles were selected and each participant is asked about 3 of them to avoid boredom (different set for each participant). They answer a Semantic Differential test [9] about the perceptions and emotions that the images trigger within them (Figure 2). A third questionnaire, based on Rokeach's list [10], is used to determine the personal values and criteria of the participants. Although the study is not finished, a large number of tests have been completed participated by 250 participants. Some preliminary results are obtained and presented here.

Fig. 2. Image of one of the impression tests with three ceramic products

From the 24 perceptions selected for the tests, 9 factors can be perceived for the ceramic tiles extracted with a factorial analysis, 80% of variance explained (see http://graficad.act.uji.es/tests/19 for the Spanish version of the test). Pearson correlations of these factors with the expressed preference (asked in a 0 to 10 scale, 10 for maximum preference) are shown in table 1. From this, it can be concluded that the most important perceptions for preference are the perception of "Functional, versatile, timeless", followed by "Stylish, innovative" and "Light, spacious". Other factors such as "Resistant", "Clean" and "Slippery" did not influence the preferences.

Table 1. Pearson Correlations of perception factors with customers' preference. **Correlation significant at 0.01 level; *Correlation significant at 0.05 level; n.s.: non-significant correlation.

	All data	Modern, elegant people	
Perception Factors	n=642	Yes (n = 219)	No (n =200)
F1: Functional, versatile, timeless	0,733**		
F2: Stylish, innovative	0,352**	0.542**	n.s.
F3: Light, spacious	0,259**		
F4: Resistant	n.s.		
F5: Clean	n.s.		
F6: Slippery	n.s.		
F7: Natural	0,178**	n.s.	0.290 **
F8: Domestic, homey	0,134**	n.s.	0.353 **
F9: Expensive	0,111**	0.200 **	n.s.

Table 1 also shows the correlations that change meaningfully by the personal value of ‘Modern, elegant’, as an example of the way that personal values may affect preference and perception. People that consider themselves as modern and elegant are influenced differently in their preference by the impression of “Stylish, innovative” and “Expensive”.

4 Conclusions and Future Work

This work takes customer preferences into account in order to enrich a model of collaborative design for the ceramic industry. A conceptual framework was developed and a pilot study is being implemented to determine the relationship among product preferences, personal criteria, meanings and emotions for people who decide or verify the product design. Some relevant perceptions and their relations with personal criteria and preferences have been identified. Further analysis will help to identify more relations. Hence, the original model of collaborative design could be enriched with technical and managerial processes associated with the customers, who are the key stakeholder in the product development process.

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Part III

Cooperative Visualization

Multi-user Multi-touch Setups for Collaborative Learning in an Educational Setting

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Abstract. In educational settings, current digital technologies often work counter-productively because people using them with separation and isolation. This paper describes a set of multi-touch multimedia interaction applications that were especially designed to enhance collaboration between users. We present the underlying framework for creating such applications. Our applications were created for supporting typical collaborative tasks performed by secondary students. We present our findings on the usage of these applications by the users in the settings of a secondary school classroom.

Keywords: CSCL, multi-touch screens, interaction techniques.

1 Introduction

Collaboration in educational settings can be supported by a variety of digital technologies offering opportunities to connect learners and teachers in shared spaces for creating and developing work. Examples of technologies that can enhance collaboration are, amongst others, wikis, blogs, learning management systems, file sharing applications or online collaboration workspaces. The domain of "Computer Supported Collaborative Learning" (CSCL) [1,2,3,4,5,6] conceptualizes the collaboration as a process of shared meaning construction; i.e. through processes of interaction, meaning is achieved. The focus here is on learning through collaboration with other learners rather than directly from a teacher. Furthermore, it is stressed that in this process of collaboration, learners learn by expressing their questions, pursuing lines of inquiry together, teaching each other and seeing how others are learning. Therefore the role of technology is to support collaboration by providing media of communication and scaffolding for productive interaction between learners.

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In this article we present a multi-touch multimedia interaction framework, whose applications were designed to enhance collocated, real-time collaboration between learners. The design and development of our multi-touch applications was based on the scenario of a school assignment where the class performs research on a specific topic in small groups. Later, their findings are presented to each other in front of the class. Both the research as the presenting activity is performed on a multi-touch surface.

The main contribution of this paper is to elaborate the acceptance of a multi-touch setup inside of a secondary school classroom, showing how this can be used as a tool to facilitate the collaboration among students.

2 Software Architecture for Multi-touch Applications

2.1 Basic Architecture

Our basic architecture has been designed based on previous experiences in developing multi-touch applications. The initial software framework, Eunomia [7], was developed for interaction with multimedia objects on multi-touch surfaces. This framework was written in C++ which meant that adding new elements to the graphical interfaces built on top of Eunomia required a profound knowledge of both the framework and C++. Based on this experience, we created an alternative software framework, *MuTable*, that is both simplified with respect to programming new behavior and more accessible for designers to add user interface designs. This section provides an overview of the architecture of the software framework, decomposed in functional components. We use the term software framework for a layered set of components that can be used to build multi-touch applications

Input Layer: There is a wide diversity of multi-touch hardware available on the market which is still evolving at a fast pace. This implies that we need an input layer that can collect touch points regardless of the hardware it is running on. We provide an input layer component that uses a client-server setup in which the hardware acts as the server sending out touch points, and the multi-touch application acts as a client receiving these touch points. The way the server works is dependent on the hardware, but we provide a set of generic implementations so the server can run on Windows 7 and use its multi-touch capabilities or at any TUIO compliant system [8]. There is a fixed protocol that is used between the client and the server, so that the clients know what to expect and how to process the input.

Core Handler: Our Framework uses the Windows Presentation Foundation libraries which belong to the .Net framework. The Core Handler of this framework is the main entry for MuTable applications. It receives the touch-events raised from the Input Layer and passes them to the touch point controller.

Touch-Point Controller: Gestures that occur over a multi-touch screen are context dependent. The simple gesture of moving two touch-points away from each other could be translated into enlarging an object, or moving to objects away from each other. The Touch-Point Controller is in charge to identify the context of each touch-event and assigns it to the correct multi-touch widget.

Multi-Touch Widget Container: All displayed widgets are contained in the multi-touch widget container. It allows adding new widgets and deleting old ones, and serves as the top-level container.

Multi-Touch Widgets: Are all components in the screen which can be manipulated by users through touch-events. They all derive from our MultiTouchObject abstract class. Multi-touch widgets are responsible for interpreting the multi-touch gestures they can be controlled with. This makes it easier to add new widgets that might work radically different. This choice has proven to be very useful for experimenting with prototypes to find the most appropriate way of interaction. Multi-touch widgets can be composed from other multi-touch widgets. This hierarchical approach allows combining several existing widgets to obtain more complex widgets. An example is a multi-touch virtual keyboard, this keyboard consist of one container and buttons that by themselves are again multi-touch widgets.

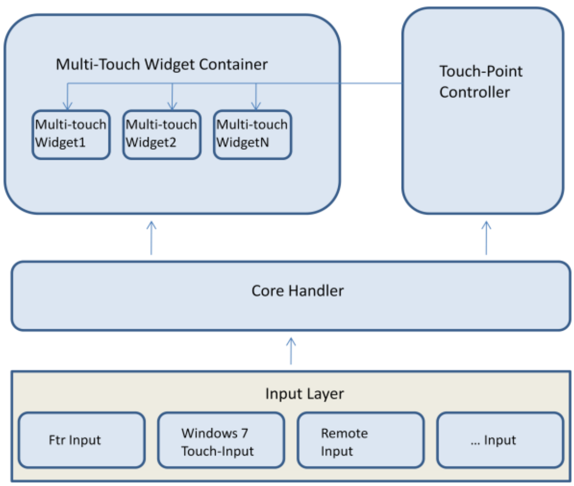

Fig. 1. Software Architecture Diagram

2.2 Common User Interactions

Multi-touch surfaces offer a different type of interaction with respect to traditional mouse-keyboard interaction. They open the possibilities for new types of interaction techniques, but also present some issues that require to be tackled [9,10] We created some common multi-touch interactions techniques for collaborative applications that were kept simple intentionally. Four basic interaction techniques are listed here: *Whole widget manipulation*: For the case of composed multi-touch widgets, it is important to know if the user wants to interact with a specific component of the Widget (button, item on a list, slider, etc) or if the user wants to interact with the widget as a whole. In order to differentiate that, as written in [10] we also use handles. Through the handles it is possible to manipulate the widget as a whole by using some common gestures that have begun to emerge for multi-touch devices [11].

Drag and Drop: Composed widgets usually contain items that can be dragged out of them and be placed somewhere else. This action is done by pressing the drag able object with two contact points (fingers) and moving one or both of them to the place where the object should be dropped

Flip Pages: Book widgets are represented visually as open books. Navigating through its pages is done by pressing the widget with three fingers. Two fingers stay still and the third one moves to the left to see the next to pages or to the right to see the previous ones.

Crop: It is possible to copy extracts of media files. To get these fragments, the user touches the media object with four fingers. A rectangle appears in the screen giving the user a visual feedback showing the area to be cropped. The user can change this area by moving the touch-points, and by releasing them an image copy of the selected region is created.

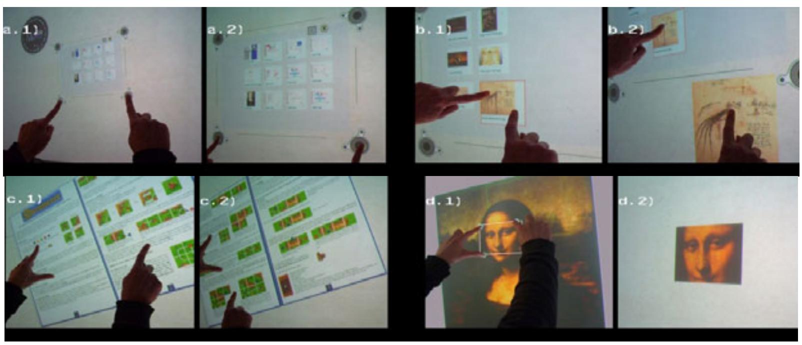

Fig. 2. a) Whole widget Manipulation b) Drag and Drop c) Flip Pages d) Crop

2.3 From Prototype to Deployment

Our applications were the result of a close collaboration between interaction designers and software developers. First, interaction designers created several low fidelity mock-ups that were iteratively tested. Afterwards, high fidelity visualizations were created based on the feedback of the low fidelity end-user tests. In a constant feedback loop, both interaction designers and developers interacted with each other on the progress made in the development and design process.

Before software development started, several cardboard mockups of the crucial low-level interface elements were created. Using tangible materials to create a "natural user interface" helped the team to make the link between how objects were manipulated in real life and how they could be transposed to the digital realm. In a second phase of low-fidelity prototyping, a tabletop prototype allowed the design team to focus on high-level user interaction: to observe how groups of users interact with each other, with the material available, and with the surface they work on in a controlled environment. This second prototype involved a physical table at which test users were asked to collaborate. They were asked to create a presentation on a given subject, using physical materials such as an analogue typewriter, material to paste, to draw, etc. The results from the second prototyping phase allowed the interaction designers to integrate the lower-level interface elements of the first phase into a larger application structure in an optimal way.

In the last phase, the lessons learned during the low fidelity tests were transferred to high-fidelity visualizations. The challenge here was matching the ideas and designs of the interaction designers (resulting from the low-fidelity tests) to a feasible technical implementation. Our framework made it straightforward to integrate the high fidelity visualizations (designs created in Adobe Illustrator) into the applications being developed: the Illustrator files were exported to XAML files using Microsoft Expression Blend, which were immediately usable in the final applications.

3 Application Support for Educational Tasks

3.1 The Collaborative Workspace

In a collaborative workspace it is important to recognize the users and let them work on individual tasks as well as on mutual ones. Platforms like the DiamondTouch are able to detect a limited amount of users [12]; still most of the multi-touch hardware technologies nowadays identify many touch-points, but not the users associated with them. We dealt with this issue by assigning each user with a delimited space on the touch-screen where he/she is allowed to work on his/her individual tasks: an individual workspace. It is, however, not possible to predict exactly how many users will be using the touch-screen at the same time. Considering the size of the table, the number of users could vary between one and four. Furthermore, size, shape and location of the workspace are intricate issues: numerous experiments have already considered this issue of work spaces, territoriality, and 'ownership' of digital artifacts [13,14,15,16].

The Mutable platform presents a workspace by a small circle on the screen, a 'central ball'. Once this central ball is touched, the options available to the user appear round the circle (which amounts to an implementation of sorts of a pie menu [17]). When selecting one of these options, the relevant application opens, connected to the central ball with a line. Users can always relocate and resize each of the applications that were opened from their workspace. In addition, the central balls themselves can also be moved around on the touch-table.

New workspaces can be created by touching dedicated buttons on the sides of the multi-touch screen. This location allows all users to create a new workspace, without having to reach too far. At first, another strategy was implemented: touching the screen border in any place opened a new work space - no matter where users are located around the multi-touch table, they are always close to an edge. However, this strategy ran into some issues: a lot of unintended workspaces were created, as people tend to rest their non-dominant hand (or elbows, if the table is placed at the appropriate height [18]) on the edge of the touch surface - even when the table has a framing that is not touch-sensitive.

'Ownership' of workspaces is not strictly organized by the Mutable platform: users can work alone on their own workspaces and applications, or they can share one workspace among several users.

3.2 Functionality Overview

The functionality consists of the functionalities of a number of separate, dedicated applications. In general, the applications can be divided in three functional groups: (i) searching and browsing contents, (ii) composing and creating contents (the main focus of the Mutable framework), and (iii) presenting contents. An instance of all applications is available for each personal workspace. All users can collaborate using a common workspace, or each one of them can use their private one. Contents can be moved from one workspace to another without restrictions, making for a very flexible framework.

(i) Searching for contents. This application contains two views. The first one shows a list with thumbnails of the media files that are available. And the second one contains a virtual keyboard that can be used to type for keywords in order to search for specific contents and narrow down the information displayed

(ii) Composing and creating contents. The contents of this application are threefold; they contain widgets to create text, free hand paintings and presentations. The widget used to create text simulates an old typewriter. It contains a virtual keyboard and a list of textboxes. With it, users can create separate 'snippets' of text that can be dragged and dropped in other documents. The free-hand painting widget contains an area that accepts user's paint strokes: they can select a color, start painting and later drag their creation and drop it into another document. The presentation widget allows students to create slides and arrange them for a presentation. It contains a list showing the thumbnail of the slides inside the presentation. Users can create, edit or delete slides. Slide layouts can be selected from a limited number of templates. After selecting a template, users can start dragging and dropping contents into the slide.

(iii) Presenting contents. For this the interface turns into the 'presentation mode'. A theater stage image becomes the background and a list showing the thumbnails of the slides appears on the bottom of the screen. By touching the thumbnails the moveable, scalable, and rotatable slides appear at their original size in the middle of the screen.

4 In-Situ Evaluation

The location for the education test was at the Leonardo Lyceum in Antwerp, Belgium. Within the education context of the project, this secondary school was able to provide a 2nd form class and a classroom. The school has an advanced ICT infrastructure. For every two students there is one computer available. The school has four ICT classrooms, each equipped with 13 computers and a smart board. The multi-touch setup was positioned in the middle of the ICT classroom, also known as the open learning center. With an extra beamer connected to the multi-touch setup, other students were able to see the activities performed on the setup. The students got an assignment to make a presentation about Leonardo Da Vinci. After a brief introduction of the setup we provided including the applications and interaction, three students made the assignment. The other students created a presentation, two by two, on normal computers using standard web search. After one hour these students were invited to accompany the first three students and continue the assignment. At this moment the students introduced already working with the multi-touch setup transferred their knowledge on the system to the other three. The students had two hours to complete the Da Vinci presentation. The third hour was used as an epilogue to discuss and compare the multi-touch setup versus the computer.

A brief explanation of the main operations and possibilities were sufficient for the three students to start the assignment. They had no additional help during the creation and instructed the other students easily at using the table. In particular, the peer-to-peer learning and collaborative working skills were frequently addressed during this test. When asked for comparing collaboration using computers versus a shared multi-touch surface, the students primarily noted that when using a mouse one person controls the whole collaboration while the multi-touch setup did not impose such leadership. Note the tasks at hand (research, creation and presentation) are well suited for collaboration, but traditional tools fail to exploit these

Fig. 3. Students working on the multi-touch setup

5 Conclusions

In this paper we presented our multi-user multi-touch setups for collaborative learning in an educational setting. We started with creating an underlying framework that supports the design of collaborative multi-touch applications. Our focus was on the collaborative aspect, where multiple users should be able to use the applications simultaneously. To validate and evaluate our framework, a set of applications were designed and developed for secondary school students. Three typical collaborative tasks were selected: searching for information, composing this information in a presentable format and presenting this information to others. The valuation showed collaboration, and thus collaborative learning, were improved using a large multi-touch surface accompanied with applications that were designed for collaboration. Concerning functionality offered, the students asked for more personalization features of the interface, also a clear 'undo' function was missing. The test at the Leonardo Lyceum showed the MuTable and its interface to be a valuable and well deployable new media technology for the educational context.

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Explore, Collaborate and Publish Official Statistics for Measuring Regional Progress

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Abstract. Official statistics such as demographics, environment, health, social-economy and education from regional territories are a rich and important source of information for many important aspects of life. Web-enabled geovisual analytics is a technique that can help illustrating comprehensive statistical data which for the eye are hard perceive or interpret. In this paper, we introduce "storytelling" means for the author to 1) select spatio-temporal and multivariate statistical data, 2) explore and discern trends and patterns, 3) orchestrate and describe metadata, 4) collaborate with colleagues to confirm and 5) finally publish essential gained insight and knowledge embedded as dynamic visualization "Vislet" in a blog or web page. The author can guide the reader in the directions of both context and discovery while at the same time follow the analyst's way of logical reasoning. We are moving away from a clear distinction between authors and readers affecting the process through which knowledge is created and the traditional models which support editorial work. Value no longer relies solely on the content but also on the ability to access this information.

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

1 Introduction

In recent years regional (sub-national) differences in economic output, labour productivity, job creation, labour force participation and education within countries have been at least the double than that among countries. Understanding the variety in regional economic structures and performance [12] is essential knowledge for initiating development which could improve regional competitiveness and in turn increases national growth. The results from our research [6] make these variations more visible, providing region-by region indicators in the form of motion graphs and maps that could lead to better identification of areas that are outperforming or lagging behind. Patterns of growth and the persistence of inequalities are analyzed over time, highlighting the factors responsible for them. How can such significant knowledge about these statistical facts be collaborated and published to analysts and citizens?

The paper introduces tools [3] for an integrated statistics analysis, collaboration and publication process facilitating storytelling aimed at producing statistical news

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content in support of an automatic authoring process. The author should simply press a button to publish the gained knowledge from a visual interactive discovery process. We present our latest research that focuses on the most ancient of social rituals "storytelling" - telling a story about a region's development over time and shape the measure of economic growth and well-being. Discoveries that more engagingly draw us into reflections about the knowledge on how life is lived - and can be improved – from region to region and in addition let the reader dynamically participate in this process and help advancing research critical to the dissemination of official statistics by means of web-enabled tools. A platform for dissemination of embedded dynamic statistics data visualization with the analytics sense-making metadata (story) joined together and publishable in any web pages such as blogs, wikis etc. Publishing official statistics through assisted content creation with emphasis on visualization and metadata represents a key advantage of our storytelling and has the potential to change the terms and structures for learning.

Geovisual analytics tools [1, 2] that address a challenge to advance research critical to collaborative visualization of statistics data facilitating seamless integration of visual exploration, collaboration and dissemination. The global dimension of such a task responds to build a repository of *progress indicators*, where experts and public users can use geovisual analytics tools to compare situations for countries, regions or local communities. A storytelling mechanism enables the transition of tedious statistics data into heterogeneous, open and communicative sense-making news entities with integrated contextual metadata that will emphasize on content creation aspects and where dynamic embedded temporal visualization could engage the user.

We build upon previous research [8] and our web-enabled application OECD eXplorer [4] platform that is emerging as a de facto standard in the statistics community for exploring and communicating statistics data. A novel storytelling mechanism is introduced for the author to: 1) import regional statistical data; 2) explore and make discoveries through trends and patterns and derive insight - gained knowledge is the foundation for 3) creating a story that can be 4) shared with colleagues and reach consensus and trust. Visual discoveries are captured into snapshots together with descriptive metadata and hyperlinks in relation to the analytics reasoning. The author gets feedback from colleagues, adopts the story and 5) finally publishes "tell-a-story" to the community using a "Vislet" that is embedded in blogs or Web pages.

2 Related Work

Volumes of official national and sub-national statistical data are today generated by statistics offices all over the world and stored in public databases such as the *OECD* Regional database but not used as effectively as one would wish for. Little focus has been given to make web-enabled sophisticated geovisual analytics technologies accessible to statisticians and advance research for collaborative dissemination to the public.

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 [11] and Jern [6,8] in geovisualization and incorporated features to capture and reuse interactions and integrate them into electronic documents. Another 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. [14] describes a method they call “Re-Visualization” and a related tool ReVise that captures and re-uses analysis sessions Keel [10] 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 [15] 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 also limit this possibility.

Research has so far focused on tools that explore data [1] while methods that communicate gained knowledge with clarity, precision, and efficiency has not achieved the same attention. Geovisual analytics tools should share discoveries with colleagues and communicate efficiently relevant knowledge to the public with the goal to advance research critical to educational communication and publishing.

3 System Implementation

The conceptual data model for our eXplorer platform can be seen as a data cube with three dimensions: space, time and indicators. The spatial dimension is represented by the regions and the indicators are various demographics measurements (GDP growth, elderly dependency rate, etc). Time is the data acquisition period. The general method for finding a value in the cube is by its position (space; time; indicator;) and fast access time is essential for motion graphs. Space-time-indicator awareness means that the data cube can be analysed and visualized across all three dimensions simultaneously. eXplorer performs this task by integrating and time-linking all its motion graphs (figure 1): choropleth map, parallel coordinates, scatter plot, table lens, data grid, pie glyphs and time graph etc.

eXplorer is customized from our GAV Flash class library [16], programmed in Adobe’s object-oriented language ActionScript and includes a collection of common geo- and information visualization representations. Statistical data are effectively analysed through the use of time-linked views controlled by a time slider. Complex patterns can be detected through a number of different visual representations simultaneously, each of which is best suited to highlight different statistics pattern and can help stimulate the analytical visual thinking process so characteristic for geovisual analytics reasoning. All graphs are time-linked, important in the synthesis of animation within explorative statistical data analysis.

Interactive features that support the analytical reasoning process include tooltips, brushing, highlight, visual inquiry, conditioned statistics filter mechanisms that can discover outliers and simultaneously update all views. Of particular interest is the common information visualization methods table lens and parallel coordinates, to a great extent unknown to the statistics community extended with special features that are important to statistics exploration, for example, compare the profiles of selected regions, motion to see these profiles change over time, frequency histograms and filter operations based on percentile statistics. The Flash-based enhanced parallel coordinates plot and table lens have slowly demonstrated to be not only functional but also productive visualizing patterns for multivariate statistical (6-12) indicators [9].

Collaboration is achieved through a mechanism in GAV Flash (figure 2) that supports the storage of interactive events in an analytical reasoning process through “memorized interactive visualization views” or “snapshots” that can be captured at any time during an explorative data analysis process and becomes an important task of the storytelling authoring analytical reasoning process.

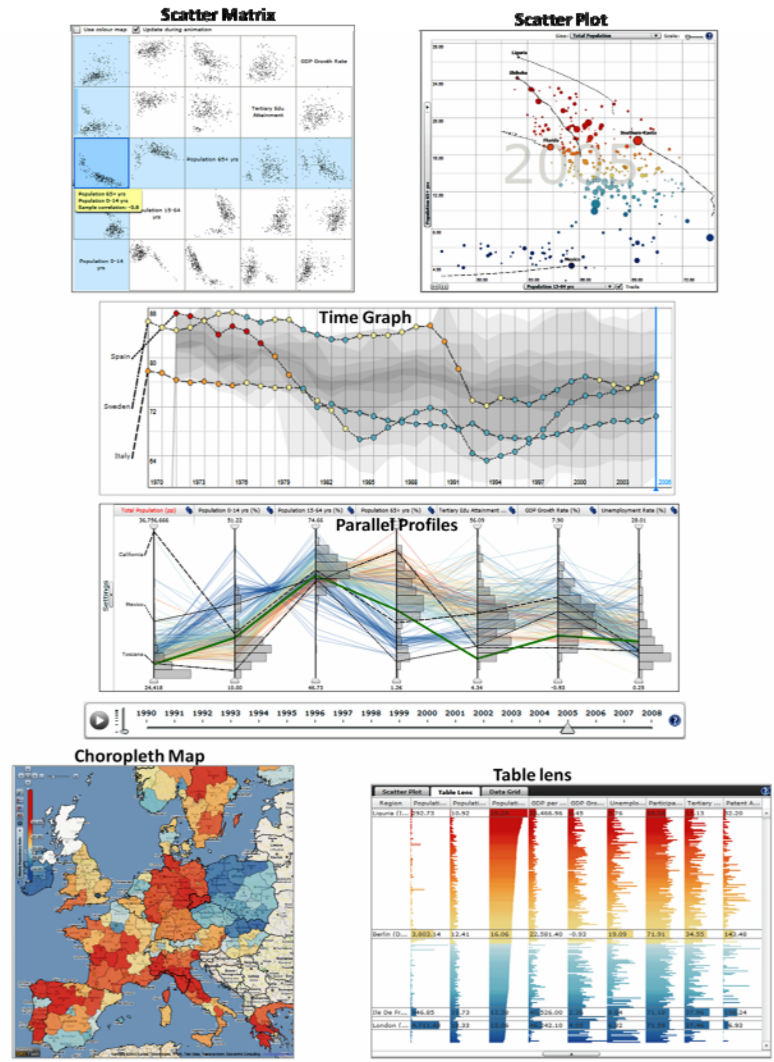

Fig. 1. eXplorer and Vislets are developed from GAV Flash components customized and optimized to sustain real-time coordinated time-linked views [17] that are simultaneously updated with changing regional statistics data for every new time step. The user can stop the time animation and start interacting with the statistics data at any time step.

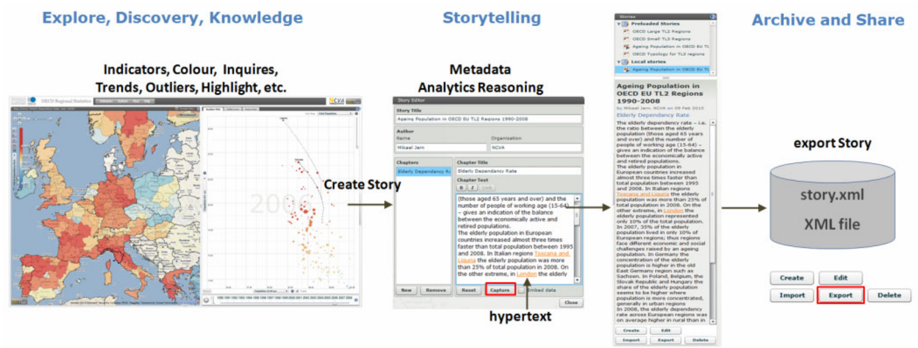

Fig. 2. The storytelling mechanism allows a sharable story to be created and saved in xml. Readers can then import the story and follow the analyst's way of reasoning through descriptive text and hyperlinks that instantiate snapshots in the visual representation.

3.1 Snapshot

When exploring and making sense of comprehensive statistics data, we need a coherent cognitive workspace to hang our discoveries on for organizing and navigating our thoughts. The GAV Flash toolkit includes such means by capturing saving and packaging the results of an eXplorer "gain insight" process in a series of "snapshots" that could help the analyst to highlight views of particular interest and subsequently guide other analysts to follow important discoveries. The snapshot tool creates a single or a continuous series (story) of visualization captures during the exploration process. In a typical scenario the analyst has selected relevant attributes, time step (temporal data), regions-of-interest, colour class values, filter conditions for selected attributes and finally highlights the "discovery" from a certain angle (viewing properties).

The analyst requests a snapshot with the *Capture* function that results in a snapshot class operation scanning through all its connected GAV Flash components for properties to be captured. Each of these properties will then be parsed into XML and written to a file that also contains details on which data (attributes and GIS regions) was used and a unique name for each component. When a snapshot is activated, the saved state of the snapshot class will be read from the XML file and parse its nodes back into component properties again. The previously marked properties will then be applied and set the state of the application.

3.2 Storytelling

Storytelling, in our context, is about telling a story on the subject of statistics data and related analytics reasoning about how gained knowledge was achieved. Storytelling within this participative web context, could more engagingly draw the user into exciting reflections and sometimes change a perspective altogether. The story is placed in the hands of those who need it, e.g. policy and decision makers, teachers but also the informed citizens. Dynamic visual storytelling is a way of telling stories through interactive web-enabled visualization. Our proposed novel storytelling technology could advance research critical to collaboration and dissemination of digital media and enable a leap in understanding by the audience so as to grasp how statistical indicators may influence our society.

Statisticians with diverse background and expertise participate in a creative discovery processes that transforms statistical data into knowledge. Storytelling tools integrate this geovisual analytics process with collaborative means that streamline a knowledge exchange process of developing a shared understanding with other statisticians and after consensus has been reached can be published. The snapshot mechanism helps the author of a story to highlight data views of particular interest and subsequently guide others to important visual discoveries.

The author creates a single or a discrete series of captures during the explorative process by electing relevant indicators, regions-of-interest, colour schema, filter conditions focusing on the data-of-interest or a time step for temporal statistics.

Hypertext, meaning "more than just text", provides a richer functionality than simple metatext by allowing the reader to click on key words and learn about topics in the story. A story hyperlink is here a reference in the story metatext that links to an external URL web site or a captured snapshot. To insert a hyperlink in the metatext then select the text and a button “Link” is made visible and two options appear: a. new capture (snapshot) b. link to an external URL.

Before the actual capture is done, the user navigates, for example, the map view to a particular country, select indicator, select indicators for the scatter plot, select time step. A new view such as parallel axes can be added to the story etc. A “Capture” is made and all preferred states are saved. When the story later is read, hyperlinks can be initiated and eXplorer will display the state-of-the-snapshots.

Hyperlinks that instantiate an eXplorer state are a central feature of our storytelling mechanism together with associated descriptive text that could guide the reader in the analyst’s way of thinking. While it’s true that a picture is often worth a thousand words, sometimes a few words and a snapshot provide the difference between a pretty picture and understanding. This focus on publishing through assisted content creation with emphasis on visualization and metadata represents a novel advantage of our storytelling.

An eXplorer story can also have several chapters where data source, contents relating to indicators and visual layout can change. For example, in “ageing population for Europe during 1990-2008” (figure 3), chapter 1 includes a map linked to a scatter plot while chapter 2 has the same map but here linked to both scatter plot and a parallel axes (parallel coordinates, profile plot) to simultaneously analyse three selected regions from different visual perspectives.

3.3 Publisher and Vislets

A Vislet is a standalone Flash application (widget) assembled from low-level GAV Flash components in a class library and Adobe Flex GUI tools and is represented by, for example, a single map view or a composite time-linked map and scatter plot view (figure 3). A Vislet facilitates the transition of selected tedious statistics data into heterogeneous and communicative sense-making news entities with integrated metadata and dynamic embedded animated visualization that could engage the user.

Publisher (figure 4) is the server tool that imports a story and generates the HTML code that represents the Vislet and metadata.

First, the user selects appropriate visual representation for the Vislet e.g. map, scatter plot, parallel axes, table lens or time graph. Then the size of the Vislet window with metadata is set and Publisher generates the HTML code. This code is manually copied and finally manually (copy/paste) embedded into a web page. The Vislet can now be opened in the reader's Web browser and dynamically communicate the story. A Publisher server maintains the Vislet flash (swf) files together with a story repository, statistical data and regional shape maps. The Vislets run locally in the client's Flash Player and can thus achieve dynamic interactive performance.

Interactive features in a Vislet are exposed to all visualizations including tooltips, brushing, highlight, filter that can discover outliers and dynamic multiple-linked views. Several specialist colour legend tasks are supported e.g. show outliers based on 5th and 95th percentiles in certain colours or dynamic sliders that control class values etc. (figure 3).

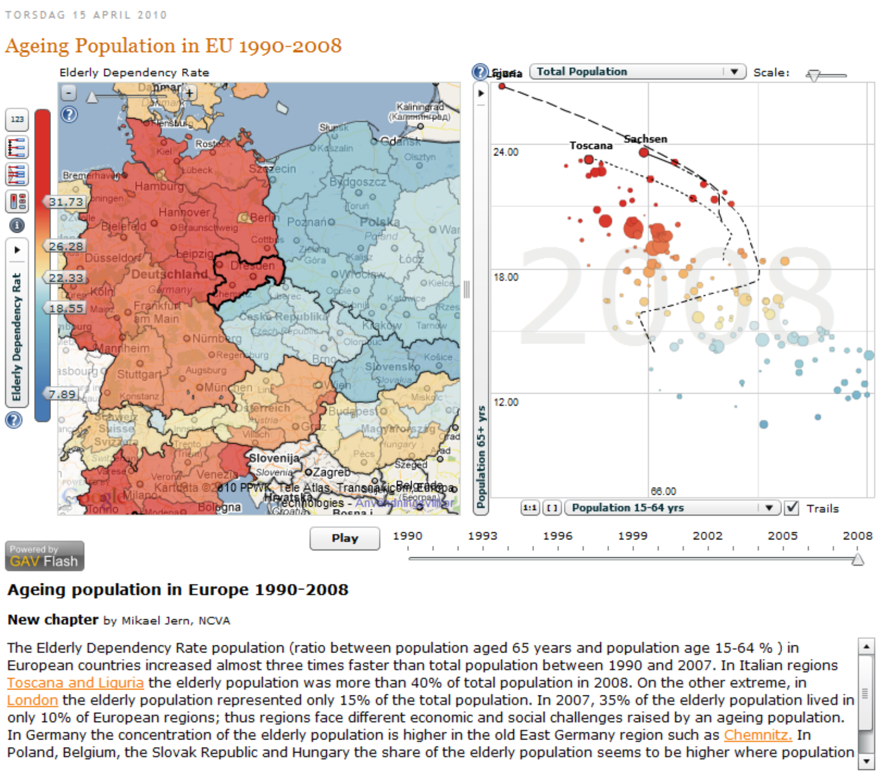

Fig. 3. Ageing population Europe 1990-2008. A Vislet with metadata is embedded in a web page using two time-linked views map and a data selection view. Only data relevant for the story is included. The user can click on the hyperlinks in the metatext and see snapshots – for example here "Chemnitz" is initiated.

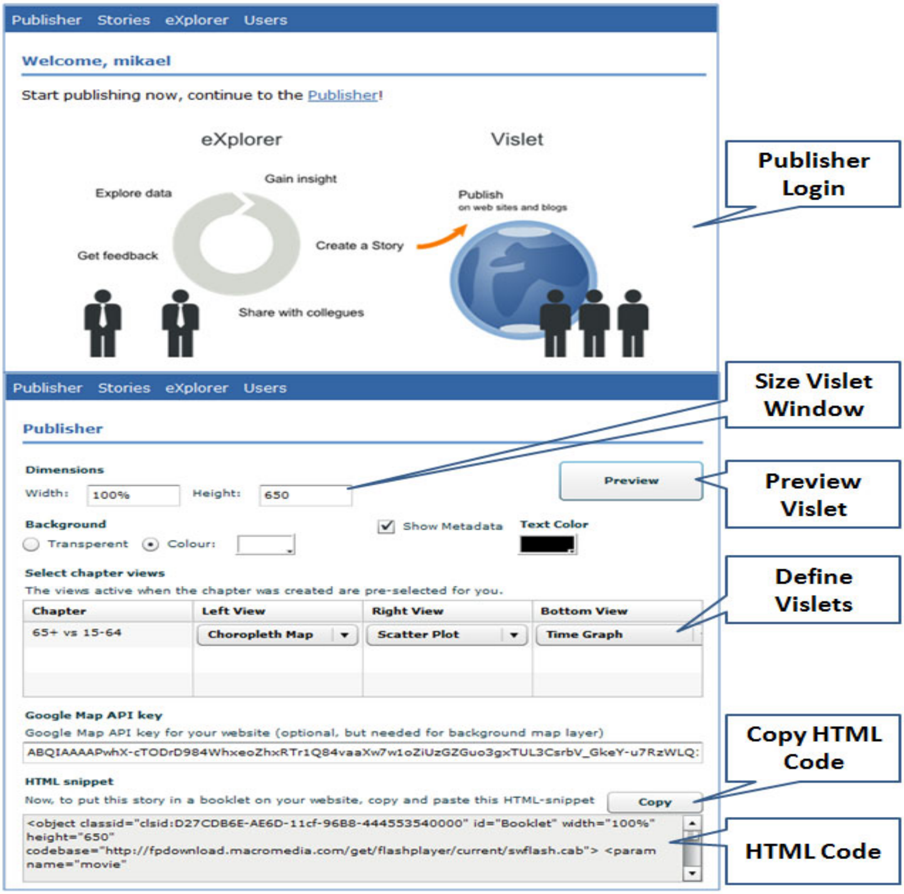

Fig. 4. Statistics Publisher imports stories and produce HTML code representing Vislets

4 Case Study

Our case study is based on an OECD eXplorer "explore, discover trends and gain insight" scenario and is here used to explain the process from creating a story with snapshots and metatext, save the story and finally use Publisher to load the story and generate the HTML code that is placed in a web site and a Vislet is created:

I. <u>Create new or select existing Story in OECD eXplorer</u>

OECD eXplorer is used to 1) select spatio-temporal and multivariate statistical data; 2) explore and discern trends and patterns; 3) orchestrate and create snapshots in the Story Editor for important discoveries and associate these snapshots with hyper-links in the metatext; 4) Save the story in XML format; 5) collaborate with colleagues to confirm.

II. Use Publisher to customize your Vislet

Set Vislet properties in the Publisher (figure 4) panel e.g. height, width, graphics layout for visualization and metadata, background and text colour.

III. Choose visual representations and copy HTML code

Select visual representations (map, scatter plot, table lens, parallel coordinates or time graph) in drop-down menus. The HTML-code is now automatically generated by Publisher and copied when you press "Copy". This HTML code, when pasted into a web page or blog, will load your Vislet with associate metadata and hyperlinks using the settings you have chosen (figure 4).

IV. Paste the HTML-code into your web page

Paste the HTML code either into a web page or directly into a CMS or blog. The resulting Vislet can be evaluated at: http://vitagate.itn.liu.se/GAV/vislets/html/test1.html.

5 Conclusions and Future Development

The technique introduced in this paper allows the analyst (author) to communicate with interested readers through visual discoveries captured into snapshots together with descriptive text. Selected indicators and visual representations can be published together with their metadata, thus facilitating the comprehension of statistical information by non expert readers. We believe that this advanced storytelling technology can be very useful for media as some examples of using eXplorer to tell a story have already showed. At the same time, the Vislet technique applied to OECD eXplorer can help developing agile on-line publications, which draw the attention on recent trends and inequalities among OECD regions. Reviews from our partners (OECD, Sweden and Denmark Statistics, Eurostat, Italy Statistics, Goteborg City) who have evaluated the platform and tool highlights the following features:

- eXplorer can easily be customized by a statistics organisation - requires only regional boundaries (shape file) and associate indicator data;
- eXplorer is a comprehensive tool for advanced users – the Vislet approach is regarded as a painless and more attractive to public;
- Encourage collaboration between statistics analysts and users of statistics;
- Possibility to capture, save and open discoveries (snapshots) with attached analytics reasoning metadata e.g. Storytelling;
- IT expertise is not required to publish interactive visualization embedded in blogs or web pages;
- Possible strategic tool for news media to publish statistics news on the web;
- Easy-to-import external statistical data into eXplorer;
- Ability to have dynamic time-link views and see the multi-dimensionality of regional development;
- Increased expectations in terms of user experience;
- Will encourage more educational use of official statistics;

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Pattern Browsing and Query Adjustment for the Exploratory Analysis and Cooperative Visualisation of Microarray Time-Course Data

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Abstract. This paper presents work to support collaborative visualisation and data analysis in the microarray time-series explorer (MaTSE) software. We introduce a novel visualisation component called the 'pattern browser' which is used to support the annotation and adjustment of user queries. This includes an explanation of why this component is required and how it can be used with our online pattern repository by biologists collaborating in the analysis of a microarray time-course data set. To conclude we suggest which other types of collaborative visualisation would benefit from the introduction of a component with comparable functionality.

Keywords: Cooperative Visualisation, Combined Multiple Views, Bioinformatics, Microarray Data Analysis.

1 Introduction

In the past decade there has been a rapid increase in the amount of data generated by high-throughput genomic technologies [1], [2]. While this data shows great potential for allowing biologists to increase their knowledge of biological systems and processes, there remain significant challenges concerning effective exploitation. These relate to the scale and complexity of the data. In the first instance biologists need to be able to analyze data from their own laboratory and must contend with the large amount of data generated by individual experiments. There is also an increased need for biologists to be able to share data and analysis results in order to benefit from experiments and research undertaken outwith their own laboratory.

While published results of microarray experiments tend to focus on a small group of findings, the data on which any publication is based has the potential to reveal a range of findings related to a variety of biological processes. In order for the scientific community to better exploit this potential, biologists are encouraged to use online data repositories [2]. If a biologist who downloads data from one of these repositories has similar objectives to those of the original authors it is also likely that they will want to explore the results of the original authors' analysis together with details of how that analysis was undertaken with a view to performing a similar analysis themselves. This

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process is not well supported in current software. While a number of tools allow users to share findings by saving and restoring application states (for example Spotfire DesisionSite and Agilent Genespring), analysis steps cannot be adjusted in a predictable way or with adequate feedback of results. The work we have undertaken with the MaTSE application and its pattern-browser component addresses this problem by providing users with a platform that allows them to discover and define patterns in their data using queries that can be shared, explored and adjusted in a manner that is both meaningful and informative.

2 Related Work

The majority of software applications used for the analysis of microarray data rely on clustering algorithms which prescribe a fixed set of gene clusters based on gene-gene activity similarity scores. Information visualisation is used to explore the results of these algorithms. A finding from this type of interface tends to be an individual cluster exhibiting a pattern of gene activity with a gene population that is correlated with a predefined gene grouping or biological pathway sourced from the literature. For a user to alter a query on which a clustering finding is based they would need to select an alternative grouping, specify alternative clustering parameters (such as the distance metric) or use an alternative clustering algorithm. In the former case the results would be unrelated to the original result and in the latter two cases the outcome is highly unpredictable as an entirely new set of gene clusters will be generated with no relation to the original set [3], [4].

Other software applications for the analysis of microarray time-course data allow users to query their data by using a line-chart representation to specify a required pattern of expression, such as an acceptable range of values, over a given interval of the time-course [5], [6]. They allow queries to be adjusted but do not support data sharing since the attributes upon which queries are based are not particularly useful for most biologists who prefer to quantify patterns in their data using fold-changes in differential expression [1]. These techniques also fail to provide adequate feedback of results when queries are adjusted since the overview provided is unable to reveal anything other than the range of values at individual time points [7]. Changes in activity are represented by angled lines between time-points in a line-chart and the majority of lines are occluded.

3 MaTSE

MaTSE [7] is a different type of analysis tool which forgoes the clustering step prior to visualisation using a more direct representation of the data that allows selections to be explored and adjusted. Instead of prescribing a fixed set of gene clusters MaTSE allows the user to explore their data using a scatter-plot that can be animated across time-points and time-intervals to display measurable attributes of the data.

The MaTSE technique uses two coordinated views of the data: a line-chart and a scatter-plot (see figure 1). The line-chart view overlays value versus time representations of the recorded activity for all genes and allows the user to control the interval of the data for displayed in the scatter-plot. The scatter-plot summarizes the data within the selected interval by representing each gene as a single point with its translation along the Y-axis corresponding to its activity over the selected interval and its translation along the X-axis corresponding to its fold change-in-activity from the start to the end of the interval. As the line-chart view controls are manipulated and the interval selection is adjusted, the positions of genes in the scatter-plot are recalculated to reflect the change in temporal context. Continuous adjustment of the selected interval (where the start and end times of the selected interval are moved independently or in parallel) cause the position of genes in the scatter-plot to be shifted with the resulting animation allowing the user to perceive patterns of gene activity over time [7].

Evaluation of an early version of MaTSE demonstrated that it was capable of allowing users to find previously unexpected patterns of temporal activity [7]. However, further requirements analysis in preparation for the design and development of the current version of the software revealed that users wanted to be able to quantify the queries used to uncover and define those patterns so they could share their findings with other users. This led us to incorporate a new component, the pattern browser, into our latest version of MaTSE.

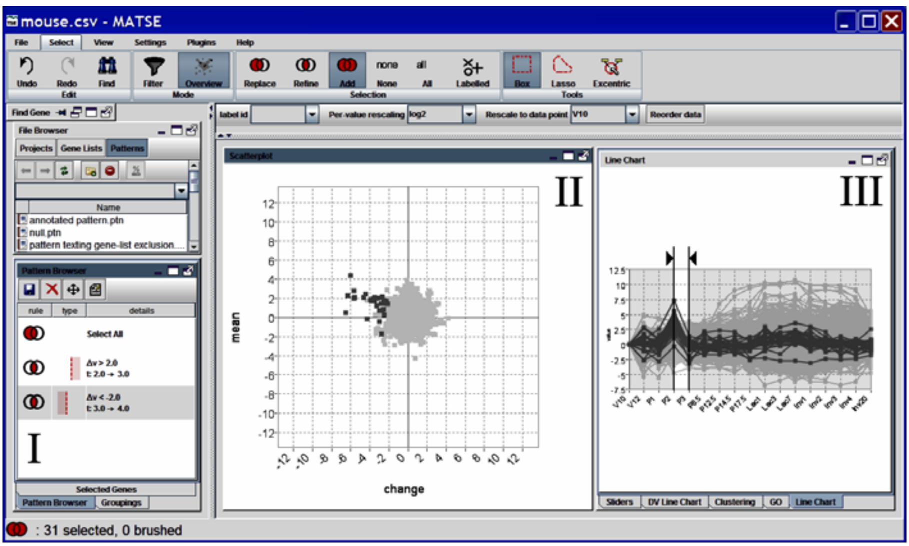

Fig. 1. A screenshot of the MaTSE interface. Labeled components are **I)** The pattern-browser, **II)** scatter-plot and **III)** line-chart. The current pattern is the result of two separate queries.

4 The Pattern Browser

The primary functions of the MaTSE pattern-browser component are to store query components, combine query components, allow queries to be explored and allow query components to be adjusted. The browser is allocated its own separate panel within the MaTSE interface and is coordinated with other MaTSE components. These components are adapted to allow query parameters to be adjusted and ensure that stored queries are concise without the inclusion of superfluous values or values a user might find difficult to interpret.

4.1 Composing Box Queries

MaTSE allows users to compose queries in the scatter-plot by clicking on a point and dragging a box around the genes they want to select. Since these queries will be revisited via the browser panel it is in the users' interest that they are as concise as possible. This makes it important to insure that stored queries omit superfluous parameters. Superfluous parameters are included in a box query when a user attempts to specify a threshold on the value of a single axis. This situation is illustrated in figure 2. Here it can be seen that the user uses one edge of the box to separate the genes to be included in their query from the rest of the data. The other edges of the box specify additional query parameters which have no effect on the overall query result. These redundant parameters are removed before any query is stored.

Our users also wanted to limit query parameters to rounded values with a smaller number of significant digits. To ensure that only these values are included in stored queries a cross-hair, positioned at a rounded approximation of the mouse position, is used for query formation rather than a direct mapping of the mouse position. Oversized labels detail the cross-hair position on each axis to inform the user of the current cross-hair position (see figure 3a). Once a query is executed a text and icon representation of query parameters is displayed in the pattern-browsing panel.

4.2 Combining Queries

MaTSE allows users to combine queries to find and specify more complex patterns of activity in the data. An example of such a pattern is illustrated in figure 3b. Here a group of genes have activity rising over one interval and falling over another. Patterns can also include queries that select gene-groupings (imported from the Gene Ontology online database) or lasso queries formed by drawing a line-loop around genes in the scatter-plot. The user can specify how queries are combined using options in the 'select' tab of the main menu. The options are to replace, refine or add to the results of the previous queries, select all genes or select no genes.

The selected option for combining queries affects how the pattern browser stores query parameters. When the 'refine' or 'add' options are selected the result of any new query is combined with the previous result. This makes it necessary to keep a record of how the previous result was obtained so new queries are added bellow existing queries to form a list in the pattern-browser panel. Conversely, when the 'replace' option is selected and a new query is performed the results of previous queries are discarded so their entries are removed from the panel. The 'select all' and 'select none' options also remove the results of previous queries but do this as soon as either button is pressed.

4.3 Annotating, Storing and Restoring Patterns

Adding and editing pattern annotation is a relatively straight-forward process. When the user wants to view the annotation they simply need to click on the note-pad icon in the pattern-browser menu. This causes a pattern-annotation dialogue to appear with

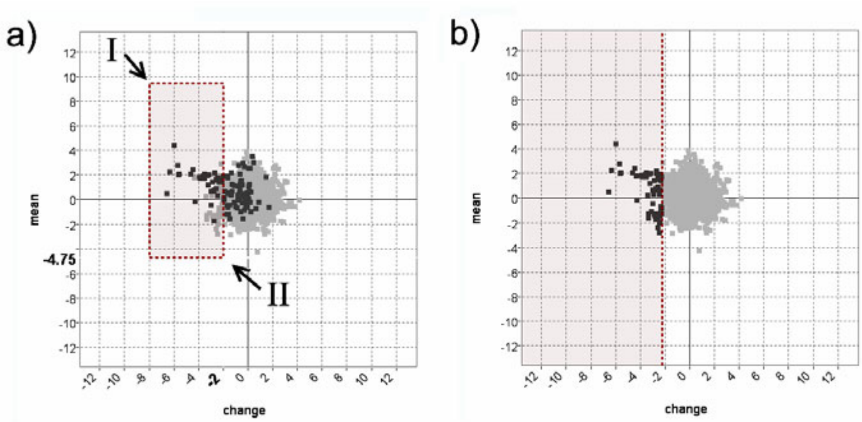

Fig. 2. a) A users attempt to specify a threshold on the value of a single axis by dragging a box query. The user clicks on point I and drags to point II to form the box-query illustrated with dotted lines. **b)** The dotted line indicates the threshold the user wants to set and the threshold sent to the MaTSE pattern browser as the recorded query.

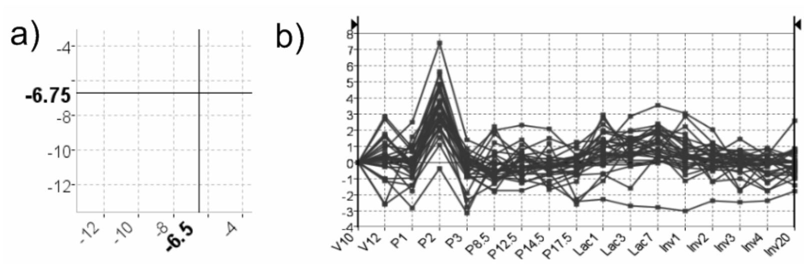

Fig. 3. a) Cross-hair positioned at a rounded-value approximation of the mouse cursor position. The coordinates of the cursor are used to when forming queries. Oversized labels on the axes describe the cross-hair position to inform the user before and during query specification. **b)** Line-chart representation of a compound query result.

text of the current annotation. The text in the dialogue is editable so it can also be used to add new annotation or amend existing annotation.

MaTSE patterns can be saved either offline to the user's hard-drive or online to the MaTSE website. Patterns are stored offline by clicking on the save button in the pattern-browser panel menu. Once the pattern is named it is saved in XML format within the current project's directory. This file includes the pattern's queries, annotation and any transforms applied to the data. Patterns can be renamed and organized into sub-directories using MaTSE's file browser panel. Double-clicking on a pattern file in the file browser restores the pattern to the pattern browser and sets the gene selection to match the result of the final query combination. Patterns are uploaded to and downloaded from the MaTSE website in a similar manner. The advantages of uploading patterns to the MaTSE website are that they are made public and can be downloaded, further explored and discussed by other users. The ability to share the result of an exploration while also giving access to the intermediate steps leading up to it is a unique feature of MaTSE that can further stimulate cooperation between biologists. The quick turn-around time that is achieved by direct access to the online repository from the application guarantees a smooth interchange between users in different locations.

4.4 Browsing Patterns and Adjusting Queries

MaTSE patterns can be explored and adjusted at any point during their formation or after they are restored to the application. Patterns are explored by clicking on the visual representations of individual queries in the patter browser. If the query has an associated time-interval context the scatter-plot animates to that particular interval before the original query parameters are highlighted on the scatter-plot. The highlighting remains for as long as the mouse-pointer hovers over the pattern-browser panel. The highlighting uses the same visual encoding of the original query formation tool (see figure 2b). Use of automated animation between query intervals allows users to rapidly alternate between queries to gain a better idea how individual query parameters relate to the underlying data.

Patterns can also be adjusted by clicking on the visual representations of individual box queries in the patter browser. Clicking on a query then the 'delete' button in the pattern-browser menu deletes a query from the pattern and removes its influence on the set of selected genes. Clicking on a query followed by the 'adjust' button allows queries to be adjusted incrementally. After this button is pressed the selected query remains highlighted on the scatter-plot. Clicking and dragging on the edges of this representation resizes it and updates the associated query parameters with the set of selected genes updated continuously to provide visual feedback of the adjustment's effect on the data-set. This type of dynamic feedback is useful if, for example, a user sees that a threshold is set high and they want to see the result if it is set lower. On setting the threshold lower and revealing that this has little or no effect on the overall result the user can immediately return the parameter to its original value by continuing their dragging action in the opposite direction.

5 Evaluation

User evaluation of the MaTSE pattern-browser functionality was undertaken with five different biologists working in the areas of toxicology, stem cell research, plant biology and bioinformatics. The evaluation included sessions with and without the pattern-browser functionality. The previous method for storing patterns was for users to save selections as gene-lists which included annotation but did not include query parameters. Evaluation sessions included a tutorial where the biologists where taught how to use new functionality and free exploration sessions where users were asked to use the tool to analyze their own data using the functionalities of the tool they felt most appropriate, in the way in which they felt most comfortable. We applied a think-aloud protocol during the free sessions and conducted follow up interviews to record results.

Overall, we found that reaction to the pattern-browser functionality was positive from all users and all users expressed a strong preference for using the pattern-browser rather than the previous method for storing patterns. The pattern-browser was found to have a number of clear benefits and tended to be used in a distinctive way across the different user groups. As users formed compound queries they tended to monitor the pattern-browser panel to confirm their query was committed. If a user moved away from the MaTSE interface during their MaTSE session (to, for example, answer the phone or look up the function of a particular gene) their first task on returning would be would be to quickly review the list of query parameters in the pattern-browser. Occasionally this involved clicking on queries in the browser to view them in the scatter-plot. The users expressed a degree of satisfaction with the pattern browser and its ability to help them recall their previous selections. The converse situation was apparent in our evaluation of previous prototypes where, on returning to MaTSE from another task, users often became frustrated when they forgot what their previous selections had been.

While all users stored their patterns and restored them to the tool from time to time, it was only the biologists working in a research orientated environment who tended to adjust query parameters. The toxicologists who operated in a commercial environment worked in a more rigid fashion tending to set query thresholds to a fixed level with little motivation to adjust query parameters during their exploration of the data. The other biologists would often adjust parameters as part of their exploration of the data. Here, the continuous feedback of results in all views was found to be useful with biologists adjusting parameters to see how the overall selection changed or if a particular gene became selected before deciding on a final query parameter value.

The online storage and annotation of MaTSE patterns has not as yet been formally evaluated with biologists. The biologists in our other evaluations have however expressed enthusiasm for the idea of being able to share their results with colleagues using the pattern-browser functionality. They also believed that they would be able to understand and make good use of stored patterns if they were submitted by experts in their own particular field.

6 Conclusion and Further Work

We have adapted the MaTSE software to support cooperative visualisation of microarray time-course data with the addition of a new component called the 'pattern-browser'. The adapted interface stores meaningful query parameters allowing the user to define patterns which can be recalled, explored and adjusted. Query parameters are restricted to rounded values and superfluous parameters are removed as queries are formed. Animation is used when patterns are explored and there is continuous feedback of results as query parameters are adjusted. In our evaluation of the new interface, users have been able to identify a number of benefits. These related to the ease in which query parameters could be recalled and the additional information that could be gleaned from the data when adjusting parameters. Our users also believe that the new functionality will serve them well to share findings during the process of cooperative visualisation.

In MaTSE the use of a pattern browser panel for exploration of query parameters is necessitated by the fact that the scatter-plot is animated and the relative position of data point's changes according to the selected time-frame. This makes it impossible for all selections to be presented in the scatter-plot at the same time and the pattern browser is needed to allow the user to access selections individually. Including a separate scatter-plot for each selection would be another solution if not for the fact that screen space is at a premium and a suitable resolution is necessary for the scatter-plot to be functional. The results of this paper should be of use to designers of other visualisations using multiple projections of the data where all user selections cannot be summarized at the same time by overlaying them on top of the visualisation. Examples of such visualisations include visualisations for data-cubes [8] and similar data with a large numbers of dimensions.

For future-work we aim to demonstrate the MaTSE technique in a published case study with data from an original experiment so we can promote the general technique and encourage use of the online pattern-repository. We also plan to adapt the pattern browser technique for use with other visualisations developed in our research group.

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CAD and VR Technologies Used in Civil Engineering Education

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Abstract. Virtual Reality (VR) technology could be applied as a complement to three-dimensional (3D) modelling, leading to better communication whether in vocational training, in education or in professional practice. Techniques of 3D modelling and VR were applied to the development of models related to the construction process. The 3D models created to support rehabilitation design emerge as an important tool for the monitoring of anomalies in structures and to assist decisions based on the visual analyses of alternative solutions. The VR model created to help the management of lighting systems in buildings allows the visual and interactive transmission of information related to the physical behaviour of the elements, defined as a function of the time variable. Didactic interactive models showing construction works were also developed. The introduction of CAD and VR techniques in school is helpful to students in order to prepare them to consider these technologies as important supports, later in their professional practice.

Keywords: Cooperative visualization, Engineering Education, Didactic Models, 3D models, Virtual Reality.

1 Introduction

Concerning educational tasks, the interaction allowed by three-dimensional (3D) geometric models could bring an end to passive learner attitudes which are often found in traditional academic teaching situations. In addition, virtual reality technology (VR) could be applied as a complement to 3D modelling, leading to better communication between the various stakeholders in the process, whether in training, in education or in professional practice. This role is particularly relevant to the presentation of processes which are defined through sequential stages as generally is the case in the learning of new curricular subjects. Besides this constant updating of training in the new graphic resources available to and in widespread and frequent use in professions in the fields of engineering or architecture, the school should also adapt its teaching activities to the new tools of visual communication.

Today, 3D models and VR technology are used in engineering schools to aid both the lecturers and students. An aspect that must be improved is the preparation of didactic materials to support teaching. They offer students the opportunity to visualize

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the engineering concepts they learn in the classroom. The 3D and VR models are important mean of cooperation between collaborators involved in engineering education

2 3D and VR Models in AEC

The use of CAD and VR systems is helpful in areas such as Architecture, Engineering and Construction. At present, when carrying out a project, the use of graphic systems and, in particular, those relating to 3D modelling, makes a very positive contribution towards improving the transmission of rigorously correct technical information and, in general, to the understanding of spatial configurations in their environment. This means of expression surpasses a drawing, a picture or a diagram [1].

2.1 Construction

Rehabilitation is a type of construction work where the final result is of utmost importance and which must be evaluated at a very early stage, before any decision or construction work becomes definitive. Two recent pieces of work related to Bologna master's theses were developed based on this technology. The students J. Neves and B. Martins had to learn 3D advanced modelling. In both cases, 3D models appear as an important tool for anomaly surveillance in the structures and for supporting decisions based on the visual analyses of alternative rehabilitation solutions:

- Neves studied an historic building that was submitted to a rehabilitation process that includes the detection of structural anomalies, the replacement of damaged resistant elements and the adaptation of the building to new uses (Fig. 1).

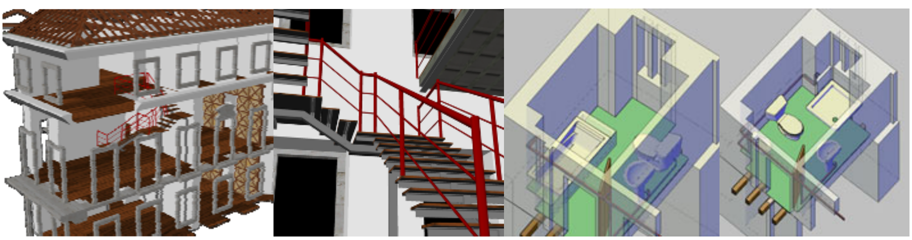

Fig. 1. 3D models in rehabilitation cases

- Martins considered the installation of new sanitary equipment in an old building, which presents a significant degree of dilapidation. In this case, two alterative solutions were worked out and modelled (Fig. 1). By manipulating the models, the understanding of the organization of the interior space is quite clear, better then that gained by just analyzing plan drawings.

The main aim of a research project, which is now in progress at the Department of Civil Engineering of the Technical University of Lisbon, is to develop virtual models as tools to support decision-making in the planning of construction management and maintenance. A first prototype concerning the lighting system was developed [2]. It integrates VR system and a computer application implemented in Visual Basic (VB) language. The model allows the examination of the physical model, visualizing, for each element modelled in 3D and linked to a database, the corresponding technical information concerned with the wear and tear aspects of the material, defined for that period of time (Fig. 2).

Fig. 2. VR model and updated information concerning lighting elements

2.2 Didactic VR models

The aim of the practical application of the developed didactic virtual models is to provide support in Civil Engineering education namely in those disciplines related to bridges and construction process, both in classroom-based education and e-learning technology. The virtual model can be interactively manipulated allowing the teacher or student to monitor the physical evolution of the work and the construction activities

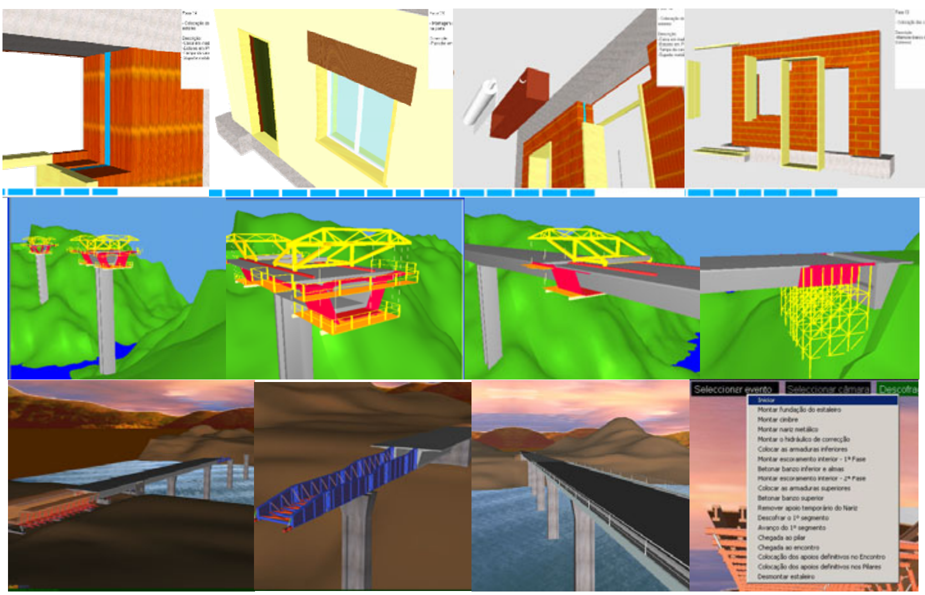

Fig. 3. 3d didactic models in construction

inherent in its progress. The selected examples are three elementary work situations [3] (Fig.3): The first concerns the building of an external wall, a basic component of a building; The second presents the cantilever method of bridge deck construction, a frequent construction technique; And the last concerns the incremental launching method of bridge deck construction.

The user is able to grasp the most important details of the construction method because of the camera movement which consistently shows the model throughout all the sequences of events http://www.octaviomartins.com/lancamentoIncremental.

3 Conclusions

This paper has focussed on the importance of teaching CAD systems at school, not only as a good instrument for "drawings" but mostly as a helpful tool to be used to develop research work and, as a professional support in their activity as engineers. Regarding Bologna, these two recent examples of 3D modelling were created to support rehabilitation design. The models were useful to the outcome of building anomaly surveillance and to workout alternative solutions. The VR model created to help the management of lighting systems in buildings was developed within a research project in school. Thus, teaching CAD and VR technologies in school may well induce students to consider this knowledge as elementals in their future professional activity, while to establishing the link between CAD systems and engineering theory.

The didactic VR models presented in the text shows the sequence of construction processes allowing step-by-step visualization. The models concern a wall, as a significant component of a building and two methods of bridge construction, each with different degrees of detail and technical information. The target users of these models are Civil Engineering students. Here, the VR technology was applied for educational purposes.

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Complicated Simulation Visualization Based on Grid and Cloud Computing

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Abstract. Many complicated applications use grid and cloud computing for their visualization. After completion of each partial simulation step, the results are stored in reserved output area of the storage element and accessible for further processing. In this paper we present a visualization tool to visualize astrophysical simulations and natural disasters simulations using grid and cloud computing.

Keywords: Grid, Cloud, Virtual Reality, Visualization Tool.

1 Introduction

In this paper, we present a visualization tool which has been used on parametric astrophysical simulations and natural disaster simulations. The first simulation project is a collaboration among Astronomical Institute (Slovakia), Catania Observatory (Italy) and Adam Mickiewicz University in Poznan (Poland). The second project performed natural disasters simulations computed at our institute. The applications were ported to EGEE grid infrastructure by the Institute of Informatics Slovak Academy of Sciences (Slovakia) [3], [5].

Parametric studies are a bigger group of grid and cloud applications. Parametric studies execute one application many times with different sets of input parameters. The parameters describe sets of input values. Each set of input values specifies the values for execution of one application, which is referred to as a single job. For a long time, one of the main problems in computing intensive parametric studies is to control the executions and guarantee it to run correctly. Another is to show the intermediate results to the clients. Such problems require a correct way of reducing the number of submitted jobs and the visualization for partial results along the time, while the application is still running. To solve these problems, we developed two tools: one for job submission and the other is for continuous sequential visualization. With these tools, we provided a complete solution for the specific main problems in the grid computing environment. We tested our job submission tool as well as the on-line partial visualization tool in the modal parametric studies for the astrophysical simulations.

There are related works dealing with the problem of how to visualize the complicated applications in grid environment and the computations are rather expensive.

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One of them is the grid visualization kernel developed at Johannes Kepler University in Linz, Austria [8]. There are efforts to provide a grid-based parallel visualization environment to visualize a massive dataset in parallel. The visualization environment is implemented as a visualization service on grid. With respect to our experiences in grid computing and visualization we aim at developing a new visualization tool. In our tool, all client requirements are considered. Our method is based on a new way of adaptive visualization to grid environment and currently to cloud computing. Specifically, the visualization application is included in grid infrastructure as an additional grid application. The major difference between our visualization tool and the grid visualization kernel [8] is that our tool gives the direct output as part of the online process with variability which is replaceable.

2 Grid Computing Based Applications

2.1 Astrophysical Applications

Astrophysical applications are typical parametric studies, which created a large group of applications using grid and currently cloud computing (an example is shown in Fig. 5).

One of them are the dynamical evolution of proto-planetary disc and formation of Oort cloud during the period from 1 to 1000 Myr (Myr – million year) in the first evolutionary phase, and during 2000 Myr in the second evolutinary phase [2], [7]. An unsolved question of the solar system cosmogony is the origin of comets and minor bodies with respect to the solar system evolution [1]. In the past, authors predicted the existence of reservoirs of the objects and tried to explain the origin and subsequent evolution of these reservoirs. Several partial theories have been developed to clarify the problem. Recently, the researchers try to present a unified theory of the formation of small-body reservoirs in the solar system: the Kuiper Belt, the Scattered Disc situated beyond the orbit of Neptune. In our application we developed a new improved model for explaining the formation of the Oort Cloud. One has to assume dynamical evolution of a high number of particles under gravitational influence of the giant planets: Jupiter, Saturn, Uranus, Neptune, the Galactic Tide and nearby passing alien stars. Before our work, only two similar simulations have been performed by Duncan et al. [4] in 1987 and by Dones et al. in 2005. In our application we assumed 10038 test particles. It is several times more than in the previous simulations. Our extensive simulations required very large computing capacity. To complete our model on a single 2.8GHz CPU would last about 21 years. Using the grid infrastructure, the whole computation lasted 5 months; thus, it was more than 40 times faster. The result of our simulation is the dynamical evolution of orbits of test particles during the first giga year of the solar system lifetime. Detailed study of this first giga year evolution results in a general agreement with the results of previously mentioned models as well as in new facts and questions. Having used the mentioned visualization tool we obtain the ouputs structured for rendering in the files with VRML (Virtual Reality Modeling Language) syntax. The tool developed by us and used for the astrophysical application provides pictures and videos from simulation of the evolution of proto-planetary disc from 1 to 2000 Myr.

2.2 Natural Disasters Applications

The second type of application that the cloud computing can apply is the natural disasters applications. Every year, forest fires, floods and landslides cause enormous damage to vegetation, fauna, environment, properties and other significant human resources. (Fig.1 and Fig. 2 show examples). Particularly in national parks and natural reservations, unique areas with high degree of protection can be devastated by fire. For instance, during the destructive forest fire in the Slovak Paradise National Park (Slovakia) in 1976, very unique vegetation was destroyed in the Kysel' Gorge, where the recovery into the former state will last 200 years [6]. Till now this locality is closed for tourists because of the vast damages. There have been numerous projects on how to prevent such disasters.

Our research also deals with complies natural disaster simulations such as fires simulations [6], and grid based flood simulations. Many international projects focused on natural disasters utilize the visualization service to show intermediate or final results. The basic aim of our research within these projects is the creation of visualization service for modelling and 3D rendering the results of natural disasters such as

Fig. 1. Forest fire visualization in Krompla region – 3D Virtual Reality model

Fig. 2. Flood visualization on the river Vah – 3D Virtual Reality model

fires, floods and landslides which requires huge amount of computing power. Grid and cloud computing using numerous clusters or supercomputers as on-line 3D visualization service has been proved to be the right solution.

3 Visualization Service

3D visualization service for animation of natural disasters applications, astrophysical applications and all complicated applications based on grid and cloud computing have to integrate the visualization requests. Many applications from this area are using different kinds of simulation tools, which produce output data in different formats for displaying their computation results. The purpose of our visualization service is to model and display the results of various simulations. The visualization service requires unified standards such as integration of different formats of input data and the creation of unified visualization tools for them.

3.1 Visualization of the Final Results

When running parametric simulation with a large number of jobs (such as astrophysical simulations), the main problem was in the grid infrastructure reliability. The job management was rather time consuming due to the analysis of failed jobs and to their re-submission. Moreover, the jobs, waiting in a queue for a long time, can block the simulation. To overcome these problems, we developed an easy-to-use framework based on pilot jobs concept that uses only services and technologies available in EGEE (Enabling grids for E-science) infrastructure, grid middleware gLite and Bourne Shell scripting language. The framework consists of pilot jobs – workers, and automatic job management script. Workers are executing the application code in cycle with input datasets downloaded from a storage element using remote file access. The storage element contains the input, working and output areas (as subdirectories of the directory created by the user for each parameter study). The user prepares input datasets on the user interface and transfers them into the input area before starting the simulation. The working area is used by workers to store static information about computing nodes such as names of the computing element and computing node, CPU type and available memory. It is also used to monitor the information updated in regular intervals, the datasets, that are currently processed, and the statistics about processed datasets. Output data is stored into the output area, where the user can see the progress of simulation. To check the progress, the user only needs to list the contents of the output folder. The storage element is also accessible for grid FTP clients, therefore grid portals can also be used to watch the progress. To identify hanging jobs or jobs that perform too slowly, workers are periodically sending monitoring information to the storage element. To avoid termination of the workers by the queuing system, workers are executed only for a limited period of time. We use job management script for controlling the use of workers. The main function of the job management script is to maintain the defined number of active workers taking into account the number of failed submissions, the number of finished and waiting workers. The script uses job collections to speed up the start up and automatic blacklisting of full and erroneous sites. In case of our application the output data of the simulation located on the storage element can be directly used as the input for the visualization tool. The whole process is shown in Fig. 3. The architecture of the submission process is shown in Fig. 4 (left).

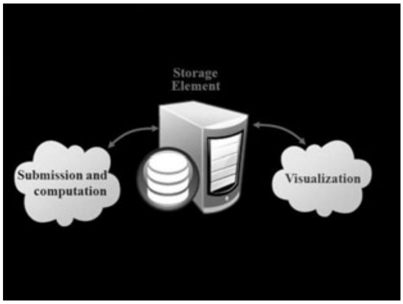

Fig. 3. Process of submission and on-line visualization

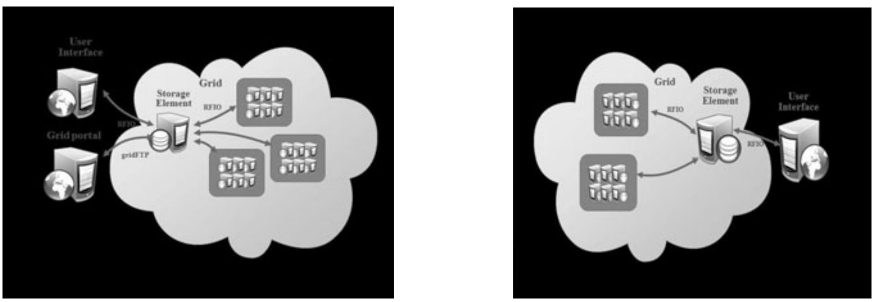

Fig. 4. Process of submission application to the grid (left), on-line visualization process (right)

3.2 The Visualization Tool – Architecture

The visualization tool is composed of several modules, which are responsible for creating scenes and converting data to the format possible to visualize. The visualization tool is designed as a plug-in module. The components generating rendering of scenes are easy to exchange, according to the requirements of the given application. The final product of the visualization tool includes a set of files containing data in the VRML (Virtual Reality Modelling Language) format. These output files can be rendered by many available VRML web-browsers (for example, FreeWRL/X3D, Cortona3D Viewer, etc.). The whole visualization process is maintained through visualisation script, whose basic function is to invoke the individual visualization tool components in successive steps, transferring data, and handling error events. The script is written using the Bourne Shell and all VT modules are implemented in the C++ language. The visualisation tool can be embedded into the framework described above, or used separately as a stand-alone program. The visualization architecture process is shown in Fig. 4 (right). The following images show the views obtained from visualization of the evolution of the proto-planetary disc in period 1 Myr and 1000 Myr time (see Fig. 5). We can see from the figures that during the specified time numerous particles moved from the inside to the outside of the sphere.

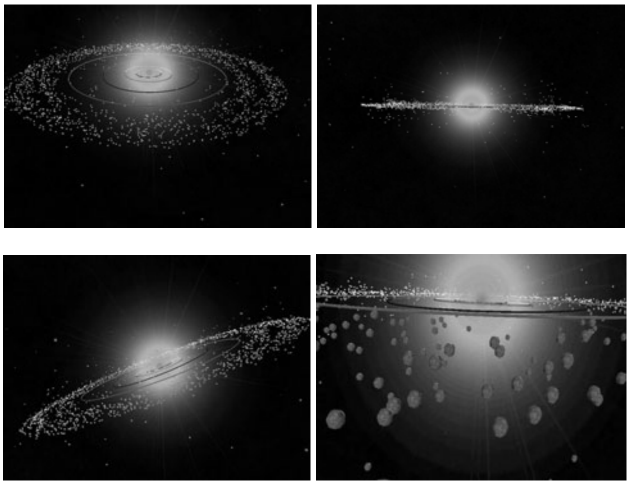

Fig. 5. Final results of dynamical evolution of Oort cloud in 1 Gyr time – the evolution phase

4 Conclusion

Due to some of its advantages, cloud computing appears to be more feasible for smaller applications. Cloud computing and grid computing are scalable. Scalability is accomplished through load balancing of application instances running separately on a variety of operating systems and connected through Web services. CPU and network bandwidth is allocated and de-allocated on demand. The system's storage capacity goes up and down depending on the number of users, instances, and on the amount of data transferred at a given time. Both computing types involve multi-tenancy and multitasking, meaning that many customers can perform different tasks, accessing a single or multiple application instances. Sharing resources among a large pool of users assists in reducing infrastructure costs and peak load capacity. Cloud and grid computing provide service-level agreements (SLAs) for guaranteed uptime availability of, say, 99 percent. If the service slides below the level of the guaranteed uptime service, the consumer will get service credit for receiving data late. The "Amazon S3" (S3) provides a Web services interface for the storage and retrieval of data in the cloud. Setting a maximum limit the number of objects you can store in S3. You can store an object as small as 1 byte and as large as 5 GB or even several terabytes. S3 uses the concept of buckets as containers for each storage location of your objects. The data is stored securely using the same data storage infrastructure that Amazon uses for its e-commerce Web sites. While the storage computing in the grid is well suited for data-intensive storage, it is not economically suited for storing objects as small as 1 byte. In a data grid, the amounts of distributed data must be large for maximum benefit. A computational grid focuses on computationally intensive operations. Amazon Web Services in Cloud computing offers two types of instances: standard and high-CPU. As evidence of the capabilities of the newly enhanced Visualization API, Google points out that Salesforce.com has created tools to enhance usage of the new API. The Visualization API will bring a new level of respect to the cloud computing movement in the enterprise world. Currently we are testing to port the new simulations to the cloud environment. Our visualization in cloud computing is based on visualization API platform [9].

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Visualization of Neutral Model of Ship Pipe System Using X3D

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Abstract. For ship-CAD data exchange among heterogeneous shipbuilding CAD systems such as PDMS and Tribon, and for long-term archiving of data, we define a neutral model for ship pipe model data.

For long-term archiving and for CAD data exchange, we make a pipe-design file using ISO10303 AP227, where the pipe-design file has information on the location and orientation of piping components. We created a catalogue database for the templates of every piping component in the ship-CAD using ISO15926 and we built a shape database for the shape of each component and specification files from a model of a commercial shipbuilding CAD system. We refer to these entities as pipe DESIGN file, CATALOGUE Library, SHAPE DB, and SPEC file, and together they comprise a "Neutral Model".

In this situation, the neutral model is distributed in remote locations and local systems, as noted above. As such, it is difficult to check the archived status of specific piping components. Therefore, visualization of the neutral model is mandatory to check the archived status of the pipe model.

In this research we extract pipe model data from a distributed neutral model and visualize the extracted data using X3D, a web based 3D graphics international standard.

Keywords: Ship CAD, Long-term data Archiving, Visualization, X3D.

1 Introduction

There is growing demand for ship CAD data long-term archiving in the shipbuilding industry for data storage and data exchange. The life cycle of ship CAD data is far longer (several decades) than the capable life cycle of the application software and digital warehousing technology (about a decade).

Shipbuilding companies want to archive design data in order to retain their know-how of design and manufacturing products over a long time period as so as to ensure competitiveness in their business domain [1]. Also, the archived data should be interoperable among the heterogeneous commercial shipbuilding CAD systems, because many subcontractors are involved in the ship design procedures, and thus design work is done in cooperation with numerous companies who inevitably use various ship CAD systems.

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To address the aforementioned problems, we built a neutral model of ship CAD data of piping components for data exchange and employ it as the basis for long-term data archiving based on ISO10303(STEP[1]) AP227[12] – "Process Plant Configuration" and ISO15926[13] – "Industrial automation systems and integration of life-cycle data for process plants including oil and gas production facilities". To visualize the data, we employed X3D, a web based 3D graphics international standard. In this paper, we focus on visualization of the archived pipe neutral model rather than creation of the model. We introduce the pipe neutral model briefly and explain the data extraction method and visualization of the pipe neutral model. We use a test model as a sample pipe model from real ship block data used in a shipyard. For more details on why we chose this approach for data exchange and archiving, refer to Li[2], who researched data exchange using a neutral model based on an international standard.

1.1 Pipe Neutral Model

The pipe neutral model is shown in the center part of fig. 1. In this study we deal with the commonly used CAD systems Tribon[14] and PDMS[15]. The design interface of a ship CAD system is different from the interface of a mechanical CAD system. The ship CAD system uses a reference data library for designing a piping component. The ship CAD data structure is as follows: The DESIGN file contains the location and orientation of piping components from the CATALOGUE library. Hence, the DESIGN file first refers to a SPEC file for specifications of the component and the SPEC file refers to the CATALOGUE library for properties of the corresponding piping component and shape of the component.

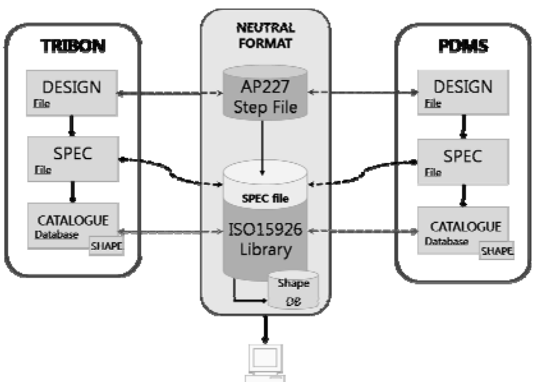

Fig. 1. Structure of neutral model and commercial CAD system [2]

We built the structure of the neutral model to correspond with the data structure of a ship CAD system for interoperability among other commercial CAD systems. The DESIGN file is described using the AP227 scheme and the SPEC file is built using an ordinary ASCII file and it has the same structure as PDMS. The CATALOGUE library is translated to an ISO15926 library and the shape of the components in the

[1] Standard for Product data representation and exchange, a name of ISO 10303.

CATALOGUE is translated to the SHAPE DB of the neutral model using an ordinary relational database and it has the same structure as the shape repository of PDMS. In the neutral model, SPEC file and SHAPE DB are built based on the PDMS structure, because PDMS has more information and is based on parametric primitives, thus making it easy to build a database. This neutral model is used for CAD data translation and provides the basis of long-term data archiving.

1.2 X3D

X3D[16] is an ISO standard XML-based file format for representing 3D computer graphics, the successor to the Virtual Reality Modeling Language (VRML). X3D features extensions to VRML (e.g. Humanoid Animation, NURBS, GeoVRML etc.), the ability to encode a scene using XML syntax as well as the Open Inventor-like syntax of VRML97, or binary formatting, and enhanced application programming interfaces (APIs).

X3D is royalty-free open standards file format. It is based on XML and, as such, can be extended for any platform. In addition, its file size is compressive. On these strengths, X3D is widely used in engineering and scientific visualization and CAD areas.

2 Problem Definition

The pipe neutral model is composed of four elements, AP227 Design file, Spec file, ISO15926 Catalogue library, and Shape DB, and is distributed to remote locations and local systems. Initially, all four elements are located in the same server, but a user from a remote location can access the server and download the AP227 design file and SPEC file, and the neutral model is thereby distributed to remote and local locations.

In this situation, if the user wants to check or get information regarding a certain piping component, he or she should navigate all four elements of the neutral model. However, the user only gets numeric and string values; without visual information, it is difficult to recognize a piping component using only these values. Our ultimate goal is to be able to visualize an archived pipe neutral model that is composed of the STEP AP227 scheme, the ISO15926 scheme, and another database and file format.

2.1 Related Research

A number of works on long-term archiving of industrial CAD data have been reported to date[3~6]. (See table 1), including the Long Term Data Retention (LTDR) project of PDES Inc., the LOng Term Archiving and Retrieval (LOTAR) project of ProSTEP, and the Long-term CAD Data Archiving project of MOSLA[2]. However, these studies do not provide a method to visualize the archived data. Table 1 compares the present approach with existing archiving methods. All the related research deals with data long-term archiving of industrial CAD data but they do not provide a visualization tool. While the user can still visualize the data using a commercial STEP viewer, the life cycle of STEP viewer is typically not long enough to visualize archived data.

The main feature that distinguishes our approach from related research is that archived ship pipe data based on various international standards can be visualized using a X3D format.

Table 1. Comparison of existing archive schemes[2]

	PDES[3]	ProSTEP[5]	MOSLA[6]	This paper
Domain	Aerospace	Aerospace	Automotive	Shipbuilding
Scope	3D Geometry Product structure 3D tolerance	Product structure Documents Life cycle	2D, 3D CAD	3D Geometry Product structure
Data format	STEP	STEP	STEP	STEP, ISO15926
Visualization	X	X	X	X3D
Country	U.S.	German	Japan	Korea
Time	1995	2002	1998	2009

3 Data Integration Scheme

Before visualizing a piping component, it is necessary to integrate data from the neutral model. Our visualization scenario is shown in fig. 2. First, all the data from the neutral model is gathered and then integrated into the internal data storage of the data integrator. It is then exported to a xml file. Using this xml file, the X3D viewer visualizes the shape of a piping component.

Our overall framework is composed of two main parts, a data integration part and a X3D visualization part, as shown in fig 2. The numbers marked in fig. 2 indicate the sequence of the process. The two major components of the framework are connected with a xml file that contains all the information needed for visualization.

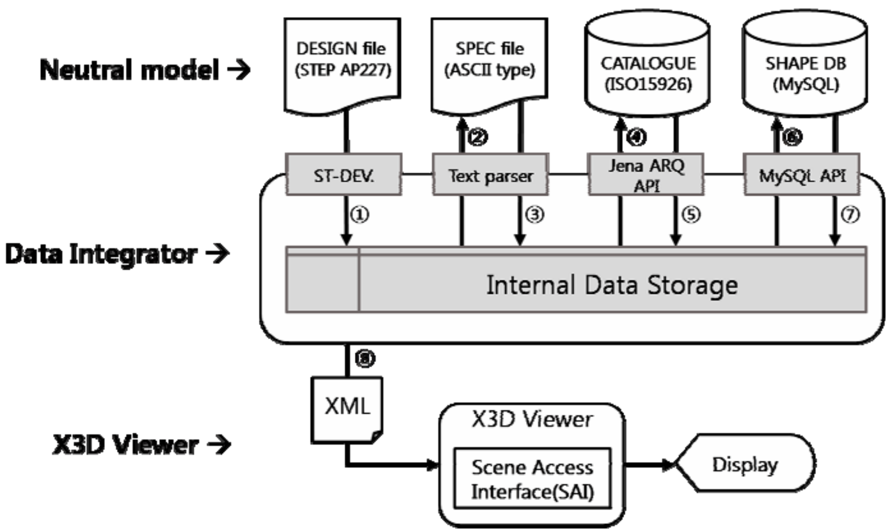

Fig. 2. Overall framework to visualize the pipe neutral model of a ship

The data integration process is similar to the design process of a commercial shipbuilding CAD system. First, DESIGN and SPEC file are downloaded from the archive and the DESIGN file is parsed with the STEP AP227 scheme to obtain information on the orientation and location of piping components and the SPEC reference ID is retrieved to obtain the corresponding specification. Second, the SPEC file, which is already loaded, is parsed, and using the SPEC reference ID we find the used component reference ID. Finally, using the component reference ID from the SPEC file, we retrieve all properties from the CATALOGUE library and get a key of the SHAPE DB and obtain the shape information from the SHAPE DB.

3.1 Parsing DESIGN and SPEC File

The STEP AP227 scheme used here is shown in fig. 2. The figure shows only core entities to describe information of piping components. Data integrator navigates from the entity *property_definition_representation* and gathers all the related information. From the entity product we get the ID and name of the piping component. The position and orientation of the piping component are specified using the entity *plant_item_connector*, and from the entity *representation_item* of *plant_item_connector* we obtain the necessary information. SPEC Reference ID is defined in the

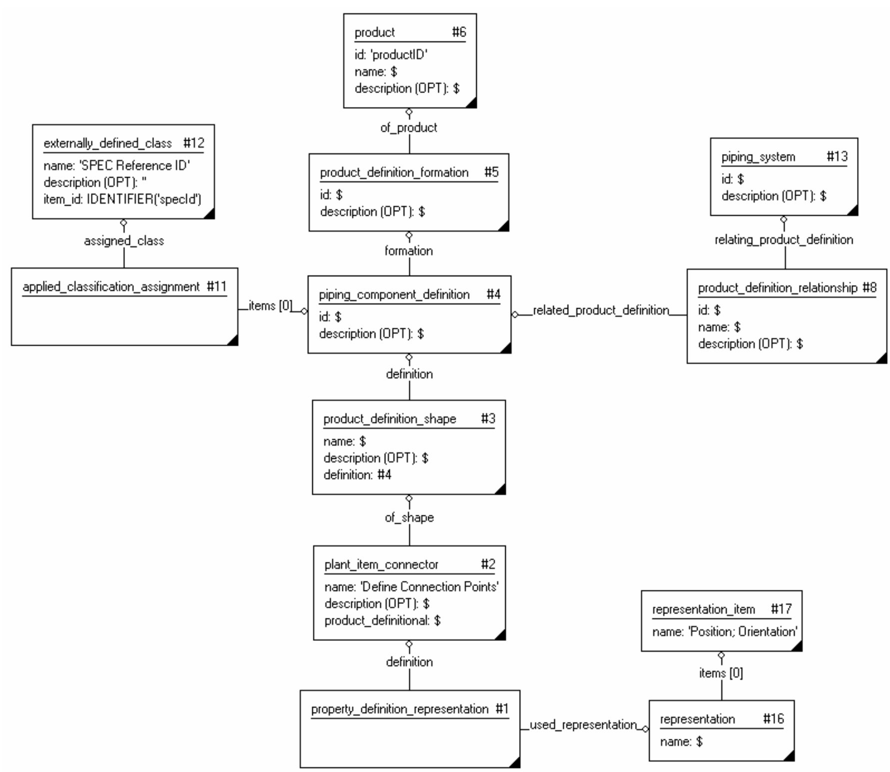

Fig. 3. STEP AP227 scheme

entity *externally_defined_class*, because SPEC is the start point of the referencing CATALOGUE, which is defined outside using ISO15926; therefore, we get the SPEC Reference ID from the entity. We used a ST-Developer V.12 for STEP programming SDK. The SPEC file format is a .CSV file format, so we simply implement a text parser for the SPEC file to obtain only the CATALOGUE reference ID using the SPEC reference ID.

3.2 Querying Databases

We use SPARQL for querying the ISO15926 database. SPARQL is RDF query language. SHAPE DB querying is performed using SQL API, and thus all shape information is gathered using SQL API.

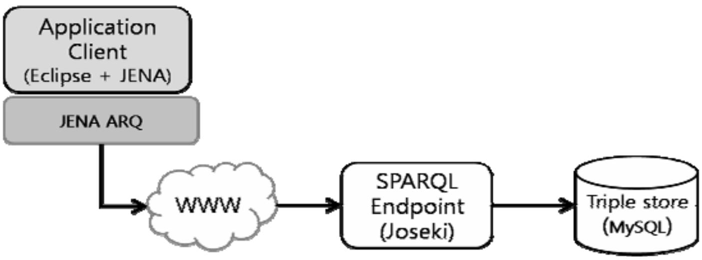

Fig. 4. CATALOGUE query scheme

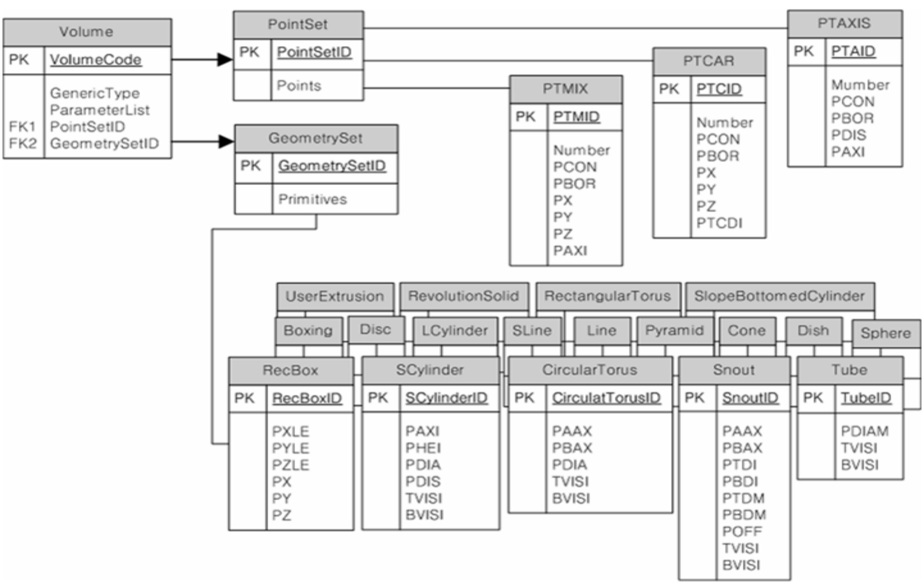

Fig. 5. Table diagram of SHAPE DB

We use the SPARQL querying server *Joseki* to query data from the ISO15926 database. *Joseki* is an open source SPARQL server developed and distributed by HP since 2003. HP also developed *Jena*. *Joseki* and *Jena* are the most widely used platforms in implementing semantic web environments. Typical architecture of implementation of semantic web is shown in fig. 4. This architecture is implemented by using API, which supports SPARQL such as *Jena*. We query a remote server using *Joseki* and then decode the query result for our purposes.

Each component in the CATALOGUE library refers to the SHAPE DB, which has shape information of the piping component. The SHAPE DB table scheme and structure are shown in fig 5. Table Volume is on top of the SHAPE DB and it contains the value of type of shape, parameter list, *PointSet* ID, and *GeometrySet* ID. *GeometrySet* ID indicates the type of primitives used in a given piping component. There are eighteen primitives in our SHAPE DB, as shown in the figure. *PointSet* ID indicates the type of structure of the coordinate system, and primitives are built based on this coordinate system. *GeometrySet* and *PointSet* use parameters in *ParameterList* in the volume table. Hence, we start query data from volume first and then query *PointSet* to obtain coordinate information and obtain the primitive type from *GeometrySet* using a SQL statement.

4 Visualization with X3D

Using X3D we visualize the xml file from the data integrator. The xml file has all the information of piping components related to visualization. Shape data of our neutral model is based on parametric primitives but X3D has only four primitives (box, sphere, cone and cylinder). Therefore, using these four primitives we can only visualize six primitives (RecBox, Cone, SCylinder, LCylinder, Sphere, and Disc) in the neutral model. In order to visualize the remaining twelve primitives we use the extrusion node in X3D.

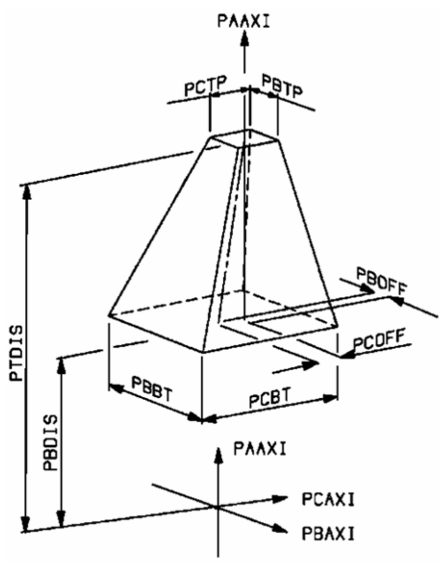

Fig. 6. Pyramid primitive in SHAPE DB

Extrusion is basically defined by *crossSection* and *spine*. *crossSection* represents contour information of an extrusion and is composed of a set of two dimensional vertices. *crossSection* is extruded along the route of the spine, which is a list of three dimensional vertices. Additionally, we can add a *scale* factor to scale *crossSection* for each spine vertex. For example, the primitive pyramid in the neutral model in fig. 6 can be approximated as fig. 7 using the following code.

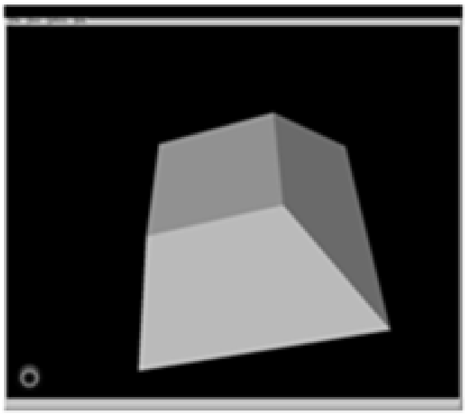

Fig. 7. Pyramid visualization result in X3D

X3D code for extrusion feature

```
<Scene><Shape>
<Extrusion
  crossSection = '0.5*PBBT 0.5*PCBT,
                 -0.5*PBBT 0.5*PCBT,
                 -0.5*PBBT-0.5*PCBT,
                  0.5*PBBT -0.5*PCBT,
                  0.5*PBBT 0.5*PCBT'
  scale = '1 1, PBTP/PBBT PCTP/PCBT'
  spine = '0 0 PBDIS, 0 0 PTDIS'/>
</Shape></Scene>
```

5 Implementation and Results

The implementation environment is outlined in table 2. We use ST-Developer V12 for STEP programming SDK. the data integrator is implemented with C++ language. The X3D viewer is implemented using iXj3D[17] with Java language. iXj3D is developed by PartDB, Inc[17] based on Xj3D[2]. iXj3D have more functionality, such as X3D script parser, than original Xj3D.

[2] An open source library and is the best supporter for X3D format.

Table 2. Development environment

	Development environment
OS	MS Windows XP SP2
STEP programming SDK	ST-Developer V12
Database API	MySQL5.1 API
IDE for data integrator	Visual studio 2008
JDK	Java Development Kit 1.6.0_16
Xj3D Toolkit	Xj3D Toolkit Version 2.0 (Dev. Release 20090518)
IDE for X3D viewer	Netbean 6.5

Results of visualization of the pipe model are shown in figs. 8 ~9. Fig. 8 presents the test model of the pipe system in ship block data. There are twenty-four piping components and seventy instances of corresponding components are used in the test model. The main goal of our implementation is to visualize this test model precisely. Fig. 9 presents the result of visualization of the entire ship block data. Note that missing components are substituted with straight pipe. We are currently planning to visualize all piping components in ship block data (there are roughly five hundred piping components).

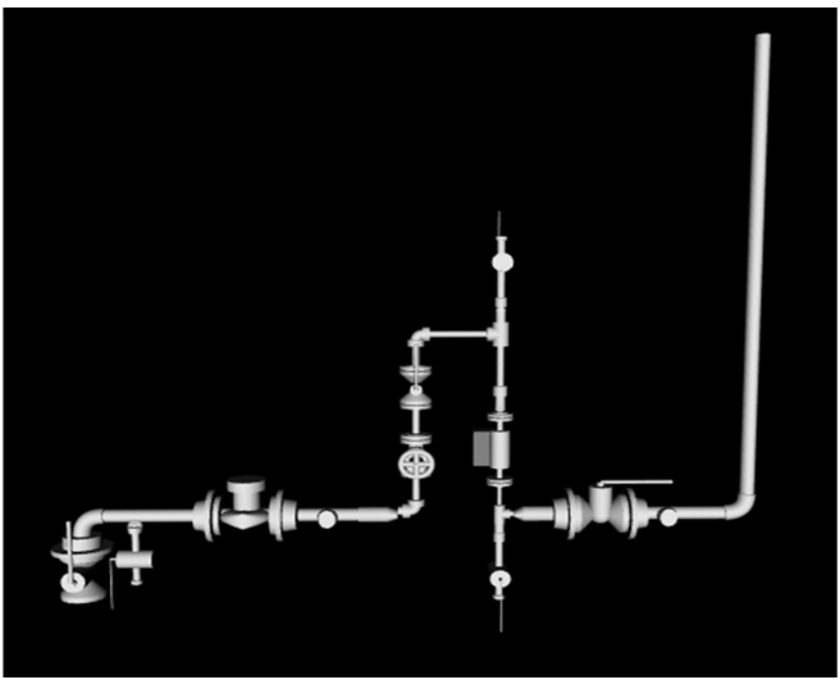

Fig. 8. Test model: a pipe line

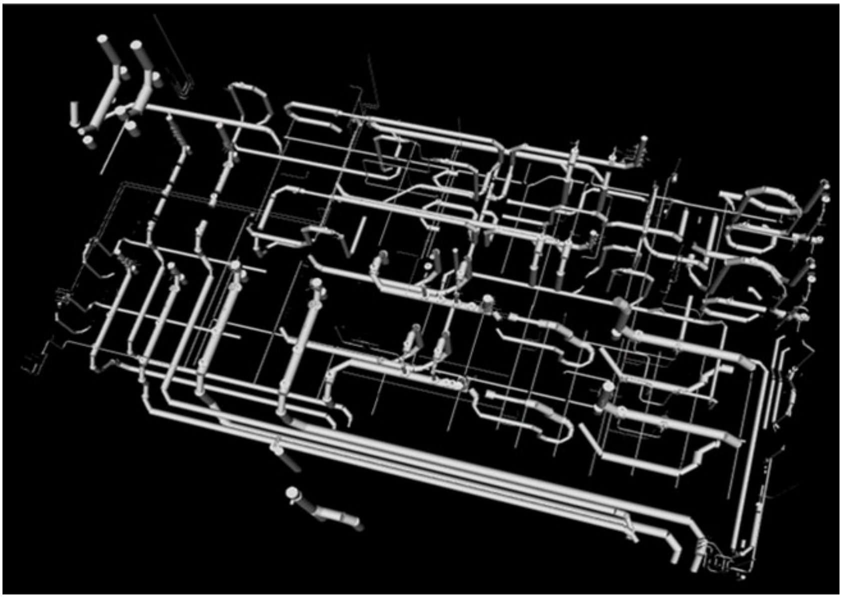

Fig. 9. Pipe model in ship block data

6 Conclusion

In this paper we introduced a method to visualize ship pipe models using X3D to resolve shortcomings in usability when a user wants to check data of piping components in archived data. The ship pipe model is based on international standards ISO10303 and ISO15926 and relational databases and ASCII file format. We integrate all data that is distributed to local systems and remote locations and then visualize the integrated data. The main contribution of this paper is that it will provide the capacity to visualize an archived ship pipe model that is based on data used in shipbuilding companies using X3D, an international standard. Because the X3D format is platform independent and very light weight, our visualization scheme can be easily migrated to any platform such as a mobile environment. In future work, we plan to make it possible to visualize all piping components used in ship block data.

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Part IV

Cooperative Engineering

Coordinating a Cooperative Automotive Manufacturing Network – An Agent-Based Model

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Abstract. One of the problems to be solved in manufacturing networks, with several production centers, is the selection of a suitable manufacturer for each component in order to obtain competitive costs while making full use of the network's capacity. A solution is to own redundant information channels which, despite offering the network greater resilience, generate high costs. The coordination of the nodes in the manufacturing network could lower materials and information flows, thus cutting lead times and total costs, and regulating the system's total productive capacity. This work proposes a coordination model that centralizes materials and information flows, and cuts the costs and overall lead times. It also makes the self-adjustment of productive capacity possible.

Keywords: Manufacturing Network Coordination, Capacity Planning, ABM.

1 Introduction

One of the major problems that manufacturing networks and supply chains face is controlling the system's total capacity [1]. There is no problem when there is a single producer for each type of product. When demand increases, capacity increases; therefore, demand and capacity evolve in parallel. When several producers compete for the same item and no information is shared among them, the system's capacity destabilizes as total demand becomes much lower than that perceived. There are two options to solve this problem and stabilize the system's total capacity: to create centralized planning for each group of the producers and link some factories with each other which can self-adjust the network's capacity; or to create a system that centralizes information of the total capacity. In either case, the system is a two-stage model. There is an assembly plant at the second stage which assembles the mechanic components produced by the manufacturing plant at the first stage. This article is centered on the first option because we consider that the results of the first option are more stable. In order to observe how the system's capacity performs regarding each customer's demands, two multi-agent-based simulation models have been created. In the first

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model each assembly plant may freely negotiate with another manufacturing plant. The second model includes the coordinating agents which can enable the system capacity self-adjustment. At the same time, it can provide quicker material and information flows and shorter manufacturing time, thus reduced costs.

Based on our model proposed in [2], where the capacity adjustment of the manufacturing network's factories is restricted, a new model is proposed which enables the system's productive capacity to evolve. However, because the change of the network factories' productive capacity is restricted, the system can collapse when the demand increases. It is necessary to adjust this restriction. We have designed new models according to the cooperative-group-based model of the automobile sector presented in [2].

The rest of the article is organized as follows. Section 2 presents a review of the agent-based modeling situation and introduces the simulator: AnyLogic™. The engine manufacturing network features is described in section 3. Section 4 describes the model without coordinating agents. The description of the coordinating agents' model is given in section 5. Section 6 shows the system's total capacity and the real capacity employed, as well as the total transport costs and lead times in both of them. Finally, section 7 gives the conclusion and future lines.

2 Introduction to Agent-Based Models Simulation

Simulation makes research possible and useful when experimentation in a real situation proves too costly or more likely because the gap between decisions and their consequences is too wide in space and time terms [3]. It is quite normal to use any of the three following simulation paradigms when addressing operations: Systems Dynamics (SD), Discrete Simulation (DS) and Agent-Based Modeling (ABM).

Agent-Based Modeling enables modeling in increasing complex situations. Systems which are to be analyzed and modeled are becoming increasingly complex, and traditional modeling tools are no longer as useful as they were in the past [4]. Reference [5] emphasizes multi-agent systems as a means to allocate subtasks among those participating in the project. Indeed, multi-agent settings are suitable for studying the coordination themes of multiple autonomous and semi-autonomous agents where knowledge is relocated and agents communicate by messages [6]. The simulation models describing individual organisms (Individual-Based Models, IBM) or ABMs have become tools that are often used in not only the field of ecology, but in other disciplines with complex systems formed by autonomous organizations, such as social sciences, economy, demography, geography or political sciences [7]. The use of ABM in research to manage one supply chain is quite recent. Authors in [8] used the agent-based concept to propose a flexible models framework that permits the rapid development of personalized support tools for supply chain decision making. Thus most of the works conducted define an ABM to represent supply chains [8, 9]. Agent-based technology has been receiving considerable attention in recent years and, consequently, industry is starting to show an interest in adopting this technology to develop its own products [10]. Advances in computing have enabled a larger number of agent-based applications in several fields [4]. Manufacturers obtain more profits by applying agent-based technology [11].

Authors in [12] define agents as autonomous, integrating and collaborative organizations that tend to work as separate systems. Authors in [13] define agents as objects with not only a capacity such as acquiring regulations on performance, autonomy, cooperation, mobility, memory, but with learning capacity. Therefore we may state that agents are autonomous units; that is, they control their own actions in order to meet an objective [14] , they are programmable and have a decision-making capacity, and can adapt to changes depending on the conditions of the setting and relate with other agents. Authors in [13] also emphasize that cooperation is a main characteristic of an agent and includes perception, action and communication. Agent-based systems are used to represent the performance that agents might exhibit in accordance with the decisions made by the other agents belonging to the same setting; in other words, evolution in dynamic settings because they must adapt to the changes taking place in the setting. They define the basic idea of the ABM system as that consisting in modeling only those agents of a specific system and in simulating their interaction in order to analyze overall system performance. Apart from several agents co-existing in the same setting, there must also be interaction and a negotiation process among them for a system to be considered multi-agent. By considering that the logical decision made by an agent depends on its neighbor's actions, a resourceful problem is created where each agent's strategy entails anticipating its neighbors' decisions [14]. Moreover, agent-based systems provide competitive advantages like cutting replenishment costs through more profitable acquisition policies or improving the efficiency of manufacturing processes in dynamic settings.

We have used AnyLogic™ to simulate our proposal because it is a multi-paradigm program that allows working multiple approaches. Moreover, it allows the use of Java programming, which facilitates the inclusion of external programs written in Java, and any type of file may be read, regardless of their type. In our case, input simulation data are read from external spreadsheet files. In addition, AnyLogicTM has systems that analyze and detect errors while programming, compiling and running the simulation which specify the location of errors and what may possibly cause them.

3 An Engine Manufacturing Network

In order to manufacture an engine, five main components have to be taken into account, the so-called 5 Cs: cylinder, crankcase, camshaft, connecting rod and cylinder head. Other components are also needed, but are not included in the model as they are not so relevant. Each assembly plant will be preferentially, and almost exclusively, supplied by five assembly plants, one for each of the 5 Cs. Moreover, Suppliers supply the required raw materials to the manufacturing plants.

We have designed two models in order to achieve our goal. They are multi-agent-based systems and simulate a manufacturing network. In both models, the product is manufactured with the same number of phases: (1) Suppliers, which are in charge of producing raw materials, (2) Manufacturing plants, which manufacture components, and (3) assembly plants, which make up the final product. The first model shows a manufacturing network operating without any coordination elements in its stages and with open negotiation (all to all). The second model includes coordinating agents.

A series of conditions for both models has been established to focus on the important part of this study. First, costs relating to manufacturing, raw materials, components, products, and production or inventory are not considered. The only costs taken into account in our work are transport costs because the product is produced under the same conditions in any factory, and what may considerably change the product price is the transport. Nonetheless, each factory's productive capacity is considered by the Daily Rate. This information is used to measure both the used and unused capacities in each factory because, as the case may be, each factory extends its capacity according to the demand it receives. Thus should there be no coordinating agent, all the factories will receive all their demands, and the system's total capacity will have to increase considerably. Conversely with the coordinating element, the flow of demands is channeled by assigning the demand that each factory can take on.

Suppliers have unlimited access to the materials; that is, there are no restrictions obtaining the materials they require, although materials have a Daily Rate. Each product is made up of five different components, so each assembly plant has five manufacturing plants for preferential components which supply it directly. The assembly plants are able to assemble any version of the product, unlike the manufacturing plants which are limited to the type of versions for each component. This situation exists because, should any factory not be able to produce a specific component, it can be ordered to other factory, but the assembly cost increases.

Each agent, except coordinating agents and end customers, has a warehouse to receive raw materials and another warehouse from which finished products leave. Despite the Just-in-Time production of the automobile sector, there will be many stock-outs if there are no adjustment buffers.

4 Description of the Model without Coordinating Agents

This model is made up of 4 agent types which could be replicated according to the type of manufacturing network. The first one is the Customer Agent, which represents those customers who consume the network's products; the second and third ones are the assembly plant and the manufacturing plant agents, which are equivalent to the assembly plants and manufacturing plants; and the fourth one is the Supplier Agent which is in charge of supplying raw materials to the whole network.

Apart from selecting the number of agents of each type, some initial data must be introduced in order to indicate the network's initial situation. It will serve as the agents' performance regulation when decisions must be made. Figure 1 illustrates the information flow produced with a single product demand. This case proposes a manufacturing network made up of 2 assembly plants, 10 manufacturing plants (5 for each assembly plant), and 7 suppliers of raw materials. The real case might be larger but we decided to show only two assembly plants for the sake of clarity.

The customer requires a given product and sends a product demand to both assembly plants to decide which of them is better. The decision criterion is based not only on the lead time, but also on the total transport cost. Each customer has its own different decision criterion which is indicated in the initial data. Next, each assembly plant requires components and, therefore, creates its own demands which are sent to its 5 preferential factories. Each factory is in charge of manufacturing one type of component. Because there may be different versions of each type of component, demand may not be met. When a manufacturing plant cannot supply its assembly plant with a specific version of a given component, it sends the demand to another manufacturing plant in the network, even though it belongs to a different assembly plant. So, a manufacturing plant may receive demands for components from other manufacturing plant.

Whenever this demand comes from, another raw materials demand is generated and sent to all the manufacturing network's suppliers. Then, between all the responses received, the most suitable option is selected in accordance with the customer's selection criterion. In our simulation, each manufacturing plant can receive only one response from another manufacturing plant because there are only two assembly plants. Finally, when a supplier receives raw material demands from the other manufacturing plants, it will supply them the requested raw material if it has sufficient capacity to do so, otherwise it will decline.

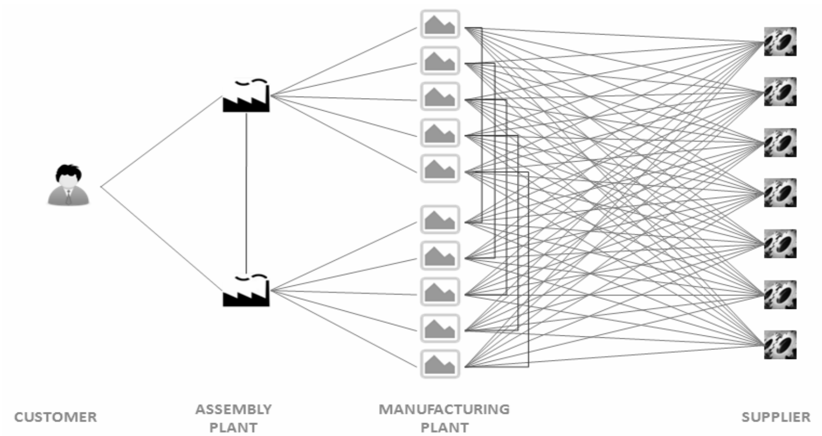

Fig. 1. Manufacturing Network's Model 1 without coordinating agents

5 Description of the Coordinating Agents' Model

This second model has the same agents as the first model, but it also includes the coordinating agent. There is one coordinating agent per production group which is formed by an Assembly plant and its 5 preferential manufacturing plants. In our case, there will be two coordinating agents. Each coordinator agent has information about all the factories in its production group, all plants of the same group, and is in contact with the coordinator of the group of the five manufacturing plants. Its main function is to efficiently assign the production of the 5 Cs to supply the assembly plant. So, when a manufacturing plant of one component does not have enough capacity for what its assembly plant claims, the coordinator does not send the demand to it, but is brought into contact with another coordinator in order to find another factory that produces the same component and has enough capacity to do it. Thus it prevents a manufacturing plant being required to produce some demand that induces it to increase its capacity, when there is another one with spare capacity to serve it.

In this model, the demand requested is produced in 3 stages: the first one assigns the manufacturing plants to each assembly plant (figure 2). It involves a customer sending a product demand to the assembly plants, which generates a components demand. This demand is forwarded to the Coordinators, instead of being sent to the manufacturing plants. As each agent has the necessary information about the factories, it knows the availability of this given product. Should any of the 5 factories not be able to cover this

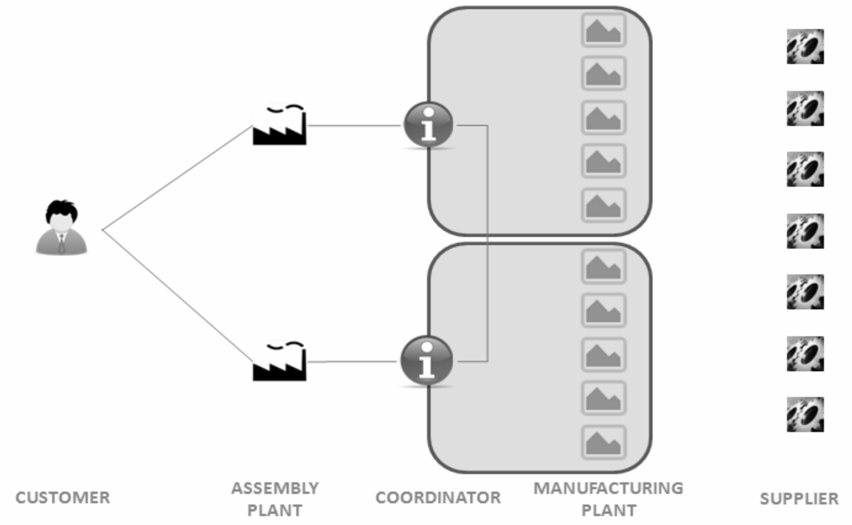

Fig. 2. Stage 1 of the Manufacturing Network's Model 2, with coordinating agents

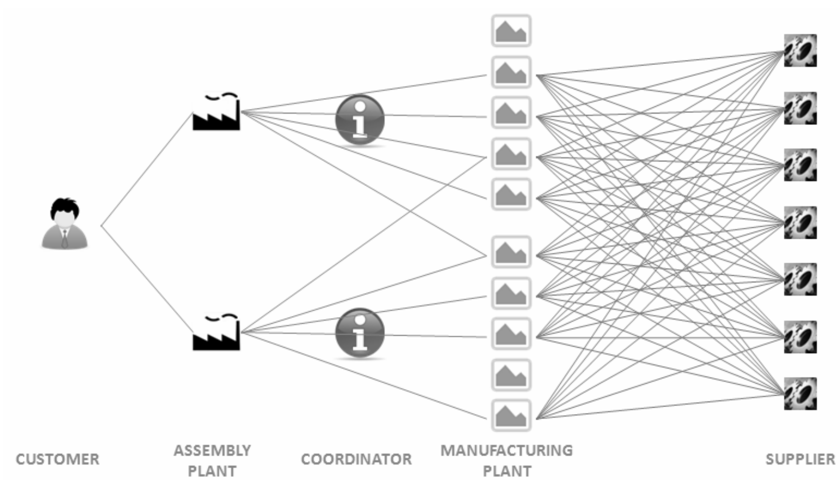

Fig. 3. Stage 2 of the Manufacturing Network's Model 2, with coordinating agents

demand, the other Coordinator is contacted. The second one involves the direct factory-to-factory negotiation (figure 3). The final step (where raw material demands are sent to the Suppliers) is the same as in the first model, except that it includes manufacturing plants which have not been assigned components demands.

6 Comparison of the Results Obtained in the Models

The evolution of Model 1's capacity is represented in figure 4. This figure illustrates how the system's total capacity performs in terms of the demand received being

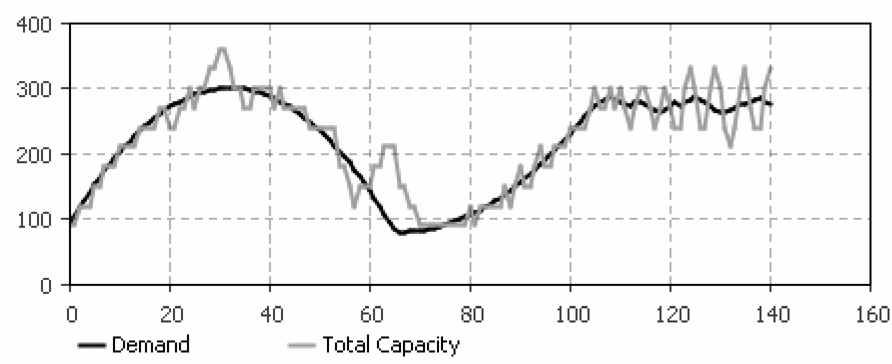

Fig. 4. Evolution of total capacity as opposed to demand in Model 1

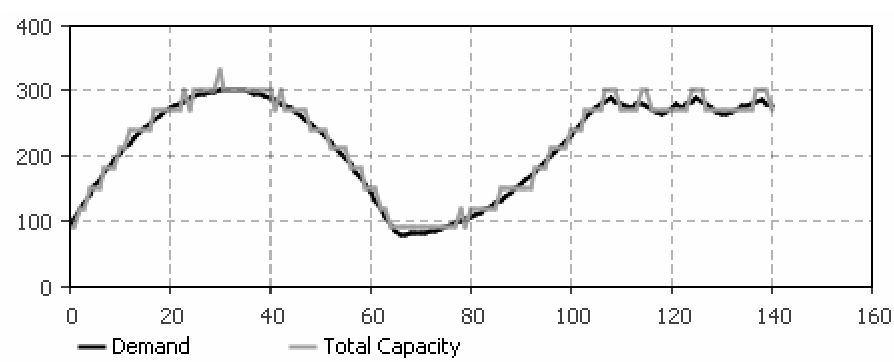

Fig. 5. Evolution of total capacity as opposed to demand in Model 2

incoherent at many points. Although both parameters initially show a parallel trend, the capacity strays from demand. Toward the end of the first decline we see that even though demand decreases, the system's total capacity tends to increase.

Figure 5 depicts the evolution of the capacity in relation to the demand for the Model 2 case, which includes a Coordinating Agent. Better adjustment is observed as the system's total capacity is adjusted in each period, and does not act independently in each Factory, which occurred in Model 1. In both figures 4 and 5, the demand generated was identical in order to compare the results.

To compare both models we simulated a case including three assembly plants, and consequently, 15 manufacturing plants. This simulation could be done with a larger number of agents, but the result would not added relevant information. We have to keep in mind that in manufacturing networks as studied, there is not such large number of manufacturers and they produce slightly different types of products.

7 Conclusion and Future Lines of Research

In this paper, we have shown that in manufacturing networks where each participant's information is private and there is no coordination element, the system's total capacity destabilizes in relation to the demand received. The system is improved when coordination agents share certain information. It is important to make forecasts in order to anticipate the markets behavior because, the system's total capacity tends to increase as demand drops when there is no forecast. Another finding is that the capacity-adjusting warehouses are important to not cause stock-outs.

Future research lines will study the creation of models in which there are improved capacity forecasts apart from coordination elements to not only coherently reorganize the resources available, but to also anticipate the resources required.

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A Constraint Solving Method for Collaborative Product Development

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Abstract. In order to shorten new product development cycles, parallel approach is emphasized to organize and plan the process of product design in Collaborative Product Development (CPD), in which a great deal of constraints of interdependent, interactive and restrictive relationships exist. The motivation of this article is to provide a simple and effective method to solve this problem. In new product development, collaboration is usually conducted according to product structure. In accordance with this principle, a constraint network is presented and an algorithm is given out. While the constraints can not be met, then conflict will arise. A consultation model is established. Finally, a case is put forward to explain how the algorithm for constraint network and consultation model work.

Keywords: constraint network, constraint algorithm, consultation model.

1 Introduction

In today's competitive world, enterprises are moving towards providing better and better customer-centric products and services to improve market share and market size, while the product itself is seen more complex than just a physical object. Manufacturing enterprises will require significantly improved technological, managerial, and logistics capabilities. The acquisition of these capabilities represents a serious challenge facing manufacturing. In order to shorten new product development cycles, parallel approach is emphasized to organize and plan the process of product design in Collaborative Product Development (CPD). This makes the multi-group multi-disciplinary designers not only need to face many innate constraints of interdependent, interactive and restrictive relationships, such as product design specification, resource constraints, requirements from users, but also need to take into account all relevant factors of product life cycle (from manufacturing to abandonment) in the early stages of product design, such as manufacture, process, assembly, testing factors. All these constraints and factors can be uniformly expressed and form a constraint network.

In new product development specialized multi-disciplinary developers usually have their own concern for specific constraints and give out their own values. Because they come from different disciplines and have different objects, domain knowledge, evaluation criteria and preferences, some constraints may not be met while they give

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out satisfied value to some other variables. Therefore solving approach is needed to establish an effective constraint network and give out an efficient constraint solving method.

The constraint problem has a long tradition in artificial intelligence. It can be traced back to the use of constraints in Sutherland's SKETCHPAD [1] and researchers looked into the problem from many different perspectives. Hooey and Foyle [2] reported on the requirements for design rationale capture tool to support all the design phases of NASA's complex systems. They stressed the need to capture the assumptions and constraints as the rationale for a given design element particularly in the conceptual design phase. Suraj Ajit developed designers' workbench to enable a group of designers to produce cooperatively a component which conformed to the component's overall specifications and the company's design rule books [3]. Meng proposed a collaborative constraint model [4]. Wang analyzed the characteristics of collaborative product development, and gave out a set of algorithms [5].

Negotiation has been viewed as an effective approach for coordination and conflict resolution [6] in constraint solving problem. Protocols are developed to facilitate the negotiation process [7], automated negotiation support systems are proposed which use multi-autonomous-agents serving as negotiators and/or mediators [8]. The analytical approach [9] and the knowledge-based approach [10] are applied to smooth the negotiation process.

The motivation of our work is to present an effective constraint solving method which seems not to be so sophisticated and can be well used in CPD. According to product structure, a constraint network model for CPD is proposed, and an effective algorithm and consultation model are presented. And we put forward a case to explain how our method works well.

2 Constraint Network Model for CPD

After researching more than 10 companies through asking R & D leaders questions and statistical analysis of the answers, we find that in new product development, collaboration is usually conducted according to product structure. Based on product structure, a constraint network model is proposed shown as Figure 1, which has following components.

Product/Component/Part, A set of collaborative design objects, denoted as O.

Variables, A set of product attributes, component attributes or part attributes, denoted as V.

Constraints, A set of specifications, rules or relationships of variables that confines or restrains, denoted as C.

OO $\subseteq$ **O×O**, partially ordered object hierarchy. According to product structure, hierarchical relationships are established between objects, denoted as (o_m, o_n) where $o_m \in O$ and $o_n \in O$.

VO $\subseteq$ **V×O**, variable to object subordinate relation, denoted as (v, o) where $v \in V$ and $o \in O$.

VV $\subseteq$ **V×V**: Variable mapping representing direct relation between two variables.

CC $\subseteq$ **C×C**: Constraint mapping representing direct relation between two constraints.

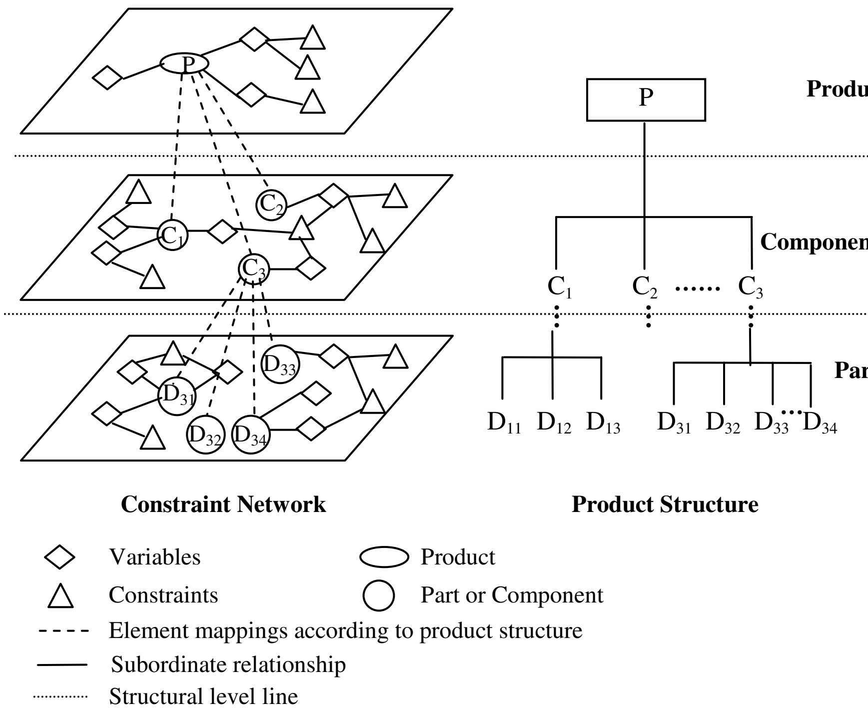


Fig. 1. Constraint network model for CPD

To explain the presented concepts we give an example. Suppose now a company wants to develop a machine tool, total weight is required to no more than 4000kg. Here we can call weight is a variable w and (w, machine tool) is a VO relation and c is a constraint expressed as w≤4000kg. According to product hierarchy the task is then assigned to some creative groups, including engine group, spindle box group, etc. And the weight requirement is also decomposed as engine and spindle box weight limit denoted as c1and c2. Here c maps to c1 and c2.

From the constraint network, we can deduce if there exists a constraint set $\{c_{k1}, c_{k2}, c_{k3}, \ldots\}$ at level k+1 and elements in the constraint set belong to a common variable, then there will be a constraint at level k mapping to the constraint set.

3 An Algorithm of Constraint Network

According to our constraint network, there can be four kinds of constraints, including independent constraints related to single variable of single object, constraints related to several variables of single object, constraints related to one variable of several objects and constraints related to several variables of several objects. It is easy to solve the first kind and the last kind can be simplified to the second or third one. Therefore in this paper we only consider the remaining two kinds.

We can always recognize CPD as a system optimization problem and all constraints in the network relate to ultimate purpose. Therefore the remaining two kinds of constraints can be abstracted to a system optimization problem, depicted as Fig.2. In this problem, system variable is mapping to a set of sub-system variables and constraints mapping to variables while variables mapping to objects. Multi-disciplinary designers define their sub-system variables to finish their own tasks. As a result, sub-system and system constraints should be satisfied.

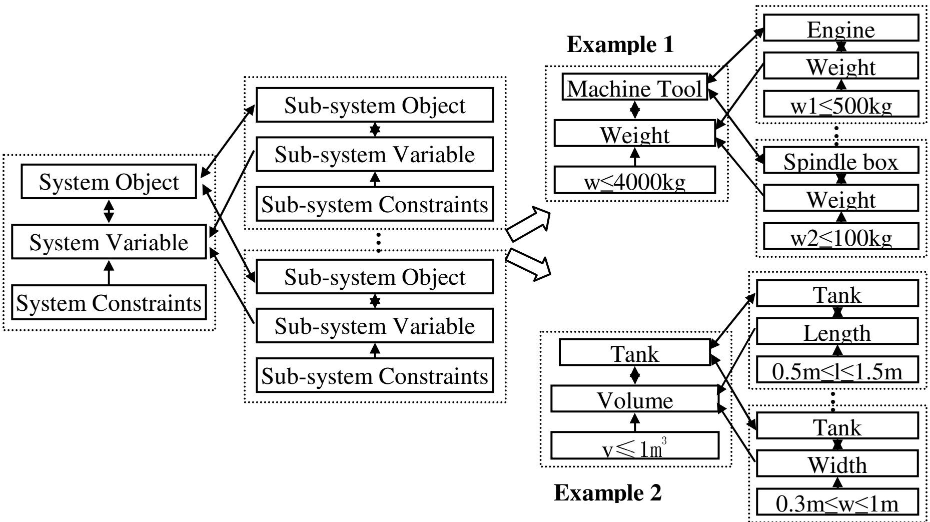


Fig. 2. Abstracted constraint problem for CPD

Considering the mapping relation between system variable and sub-system variable set, an algorithm is given out to solve upon problem supposing the collaborative object is clear defined and all variables and constraints are well prepared.

The algorithm of constraint network for CPD

Input: $x = x^*$, system variable

$\{ x_1 = x_1^*, x_2 = x_2^*, ..., x_n = x_n^* \}$, sub-system variable set

c , system constraints

$\{ c_1, c_2, ..., c_n \}$, sub-system constraint set

ε, acceptable system variable error limit

K, iteration number

$k = 0$

Output: $\{ x_1^*, x_2^*, ..., x_n^* \}$ or conflict information

STEP1: Check whether $\{ x_1^*, x_2^*, ..., x_n^* \}$ satisfy $\{ c_1, c_2, ..., c_n \}$. If satisfying, go to step 3; else go to next step;

STEP2: Adjust $\{ x_1^*, x_2^*, ..., x_n^* \}$ to satisfy $\{ c_1, c_2, ..., c_n \}$;

STEP3: $k = k + 1$. If $k > K$, then go to step7; else, go to next step;
STEP4: According to variable mapping relation, calculate system variable $x^{**} = f(x_1^*, x_2^*, \ldots, x_n^*)$

STEP5: if $\left| x^* - x^{**} \right| \le \varepsilon$, then go to end; else, set $k = \left| \frac{x^*}{x^{**}} \right|$ and $x_i^* = k^{\frac{1}{m}} x_i^*$;

STEP6: Check c_i, if c_i is not satisfied, then set $x_i^* = \frac{x_i^*}{k^{\frac{1}{m}}}$, Go to step3.

STEP7: Output conflict information.

4 Consultation Model

The algorithm is an effective quick method for the constraint network in CPD. However, it can not solve all the problems. While the constraints can not be met, then conflict will arise. Consultation is frequently used to solve conflicts and multi-disciplinary collaboration in CPD which makes it an important method to solve conflicts.

In accordance with the characteristics of the consultation in CPD, consultation environment needs to provide tools for information communication, allow negotiators to make recommendations, support negotiators to evaluate other proposals and provide method to break deadlocks. Considering these requirements, we propose a consultation model as consequent work of constraint network algorithm, shown as Fig.3.

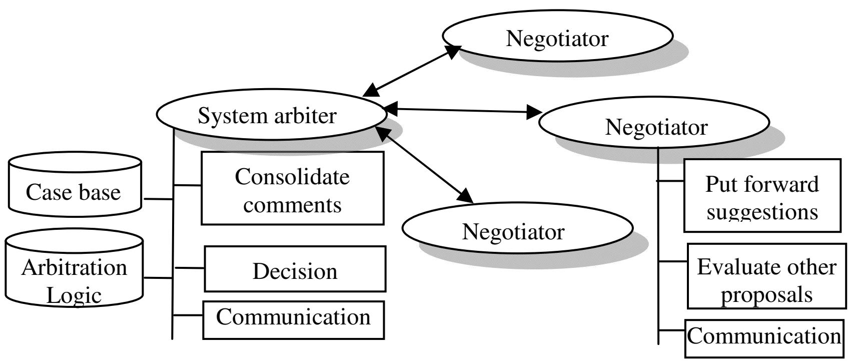


Fig. 3. Consultation model

In this consultation model, negotiator's tasks include:

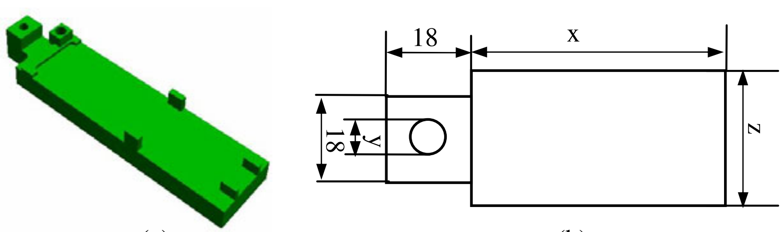
- ✧ Communication: To communicate with other negotiators and change information;
- ✧ Evaluate other proposals: To evaluate collaborator's proposal in the light of his own domain knowledge;
- ✧ Put forward suggestions: To raise proposal in the light of constraints he concerns, his own domain knowledge and system arbiter's view.

System arbiter's tasks include:

- ✧ Communication: To communicate with negotiators, transfer information from negotiators to the group members;
- ✧ Decision: to judge whether a deadlock occurs, the consultation has timed out or the result is satisfying according to case base and arbitration logic. If a deadlock occurs, system arbiter should break it to smooth the process.
- ✧ Consolidate comments: To collect all the recommendations of the consultations and give out a comprehensive view.

5 Case Study

We have developed a constraint management system in which the algorithm and consultation model are applied. Now we use the development process of a part produced in an electronic factory to explain how the algorithm of constraint network and consultation model work. The picture of the part is shown in Fig. 4.



(a) (b)

Fig. 4. Part picture for case study

Suppose the factory wants to redesign it and the task is assigned to Li. Li considers the past edition and redesign object, gives out following constraint to guarantee weight object: $xz - \pi y^2 / 4 < 1800$ and a satisfying value $xz - \pi y^2 / 4 = 1400$

He then asks Zhang to design the total size and asks Huang from manufacturing workshop to suggest y size. Huang and Zhang then define following constraints (Fig. 5)100>x>70, x>2z, y<12 and give their design result: x=85, y=4, z=25

Applying the algorithm of constraint network, the calculation process can be shown as table 1.

Table 1. Calculation data of the case

Initialization: x=85, y=4, z=25, f(x, y, z)=1400, k=10,ε<30				
	x	y	z	f(x, y, z)
1	85	4	25	2027.4
2	70.8	3.3	20.8	1464.1
3	70.8	3.2	20.4	1436.3
4	70.8	3.2	20.2	1422.1

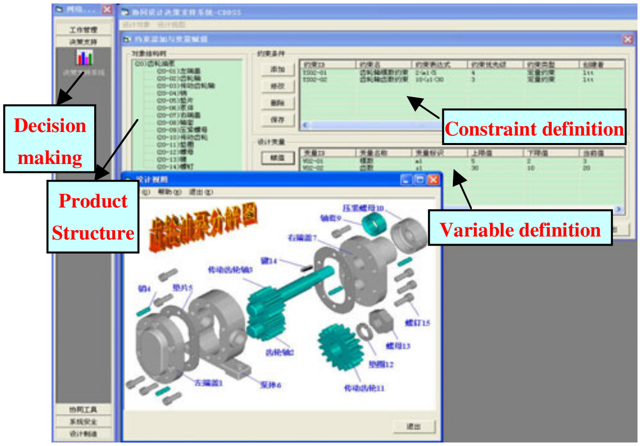


Fig. 5. Constraint definition

Now, zhang and Huang get a satisfying data. Suppose the result is not satisfying or conflict occurs, a consultation environment needs to be established. Li launches a meeting and asks collaborators to take part in.

First, Li tells all the collaborators the object of this consultation and asks the group to submit suggestions. Collaborators can send or receive information from other members through chat room, submit their suggestions to Li. After all the members submit their suggestions, Li can get a complex view considering past cases, suggestions and make decision (Fig.6).

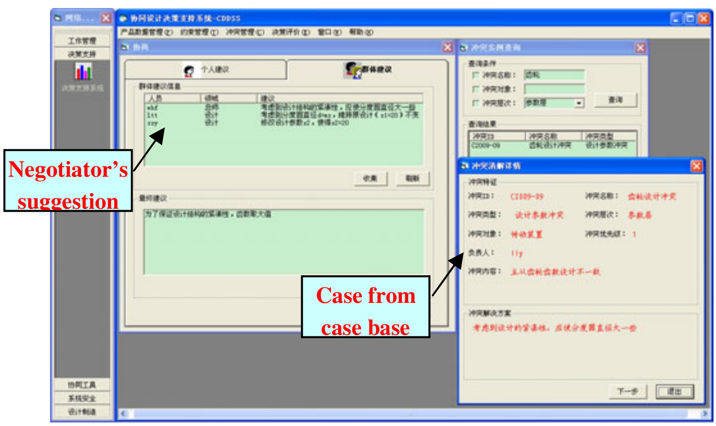


Fig. 6. Consultation environment

6 Conclusion

During the last years, various new technologies such as networked manufacturing (NM), concurrent engineering (CE) and rapid prototyping (RP) have emerged and are regarded as enabling tools with abilities to shorten the product development and manufacturing time. The constraint problem in product development is always a focus for researchers. Based on the constraint network we propose, a constraint algorithm and consultation model is presented in this paper. Compared with existing method, the main contribution of our work is as follows: (1) from the view of product structure, we developed a constraint network. It makes the network suit for many manufacturing enterprises and easily use because product structure often has been established. The only work enterprises need to do is to define variables and constraints; (2) the algorithm and consultation model together can solve constraint problem effectively.

Acknowledgements

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A Solution of Manufacturing Resources Sharing in Cloud Computing Environment

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Abstract. The emerging and spring up of cloud computing gives manufacturing a new solution and chance to realize resource sharing and cooperative work between enterprises for global manufacturing, the paper proposes a new service-oriented networked manufacturing model—cloud manufacturing, which is the combination of cloud computing and SOA. The resource sharing method in cloud manufacturing environment is proposed to support resource sharing and cooperative work between enterprises for global manufacturing. The description of manufacturing services and the business-driver building cloud manufacturing application method are introduced in detail. At last, we make a conclusion and put forward the future work.

Keywords: cloud computing, service-oriented architecture, manufacturing resource share, encapsulation.

1 Introduction

Economic globalization makes manufacturing enterprises face the competition of market, resource, technology and person with ability. The design and manufacturing of product are becoming more and more complex. In this environment, manufacturing enterprises desiderate integrate just-in-time many kinds of manufacturing resources to meet the various requirement of business and develop the extensive collaboration among enterprises to cope with quickly changing market requirements. There are many kinds of manufacturing resources, which belong to various enterprises. They are geographically distributed, morphology diversity and autonomy, which make the resource sharing and management is very complicated.

Cloud computing [1-3] is becoming an increasingly popular enterprise model in which computing resources are made available on-demand to the user as needed. Cloud computing aims at realizing scalable integration of all kinds of distributed resources for effective use. As summarized in [4] typically there are four types of resources that can be provisioned and consumed over the internet, including infrastructure resources, software resources, application resources and business process. And it promises on-demand, dynamic and easily accessible computing power. The pay-as-you-use scheme is attractive for small to medium sized organizations that do not have the capital and personnel

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to purchase and maintain their own computing infrastructure.[5] Virtualization technology[6] and Service-Oriented Architecture (SOA)[7] are two key enabling technologies in cloud computing environment. [8] Virtualization provides important advantages in sharing, manageability and isolation.

The emerging and spring up of cloud computing gives manufacturing a new solution and chance to realize resource sharing and cooperative work between enterprises for global manufacturing. In this condition, the paper proposed the concept of cloud manufacturing and studied the method on resource sharing in cloud manufacturing environment.

The rest of the paper is organized as follows: Section 2 proposes the concept of cloud manufacturing. Section 3 introduces the resource sharing method in cloud manufacturing. Section 4 introduces the implementation process of application in cloud manufacturing environment; At last, the conclusion and further work are presented.

2 The Concept of Cloud Manufacturing

The cloud manufacturing combines the cloud computing and SOA technology. It follows the principle of manufacturing as a service. The aim of it is to effectively organize all kinds of manufacturing resources separated in different enterprises. Based on cloud manufacturing, enterprises could obtain various manufacturing services from the internet as conveniently as obtaining water, electricity, and gas in daily.

The concept of cloud manufacturing is as follows: Cloud manufacturing is an integrated supporting environment both for the share and integration of resources in enterprise. It provides virtual manufacturing resources pools, which shields the heterogeneousness and the regional distribution of resources by the way of virtualization. cloud manufacturing provides a cooperative work environment for manufacturing enterprises and individuals and enables the cooperation of enterprise.

3 Method of Resource Sharing in Cloud Computing

3.1 Resource Sharing Method

The paper proposed the manufacturing resource sharing model. It can be decomposed into four layers: manufacturing resources layer, concrete web service layer, logical service layer and application layer. The logical service is divided into atom logical service and composition logical service.

Manufacturing resources layer are heterogeneous and geographically distributed manufacturing resources, which is provided by different enterprises. Physical services layer aim to solve the problem of union standard and union invoking interface of various resources. Manufacturing resources are encapsulated as services, which can make them offer their services and functionality in a standard web service environment. These physical services are too complex for business users to understand and manage directly, so they are virtualized as logical services on the logical service layer. Atom logical service can not be divided, they have the absolute function. Some atom logical services are composed as composition logical service according to the certain business flow. Atom logical and composition logical services can be invoked or composed into a workflow as an activity. On the application layer, business users can build manufacturing application by orchestrating logical services; they don't care about the implementation of the concrete web services. The goal of implementing cooperation and virtual product development in many different industries can be achieved.

3.2 The Description of Manufacturing Services

From the user's point view, service should provide certain function and have some non-functional attributes such as available time, cost and so on. So we describe manufacturing services from two aspects: functional and non-functional attributes. Functional attributes describe what the service can do and non-functional attributes describe the external performance when the service is being used, for example price, usability and security. We put forward the formal definition of physical services and logical services as follows:

[Definition 1] physical service: In this paper physical services are got by encapsulating manufacturing resources. We use PS to denote physical service,

PS is defined as a 3-tuple: PS =(PB , PF , PNF)

- PB = (Name Type, Provider, Access Address, Description) stands for the basic information of the physical service.
- PF stands for the function that the web service provides, is defined as a 3-tuple: PF = (D , $Input$, $Output$), D is the description of the function. $Input$ and $Output$ are the input parameters and output parameters of the operation.
- PNF stands for a set of non-functional attributes of the physical service, such as available time, cost and so on. Every non-functional attribute item $pnf_i \in PNF$ is a 3-tuple pnf_i =(Name, Unit, Value). The "Name" is the name of the item, "Unit" is the unit of the item's value, the "Value" is the value of the item, such as the cost item is (cost, RMB, 200).

[Definition 2] Logical service: Logical services are user-understandable, business-level reusable services. Each service can fulfill certain business functionality. We use LS to denote logical service, which is also defined as a three-tuple: LS = (LB , LN , LNF).

- LB =(Name, Type, Description, Granularity, Flow, stands for the basic information of the logical service, including the name, the type, description of the service, atom service or composition service, the business process (only for composition service) etc.
- LN = (D , $Input$, $Output$), stands for the business function of the logical service. Generally a logical service has one business function. " D " is the description information of the function; $Input$ is the input information; $Output$ is the output information.

- $LNF = \{lnf_1, lnf_2, lnf_3 ......\}$ stands for a set of non-functional attributes of the logical service, such as cost. Each of them is also (N,unit,ValueF), but the value is different from the physical service's , it is a value range, which can be discrete or consecutive, such as {100,150,160}RMB or {100-200} RMB.

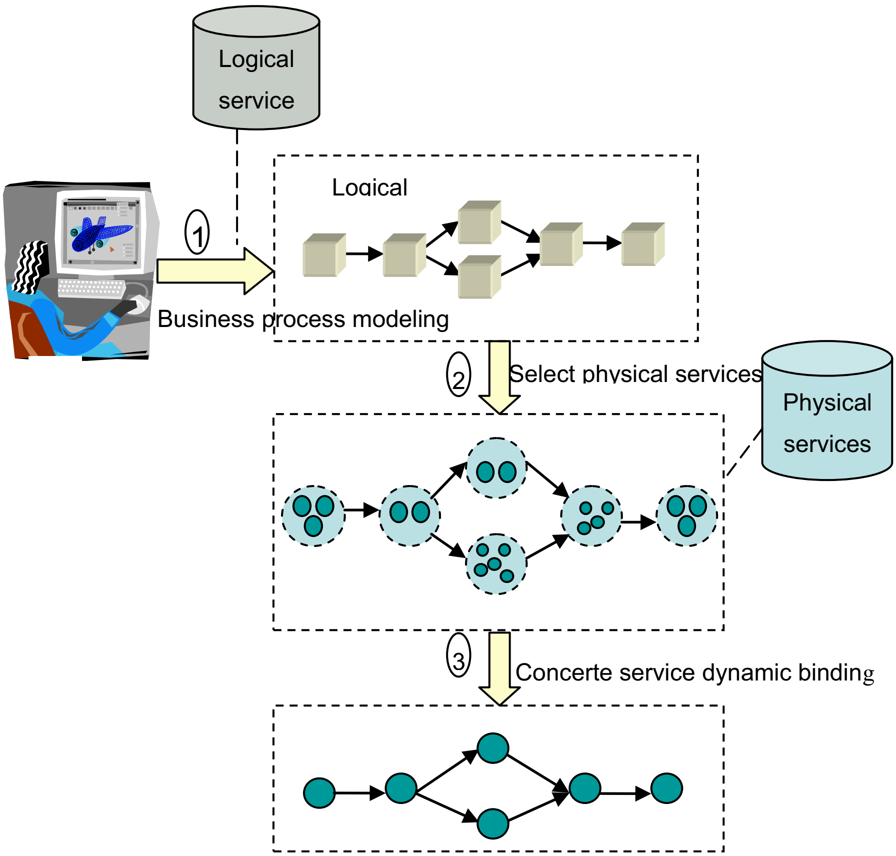

Fig. 1. The Implementation Process of Application

4 The Implementation Process of Application in Cloud Manufacturing Environment

Fig.1 shows the implementation process of application in cloud manufacturing environment. The method satisfies the requirement of the dynamic treatment of workflows at the execution phase. The process as follows:

Step1. Business process modeling: the business users select appropriate logical services according to certain business logics and goals. They give the business process model.

Step2. Physical services selection: select appropriate physical service for every logical service in business process. At first, we should determine the logical service is atom logical service or composition logical service. If it is composition logical service, please return Step2. If it is atom logical service, we should select appropriate physical service from physical service library based on the function and non-function needs. Sometimes there are a group of physical services can meet the requirement. We should sort these physical services through Multi-objective decision-making method.

Step3. Service instance dynamic binding: selecting Optimal or suboptimal physical service according to dynamic attribute of service and get the concrete physical service process.

Step4. The process engine drivers the business process. The concrete physical services are called.

This business-driver building application method can adapt the rapid change of the business process and enable business users themselves to dynamically reconfigure service-oriented applications according to business changes.

5 Conclusions and Future Work

The research of cloud computing in the application of specific industry has just begun and has not mature solution. The paper proposes the concept of cloud manufacturing, which is the combination of cloud computing and SOA. The resource sharing model provides the method of resource sharing in cloud manufacturing environment. Through virtualization, an insulation layer is established between manufacturing resources and application, which make the application not depend on given manufacturing resources.

We are studying the manufacturing resource encapsulation method and the pattern of virtualization in the cloud manufacturing environment.

Acknowledgment

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Cluster Analysis on Candidates of Cooperative Product Development Team

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Abstract. Project managers of the cooperative product development projects have to face the problem of how to set up a development team from the wide-spread candidates all over the world. In this paper, cluster analysis is used in selecting candidates of cooperative product development team. Five attributes including technical ability, innovation ability, cooperation ability, experience level and credit level are proposed. Attribute cluster process is presented in detail as well. Case study shows that the cluster analysis can effectively reduce the configuration difficulty of the collaborative product development team.

Keywords: Cluster, candidate selection, cooperative product development.

1 Introduction

Project managers of the cooperative product development projects have to face the problem of how to set up a development team from the wide-spread candidates all over the world. In order to make up a highly effective team, many researchers focus on evaluating indicators and selection algorithm of candidates. Mikhailov[1] picks price, quality stability, financial service, customer satisfaction as criteria and present a fuzzy analytical approach to select partners in formation of virtual enterprises; Ip et al [2] take account of the cost and due date of the project, success probability and fail risk etc.. Zhan[3] considers running costs, response time, failure risk and builds a colonial selection algorithm to find partners of dynamic alliance. With individual and collaborative performances, Feng et al [4] develop an improved non-dominated sorting genetic algorithm II (INSGA-II) to solve member selection problem. Cheng et al [5] proposed an optimized selection method based on evidence theory and genetic algorithm, which is used to choose partner of dynamic alliance.

However, as the number of team candidates will be very large and the attributes and evaluating indicators involved also have a significant diversity, this brings more difficulty in the algorithm application. Therefore, in this paper, before the formation of a team, we suggest to cluster candidates according to attribute types so as to effectively reduce the scope and difficulty of the choice for the application of above mentioned algorithm.

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2 Attribute Analysis in Candidates

Suppose that there are n candidates, and ma_i stands for the attribute of candidate i, therefore U= { ma_1, ma_2, …, ma_n} stands for model space consisted of all the objects to be classified. Considering the demand of cooperate development, we select 5 attributes from attribute sets in candidate: technical ability, innovation ability, cooperation ability, experience level and credit level in the alliance members. The first three attributes are objective requirements of tasks to the capability attributes, and the latter two attributes which mainly to further narrow selection scope in candidate are subjective requirements for the alliance leader. Each sample ma_i can be characterized by a set of five-dimensional data:

$$ma_i = \{ma_{i1}, ma_{i2}, ma_{i3}, ma_{i4}, ma_{i5}\}, \quad i = 1, 2, \cdots, n \tag{1}$$

Experts evaluate the attribute indicators in candidate and set five levels –high, higher, medium, lower, low-by language class indicator, corresponding to the five interval value because of their fuzzy. Each member indicator is marked as follows: $ma_{ij} = [x_{ij}^-, x_{ij}^+]$. In order to analysis the data indicators with different dimensions and prevent indicator losing their role due to data too small, we need to standardize these indicator values. By proportional transformation, we can get standardization j indicator of alliance member i, $ma_{ij}' = [x_{ij}^{-'}, x_{ij}^{+'}]$:

$$\begin{cases} x_{ij}^{-'} = \dfrac{x_{ij}^- - \bigwedge_{i=1}^n x_{ij}^-}{\bigvee_{i=1}^n x_{ij}^- - \bigwedge_{i=1}^n x_{ij}^-} \\ x_{ij}^{+'} = \dfrac{x_{ij}^+ - \bigwedge_{i=1}^n x_{ij}^+}{\bigvee_{i=1}^n x_{ij}^+ - \bigwedge_{i=1}^n x_{ij}^+} \end{cases} \tag{2}$$

$\bigvee_{i=1}^n x_{ij}^-$ and $\bigvee_{i=1}^n x_{ij}^+$ respectively stand for the maximum value of the left and right interval value with indicator j ; $\bigwedge_{i=1}^n x_{ij}^-$ and $\bigwedge_{i=1}^n x_{ij}^+$ respectively stand for the minimum value of the left and right interval value with indicator j. At result, it will get the standardization data of every object:

$$ma_i' = \{ma_{i1}', ma_{i2}', ma_{i3}', ma_{i4}', ma_{i5}'\}, \quad i = 1, 2, \cdots, n \tag{3}$$

3 Attribute Cluster Process

Let A be the attribute set, A= {A_1,A_2,…,A_l }. On the characteristic space, X is a set with n data, X={X_1,X_2,…,X_n}. Given the similarity definition between of any two data points, similarity(X_i, X_j)=f(X_i, X_j), X_i, $X_j \in$X. According to similarity definition, the set is divided into several non-empty subset C by cluster analysis, C={C_1,C_2,…,C_k}, $C_i \in$C. The class C_i makes the similar datum in the same class, vice versa. Cluster analysis does not only reveal internal relation between the datum, but also provides important basis for further data analysis and knowledge discovery.

Cluster analysis facing to the alliance members is to classify different members by attributes in the same field; in other words, put members with similar attributes into a same class; while put others with dissimilar attributes into a different class. After standardization, each ma'_{ij} , which indirectly describes the essential characteristic of each object, stands for the membership of the set ma'_i subordinated the indicator j. From the geometric point, each sample can be regarded as a point of five dimension space and n sample compose n points of 5 dimension space. Thus, the similarity between the sample i and k can be measured by Euclidean distance:

$$d_{ik} = \left[\sum_{j=1}^{5} ((x_{ij}^{-} - y_{kj}^{-})^2 + (x_{ij}^{+} - y_{kj}^{+})^2) \right]^{\frac{1}{2}} \tag{4}$$

We definite the distance of two classes as the distance of the two recent samples, then, D_{pq} is the distance of C_p and $C_{q,}$:

$$D_{pq} = \min_{i \in C_p, k \in C_q} d_{ik} \tag{5}$$

With formulas (4) – (5), we can divide the sample by the minimum distance system cluster algorithm, and the step-by-step procedure is described as follows:

Step 1: Define the distance between the samples and calculate the symmetric matrix $D_{(0)}$from every two samples. At the beginning, each sample is a class, $D_{pq}=d_{pq}$
Step 2: Choose the smallest element D_{pq} of $D_{(0).}$ Join C_p and C_q into one class which marked $C_{r,}$ $C_r=\{C_p\ C_q\}$.
Step 3: Calculate the distance between the new class and other classes:

$$D_{rh} = \min\{\min_{i \in p, k \in h} d_{ik}, \min_{i \in q, k \in h} d_{ik}\} = \min\{D_{pk}, D_{qk}\} \tag{6}$$

In the $D_{(0),}$ join row p, q into a new row and join column p, q into a new column, then we get the matrix $D_{(1)}$.
Step 4: Go to step 2 and step 3 to get $D_{(2),}$ and so on until all the elements cluster into one class. After cluster have completed, we can divide the attributes in candidate into several classes under the specific circumstance.

4 Case Study

Suppose that there are 20 candidates who have product design optimization and analytical skills. Through evaluating all members in the technical ability, innovation ability, cooperation ability, experience level and credit level, we get the initial evaluation data of member attributes. According to Section 3, the distance of samples (D(0)) can be calculated, then through applying minimum distance cluster algorithm to divide the sample type, we get cluster pedigree diagram of candidates is shown in Figure 1:

According to the result of cluster analysis, the candidates can be divided into 7 classes: $C_1=\{ma_2, ma_9, ma_{12}, ma_{17}\}$, $C_2=\{ma_1, ma_5, ma_7, ma_{11}, ma_{15}, ma_{20}\}$, $C_3=\{ma_6, ma_{18}\}$, $C_4=\{ma_3, ma_{10}, ma_{16}, ma_{19}\}$, $C_5=\{ma_{13}\}$ $C_6=\{ma_4, ma_8\}$, $C_7=\{ma_{14}\}$. The result can be seen as follows: to the C_1 attributes, technical ability and innovation ability are at the middle level; cooperation ability, experience level and credit level are at the higher level. To the C_2 attributes, innovation ability is at the lower level and other indicators are at the higher level. To the C_3 attributes, all indicators are at the higher level. To the C_4 attributes, technical ability, experience level and credit level are at the high level; innovation ability, cooperation ability are at the middle level. To the C_5 attributes, credit level is at the lower level; technical ability, innovation ability, and experience level are at the higher level; cooperation ability is at the middle level. To the C_6 attributes, all indicators are at the low level. To the C_7 attributes, cooperation ability, and experience level are at the middle level; and other indicators are in the lower level.

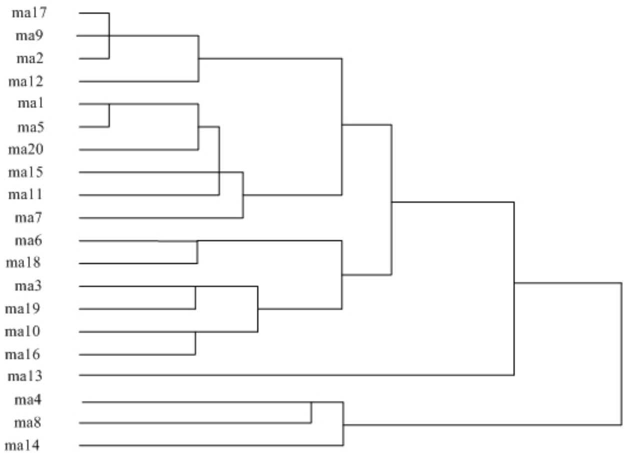

Fig. 1. Cluster Pedigree Diagram of Candidates

5 Conclusion

When there are too much wide-spread candidates, it will have more necessity of cluster analysis in candidate. After dividing of attributes, we can choose the appropriate type and distribute the task to optimize resource allocation according to different needs of capacity of the task. Further study would focus on the selection algorithm based on the cluster analysis.

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Collaboration Support in a Web-Based SCADA System

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Abstract. This paper presents the approach to develop the SCADA system supporting the expertise distributed amongst multiple persons. SCADA systems are briefly presented and the analysis of sources of conflicts in the multi-user SCADA system is provided. To assess the scale of conflicts two usage scenarios are assumed, i.e. the collaborative environment for skilled engineers and experts, and competitive environment for students and researchers. The implemented solution allows the users to take exclusive control of specified parameter of the plant by dividing the users into specific groups and using the token-based mechanism. The proposed conflict resolution mechanism has been implemented in the industrial pilot plant setup.

Keywords: remote learning, cooperative research, multiuser system, conflicts.

1 Introduction

SCADA applications (Supervisory Control And Data Acquisition) are an essential component of the control systems for industrial plants. They enable a remote user to perform maintenance and supervision tasks over the communication link, which is nowadays a common requirement due to the scarceness of the expert knowledge. The formal definition of the Supervisory Control and Data Acquisition system is found in [1]. The typical structure of SCADA system (Fig. 1) is usually sufficient for the industrial applications in which there is only one remote control panel used by a single expert. The operator is able to read the values of controlled variables (CV) and process variables (PV) and to change the parameters of the system, i.e. the setpoints (SP) and the tuning parameters of the control algorithms (CP). However, nowadays the expertise is often distributed amongst multiple persons. It would be desired that the multiple experts involved could cooperate concurrently during the supervisory tasks. A multiuser SCADA system could also be useful in education and research, since there are educational industrial systems which attract the attention of multiple students and researchers at the same time (see [2]).

To allow the multiple users to work concurrently with the system, a multiple access framework was developed, allowing the multiple users to connect to the plant using a Web browser (as in [3]). Web-based approach was chosen, because it allows the industrial data to be accessible in the broad range of higher level processes, e.g. in education [4][5], or business [6]. However, during development, several issues of inter-user conflicts have arisen, since each of the parameters of the control system can

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be physically controlled by only one user at the time. Typically, this problem of a multi-user access to a SCADA system is solved by designating one privileged user which has the right to perform supervisory control task. In case of cooperative and collaborative experimentation such the approach is too simple and requires distribution of privileges amongst specific variables. Therefore, the mechanism of privileges was additionally augmented with the token-based procedure for each of the variables. This combined approach is novel in the field of continuous control systems and along with the test implementation proving the applicability of the method for cooperative control is the main contribution of this work.

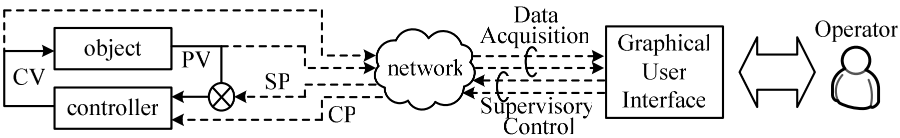

Fig. 1. The structure of a typical single-terminal SCADA system

2 Conflict Resolution

As [7] states, the following sources of conflicts in collaborative work may arise: misunderstanding, lack of information, differing interests, and personal values. To assess the factors in the described applications, two usage scenarios are assumed. The first scenario is the collaborative environment. In this variant, operators of the plant are the skilled engineers and experts, who share the common goal i.e. possibly efficient operation of the plant. The second scenario is the competitive environment. Operators of the plants are the students and researchers, who want to perform various experiments according to their own agenda. In the first scenario the only sources of conflicts are misunderstanding and lack of information, while in the second case the most influential factor is differing interest.

The proposed token mechanism allows the users to take exclusive control of the selected parameters of the plant. As long as the user holds the token, he is able to modify the parameter corresponding to the token. To eliminate the sources of conflicts, the GUI (graphical user interface) is employed and the parameters of token procedure are properly tuned:

- Misunderstanding is eliminated by setting the token time-out in relation to the dynamic behavior of the controlled process. This ensures that the token owner can be held responsible for the effect of the atomic control task he performed while holding the token, and on the other hand it is ensured that the performance of the process at the moment is the result of actions of this user only.
- Proper amount of information is provided by the GUI, which displays current state of the system, ownerships of tokens, and expected times in which each of the token will be returned to the pool.
- Differing interests are crucial in the competitive scenario. These conflicts are solved by extending the token lease time to be long enough to perform full operation. Additionally, queuing of the requests for tokens is required. This

prevents the process from being taken over by a single user, and ensures that the other users waiting for the availability of the process have their opportunity to take the control.

The exact parameters of the token mechanism (grouping of variables into clusters, time-out durations, number of user classes and their hierarchy) have to be determined depending on the character of the users concurrency. It can be concluded that for the cooperative system just one class of user is enough with the maximum token lease time of the order of seconds (depending on the dynamics of the system). For the competitive system a few user classes are needed (e.g. students, teachers, and researchers) and the token time-out of order of minutes.

3 Implementation and Conclusion

The mechanism proposed was implemented in the set of semi-industrial pilot plants available in the Institute of Automatic Control (Gliwice, Poland), which has already been the subject of research on the collaboration and cooperation during concurrent educational and research experimentation. The system consists of six semi-industrial pilot plants focused on various domains of continuous control. The core of the interfacing hardware is the desktop computer designated to fulfil the role of proxy. From the pilot plants' point of view it acts as a client, while from the office-grade local area network it is seen as a typical Web server providing the data read from the control instrumentation as adequately formatted XML files. The HTTP requests sent to the server main contain the supervising control commands, which are then relayed to the

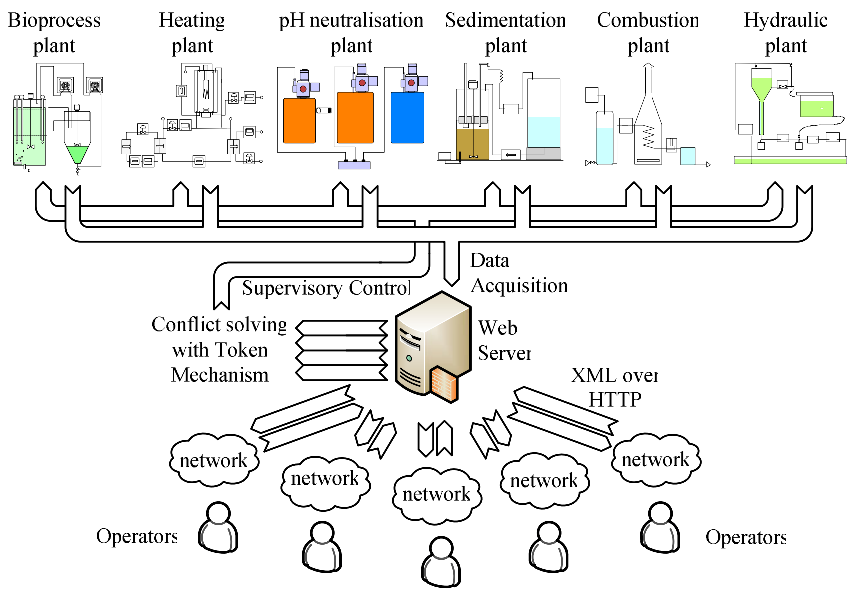

Fig. 2. The structure of the system

plants as the changes of values. It is the stage of the relaying, where the token-based mechanism is implemented. The flow of the data in the framework is graphically illustrated in the Fig. 2. The openness provided by the XML standard was primarily intended to support external automated modelling and simulation of the plants (actively investigated for a long time – see [8]–[10]), but it naturally allows for any modern external software to be integrated with the framework.

The token mechanism, although uncommon in continuous process automation, proved useful; the system is conflict-free, and as long as the operators share the common goal, there are no disturbances in the plant. The differences of opinions on reaching the solution of a given control problem are solved by allowing the processes to reach their steady states before another control action may be applied. The approach adopted passed the preliminary test and will be developed further.

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Collaborative Control of Hierarchical System Based on JADE

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Abstract. The paper deals with the design process supported by sharing information through a Multi-Agent System environment. SCADA (Supervisory Control And Data Acquisition) software systems are one of the typical applications in automation industry and are used for monitoring, measurement and control systems. The presented solutions are intended to enable collaborative control for automated plants in a platform independent way. In the proposed Multi-Agent heterogeneous system the OPC plays an important role as a powerful communication technology especially dedicated for real-time distributed control systems. Based on the OPC native protocol OPC Agents Ontology brings this automation communication protocol idea into pure Java JADE Agents environment and also supports in decision making process while participating in concurrent engineering process.

Keywords: collaborative control, concurrent engineering, collaborative design process, Multi Agent System, JADE, OPC.

1 Introduction

Design of a product is greatly influenced by the appropriate computer system enabling access to structured data, integration of data, and coordination of the design process. The purpose of the described software is support of the design process by sharing information through a Multi-Agent System (MAS) environment.

In case of automatically controlled plants, sharing knowledge for operations enabling design and production planning is possible using SCADA (Supervisory Control And Data Acquisition) software. SCADA software systems are one of the typical applications in automation industry and are used for monitoring, measurement and control systems [1], [2]. This software is strictly connected to distributed control systems and in most commercial systems it has a hierarchical structure. Understanding and managing of complex hierarchical repositories is a common task for collaborative design and control [3], [4].

In the proposed Multi-Agent heterogeneous system the OPC plays an important role as a powerful communication technology especially dedicated for real-time distributed control systems [5]. This technology consists of OPC standard and specialized software architectures offered by most of Distributed Control System (DCS) vendors. One of the valuable features of OPC is that it provides a common interface

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for communicating with diverse process control devices, regardless of the controlling software or protocols used in the process. Because of the success of OPC, many of the automation software vendors are facing a new challenge when constructing the next generation of SCADA software system.

OPC is an automation protocol which enables the user to obtain various pieces of information from remote data sources (remote process controllers). OPC protocol provides an easy and generic way in which each client application can connect with various types of OPC Servers. OPC Server basically is a third party piece of software which provides OPC protocol specific data from various types of controllers. Moreover it can be accessed by various number of OPC Client applications at the same moment providing them with needed information.

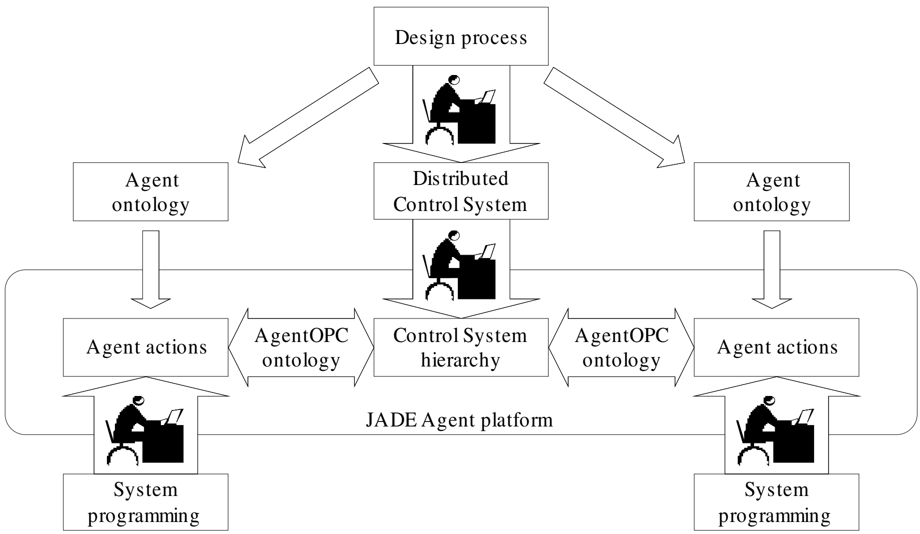

Fig. 1. The Multi-Agent System approach for design process

Ontology is a formal explicit hierarchical representation of the knowledge about the specific domain. Fundamental feature for agents is the aspect of exchanging messages by means of an ontology paradigm (Fig. 1). Based on the OPC native protocol OPC Agents Ontology brings this automation communication protocol idea into pure Java JADE Agents environment [6]. Each OPC Agent (besides the fact that it implements pure native OPC protocol via JNI interface mechanisms, which ensures an easy way to communicate with various types of OPC Servers) is able to communicate with other alike OPC Agents using JADE FIPA compliant messaging protocol.

2 JADE Agent Platform

Java Agent Development framework (JADE) is a Java technology based tool upon which multiple FIPA compliant agents can be created, managed and distributed.

JADE incorporates FIPA methodology concept. Basically, JADE [7] is build upon FIPA specification concept and in some ways extends it.

Foundation for Intelligent Physical Agents known as FIPA in short is an IEEE Computer Standard organization which is focused around heterogeneous, Multi-Agent Systems (MAS). Its most widely adopted standards are FIPA-ACL (Agent Common Language) specifications.

JADE can function on one or more remotely controlled hosts. When distributed over more than one host it creates dynamic number of containers which refers to quantity of those hosts from which dispatched agents can be managed.

From the development point of view JADE delivers all necessary API classes, methods and interfaces for developer to create its own fully customized, solution specific pieces of agent methodology compliant software. Amongst other capabilities JADE introduces a common way for each agent to communicate, dynamic way of mobility technique on different remote hardware platform, possibility of deployment on mobile devices with limited hardware resources, simplified, flexible and easy to understand agent structure and common, extendable and generic language and ontology concept.

2.1 JADE Agents

The most fundamental concept that makes a Java piece of code an agent besides most obvious – mobility; is ontology. This is what differs each an agent from a traditional object oriented solution. Second feature that distinguishes agent from the rest kind of software is its dynamic way of reasoning and decision making process. Each agent in order to prosper needs to communicate not only with specific process but also with other agents that it knows. This goal is established via agent actions. In addition to that it is worth mentioning that each agent piece of software is also capable of existing on its own without the need of cooperation with others. It is in some ways quite independent entity which can act and reason separately based on discovered facts and prior knowledge.

Each agent administrates a finite set of actions that are designed and created during development process. After agent deployment operation there is no way to extend its capabilities. This drawback is partially compensated with possibility of publishing each agents services via yellow and white page services. Each agent can register its services with JADE Directory Facilitator a common place for all JADE agents that wish to publish its services. Process of service registration is similar to a phonebook concept. If registered, each particular service can be discovered and exploited by other agents that take part in process.

In current stage of development JADE OPC Agent platform consists of four basic agents: OPC Management Agent, OPC Network Scanner Agent, OPC Discovery Agent and OPC Agent. OPC Agent is responsible of supporting OPC Server connection; OPC Discovery Agent is responsible of acquiring information about existing OPC Server services, OPC Network Scanner Agent is responsible of acquiring information about JADE OPC Agent platform environment and last, OPC Management Agent is responsible of gathering, processing and presenting of acquired information to the endpoint user.

2.2 Agent Ontology

Ontology is a formalized and abstract "model" of controlled process. Ontology is written based on some a-priori known facts, assumptions and beliefs. It is a notion which commonly refers to what we know about the control system. Moreover, it is a predefined set of concept (rules), predicates (expressions) and actions. Each concept or predicate can be structured in a more sophisticated and complex form based on the fact that each can incorporate a simpler one. Concepts express facts, predicates express beliefs. Third most significant structure besides concepts and predicates are actions. Actions can also be built upon less complicated concepts and simpler actions and express demands to be executed. Only deep knowledge of the controlled process assures a well designed and well structured ontology [8]. If deployed, ontology is shared through running agents. Basically speaking ontology is a skeleton of knowledge for any agent participating in the process. This prior complete knowledge, besides the fact that it helps agents during system specific problems decomposition also supports agents in decision making process while participating in concurrent engineering process. Furthermore, it helps to discover in which state the control system currently resides in and how to deal with it in such situation.

A-prior knowledge about process is based on rules of the hybrid systems with explicit models. A hybrid system consists of two subsystems: a subsystem representing a continuous dynamic and a subsystem representing discrete events and mutual interactions with other systems. One of the important features describing such systems refers to the description of condition for transitions between states. Those conditions are given either explicitly – are computed beforehand based on the knowledge about the plant and are dependent on a measurable state, or implicitly - are given by differential and algebraic equations describing a divisible state space and transitions specifications [9]. Those equations must be solved on-line [10], [11]. and [12]. In both cases, a continuous controlled plant (as a whole) must be approximated in order to use discrete control on the higher level of the hierarchy.

Hence, ontology supports agents in decision making problem and for communicating agent in negotiation process. It is organized in a hierarchical manner and consists of various pieces of information completeness and content of which determines about

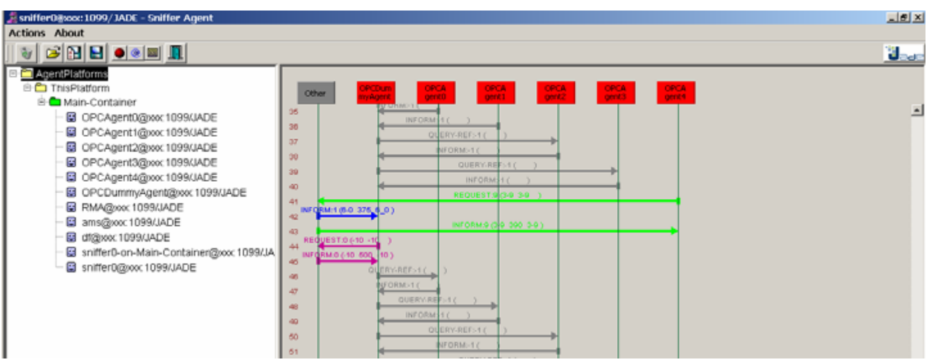

Fig. 2. JADE OPC Agent platform negotiation process

how agent should behave. Two issues are important for the definition of negotiation strategy rules. First, what kind of model is sufficient to provide an approximation that will be abstract enough (hence maximally independent from the physical details, because measurements are eliminated and replaced by discrete states) and deterministic from the point of view of control for the discrete part. Secondly, how to exchange information between layers (which is made difficult by the conversion of measurements into states and vice versa). Such models are usually developed only for part of the parameters describing the controlled plant [13]. Therefore, it is necessary for agents to negotiate. Figure 2 presents an example of such process.

2.3 OPC Agent Ontology

Based on the OPC native protocol OPC Agents Ontology brings this automation communication protocol idea into pure Java JADE Agents environment. It then gives the ability for each agent to act as a common OPC client. Not only agents are able to manipulate OPC protocol native data, for example read and write, but also browse through each available OPC server structure, obtain each OPC item properties, obtain each OPC server status values, add or remove and configure or modify OPC groups and items.

Each OPC Agent is capable of establishing one OPC Server connection at the given time. Therefore, in order to access more OPC Servers at one time, more OPC Agents are needed. OPC Agent Ontology takes into account the fact that such situation occurs and gathers single pieces of information into one structure that is available at any time to whole existing set of OPC Agents. The ability of browsing OPC Server structure is a crucial and the most basic functionality of each automation application. It gives a possibility to dynamically gain access to each data point as needed. Therefore, if only one agent gains access to a dynamically created data point all the other agents gain such access as well. Another conclusion comes out of this concept. There is no need to add the same data point twice which simplifies the whole idea of working with agent software.

OPC Agent Ontology is tightly connected with concept schema, predicate schema and action schema classes. This solution saves much real processing time because is not necessary to query the OPC Server each time.

The most basic and atomic part of ontology is vocabulary. Vocabulary class fields are closely connected with both concept, predicate, action and schema classes. Moreover, naming convention used during vocabulary creation should be preserved further onto concept, predicate, action and schema classes creation level because JADE internal mechanisms recognize ontology's class fields by names specified in the vocabulary.

Each JADE agent in order to function properly needs to communicate with other agents to obtain various pieces of information. Because of that each JADE Agent has to possess the ability to understand and share knowledge between other agents. Because communication is for JADE Agents the most crucial term, there must be a way to define and validate each message. It is being done by means of ontology's schema. Schema holds information about how the received message is or should be structured. It is ontology's schema that takes imperious role during agent messaging process. On the schema level if one parameter is obligatory or not, if there could be zero, one or more elements in message etc are defined.

3 JADE OPC Agents Platform Feasibility and Implementation Details for Hierarchical System

In the real plant a control system has many subsystems of varying complexity levels. It can be distinguished on various levels of abstraction and each of the subsystems belongs to many structures depending on the assumed grouping criterion. Independently of subsystems distinction, the whole control system has some functions defined. Those functions are a consequence of control systems designed tasks.

This structure of subsystems hierarchy taken together with boundary conditions of the systems' variables defines the system as a deterministic finite state automaton [14]. The ontology is taken into account when definition of functions taxonomy is built. Taxonomy of functions performed by the system is derived from models of processes being automated. Finally, both state automaton definition and set of system's functionalities define the architecture of hybrid system which is the final product of the design process.

JADE OPC Agent platform is a real time processing, distributed control system capable of dynamical adjustment to existing situation. Its existence is dictated by today's constantly arising problem of having rapidly changing environment which should be handled with extreme caution in order to maintain high level of quality of acquired information. JADE OPC Agent platform is designed especially to be responsible of dealing with situation of having probability of such dynamic changes.

OPC Agent Ontology refers to knowledge about how agents can interact with each other. This knowledge and functions taxonomy helps them to discover and negotiate over each single OPC Server service. It also provides a way to manipulate OPC Server specific data on a higher level of expertise. OPC Agent Ontology can be considered as a formal knowledge that each single agent is aware of at any time. OPC Agent Ontology plays major role in decomposition problem of hierarchical system. Based on this ontology each single JADE OPC Agent platform agent is capable of composing and decomposing messages. OPC Agent Ontology is build upon hierarchical expressions which are combined together. Simple expressions take part in more advanced, more sophisticated structures. Those predefined structures play major role during real time messaging process and each one is highly parameterized.

OPC Agent initializes and performs connection with desired OPC Server and in response to that retrieves OPC Server's status, structure and tags properties and sends this information back to OPC Management Agent which will build hierarchical relationship tree and present it to the endpoint user.

JADE OPC Agents platform functionality in the current stage of development depends mainly on OPC Agent and OPC Management Agent entities. Those two agents stand in the middle of current communication mechanism. OPC Agent is used to configure and gather data from a single OPC Server. It can function separately from other agents as well as cooperate with different agents playing major role in communication act. OPC Management Agent is used mainly to gather data from various OPC Agents entities. It has superior role in the JADE OPC Agents system which means that it can create and dismiss desired OPC Agents entities; it can configure various OPC Servers via OPC Agent mechanisms, it can propagate various types of notifications to desired OPC Agents, it can be also notified by various OPC Agents. Because of the fact that OPC specific operations are limited only to OPC Agents each notification that is somehow connected with OPC Server functionality initially is created in OPC Agent entity. OPC Server is capable of notifying about its status, its tags properties, tags structure and tags readouts. Based on this data OPC Agent creates proper notifications and propagates them amongst available OPC Management Agents. Each JADE OPC Agent entity stores newly obtained; fresh data inside ontological objects which means that each of them can share its knowledge with other agents that requests it. As a matter of fact all created JADE OPC Agent platform agents are implemented in one universal way from the messaging mechanism point of view and therefore implements the same set of behaviors and messages types which are customized on the specific agent level. This approach assures great durability, robustness and unanimity of the proposed solution as well as it greatly speeds up development effort. Moreover, because of the fact that JADE OPC Agent platform agents immediately register itself in the system data sharing process is quick and effective assuring that at the current point of time each agent dispose actual data.

4 Conclusions

The platform independent Multi-Agent System for collaborative software implementing for control of the hierarchical system is presented. The implementation of agent ontology brought communication automation and knowledge sharing across the structure of the supervisory control structure.

The OPC native protocol operation is treated as an OPC Agents ontology action of a priori specified type. Each JADE Agent in order to function properly needs to communicate with other agents to obtain various pieces of information. Because of that each JADE Agent has to possess the ability to understand and share knowledge between other agents. An agent in Multi-Agent System can operate autonomously and has the ability to cooperate with others agents to achieve several common goals and conflicts as well. The presented system can model concurrent engineering with dynamically changing communication configuration. However, such an approach has disadvantages as well. The ontology is taken into account when definition of functions performed by the system is derived from models of processes being controlled. For that reason current and future effort is targeted at the negotiating protocols based on the rules of hybrid systems with explicit models and its implementation as a taxonomy functions. Finally, both state automaton definition and set of system's functionalities define the architecture of a hybrid system which is the final product of the design process.

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Requirement Specification for Agent-Based Cooperative Control of Dynamical Systems

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Abstract. The paper presents requirements for a layer supervising the transition between different agents controlling a dynamical system. Dynamical systems often require uninterrupted control over certain parts of the process, for which different control algorithm may be applied. Transition of control from one agent to another is possible and may sometimes be desired. Therefore, it must be ensured that the transition does not result in process deterioration. The paper presents data structure and basic mechanisms that enable transition of dynamical system control between different agents to be performed in a desired way.

Keywords: agent-based technology, dynamical systems, cooperative control and monitoring.

1 Introduction

Agent-based technology has received a lot of attention recently, especially in manufacturing processes [1], but also in control of continuous processes [2]. Agent-based approach is especially applicable in case of distributed control systems [3], and in other engineering applications [4]. Supervisory control and data acquisition systems (SCADA) also benefit greatly from agent approach [5], [6].

Cooperation of agents with the goal of controlling a dynamical system requires special requirements to be fulfilled. Dynamical systems often require uninterrupted control over certain parts of the process, for which different control algorithms may be applied. Transition of control from one agent to another is possible and may sometimes be desired. However, this transition will most likely require special attention to be paid not only to the particular process variable but also to other process variables that are in one way or another dependent on the variable under consideration. Additionally, any transition of control should be performed in a bump-less manner, e.g. without any rapid change of controlled variables as is the case in transition between manual and automatic control.

This paper aims at specifying the requirements for a Management of Agent Based Control of Dynamical Systems (MABCoDS) layer, the purpose of which is to accommodate a proper transition of process control between different agents. In this paper an agent is understood as a software application or as a distant human expert accessing the plant under consideration in order to carry out experiments or other

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expert tasks. The paper aims at specifying requirements of the system rather than discussing details of any particular implementation.

2 Architecture of the MABCoDS Layer

Data structure of the proposed MABCoDS layer is presented in Fig. 1. It provides information about all variables in the dynamical system under consideration (**Variables Table**), dependencies between those variables (**Dependency Table**) and agents currently interacting with the controlled dynamical system (**Agents Table**).

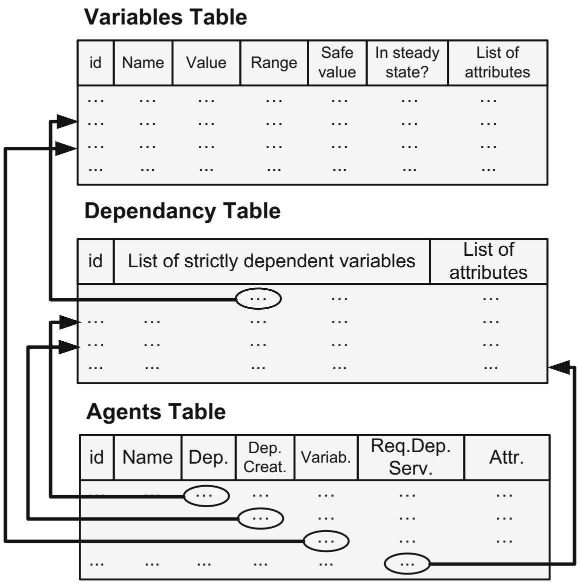

Fig. 1. Basic structure of data stored in MABCoDS

For illustrational purposes, a control system presented in Fig. 2 is used, in which level of liquid in a tank is controlled.

2.1 Variables Table

Three different types of variables are distinguished from the point of view of a control system:

- **Process variable** – the value of which is usually provided by measurements. A process variable may also be the result of a soft-sensor agent computing its value based on other values. In the tank level control example, the following process variables are listed: L – measured level in the tank, Q_1, Q_2, Q_3 – flows of liquid to and from the tank.

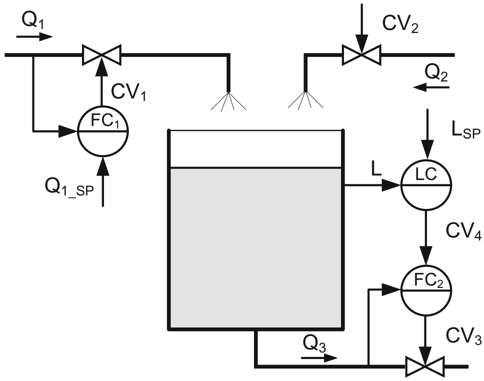

Fig. 2. Tank level control example

- **Controlled variable** – a variable which provides a way of influencing the process. Usually, a controlled variable represents a direct control over a certain device e.g. valve, stirrer, heater etc. In the example, the following controlled variables are listed: CV_1, CV_2, CV_3 – representing valve positions, CV_4 –representing a controlled variable for the level controller (LC). CV_4 represents a set point value for the flow controller no. 2 (FC_2).
- **Set point variable** – although this type of variable has no direct link to the real process (it is neither a measurement nor an actuator) it provides a desired value of a certain process variable to which is associated. Three different set point values are listed in the presented example: Q_{1_SP} – the desired value of Q_1 flow, L_{SP} – the desired level L in the tank, and CV_4 – the desired value of Q_3 flow. Note, that CV_4 is also listed as a controlled variable since it is used as an output from the LC controller, forming a cascade control strategy.

2.2 Dependency Table

Once the variables of the system are defined, it is important to specify dependencies between those variables. In other words, variables must be grouped. Each specified group names the variables that are strictly dependent on each other. For example, all variables of a single control loop must be grouped together to signify their dependency on a control algorithm that is realized by an agent. The table therefore, holds two items:

- List of variables specified in the Variables Table that are part of a strictly dependent group – the first variable is the variable being depended on all the other variables listed afterwards.
- List of attributes applicable to the given group. A dependency may either be caused by physical properties of the process – "`Process`" attribute (when for example the level in a tank depends on the flow into this tank), or it may be caused by an agent interacting with the process – "`Agent`" attribute.

In case of the presented example, the following dependencies may be distinguished:

```
Id = 1;   Variables:  L     | Q1 Q2 Q3   ; "Process"
Id = 2;   Variables:  Q1    | CV1        ; "Process"
Id = 3;   Variables:  Q2    | CV2        ; "Process"
Id = 4;   Variables:  Q3    | CV3 L      ; "Process"
Id = 5;   Variables:  CV3   | CV4        ; "Agent"
```

The first four dependencies (id:1-4) represent process dependencies. Level in the tank depends on all flows Q_1, Q_2, Q_3, but at the same time, flow Q_3 depends on the level (id: 4). Naturally, flows depend on valve positions (id: 2-4). The last dependence (id: 5) is caused by the structure of agents currently in possession of the process (FC_2 in particular).

Two types of dependencies may be distinguished:

- **Strict dependency** – variables are either directly dependent because of the process (“`Process`” attribute) or may be a part of a single control loop (“`Agent`” attribute) resulting in the necessity to take over control of all variables in this group at the same time.
- **Weak dependency** – variables are not strictly depended, but are indirectly depended because of the process. Weak dependency may be determined through analysis of the Dependency Table. Two variables are weakly dependent if they belong to different strict dependencies, but there exists another variable that is part of those two dependencies at the same time. In the presented example, flow Q_3 is weakly depended on flow Q_2 and controlled variable CV_2 because level L belongs to both dependencies (id: 4 and 1).

The number of listed dependencies depends on the particular application. In case of a safety critical system, a strict definition of dependencies may be needed. In other cases, some dependencies existing in the system may be omitted.

2.3 Agents Table

Information about all agents currently inserted into the system are listed in the Agents Table. In general, agents may be classified into two main groups as seen from the point of view of the MABCoDS layer:

- **Monitoring agents** – an agent belonging to this group is not influencing the process in a direct way. Usually it will monitor the process for simple monitoring purposes, diagnostics purposes, or for soft-sensor purposes. However, other agents may still control the process based on the information obtained by an agent belonging to this group.
- **Control agents** – an agent belonging to this group requires a direct influence to be granted over a certain controlled variable.

Information that needs to be stored in the Agents Table is as follows:

- List of dependency groups that correspond to the agent (`Dependencies`). In most cases, one agent will correspond to only one group of dependent variables. However, it is easy to envisage an agent possessing control over two groups of variables that are not dependent upon each other (for example two control loops that are not correlated).
- List of dependencies created by the given agent (`Dep.Created`).
- List of variables to be controlled, that are not part of any dependencies (`Variables`). Note, that in most cases, it is sufficient to specify only the dependencies since they define the variables to be taken over.
- List of dependencies that are required to be serviced by other agents (`Req.Dep.Serv.`), for the given agent to work properly.
- List of attributes. The attributes will signify to which class of agents the agent under consideration belongs to (Monitoring Agent or Control Agent).

In the presented example, the following agents are defined:

```
Name = "FC1"; Dependencies: 2     ;     "Control"
Name = "FC2"; Dependencies: 4     ;     "Control"
Name = "LC" ; Dependencies: 1     ; Dep. Created: 5 ;…
                Req.Dep.Serv.: 4;      "Control"
```

Insertion of an agent into the system may result in insertion of additional items into the Dependency Table (dependencies with the "`Agent`" attribute). In case of agents that only take an existing dependency into possession (FC_1, FC_2) no additional dependency is created since those agents operate on process dependencies (id=2 and 4). In case of the level control (LC) agent, dependency 4 must be serviced prior to insertion of LC agent (as stated in the `Req.Dep.Serv.` list). Additionally, a non-process dependency is created (id=5). This dependency possesses an "`Agent`" attribute and in this particular example represents the cascade control loop with the LC agent providing a set point value for the FC_2 agent that realizes flow control in the output pipe of the tank.

3 MABCoDS Layer Mechanisms

The main purpose of the MABCoDS layer is the assurance of a safe transition of control over certain variables from one agent (or a group of agents) to other agent (or a group of agents). The main mechanism that must be provided by this layer is insertion of a new agent (usually in replacement of other agent) into the set of already working agents. The sequence of agent insertion into the system begins with a request from this agent to take over control of a particular set of variables and/or to start monitoring a particular set of variables. If there are only variables specified for monitoring purposes, insertion may proceed. However, proper information must be inserted into the Agents Table to denote on which variables this monitoring agent relies on. In other cases, e.g. when a list of variables to be controlled is provided (either in the variables list or indirectly in the dependencies list), the MABCoDS must check for any variables not specified by the agent that are strictly dependent on those variables over which control is desired. The system also verifies, whether taking over control of a certain set of variables will not cause any monitoring agents to lose the possibility of correct data interpretation.

3.1 Bump-Less Switching Between Agents

When an agent requires to take over control of a certain part of the process, it may be necessary to ensure, that the new control algorithm will not result in a rapid change of the controlled variables. For example it is undesirable for any controlled variable connected to controlling devices (CV_1, CV_2 and CV_3) to change is a step fashion in case of transition of control. Because information about dependency of variables is stored, it is possible to provide the newly inserted agents with information regarding the initial values of controlled variables, thus ensuring a bump-less transition.

4 Example: Biotechnological System

A biotechnological pilot-plant designed and operated at the Institute of Automatic Control serves as an example of different modes of control, and has been an object of cooperative agent technology implementation before. It is an activated sludge plant consisting of a reactor and a settler, enabling experiments to be performed concerning both conventional control of wastewater treatment plans but also some advanced biotechnological methods including lipase bioaugmentation [7] as well as advanced control algorithms in general [8].

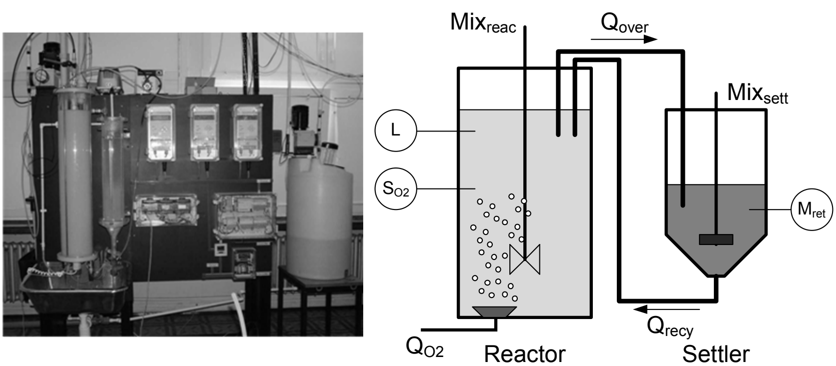

Fig. 3. Biotechnical pilot-plant

Additionally, The pilot plant serves as a platform for modeling and simulation tests [9], [10] enabling a wide range of identification experiments to be carried out.

The following process variables are defined for this plant (in the Variables Table): S_{O2} – dissolved oxygen concentration, L – level in the reactor, M_{ret} – mass of sludge stored in the settler. The following controlled variables are defined: Q_{O2} – flow of oxygen through the reactor (aeration), Q_{over}, Q_{recy} – overflow are recirculation of sludge, Mix_{reac}, Mix_{sett} – mixers in the reactor and in the settler. Set point values are omitted in this discussion for clarity.

The following process dependencies are defined due to the nature of the process:

```
Id = 1; Variables: S_O2      | Q_O2           ; "Process"
Id = 2; Variables: S_O2      | Mix_reac       ; "Process"
Id = 3; Variables: L         | Q_over, Q_recy ; "Process"
Id = 4; Variables: M_ret     | Mix_sett       ; "Process"
```

The first dependency (id: 1) represents the aeration of the sludge in the reactor, while the second dependency (id: 2) represents the fact, that the measurement of S_{O2} is not valid if the reactor is not properly mixed. Level in the reactor (L) depends on the two flows (id: 3), and the mass of activated sludge stored in the settler depends on the appropriate mixer (id: 4).

In a normal mode of operation, the following agents are activated:

```
Name = "Aeration"   ; Dep.: 1                ; "Control"
Name = "Mixing"     ; Dep.: 2                ; "Control"
Name = "OUR"        ; Req.Dep.Serv.: 1,2     ; "Monitoring"
Name = "Level"      ; Dep.: 3                ; "Control"
Name = "Retention"  ;        Dep.: 4         ; "Control"
```

The first two agents (`Aeration` and `Mixing`) represent control of dissolved oxygen in the reactor through aeration and an appropriate mixing regime in the reactor. The `OUR` agent represents a monitoring algorithm that determines the oxygen uptake rate in the reactor. In order for the OUR determination to be possible, a proper mixing and a proper control of dissolved oxygen in the reactor must be assured. Hence, the OUR agent requires dependencies 1 and 2 to be serviced prior to insertion. Additionally, level of liquid in the reactor is controlled by the `Level` agent servicing dependency 3, while the mass of activated sludge maintained in the settler is controlled by the `Retention` agent servicing dependency 4.

The system working in the presented control scheme needs to be serviced periodically by stopping the aeration and mixing in the reactor. This enables a portion of the clarified liquid to be removed from the reactor after the biomass is settled at the bottom of the reactor. Therefore, an additional agent may be activated:

```
Name = "Decantation"  ; Dep.: 1,2,3      ; "Control"
```

This agent however, requires to take control over the first three dependencies. Since, in the normal process operation, those dependencies are already serviced by other agents (`Mixing`, `Aeration` and `Level`), the MABCoDS must disable all those agents from interacting with the process in order to enable the `Retention` agent. Therefore, it checks for any agents in possession of the dependencies in question, and ensures that the newly inserted agent takes control over those dependencies without interference with other agents.

5 Concluding Remarks

Basic requirements for a layer supervising the transition between different agents controlling a dynamical system are presented in this paper. Although, the presented problem may be generalized into a more universal system, those basic requirements must be ensured in order for a successful collaborative control of a system that must not be left without control. Future research in this topic should concentrate at fulfilling the presented requirements using existing agent based control systems software and hardware.

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Web Engineering Process Matrix for Sustainable Deployment of Web-Based Applications

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Abstract. Sustainable deployment needs a clear cooperative model of actors during different phases of planning, design, implementation and maintenance for a Web-based application project. Solving Web engineering problems involves multifaceted working stages, multi-domains expertise and multidisciplinary workers. The key to success is effective communication among actors. Actors can be both active and passive, either humans or non-human entities. Cooperative models can ensure effective flow of information between actors at all stages.

Keywords: cooperative model, process matrix, sustainable deployment, Web-based applications, effective communication.

1 Introduction

Web engineering [3], as in any engineering endeavour, is a complex process [4]. In addition, it is a common knowledge that IT projects failure rates are among the highest across all industries. Therefore, solving Web engineering problems involving; 1) multifaceted working stages, 2) multi-domains expertise, and 3) multidisciplinary workers, is often a direct result of; 1) effectiveness in communication reflected by cooperative models used, 2) willingness to accommodate new ideas and technology, and 3) the ability to change at any of the development, implementation and maintenance phases of a project. These are easily said then done due to the complexity in the communicating network of actors and the dynamic of the interactions.

By identifying important actors within a software project and their communication behaviour during different phases of the project, a cooperative model can be made and be used as guidelines on how a specific project management can be best done, before, during and after a project's period. Actors can be both active and passive, either humans or non-human entities. A cooperative model can ensure the effectiveness of information flow between active human actors. Most basic and important information is provided by the passive non-human actors. Passive non-human actors indirectly play important roles within a specific software project by influencing decision making processes throughout the whole workflow.

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2 Project Failures

The latest Standish Group's CHAOS 2009 survey, taken from 400 different organizations, reported the following IT projects success/failure distribution; 1) 32% success, 2) 44% were considered challenged, and 3) 24% fail, [9]. A project is considered successful if it had been completed on time, on budget and deployed with all the required features and functions. A project is considered challenged if it was completed late, over budget and with fewer than the required features and functions. A project is a failure if it was cancelled before completion or it had been delivered but never deployed in a production environment.

Nearly two third of all IT projects were considered challenged or failed. Lately, economic recession can be one of the contributing factors. However, the low success rates can be attributed to common management causes of; 1) poor planning, 2) poor communication, and 3) poor resource allocation, [1], [2]. Therefore, with good planning, better communication and efficient resource allocation, an increase of success rates can be achieved.

3 Actors and Stages

The two fundamental aspects of a software project to be discussed in this article are; 1) actors, and 2) stages, in particular the different communication and cooperative models to be used between actors at different stages of the project, thus reducing the complexity of interaction.

One possible graph of communicating network of actors for projects is presented in Fig. 1 where; 1) *passive actors* {**G** - government, **C** - science, **T** - technologies, **S** - systems}, and 2) *active actors* {**M** - management, **E** - experts, **B** - builders, **U** - users}. Passive actors constitute important influential factors within a project work but do not actively participate in the negotiation processes, for example government can pass a legislation which can effect a project

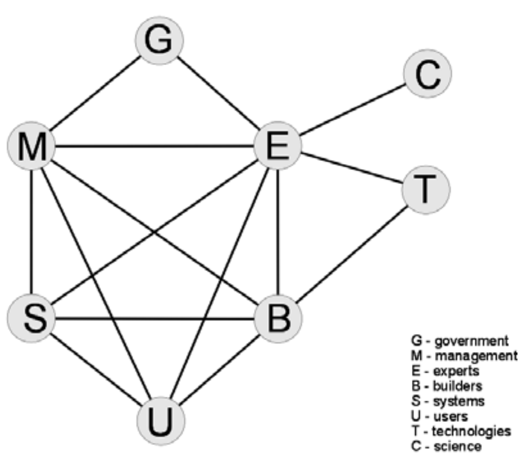

Fig. 1. Actors Communication Network

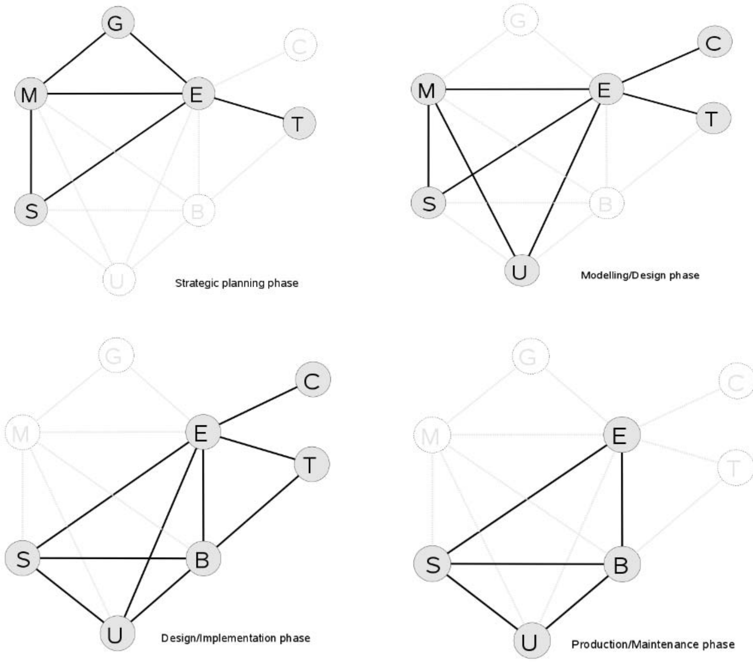

Fig. 2. Actors Communicative Phases

outcome. Active actors are humans having different roles, for example a manager who manages resources.

At different stages of a project work, communication and cooperation networks of actors take different practical forms as shown in Fig. 2. The experts, **E**, participate in all phases. They need to know and understand legislations, technologies and operating systems during the strategic planning phase. An expert usually plays the role of a system architect and is directly connected to management. The management **M**, takes the economic aspects, while the experts take the technical aspects of the project work.

4 Project Management Tool (PMT)

A preferred PMT should facilitate collaborative efforts of different actors at different stages of a project and could easily implement cooperative models mentioned in Section 3. A Web-based PMT such as *Redmine* [5] is a good candidate. The PMT provided by *Redmine* is cross-platform and cross-database, built on top of *Ruby on Rails* Web framework, [7], [8]. It is flexible and customizable. With some minor changes *Redmine* can be used as both project management tool and project collaboration tool, in particular, *Redmine* supports sub-projects, gant diagrams, events notification, issues tracking, and wiki.

5 Conclusion

Cooperative models suggested by Fig. 2 ensure effective flow of information among active actors at a particular stage of a project work. Using a PMT like *Redmine* will assure that all project's plannings, worklogs and documents are stored in one database for easy access to all participating parties. Agile [6] Web engineering is possible since changes can be dealt with effectively. By devising practical cooperative models for all stages of a project, a higher probability for a sustainable deployment is ensured.

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Collaborative and Visualized Safety Planning for Construction Performed at High Elevation

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Abstract. To eliminate unsafe conditions and to reduce a number of accidents at construction sites, engineers and supervisors in charge should have knowledge related with the requirements of safety procedures and safety facilities of construction activities performed at high elevation. Since the level and amount of knowledge and experience depend on the person, engineers and supervisors should discuss various aspects of hazards and safety collaboratively. While supervisors should visit construction sites, they are usually too busy to pay a visit to site. Thus, an innovative approach is needed to provide the engineers and supervisors with a collaborative platform where some engineers are at the site and some supervisors are the office and where they can see the options of safety measures as well as the real construction site, for discussing safety measures. This study aims to develop a visualized and collaborative approach for simulating the construction activities operated at high elevation using Augmented Reality. This research is on-going and the prototype system is under development. The prototype will be tested at a real construction site.

Keywords: collaboration, construction safety, augmented reality, falling.

1 Introduction

The accident costs in construction were reported for billions of dollars in economic loss. Additionally, the cost exceeds beyond its evidence. Indirect cost of accidents might be as much as six times the direct cost or more[1]. The major cause of accidents in construction which leads to fatalities is fall from height[2]. The accidents frequently occur in building construction projects, particularly commercial buildings because most of them are high-rise buildings and comprise of multi-stories[3].

Even though many safety guidelines, rules and regulations have been implemented and enforced at construction site in Thailand, safety measures such as guardrails, working platforms, safety nets, lanyards, climbing protection systems, and lifeline systems are still provided inadequately. These unsafe conditions are ignored by involved project engineers, site engineers, and supervisors.

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Omission in unsafe conditions may be caused from ignorance and unawareness of in-charge personnel related to hazards and risks. Occasionally, involved participants, who take responsibilities to arrange safety facilities at construction sites, do not have enough experiences and cannot execute safety measures adequately and effectively.

To eradicate unsafe conditions and reduce accidents, in-charge personnel should understand and have knowledge associated with the requirements of safety procedures and safety facilities of construction activities performed at high elevation for planning and execution works. In fact, they should gain experiences and perceive inherent hazards and risks of those activities in the actual construction environment. Since the level and amount of knowledge and experience depend on the person, involved engineers and supervisors should discuss various aspects of hazards and safety collaboratively at the site. Although supervisors should visit construction sites, they are usually too busy to pay a visit to high construction sites.

Thus, an innovative approach is needed to provide the engineers and supervisors with a collaborative platform where some engineers are at the site and some supervisors are the office and where they can see the options of visualized safety facilities as well as the real construction site, for discussing safety measures. This study aims to develop a visualized and distantly collaborative approach for simulating the construction activities operated at high elevation using Augmented Reality and to implement this approach for investigating the improvement of construction personnel considerations in safety planning.

2 Proposed System Architecture

Augmented Reality technology is employed to develop the visualized approach for simulating construction activity performed at high elevation. This technology can supply amount of information through computer graphics and merge the virtual objects into the real world scene[4]. It enables the user perceive, understand and memorize information easier[5]. The proposed system architecture is configured and shown in Fig. 1. The hardware components for developing this system consist of a laptop computer, a video camera, and a head mounted display (HMD). For implementation of AR, ARToolkit[6] is employed. The project data is represented as a Building Information Modeling (BIM) model data such as Industry Foundation Classes[7] (IFC) of International Alliance for Interoperability (IAI). The proposed system consists of five modules providing various information to the AR system and five databases. The Module 1 provides information of building components. The Module 2 provides construction method and temporary facilities based on the selected building component from the database. The Module 3 provides minimum set of safety measures based on laws and regulations stored in the database. The Module 4 modifies the safety measures based the experts' knowledge and experiences stored in the database. The Module 5 records the final selection of safety measures for the construction in consideration.

At a construction site, several engineers use the system, which can show structural members to be constructed and necessary safety facilities by AR. In a conference room at an office, supervisors can see one of the selected video images of the engineers at site on a projected screen and can discuss with engineers at site as well as supervisors in the conference room via the Internet communication system with microphones and speakers (Fig. 2). Basically, anyone who is involved in the system can select safety measures and the selection can be visualized immediately so that the participants should be able to discuss the selection. They may change them or add more safety measures.

A prototype system is being developed to demonstrate the effectiveness and practicality of the proposed method. Fig. 3 shows a screen shot of a prototype's user interface window and a video image of a construction site with a reinforced concrete column to be constructed and safety facilities.

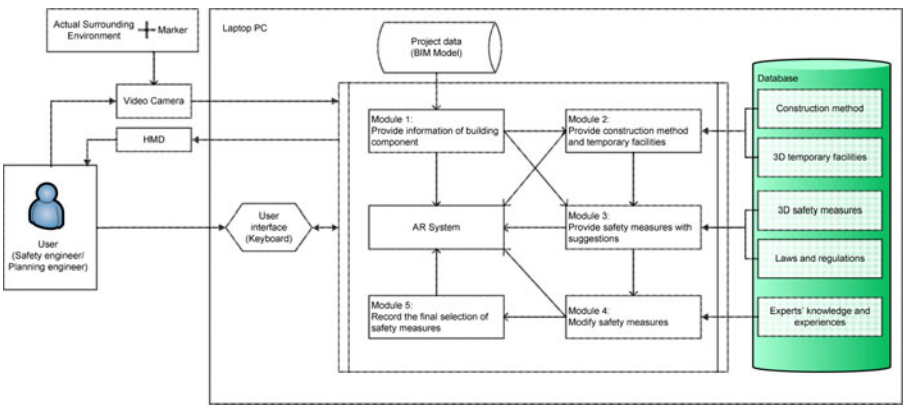

Fig. 1. System architecture

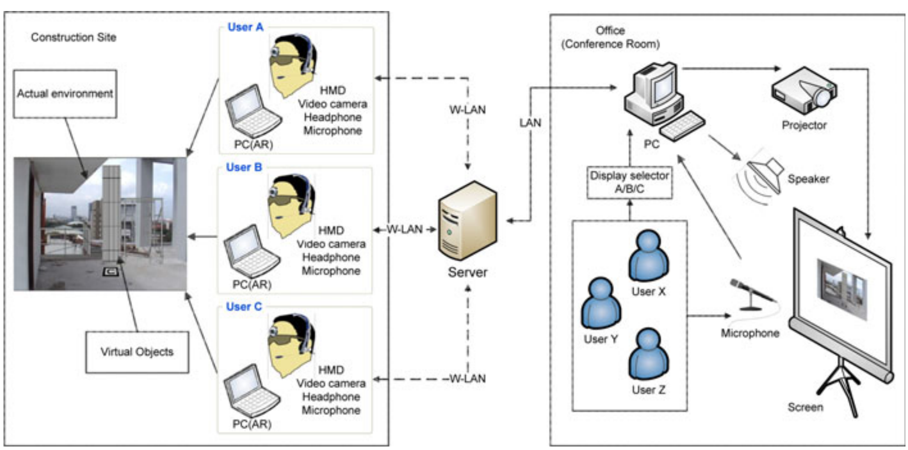

Fig. 2. Collaborative utilization of the proposed system

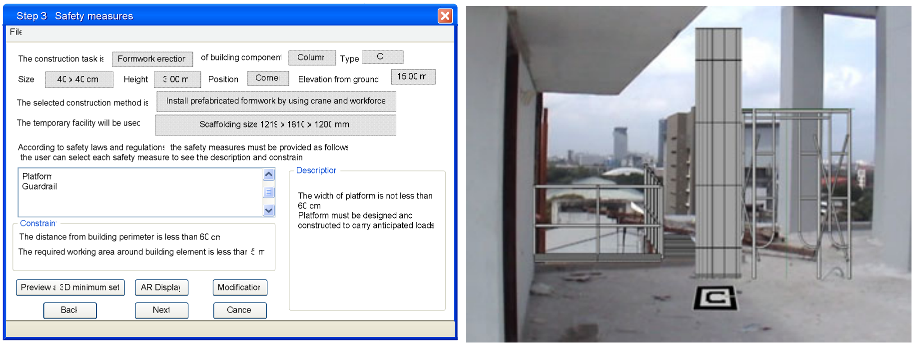

Fig. 3. A screen shot of a user interface window of the prototype system and video image (under development)

3 Conclusion

To minimize unsafe conditions and reduce fall accidents in construction, the collaborative and visualized approach, which provides a platform to learn, check and educate safety knowledge by construction engineers and supervisors is being developed. In this approach, engineers at construction site and supervisors at office can collaboratively discuss safety measures, using AR technology and Internet communication system.

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Product Precision Information Modeling under Cooperative Virtual Assembly Environment

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Abstract. Considering the characteristics of cooperative virtual assembly process, the product feature information is classified in this paper. A precision-oriented cooperative virtual product assembly model is presented based on the tolerance expression of the part feature. The model includes four layers: the hierarchical relation layer, the connectivity relation layer, the feature layer and the feature element layer. With the help of the relation chain within each layer and the mapping information between the layers, different engineering information is integrated. Finally, a new algorithm of automatic generation of dimension chains in cooperative virtual assembly environment is described by using searching mechanisms.

Keywords: Cooperative visualization, Cooperative virtual assembly modeling, assembly dimension chains.

1 Introduction

Cooperative virtual assembly modeling is the base to establish the cooperative visualization environment for assembly design and engineering analysis. Presently, there are two major methods in research about virtual assembly. (1) Developing assembly analysis systems embedded in CAD software by using the CAD model. Literature [1] developed a virtual assembly support system embedded in business Pro/E software. However, the model is restricted by the applications, which causes difficulty to perform virtual assembly simulation in network. Besides, it requires the same CAD environment for all users in different locations for cooperative virtual assembly. (2) Developing universal assembly analysis systems outside the CAD software, taking the advantage of neutral triangle surface models produced by the CAD software. This method uses neutral standards such as VRML, STEP and STL which are commonly used by many corporations to achieve virtual assembly[2,3,4]. The neutral triangle surface models are easy to handle. They are universal and easy to achieve real-time virtual assembly [5]. However, a lot of engineering information is missing compared to the CAD model. It performs much worse in accuracy. Therefore it is necessary to study how to complement the lost engineering information and construct assembly models that satisfy the need of engineering analysis. For example, literature [5] uses product hierarchical models based on process and history information. In the past,

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most of the virtual assembly models based on parts' triangle surfaces didn't consider the precision. However, the demand for analyzing the assembly quality becomes higher, because the accuracy and tolerance analysis and optimization of assembly dimension chain may affect not only the assembly method but also the quality and performance of the production.

In this paper, VRML files and feature information files are taken as the carrier of product information model to offer engineering information that assembly needs. Using precision information expression based on part feature freedom degree, the product hierarchical model is built and the system is developed.

2 Characteristics of Cooperative Virtual Assembly Model

Virtual assembly modeling is the foundation of the cooperative virtual assembly system. Considering the engineering information which is necessary in both distributed cooperative and the assembly plan, VRML file and feature information file are taken as the carrier of the product information model. The feature information file provides the product engineering information and complements the lost information in VRML files. Its advantage is: (a) VRML files can be transmitted easily on-line and the feature information files can carry the precise information of the products. This makes the cooperative design more convenient and assembly plan to be more precise. (b) It is easier to realize cross-platform cooperative design. Different CAD software can be used in the cooperative companies. Almost all kinds of CAD software support VRML format output, therefore the CAD modeling functions can be used here. It can be freed from the limitations of CAD software to achieve cross-platform cooperative design[6,7].

According to its characteristics, the product feature information can be classified into three categories, which are the part feature, the assembly feature and the management feature respectively.

The part feature: it describes detailed information of the product parts, mainly contains geometry features and part property features. The geometry feature is the main element to be displayed by the geometry model in the virtual assembly system. All other information is attached to the geometry feature, acting as related properties within and between parts. It provides all sorts of engineering information for analysis.
The assembly feature: it describes the assembly structure information of the products and assembly relationships, which comprises of the link, the coordination and the restriction among parts, as well as the relationships between sub-assemblies. The assembly feature is the basis for the study on the assembly path, assembly precise, etc.
The management feature: it describes the information of the product functions and assembly technology and also manages process information of the operation and behavior in the assembly.
The feature element: it is the element unit to make up the feature information. Generally, parts are made up by features, which are further made up by feature element. In virtual environment, the feature models of parts are finally constructed on feature elements. For example, a feature body of a box is restricted by topology as six feature surfaces (geometry feature elements), six sizes and angles, etc.

3 Hierarchical Expression of Cooperative Virtual Assembly Model Information

Assembly information of products is divided into four layers as displayed in Fig.1 according to different abstract degrees of products assembly information. The four layers are HierMod, ConnMod, FeatMod, ElemMod. And the expression is

Pro=(HierMod, ConnMod, FeatMod, ElemMod)

The product can be defined as an assembly set of some assembly units.

$$\text{Pro}=(\bigcup_{i=1}^{n} AssemU_i , \bigcup_{i\neq j} AssemC_{ij}) \quad (1)$$

$$\text{AssemU}_i = \{ x \mid x \in \text{Part} \cup \text{Comp}\} \quad (2)$$

$$\text{AssemC}_{ij} = \{ x| \; x=< \text{AssemU}_i , \text{AssemU}_j >, i\neq j\}, i, j=1, 2, \ldots n \quad (3)$$

In the expressions, Pro stands for the product, AssemU stands for assembly units, Part stands for the part, Comp stands for component. $AssemC_{ij}$ stands for the conjunction relationship of assembly units $AssemU_i$ and $AssemU_j$, n stands for the numbers of assembly units. Assembly unit, may be a component or a part, is the basic object that product comprises of. And a component can be further partitioned into subassembly units (componet or part), which has logical inclusion relationship with it.

The feature information can be expressed as Feat= Fp ∪ Fa ∪ Fm, while Fp stands for part feature, Fa stands for assembly feature, Fm stands for the management feature.

(1) The part feature, for a part i, Fp_i can be expressed by

$$Fp_i = Fpg_i \cup Fpa_i \cup Fpm_i \cup Fpt_i, \quad i=1, 2, \ldots, n \quad (4)$$

In the expression, Fpg is the geometry feature of the part. Fpa, is the accuracy feature of the part. Fpm is the material feature of the part. Fpt is the technology feature of the part. Geometry feature of the part is the main body displayed by geometry model in the virtual assembly environment. Table 1 shows some defined geometry features.

Assembly actions among parts are finally decided by some points, lines and surfaces. There, geometry features are further divided into FeatElem, which includes feature surfaces and topology relations. Geometry topology relation contains the normal information, size information and angle relation information, etc. Thus,

$$F_{pg}^{\,i}=(F_U^1 \cup F_U^2 \cup \ldots\ldots \cup F_U^m) \cup (F_R^1 \cup F_R^2 \cup \ldots\ldots \cup F_R^k), \quad i\in\{1, 2, \ldots, n\} \quad (5)$$

F_U^j, is a feature surface, $j\in\{1, 2, \ldots\ldots, m\}$. F_R^l, is the collection of geometry topology relation between surfaces, $l\in\{1, 2, \ldots\ldots, k\}$.

Neutral VRML files provide a series of discrete triangular surfaces which make up parts' shapes. Therefore, it is necessary to build a map from each triangular surface to feature surface, rebuild the part model based on feature. The method to build a map is to extract feature information from feature information files and establish parameter equations about feature surfaces, and then, for every triangular surface, put its vertex

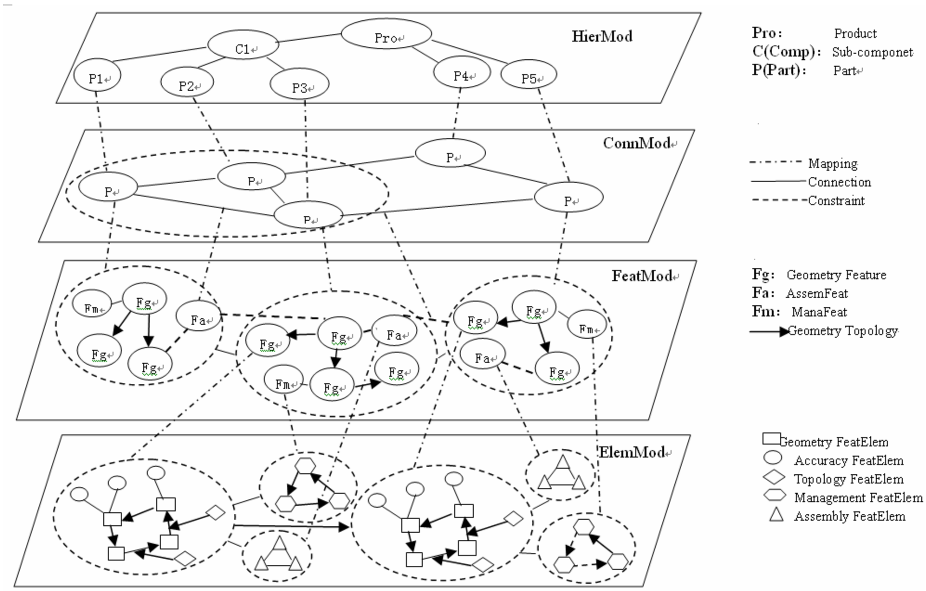


Fig. 1. Hierarchical Information Model of Product

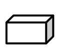
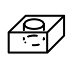
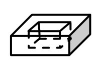
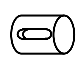
coordinates into the equation, referring to the normal orientation, to verify if the triangular surface belongs to the feature surface.

Accuracy feature of a part is the main part of the assembly tolerance analysis model and also the main basis for dimension chain analysis, collision interference and assembly accuracy analysis. The accuracy feature of a part (F_{pa}) is expressed as:

$$F_{pa}^{i} = \left(\bigcup_{j=1}^{k} F_D^{j}\right) \bigcup \left(\bigcup_{m=1}^{p} F_C^{m}\right) \bigcup \left(\bigcup_{l=1}^{q} F_W^{l}\right) \quad i \in \{1, 2, \ldots, n\} \qquad (6)$$

In the expression, F_D^j is the dimension tolerance feature, $j \in \{1, 2, \ldots, k\}$. F_C^m is the crudeness feature, $m \in \{1, 2, \ldots, p\}$. F_W^l is the geometry tolerance feature, $l \in \{1, 2, \ldots, q\}$, it includes shape accuracy, like flatness, roundness, cylinderness, etc, and position accuracy such as concentricity, parallelism, perpendicularity, etc. According to the inclusion relation of parts and components, geometry feature, geometry

Table 1. Basic Geometry Feature and corresponding GTSB

Geometry Feature	Box 	cylinder 	Cone 	Hole 	Boss 	Rectpocket 	Roundkey 
Decomposed FeatElem	Parellel plane 1 Parellel plane 2 Parellel plane 3	Cylinder susurface Parellel plane	Rotary susurface Parellel plane	Cylinder susurface Parallel plane	Cylinder susurface Parallel plane	Parellel plane 1 Parellel plane 2 Parellel plane 3	Cylinder susurface 1 Cylinder susurface 2 Parellel plane 1 Parellel plane 2
GTSB	Plane 1 ,2,3; Leng m; Width m Heig m	Axis; R m; Plane; Leng m	Axis; Line Plane Leng m	Axis; R m Plane Heig m	Axis; R m Plane; Height m	Plan 1 ,2,3; Leng m Width m; Heig m	Axis 1 ,2; R m Plane 1 ,2; Dis m Heig m

FeatElem, it takes advantage of freedom degree of geometry tolerance structure box (GTSB) that composes geometry FeatElem to display the parts' tolerance information in the three-dimension visualization. Table 1 shows basic geometry features, geometry FeatElemts and their corresponding GTSB.

(2) The assembly feature mainly describes assembly relation between parts or components and features. Its is showed below,

$$Fa = F_{am} \cup F_{ar} \cup F_{al} \cup F_{ad} \tag{7}$$

Here, Fam is the assembly feature. Far is the restriction feature. Fal is the link feature. Fad is the transmission feature. And link feature can be expressed as

$$F_{al} = \left(\bigcup_{j=1}^{k} F_{al}^{\ j} \right) \quad j \in \{1, 2, \ldots, k\} \tag{8}$$

In the expression, Falj respectively stands for bolt link feature, screw link feature, pin link feature, keyway link feature, coupling link feature, etc.

$$\text{Restriction feature } F_{ar} = \left(\bigcup_{j=1}^{m} F_{ar}^{\ j} \right) \quad j \in \{1, 2, \ldots, m\}. \tag{9}$$

$F_{ar}^{\ j}$ stands for coaxial restriction feature, fitting restriction feature, alignment restriction feature, part restriction feature, etc.

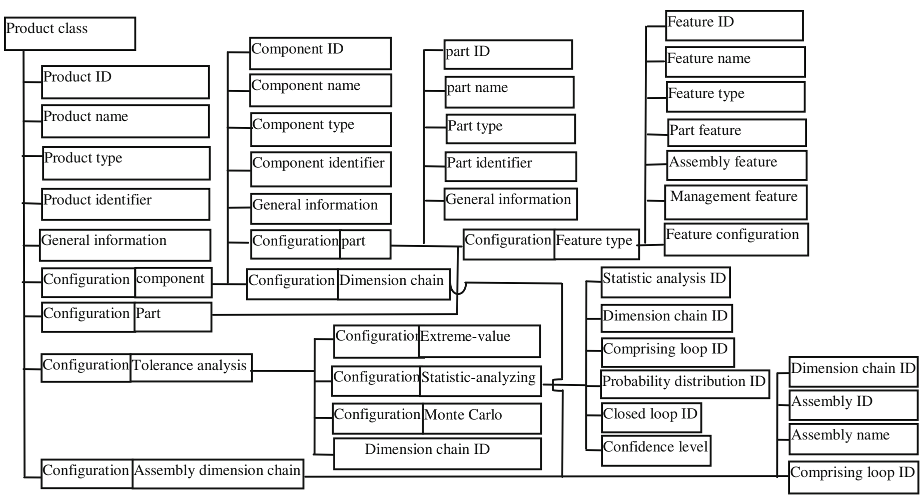


Fig. 2. Data structure of products information model

(3) Management feature is used for describing management information of parts. It can be divided as follows.

$$Fm = Fmd \cup Fmt \cup Fmm \tag{10}$$

Here, Fmd is the management of design information. Fmt is the management of technology information. Fmm is the management of assembly process information.

According to hierarchical information above, the data structure of products information model is deigned. The fig.2 shows it in detail.

4 Automatic Generation of Virtual Assembly Dimension Chain

In analyzing products' accuracy process, it is always requirements of assembly technology that to be the closed loop of given dimension chain, that's to say to designate two feature surfaces form the closed loop. How to achieve automatic search of assembly dimension chain with hierarchical relation of assembly model is studied. The method is firstly to find all assembly parts that compose closed loop and determine assembly path of assembly dimension chain, then to seek dimension of corresponding composition loops in terms of parts' feature topology information, and finally to get products' assembly dimension chain. The detail steps are as follows.

(1) Determination the parts of composition loop. Because there are many assembly relations between parts, assembly dimension chain may not be unique. The system takes the measure of depth priority algorithm to search each part of the composition loop by picking feature surface according to closed loop, the algorithm is as follows.

Step1, according to assembly technology requirement, pick the beginning feature surface (m_Surface[1]) and ending feature surface(m_Surface[2]) of the closed loop.

Step 2, search the feature list (m_pFeatList), and ascertain the beginning part (m_Part[1]) and the ending part (m_Part[2]) which the feature surface belongs to.

Step 3, judge if the normals of m_Surface[1] and m_Surface[2] are parallel. If not, exit searching.

Srep 4, determine the orientation of the assembly dimension chain by its normal, record it into the variable m_dire.

Step 5, search for parts that have assembly relation with m_Part[1] from m_pFeatList, if found, mark it as m_Part[3]. If not found, exit the searching.

Step6, judge whether the assembly surface normal of m_Part[1] and m_Part[3] are the same as m_dire's, if not, return to step 5.

Step 7, record part m_Part[3] into m-AssDimList, record assembly surface pointer of m_Part[1] and m_Part[3] into p_surfacelist, mark it as found.

Step 8, judge if m_Part[3] is m_Part[2]. If it is, go to step 10.

Step 9, mark m_Part[3] as m_Part[1], then return to step 5.

Step 10, output parts' name from m_AssDimList one by one. end.

(2) Determine composition loop dimension. After assembly dimension chain is fixed, it is necessary to search comprising loop dimension inside the part according to its assembly surface. The corresponding algorithm is as follows.

Step 1, pick the pointers of two assembly surfaces from p_surfacelist and mark them as m_Surface[1] and m_Surface[2].

Step 2, search the part which m_Surface[1] and m_Surface[2] belong to and judge if they belong to the same part. If not, exit searching.

Step 3, seek the topology relation of the feature which m_Surface[1] and m_Surface[2] belong to and judge whether they belong to the same feature. If it is, skip to step 4, else, skip to step 5.

Step 4, search the related dimension of the feature that m_Surface[1] and m_Surface[2] belong to, record its dimension and tolerance, then skip to step 7.

Step 5, search dimension and benchmark information respectively in the parts coordinates of the feature which m_Surface[1] and m_Surface[2] belong to.

Step 6, judge the location relation of dimension and benchmark in parts coordinates and calculate the dimension and tolerance of m_Surface[1] and m_Surface[2].

Step 7, judge whether m_Surface[1] points to m_Surface[2]. If it is, this comprising loop is an increasing loop; else, it is a decreasing loop.

Step 8, check if the searching is finished. If not, turn to step 1.

Step 9, output the dimension, tolerance and increasing-decreasing property of each comprising loop. end.

(3)The automatic generation method of assembly dimension chains is as follows.

Step 1, define closed loop according to the assembly requirements and determine its beginning part and ending part.

Step 2, search all comprising loops by depth-prior algorithm in the relation chain.

Step 3, according to the assembly relation of each comprising loop part, search the dimension of the part and obtain the composition loops dimension and tolerance, determine the property of increasing or decreasing of each comprising loop. end.

5 Case Study

Taking VC++6.0 as the development kit, we use the OpenGL graphics engine and CJLibrary 6.08C expansion database and adopt the object-oriented method to develop the cooperative virtual assembly system e-DPAS based on the PC computer. Firstly, it is necessary to call a cooperative conference according to the assembly task (Fig.3).

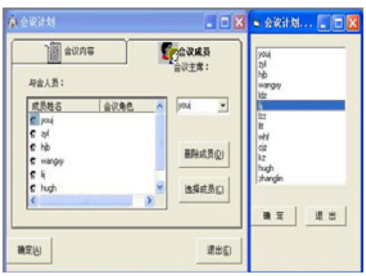


Fig. 3. calling a cooperative conference

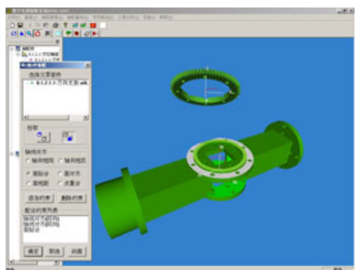


Fig. 4. Assembly simulation of product

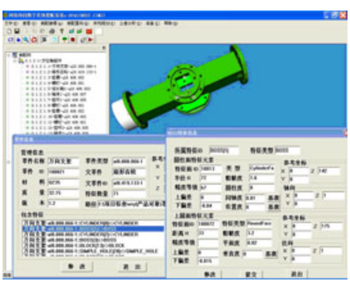


Fig. 5. the feature information of components

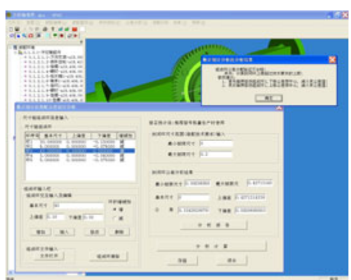


Fig. 6. tolerance analysis with statistics method

Fig.4 shows a product of which all parts are drawn in UG software and input to the e-DPAS by its VRML file and feature file. There are two parts being assembled according to the assembly constraint. According to assembly requirement, the assembly chain is automatically searched by selecting its feature surface. Fig.5 shows the hierarchical feature information of the product. According to Fig.1, the model which integrates various engineering information can be identified in the environment. It can be shown from the message box, including the name, type, material, version, father part, reference coordinate, feature number that the axis includes, etc. Fig.6 shows the assembly tolerance analysis by the statistics model method.

5 Conclusion

Compared to other systems, the e-DPAS has the advantage of not depending on any particular CAD software and can be used in more general applications, especially in cooperative designs between corporations using different CAD design systems. The model includes not only the three-dimension displaying information but also the engineering information such as size and precision. It supports the products cooperative assembly designed by different CAD systems in different places. The further research work will be on the precision optimization etc.

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Task Scheduling of Collaborative Product Design Project

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Abstract. Multi-mode resource-constrained project scheduling algorithm is widely used in project static planning. However, in collaborative product development projects, human is a kind of special resource in contrast to the technology resource which should be considered separately. Starting from this point, this paper introduces the designer-task-resource matching matrixes into the multi-mode resource-constrained scheduling model. The mathematics model of the problem was formulated and solved using a genetic algorithm. A case study was illustrated based on the model. The result shows that the method can obtain the minimum project duration by allocating most suitable person and resource to the task under the constraints of task relations.

Keywords: Task scheduling, Collaborative product design, Multi-mode.

1 Introduction

In the engineering field, project scheduling problem of collaborative product development is always a hot issue. In order to get a reasonable and satisfied development plan, many static planning and scheduling approaches are developed. To obtain an optimal plan with minimum project duration by allocating most suitable persons and resources to the task under the constraints of task relations, mathematical model should be formulated considering the characters of collaborative product development projects. Recently developed multi-mode resource-constrained project scheduling (MRPS) algorithm is suitable for this purpose [1][2]. In the existed models of MRPS problems, it is supposed that different types of resources are equivalent and have no inter-relationships [3, 4].

However, in collaborative product development projects, there are widely distributed human resource, technology resource, and tasks which have different features and requirements. As a result, project managers must try to make an optimal plan as well as to formulate a multi-functional design team which can satisfy the different task requirements and resource requirements at the planning stage.

Starting from this point, this paper introduced designer-task-resource matching matrixes into the multi-mode resource-constrained scheduling model. The mathematics model of the problem was formulated and solved using a genetic algorithm. Finally, a case study was illustrated based on the model and the algorithm.

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2 Designer-Task-Resource Matching Degree Matrixes

Task-person matching degree matrix *TP* can be calculated by analyzing the difference between abilities of the designers and the ability requirements of tasks. As shown in Table 1, design abilities structure can be divided into two parts: skill level and collaboration level. Skill level abilities include design ability and innovation ability; collaboration level abilities include collaboration experience and communication ability. Then,

Table 1. Designer abilities structure to be evaluated

<table>
<tr><td rowspan="10">Designer abilities structure</td><td rowspan="8">Skill level</td><td rowspan="6">Design professional ability</td><td rowspan="2">Knowledge amount</td><td>Background knowledge</td></tr>
<tr><td>Design experience</td></tr>
<tr><td colspan="2">Analytical ability</td></tr>
<tr><td colspan="2">Problem solving ability</td></tr>
<tr><td colspan="2">Design Perceptiveness</td></tr>
<tr><td colspan="2">Ability of knowledge conversion</td></tr>
<tr><td rowspan="2">Innovation ability</td><td colspan="2">Ability of continuous learning</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="2">Collaborative ability</td><td colspan="3">Collaborative experience</td></tr>
<tr><td colspan="3">Communication ablility</td></tr>
</table>

Table 2. Attributes structure of design technology resource to be evaluated

<table>
<tr><td rowspan="15">Attributes structure of design technology resource</td><td rowspan="6">Resource functions</td><td>Modeling function</td></tr>
<tr><td>Calculating function</td></tr>
<tr><td>Analyzing function</td></tr>
<tr><td>Product data management function</td></tr>
<tr><td>Knowledge management function</td></tr>
<tr><td>……</td></tr>
<tr><td rowspan="5">Human-machine interface</td><td>Operation robustness</td></tr>
<tr><td>Operation convenience</td></tr>
<tr><td>Operation visualization</td></tr>
<tr><td>Operation credibility</td></tr>
<tr><td>……</td></tr>
<tr><td rowspan="5">Resource performance</td><td>Running speed</td></tr>
<tr><td>Reliability</td></tr>
<tr><td>Compatibility</td></tr>
<tr><td>Corporative timeliness</td></tr>
<tr><td>……</td></tr>
</table>

the matching degree can be calculated by evaluating the ability requirements of tasks and the designer's real ability, and calculate the similarity of them.

To evaluate task-resource matching degree matrix *TR*, attributes of design technology resource, which is shown in Table 2, should be considered including resource function, man-machine interface and resource performance.

Similarly, the person-resource matching degree *PR* matrix should mainly refer to four factors: (1) usage privilege; (2) usage skill; (3) usage frequency; (4) subjective preference. The calculation method is same as the one of task-resource matching degree; the different is that subjective preference evaluation value has not the requirement value.

Because the above ability and attributes value has the character of ambiguity, the experts would evaluate by language utility value. Table 3 provides the fuzzy value interval of different language utility value.

Table 3. Data interval of expert language utility value

Data interval	(0,0.2)	(0.2,0.4)	(0.4,0.6)	(0.6,0.8)	(0.8,1)
Language utility value	Low	Relative low	Medium	Relative high	High

3 Problem Definition and Mathematics Model

The designer, task and resource are three important factors in plan phase of the project, executing efficiency would improve with high level of matching degree of these three factors. By using the idea of multi-mode resource-constrained scheduling problem, we took every matching type of the three factors as one mode.

Suppose the designer set of some design project is $P = \{P_1 \ldots P_j \ldots P_l\}$; l is the number of designers, task set is $T = \{0, T_1 \ldots T_i \ldots T_n, n+1\}$, n is the number of tasks, the start time of task is $S = \{s_0, s_{t_1}, s_{t_2}, \ldots, s_{t_n}, s_{n+1}\}$, 0 and $n+1$ show the virtual tasks; resource set is $R = \{R_1 \ldots R_k \ldots R_g\}$, g means the number of resources. t_{N_i} is the standard time of the *ith* task; t_i is the execution time of the *ith* task. r_{ijk} shows that in the unit time, task *i* consumes the number of resource *k* by designer j; The quantity *kth* resource in unit time is R_k.

Then, for the scheduling problem, there are two kinds of decision variables:

$$x_{ij} = \begin{cases} 1, \text{Task i is executed by designer j} \\ 0, otherwise \end{cases}$$

$$y_{ik} = \begin{cases} 1, \text{Resource k is occupied by task i} \\ 0, otherwise \end{cases}$$

The objective is the minimum product duration with the constraints of designer, resource, and the start time $S = \{s_0, s_{t_1}, s_{t_2}, \ldots, s_{t_n}, s_{n+1}\}$. Then the model can be formulated as:

$$\min f(x) = PD = s_{n+1} \tag{1}$$

$s.t.$

$$\sum_{i \in A_t} \sum_{j=1}^{l} \sum_{k=1}^{g} r_{ijk} \cdot x_{ij} \cdot y_{ik} \le R_k \tag{2}$$

$$\sum_{i=1}^{n} x_{ij} = 1 \tag{3}$$

$$\sum_{i \in A_t} \sum_{j=1}^{l} x_{ij} = 1 \tag{4}$$

$$\sum_{i \in A_t} \sum_{k=1}^{g} y_{ik} = 1 \tag{5}$$

$$S_{t_s} - \sum_{t_i \in B(t_s)} x_{ij} \bullet y_{ik} \bullet t_{N_i} - S_{t_i} \ge 0 \tag{6}$$

In constraints functions, formula (2) is the resource gross constraint; (3) standards that one task only executed by one person; (4) shows that at the same time, one person can only do one task;(5) shows that at the same time, one task can only use one resource, A_t is the executing task set during $[t-1, t]$; (6) is the time sequence constraint of task, $B(s)$ is the preceding task set of task T_s, $t_i = (2 - TP_{ij})(2 - TR_{ik})(2 - PR_{jk}) \times t_{N_i}$.

4 Case Study

The model and its algorithm were applied in a real design project. There are 15 tasks from TA_1 to TA_{15}, 9 designers from P_1 to P_9 and 6 resources R_1 to R_6.

The person-task, task-resource and person-resource matching degree matrixes are known as following:

$$TP = \begin{bmatrix} 0.39175 & -0.299 & \ldots & -0.03475 & -0.05178 \\ 0.45275 & 0.604 & \ldots & 0.5825 & 0.7465 \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ 0.4335 & 0.66 & \ldots & 0.37625 & 0.489 \\ 0.422 & 0.646 & \ldots & 0.367 & 0.025 \end{bmatrix}$$

$$TR=\begin{bmatrix}1 & 1 & \dots & 0.8 & 0.8\\ 0.9 & 0.8 & \dots & 0.8 & 0.7\\ \dots & \dots & \dots & \dots & \dots\\ 0.9 & 0.9 & \dots & 0.8 & 0.9\\ 1 & 1 & \dots & 0.9 & 1\end{bmatrix}\quad PR=\begin{bmatrix}0.9 & 0.8 & \dots & 0.8 & 1\\ 1 & 1 & \dots & 1 & 0.9\\ \dots & \dots & \dots & \dots & \dots\\ 0.8 & 0.9 & \dots & 0.8 & 0.6\\ 0.9 & 0.7 & \dots & 0.6 & 0.7\end{bmatrix}$$

The model was solved by Genetic Algorithm (GA) using Matlab package. Figure 1 shows that the solution process of one iteration, in which after 500 times iteration. the optimal scheduling solution was obtained at the 143th step. The efficiency and the accordance of the algorithm are satisfied.

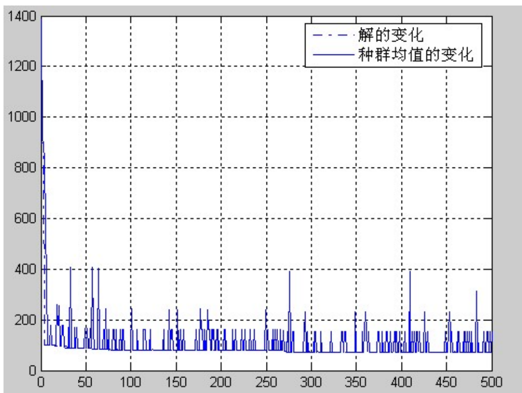

Fig. 1. Result of running 100 times with 500 times iteration

Table 4 is the solved task scheduling plan of this project, which has considered the matching degree among tasks, persons, and resource compared with traditional scheduling results.

Table 4. Solved project plan with person and resource allocation

Tasks	Person	Resource	Start time	Task	Person	Resource	Start time	Cycle (days)
TA_1	P_4	R_4	0	TA_9	P_8	R_2	14.85	72.64
TA_2	P_6	R_1	6.6	TA_{10}	P_8	R_1	46.2	
TA_3	P_4	R_2	6.6	TA_{11}	P_2	R_5	46.2	
TA_4	P_1	R_3	6.6	TA_{12}	P_1	R_6	28.57	
TA_5	P_3	R_6	6.6	TA_{13}	P_5	R_1	28.45	
TA_6	P_7	R_5	6.6	TA_{14}	P_9	R_5	66	
TA_7	P_7	R_5	14.85	TA_{15}	P_6	R_2	67.8	
TA_8	P_6	R_3	14.85					

5 Conclusion

Human as the operator of the design tasks, is a kind of special resource compared with technology resource. Different combination of human resource and technology resource caused different task execution time, which would influence the total duration of the project. Aiming at this character, this paper introduced designer-task-resource matching matrixes into the multi-mode resource-constrained scheduling model. Case study shows that the method can obtain the minimum project duration by allocating most suitable person and resource to the task under the constraints of task relations. In the near future, designers' collaboration matching degree should be considered in the model, especially when there are collaborative design tasks which should be executed by more than one designer.

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Author Index