Foreword

The second *Computer Supported Activity Coordination* workshop (CSAC-2005) intends to be a forum for debate of issues concerning all kinds of activity coordination, including business process modelling, workflow, computer supported cooperative work/groupware, e-learning, e-commerce and other types of organized activities that can benefit from computer support. The emphasis of the workshop is mainly on human activity support and not merely on technical issues. Papers are mainly related to computer-based systems that support teams or groups in workplace settings, including the integration of multiple computer-based tools and technologies and the impact on the social activities supported by those tools and technologies.

This volume contains all the papers presented at CSAC 2005, held in Miami/USA, in collaboration with Florida International University. A total of 15 papers were selected from more than 20 submitted papers. Of these, 9 were selected as full papers for 30 minute oral presentations arranged in a single track program and 6 were selected as short papers for 15 minute oral presentations, after a double blind revision process.

We would like to express our sincere gratitude to all the authors, who provided the rich material discussed at the workshop, and the members of the Program Committee who have reviewed and assessed the scientific merit of each submitted paper, thus ensuring high quality standards. Last but not least, thanks to Vitor Pedrosa for his effort in the secretariat support, and in the edition of these proceedings.

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# Table of Contents

Foreword ......................................................................................................... iii  

Table of Contents .......................................................................................... v  

## Full Papers

Application of Social Network Theory to Software Development:  
The problem of Task Allocation ................................................................. 3  
*Chintan Amrit*

Integrating Awareness Sources in Heterogeneous Collaboration  
Environments ................................................................................................. 18  
*Vijayanand Bharadwaj, Y. V. Ramana Reddy and Sumitra Reddy*

Reduction Over Time: Easing the Burden of Peer-to-Peer Barter  
Relationships to Facilitate Mutual Help ..................................................... 28  
*Kenji Saito, Eiichi Morino and Jun Murai*

Identity Management for Electronic Negotiations  
......................................................................................................................... 38  
*Omid Tafreschi, Janina Fengel and Michael Rebstock*

A Conception of Multiagent Management System of Dispersed  
Market Information – E-negotiations Area ............................................... 48  
*Leszek Kiettyka and Rafał Niedbał*

Improving Supply Chain Operations Performance by Using a  
Collaborative Platform Based on a Service Oriented Architecture  
....................................................................................................................... 56  
*Rubén Darío Franco, Ángel Ortiz Bas, Víctor Anaya and  
Rosa Navarro*
A Workflow-based Environment to manage Software-Testing Process Executions................................................................................ 66
Duncan Dubugras A. Ruiz, Karin Becker, Bernardo Copstein, Flavio Moreira de Oliveira, Angelina Torres de Oliveira, Gustavo Rossarolla Forgiarini, Cristiano Rech Meneguzzi and Rafaela Lisboa Carvalho

Using Timed Model Checking for Verifying Workflows....................... 75
Volker Gruhn and Ralf Laue

A Machine Learning Middleware For On Demand Grid Services Engineering and Support................................................................. 89
Wail M. Omar, A. Taleb Bendiab and Yasir Karam

Short Papers

A Workflow Model For Integrating IC Design and Testing.................. 103
Andres Mellik

A Web Services based Communication Services Framework for Collaborative Work................................................................. 109
Jun Liu, Bo Yang and Wei Lu

A Framework for Designing Collaborative Tasks in a Web-Environment.................................................................................. 118
Dina Goren-Bar and Tal Goori

Daisy Seng and Leonid Churilov

Other Way of Making Business: A Virtual e-Commerce Community / CVN Platform .............................................................. 141
Roberto Naranjo, Jorge Moreno, Luz Marina Sierra and Martha Mendoza
Full Papers
Application of Social Network Theory to Software Development: The problem of task allocation

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Abstract. To systematize software development, many process models have been proposed over the years. These models focus on the sequence of steps used by developers to create reliable software. Though these process models have helped companies to gain certification and attain global standards, they don’t take into account interpersonal interactions and various other social aspects of software development organizations.

In this paper we tackle one crucial part of the Coordination problem in Software Development, namely the problem of task assignment in a team. We propose a methodology to test a hypothesis based on how social networks can be used to improve coordination in Software Industry.

In a pilot case study based on 4 teams of Masters Student working in a globally distributed environment (Holland and India), the social network structures along with the task distribution in each of the teams were analyzed.

In each case we observed patterns, which could be used to test many hypotheses on team coordination and task allocation between them.

1 Introduction

“Organizations which design systems are constrained to produce designs which are copies of the communication structures of these organizations”.

Though Conway said this back in 1968, little has been done to align product architecture to the company communication structure, or the Social Network as we call it nowadays.

Software has been plagued by many problems and there seems to be a great chasm between the theoretical models and the actual implementation in the industry. In a recent article by Laplante and Neill (2004) found that as many as 1/3 of their survey respondents followed the waterfall model for Software Development. Though this model was introduced in 1970 when computer systems were archaic and user needs were very basic, the fact that it is still in use by a large section of the software development industry shows that many of the best practices in software development are being ignored by the industry (Laplante & Neill, 2004).
There is also a huge difference between the design and implementation of software and as mentioned in one report (The Standish Group, 2003), on an average only 52% of required features and functions make it to the released product.

While there is no single cause for the problems in Software Development, a major factor is the problem of coordinating activities while developing large software systems (Kraut & Streeter, 1995). Kraut and Streeter (1995) mention scale of software projects, inherent unpredictability of software specifications and tasks as well as the interdependence of software components as some of the factors that lead to the necessity of efficient co-ordination between the different work groups involved in the development process.

In this paper we tackle one crucial part of the coordination in Software Development, namely the problem of task assignment among team members of a software development team. The aim of this paper is to come up with insights on the methodology by which one can use social network analysis to improve the coordination in the Software Development Process of an IT company.

In this paper we have come up with a hypothesis and a couple of propositions based on previous work done on coordination in teams. We conducted a pilot survey on teams of students who worked on software design tasks. We then observed the social network of the teams concerned, along with the distribution of the software design tasks among the team members. We then used the propositions and hypothesis to predict the performance of the team members and then compared it with the actual performance of the teams; thereby demonstrating the methodology by which more such hypothesis and propositions can be verified.

2 Network Theory and Groups

2.1 Social Network and Metrics

The problem of coordination can be better explained by first illustrating the concepts of social networks and centrality measures. A social network consists of a set of actors (“nodes”) and the relations (“ties” and “edges”) between these actors (Wasserman & Faust, 1994). Researchers have developed a variety of metrics for quantifying the differences in network structure. Among the many frequently used metrics at the actor level are degree centrality (the extent to which actors send or receive ties) and betweenness centrality (the extent to which actors have ties with others who are not directly connected). Metrics used to describe networks include: Density (the ratio of the pairs of nodes that are mutually reachable to the total number of pairs of nodes) and Centralization (Difference between the centrality scores of the most central actor and those of all other actors in a network is calculated, and used to form the ratio of the actual sum of the differences to the maximum sum of the differences).

How is a group defined, from the network perspective? The construct of a group, when used in the social network literature has had two primary meanings: (a) a structural feature of a network, or (b) an exogenously determined or imposed category. According to the first meaning, groups (cliques, a maximally complete subgraph) are
subsets of fully connected, or almost fully connected, nodes within some population (Katz et al. 2004).

### 2.2 Internal Networks Ties

The problem of task allocation among team members is closely related to the network structures formed between them. Several researchers have asked the question “What is the optimal network for group performance?” Many have broadened the scope of investigation by moving from the laboratory to the field.

Sparrowe, Liden, Wayne and Kraimer (2001) demonstrated a relation between network structure and both in-role and extra-role performance in a field setting. They replicated earlier findings; with a complex task, and found that groups with decentralized communication patterns perform better than groups with centralized communication patterns. Cummings and Cross (2003) also found that groups with decentralized communication patterns outperformed more centralized groups.

Other researchers have focussed on the number rather than the pattern of communication links among group members. Baldwin, Bedell and Johnson (1997) and Reagans and Zuckerman (2001) established in field studies that groups with more ties performed better than groups with fewer ties.

### 2.3 External Network Ties

External networks deal with ties to particular strategic others, as well as the overall structure of those ties (as measured in quantity and pattern), where the ties may be to other groups or to the environment (Katz et al. 2004). Understanding the context in which the group is embedded as well as its relationship with key players in its environment improves our understanding of how the group functions.

Ancona and Caldwell (1992) show that the pattern of external activity is a better predictor of group performance than simply the frequency of communication. They also try to understand the types of external activities that are needed for team effectiveness.

Baldwin et al. (1997) find no relationship between a team’s external ties and its performance. They suggest that due to the nature of the group’s task the configuration of their internal ties is more important than their external ties. In other words the group’s need for external resources is defined by the nature of the task.

Reagans et al. (2004) compare two approaches to team formation, one based on the member’s demographic characteristics and the other based on the members’ social networks. They hypothesize that demographic diversity not only decreases the team’s internal density but also increases the team’s amount of range in its external network, and that both of these variables have a positive effect on team performance.
3 Team Formations and Task Allocation

Teams are the basic building block for many contemporary business organizations. We focus on how we can improve coordination in software development projects using the concepts of coordination between and among teams keeping task assignment as a moderating variable. Coordination refers to team-situated interactions aimed at managing resources and expertise dependencies (Faraj and Sproull 1995). Research on software development teams has found that team performance is linked with the effectiveness of teamwork coordination (Kraut and Streeter 1995).

Faraj and Sproull (1995) take two perspectives on coordination: administrative coordination and expertise coordination. They claim that administrative coordination (management of tangible and economic resource dependencies) is good for simple routine tasks, while for complex non-routine intellectual tasks, expertise coordination (the management of knowledge and skill dependencies) become more important. Through expertise coordination the team can recognize and access expertise when it’s needed.

Grinter and Herbsleb (1999) suggest the chief motivation for the assignment of tasks (involving a search for experts) in R&D projects to be:

- Functional Area: an expertise of distant systems,
- Product Structure: an understanding of the internals of components built at remote sites,
- Process: knowledge about what happens during other processes,
- Customisation: knowledge of core or the knowledge of how the core is customized depending on which site is involved.

Though their analysis models and solutions seem good for R&D projects, they have not used the concepts of social networks to improve their model.

Stewart and Barrick (2000) build on organization-level findings and show that differences in how responsibilities are apportioned and coordinated correspond to variance in performance at the team level. They also show that the effect of these social elements is moderated by technical demands (tasks), consistent with socio-technical systems theory.

Hansen et al. (2001) distinguish between exploration and exploitation tasks among teams. They show that teams engaged in exploratory tasks complete their projects more quickly if they have a social network structure composed of many strong external ties that are non-redundant. In contrast, teams pursuing tasks that exploit existing expertise take longer to complete if they have this type of social network structure, mainly because external ties have to be maintained but are not much needed for the task.

Sparrowe et al. (2001) hypothesize that centrality in a work group’s advice network will be positively related to an individual’s job performance. Where centrality in the advice network reflects an individual’s involvement in exchanging assistance with co-workers and engaging in mutual problem solving. An individual who is central in the advice network is, over time, able to accumulate knowledge about task-related problems and workable solutions (Baldwin et al., 1997). While the central individual develops problem solving capability and serves as a valued resource for future exchanges with co-workers, those individuals who are in peripheral positions
in the advice network find it difficult to develop expertise and competencies for high levels of performance (Sparrowe et al., 2001). Hence, Sparrowe et al. (2001) hypothesize that centralization in a work group’s advice network is negatively related to group performance.

Yang and Tang (2004) try to analyse the relation between team structure and ISD performance using a social network approach. They show how the structural properties of the work groups fluctuate during the various phases of Software Development, and how group cohesion and centrality are related to the final ISD performance. Though Yang and Tang (2004) do show how social research methods can be used to tackle “group process” factors, they do not deal with task allocation nor do they illustrate how one can solve the problem of task allocation among team members.

Though these studies indicate how coordination can be improved in industries, there has been not much work done in the analysing the use of social networks in improving coordination through better task allocation in the Software Development industry.

Sparrowe et al. (2001) hypothesize that centralization in a work group’s advice network is negatively related to group performance. But a group with a high centralization in the advice network can still perform well if the central individual contributes in all the phases of development. Adding the task component to the hypothesis 1 by Sparrowe et al. (2001) we come up with the following proposition:

**Proposition 1:** When the centralization in the advice network is high then the team performance increases if the central person(s) contributes in all the different tasks.

**Proposition 2:** When the density in advice networks is high then the team performance increases when the tasks are evenly distributed among the team members.

**Hypothesis 1:** Performance of a team is positively related to the density of the task network, when the density in the advice network is high.

### 4 Empirical Test

#### 4.1 Project Questionnaire

A pilot survey was conducted on 4 globally distributed teams of Masters Students consisting of 8, 8, 7, 7 students respectively. Approximately half of the members of each team consisted of Dutch students located in a Dutch university and other half were Indian from a university located in India. The students were asked to select a topic for a design-based project, and complete four design tasks involving the creation of a vision document, activity diagram, use case and class diagram for the selected project topic. The data was collected with the help of a questionnaire, in which among other questions we asked:

- Rate your contribution (relative to the average team member) in creating the Vision Document?
- Rate your contribution (relative to the average team member) in creating the activity diagram?
Rate your contribution (relative to the average team member) in creating the Use Case diagram?

Rate your contribution (relative to the average team member) in creating the class diagram?

Mark your team members from whom you regularly sought information and advice to help in your project work.

Mark your team members, whose advice you did not seek, during the course of the project.

Mark your team members who in your opinion are very dependable in executing a crucial part of the project.

The first 4 questions had options out of a scale of 5, while the questions 5 to 7 had the list of all the team members to choose from (multiple members could be checked for each answer). From the answers to questions 1 through 4 the relative contributions to the particular task were obtained. This helped in drawing the 2-mode task network. Where we can see the team members assigned to the tasks (making the Use case diagram, activity diagram etc.) with the links having a particular weight corresponding to the amount of effort each team member has put in performing the task. The contributions ranged from 1 (no relative contribution) to 5 (full contribution). The contribution was based on team member perception, so it was possible for all the members of the team to think that they had done the task themselves (all of them to fill 5). From the answer to questions 5 and 6 the advice network of the group members was obtained. The answer to question 6 confirmed the network obtained from the answer to question 5. From the answer to question 7 the discussion network among the members of the group was obtained.

4.2 Measures

The Network measures were calculated using the tools available in UCINET. The in-degree centrality scores were computed for each individual (Borgatti, Everett & Freeman, 1992). Where in-degree centrality (the number of ties received by a vertex) is a form of degree centrality that counts only those relations with a focal individual as reported by other group members, and it does not suffer from the limitations of self-reports, as does out-degree centrality (Sparrowe et al. 2001).

4.3 Network density

In binary network data, density is the proportion of actual nominations among the total possible number of nominations (Wasserman & Faust, 1994). This was computed by using the density function of UCINET for networks, using total number of ties present divided by the total number of all possible ties.
4.4 Network Centralization

Network centralization is the sum of the observed differences in individual centrality scores (computed by finding the differences between the largest individual centrality score and the scores of all the other individuals in the network) divided by the maximum possible sum of differences (Wasserman & Faust, 1994). This network centralization was computed using Freeman’s (1979) definition in the UCINET IV software package (Borgatti, Everett & Freeman, 1992).

4.5 Task Density

The task network is a 2-mode network (Borgatti & Everett, 1997). In order to find the density the weighted task network was first dichotomised using the standard dichotomise routine in UCINET IV software package (Borgatti, Everett & Freeman, 1992). The cut-off value was considered to be 3, as the contribution of less than 3 on 5 was considered negligible (also because 3 is the median on a scale of 1 to 5). So the dichotomization rule was as follows:

\[ y(i, j) = 1 \text{ if } x(i, j) \geq 3, \text{ and } 0 \text{ otherwise.} \]

Then the density of this dichotomised 2-mode matrix was calculated using the density routine of UCINET IV (Borgatti, Everett & Freeman, 1992).

4.6 Team Performance

The final performance of the team was rated according to the following metrics:

- Time taken for project completion
- Documentation and its revision history
- Quality of deliverables
- Relevance of alternative solutions suggested

The final grade scored by the individual teams was considered (out of 10).

Table 1. Statistics of some of the network measures

<table>
<thead>
<tr>
<th>Team</th>
<th>Centralization of Advice Network</th>
<th>Density of Advice Network</th>
<th>Density of task network</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team 1</td>
<td>52.38%</td>
<td>0.3929</td>
<td>0.7188</td>
</tr>
<tr>
<td>Team 2</td>
<td>57.14%</td>
<td>0.3036</td>
<td>0.8125</td>
</tr>
<tr>
<td>Team 3</td>
<td>53.33%</td>
<td>0.5000</td>
<td>0.9643</td>
</tr>
<tr>
<td>Team 4</td>
<td>20.00%</td>
<td>0.4048</td>
<td>0.8571</td>
</tr>
</tbody>
</table>
5 Results

Though we cannot really test the validity of the hypothesis using the statistical data we have, we can see how this statistical data can be used to predict the actual performance of the teams. On the basis of the results in table 1 we can estimate the performance of the teams according to our propositions. We expect the team with lower centralization to perform better than the team with higher centralization (Sparrowe et al., 2001). Thus, according to the centralization of the Advice network we expect the teams to have performed in the order: Team 4 > Team 1 > Team 3 > Team 2. We expect a team with a higher density in the Advice network to perform better than a team with a lower density (Sparrowe et al., 2001). Thus, according to the density of the advice network we expect the teams to have performed in the order: Team 3 > Team 4 > Team 1 > Team 2. Finally according to our hypothesis of the density of the task network we expect that a team with the higher density in the task network to perform better than a team with a lower density, when their density in the advice network is high. Thus according to our hypothesis we expect the teams to be ranked as: Team 3 > Team 4 > Team 1 > Team 2, as Team 1 has a higher density in the advice network as compared to Team 2.

We obtained the final ranking by evaluating the quality of the deliverables, which was: Team 3 > Team 1 > Team 4 > Team 2 (table 2).

Table 2. Evaluation of the Teams

<table>
<thead>
<tr>
<th>TEAM</th>
<th>Grades</th>
<th>Evaluation of Quality</th>
<th>Overall Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team 1</td>
<td>7.5</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Team 2</td>
<td>7</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Team 3</td>
<td>7.5</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>Team 4</td>
<td>7</td>
<td>10</td>
<td>3</td>
</tr>
</tbody>
</table>

6 Discussion

The results do not entirely support our hypothesis, as the survey was only a pilot survey conducted on 30 students. On the other hand, this study shows that we can use social network analysis in order to test hypothesis and propositions related to team performance in a Software Development project. The results suggest that our hypothesis is not a very bad predictor when it comes to finding the team that performed the best, or the worst. Also according to the results of this pilot survey we see that the density of the task network is almost an equal predictor of performance as the density of the advice network.
The Propositions (1 and 2) suggest that tasks in a team must be assigned in accordance to the centrality and density of the advice networks of the team. When the centrality of the advice network is large, then the team wouldn’t fare well (Sparrowe et al., 2001) unless the central individual contributes in every aspect of the development process, as an individual who is central in the advice network is, over time, able to accumulate knowledge about task-related problems and workable solutions (Baldwin et al., 1997). Then again, when the density of a team’s advice network is large then the team performs well, when the tasks are distributed more evenly among the team members.

From figures I to VIII (see appendix at the end), we can see that when the density in the advice network is high (Fig. V), along with the density of the Task Network (Fig. VI), the performance of the team is very good (table 2). While when the density of the advice network is low (Fig III) and the density of the corresponding task network is also low (Fig IV) then the performance of the team suffers (table 2).

In all the figures I to VIII we see that the advice networks consists of a structural hole (Monge & Contractor, 2003) on either side of which represents the Indian component (a connected subgraph) and the Dutch component (another connected subgraph) of the globally distributed team. The structure of these advice networks further shows the presence of gatekeepers, who are persons involved in communicating with their global (Dutch or Indian as the case maybe) counterparts. In the case when one of the components (Indian or Dutch) in the advice networks is not well connected we see that the performance of the groups suffers. This is evident in figure III, where the Indian component is sparsely connected. This can be further be used to show the differences in predicting the performance of Team 1 and Team 4. Though, the differences can be due to several factors, as is common in most Software Development Projects (Kraut & Streeter, 1995) from a network perspective we can say that the visible difference in their advice networks might have contributed to the difference in performance. We find that the advice network of the Indian component in Team 1 (figure I) is not so well connected as the advice network of the Indian component in Team 4 (figure VII). From this difference in structure one can say that the lack of a well-connected advice network of a component of a globally distributed team might have had an impact on the performance of the team, causing Team 1 to perform worse than Team 4.

7 Limitations

The primary limitation is that the empirical data is weak, as the sample size is too small for any kind of statistical analysis. The idea behind this paper is to illustrate how this methodology can be used for future analysis on larger samples.

The students in the Dutch University were without much industrial experience while the students in the Indian University had some industrial experience. Further, the teams were composed of relative equals and had limited existence, making them unlike most real world teams. In future research, more case studies/surveys need to be conducted on people working in the software industry.
The tasks, which were a part of their course project, were at best small tasks at the design stage of software development. Also, the number of modules was limited to four, while in a normal software development project the number of modules runs into thousands and corresponding number of tasks per person can be much higher. So, in future such a study can be conducted in an IT company with more demanding project requirements.

Although sociometric techniques were used with small groups in experimental research conducted in the 1950s (Shaw, 1964), it should be noted that contemporary research typically studies networks larger in size than the groups studied here.

8 Conclusion

This study adds to the growing body of theory in software development methodology, using social networks. Though there have been many papers written on the development of architecture in Software Engineering, there have been few studies on improving the development of Software using social networks with better task allocation strategies. This study adds the task component in judging group performance through advice networks, which was dealt with in the paper by Sparrowe et al. (2001) and shows a method of verification of such hypothesis.

In future research, more surveys/case studies can be conducted on larger groups in the Software Industry to test the hypothesis presented as well as other related hypotheses on task allocation and group structure. Further, such a test can be conducted in a longitudinal manner at different stages of the software development project. Adding the time component can throw more light on the way social networks change and develop during the course of a project. It could also be used to understand the different task allocation strategies needed to make a project successful.

Software engineering can only advance towards being an engineering discipline by moving away from its current dependency upon advocacy and analysis, and by employing more systematic empirically-based approaches to developing an understanding of what works, why and under what conditions. This paper is a first attempt towards such an empirically based approach. It’s an attempt at opening the black box of the complex development process, which goes into a software development project.

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References

Appendix

Fig. 1. Advice Network of Team 1

Fig. 2. Task Network of Team 1
Fig. 3. Advice Network of Team 2

Fig. 4. Task Network of Team 2
Fig. 5. Advice Network of Team 3

Fig. 6. Task Network of Team 3
Fig. 7. Advice Network of Team 4

Fig. 8. Task Network of Team 4
Integrating Awareness Sources in Heterogeneous Collaboration Environments

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Abstract. Collaboration in heterogeneous environments involves dealing with variety of information sources that generate information that users need to be aware of. Users must be empowered to tailor the quality of awareness information. Heterogeneity of sources and media adversely affects the quality of group awareness. We propose a solution in terms of integrating the sources at the information level and provide a model for the same. We discuss our progress in designing the model, its utility and benefits. We believe that such a unifying framework can increase the effectiveness of group awareness in supporting coordination and execution of collaborative work.

1 Introduction

Collaboration in heterogeneous environments has become a necessity. Heterogeneity is in the plethora of applications, supported by hardware and communication infrastructure of varying capabilities. Added to this is user mobility. Awareness among such groups is essential. Many groupware applications are designed to support group awareness but often most groups use general-purpose applications not designed to support awareness. Awareness propagation is effective if the appropriate amount of information, relevant to the user’s sphere of activity is delivered in an unobtrusive manner, without compromising the privacy and security constraints of the group. A key design goal of awareness systems is to empower its users with awareness characterized by a high degree of the above “quality factors”.

The heterogeneity of sources and mediums that generate awareness information deeply impacts the quality factors. We examine this relation in detail, and the specific problems. As part of the solution, we propose a means to effectively integrate awareness information by means of an awareness model. The next section describes the effect of heterogeneity on the quality factors. Section 3 outlines the solutions. Details of our model are in Section 4, with an example. We conclude with validation steps.
2 Awareness in Heterogeneous Environments

2.1 Awareness in Group Work

Awareness has been well researched in information technology and social sciences. Gross et al. [9] provide a good comparison of both perspectives. Various forms of awareness and terminology have been defined. However we find that three aspects of awareness in general are closely related. These are Quality of Awareness, the Awareness Information Characteristics and Awareness Sources & Mediums.

1. Quality of Awareness: The quality of awareness impacts its role in group work coordination and execution. Quality can be characterized by factors such as: 
   - Relevancy: How relevant is the awareness information to my sphere of work, both current and for the future (planning and coordination)?
   - Information Overload: Am I aware of the appropriate amount? Am I being inundated with too much or not receiving enough?
   - Obtrusiveness: How distracting is this information to my current activity? Is it interrupting my current activity?
   - Privacy: Can privacy in the form of access control be established to ensure that only one with appropriate permissions is aware of classified information?

2. Awareness Information Characteristics:
   - Type (What am I aware of): Is this about an individual’s activity or location, actions on an artifact, conversation transcript, streaming video of a meeting, or a combination of the above?
   - Form: Is it text, audio, visual?
   - Volume (How much of it am I aware of): Am I aware of every email exchanged by the group or just a synopsis; is it a long videoconference session?
   - Frequency (How often do I get that information): In a highly interactive chat session that I am monitoring, do I want to receive every line typed?

3. Sources and Medium:
   - Sources (Which is the information source): Email and IM messages, sensors relaying location, an artifact (actions on it), camera, microphone, user’s keystrokes are all sources of awareness information, capturing various aspects of work that other users would be interested in. Sources impact the Type, Form, Volume and Frequency. For instance a sensor-based application will communicate awareness information only when the appropriate stimulus occurs and at the same frequency. High rate of keystrokes can result in high frequency and volume of information relayed.
   - Medium (How do I obtain information): Wired and Wireless networks, closed-circuit video, telephone (landlines, cellular) are all media. The capabilities of the Medium impact Form, Volume and Frequency. High bandwidth network could provide streaming video at much better quality than a dial-up connection.

Quality factors are evaluated from the perspective of the consumer of awareness and how they influence his work. Awareness Characteristics are about the information and so absolute. However the perceived quality of awareness does depend on the characteristics, which in turn are determined by Sources and Mediums.
2.2 Impact of Heterogeneity on Awareness Quality

Let us consider a scenario with three groups creating documentation independently. The team leader (TL) responsible for coordinating work among them is off-site as part of duty. Each group uses a collaborative editor, and at close of business, emails the TL their drafts. Upon review, the TL sends her comments to each group using both email and/or phone. Conflicting schedules, work commitments and lack of infrastructure keep her from joining their editing sessions. Relaying instructions at the end of the day is not very efficient. Sections in the documents depend on the content of the others. When inconsistencies are detected they have to be reworked (email is checked the next day), leading to delays. The ability to simultaneously monitor the status of three groups would be very valuable as well as knowing which parts they were working on and their decisions in the process. Even if the actual artifact being edited cannot be seen, the above “meta-information” is essential. Thus “knowing of” something can be valuable even if actual artifacts cannot be accessed. In another scenario a group in one location, needs to confer with a group at another location. They engage in video conferencing. They may record their decisions on a whiteboard. How could the TL be aware of this activity remotely without access to the video session? In other words we see the use of applications (some not designed to support awareness), running on infrastructure of non-uniform capabilities, being used in unanticipated situations i.e. heterogeneity at all levels. The TL cannot access relevant information as her capabilities limit the type, volume and frequency. Thus heterogeneity impacts the quality of awareness information and its effectiveness. We are interested in how users could control the quality factors of awareness in such environments.

3 Addressing the Impact of Heterogeneity

The approach is to integrate the various sources and mediums of awareness in a manner most suitable to the group effort. This integration has to occur at two levels.

3.1 Integrating Sources and Mediums

There needs to be mechanisms to tie various sources of information that exist in a group effort. Systems such as email servers, group editors, applications such as word processors, sensors and devices such as cameras, microphones, all generate information of different types. Consumers of this information use web browsers, hand-held devices, and applications (that are themselves sources) to obtain awareness. Communication occurs over different mediums on non-uniform infrastructure. Thus there needs to be an “Awareness Middleware” that can bind all the above together. Specific interfaces would be needed to connect the sources to the middleware making integration as easy as “plugging-in” the source. The use of non-electronic artifacts in many collaboration environments poses a challenging integration problem. The middleware and interfaces would have to conform to security, reliability and perform-
ance. Notable pioneering efforts [13], [8], [1], [2], [7] have been made to create such “awareness frameworks” for awareness propagation in groups.

3.2 Integrating Information

Different types of information generated (email messages, sensor coordinates, streaming video) have no absolute relation, though related within the context of the group’s activities. They have varied source specific characteristics (Form, Volume, Frequency). These need to be woven to make the composite picture that is awareness. This integration must occur at the information level. Consumers of awareness must be able to determine quality and control it. Specifically, the implications of the awareness requirements on information integration are:

1. There must be a transformation (mapping) of the source-specific nomenclature of information generated, to the group’s terminology and definitions, as users have no knowledge of the former. One way is by providing meta-tags to the information.
2. To retrieve all relevant information based on user’s sphere of activity, there must be ways to relate information with respect to the common context, which is the group’s work. Thus users can look for awareness information they need from their work perspective as opposed to querying about the source.
3. The integration process must be straightforward. Change in various factors is inherent in group work [4] and a simple process would help change management.
4. There must be means to express the Awareness Characteristics by which users can determine and tailor the quality factors using mechanisms such as filtration.
5. Apart from manual selection, there could be agents providing context-sensitive awareness. Mechanisms to enable such agents to match the user’s profile, and work context to available information are required. This can support enhanced forms of awareness such as “intersubjectivity” (“I know, that you know, that I know”)[1].
6. Since users’ capabilities to acquire awareness may not support all formats and exact artifacts, there must be means to obtain meta-information about it.
7. Obtaining awareness would begin with searching and/or browsing for it. A complete picture of information should be available to select from.
8. Historical awareness [12] of various aspects of the group’s work is often essential and there must be means to retrieve such information.

Thus integration involves information transformation, relating different types and adding meta-information description to enable the above features. It is much more than creating databases, labeling and storing data. We propose a model as a basis for integration. This provides a common logical framework thereby decreasing the complexity in the integration process. Meta-information would be part of this framework. The Awareness Frameworks reviewed emphasized awareness propagation. Sources and information were integrated in some fashion to facilitate context-awareness and user filtration. As sources to be used cannot be anticipated, our emphasis is on a generic framework. Awareness quality, simplified integration process and adaptability to changes in group work being issues of interest that we aim to address.
4 Model-Based Information Integration

4.1 The Awareness Model

Early work in modeling awareness has used spatial metaphors [3]. Medium, aura, awareness, focus, nimbus and adapter were concepts used to model and enable interaction, determining how entities behaved in virtual worlds. This was generalized to CSCW environments by a model [14] where a pool of objects and the relation between them was considered as the space. Users acting on these objects gain mutual awareness due to their interaction. Graph theory was used to express notions like strength of awareness. Another non-spatial model emphasized the effect of awareness on behavior of the objects [15]. This was based on the reaction-diffusion metaphor. Some efforts have been towards specific forms of awareness such as a model for presence awareness using concepts such as location, presentity, watcher and vicinity [6]. Another seeks to model cooperative awareness using three abstractions viz. events, places and communities [11]. Inspired by the above we borrow some of the key concepts and constructs. Our emphasis is on integrating the information sources with respect to the quality factors of awareness. Figure 1 illustrates the model.

**Focus of Attention (Focus):** This top-level concept represents the focus of an awareness consumer. A user’s Focus consists of all active sources that are providing awareness. A Source is any entity that provides information (e.g. person, location, artifact). A Focus is a unified view of all its sources and the corresponding events and interactions occurring due to them (e.g. person’s actions, communication, actions on an artifact). For instance the Focus could provide awareness about an activity in terms of email messages exchanged by the users (sources) or awareness about people entering a room, modifying an artifact and leaving. A Focus can shift over time. The type and number of sources win a Focus can change. Each Source has a corresponding Medium, which delivers information. Its characteristics dictate the quality of awareness information. Meta-information attributes describing awareness characteristics qualify the Focus, its Sources and Medium and are essential to determine and tailor quality. These attributes are:
- **Description:** About what the Focus is providing.
- **Identifier:** A unique identifier as there could be multiple Foci.
- **Start Time** and **End Time:** Indicate the duration for which the Focus was active.
- **Source & Medium List:** A list of sources and corresponding medium in the Focus. (Source1, Medium1), (Source2, Medium2), ….. (SourceN, Medium N).

**Source:** In addition to its own Description and ID fields, each Source entity has:
- **Start Time:** The time the source comes within the current Focus.
- **End Time:** The time the Focus excludes it.
- **Foci List:** Each source element may have multiple foci it is obtaining awareness from (Focus1, Focus 2....FocusN).

**Information Content:** This describes the information generated by the Source. Its attributes are:
- **Type:** About the Information (natural language and/or keywords).
Form: Text, Audio, Video stream, others.
Frequency: How often is the source generating the information. Could be in the form of discrete notifications or continuous stream.
Total Volume: How much has been generated so far (or recorded).
Content: The actual information being generated, according to a content-specific schema depending on the source. For example, actions taken by sources, actions on artifacts, video streams, email messages and chat sessions would all be content.
Medium: Corresponding to each Source is its Medium. In addition to its own Description and ID fields, each Medium entity has:
Medium Specific Characteristics: A set of attributes about the specific medium. For example, the network characteristics for a wired or wireless computer network, cellular phone network or closed circuit television network would be of interest since they would indicate how much of information could be delivered and in what manner.

![Fig. 1. Awareness Model](image)

4.2 Levels of Awareness

An individual’s Focus consists of the sources that are actively providing awareness. Users could have multiple Foci, each providing information about different aspects of the group’s work. There are other sources that the user could access but are not cur-
rently part of his Foci. The user is aware of their characteristics but not receiving information content. This entire set of all active and potential sources is his Source Superset, which the user can access based on his role and access control policies. Sources outside his Superset are not accessible and invisible to him. Figure 2 illustrates this hierarchy. Finer levels could be enforced depending on the needs, what is important is that our model seeks to provide such control.

The user’s view of all sources, media, and Foci in his Supersets with corresponding meta-information is his “Awareness Map”, a concept inspired by [10]. On selecting an element of the map, one can zoom-in to get details about the content as well as source and medium characteristics. Such a view helps ascertaining, who else is aware of what I am aware of? Who is aware of me? intersubjectivity, and so on, which is valuable in coordination. Context-sensitive awareness sources could be added manually or programmatically based on the user’s profile of work. Access control policies limiting what users can access can be established with this view. A super user would have unrestricted view of all users and their Source Supersets.

Fig. 2. Awareness Map

4.3 Illustration of Awareness Model

Figure 3 illustrates the scenario considered in section 2.2. The generic architecture of an Awareness Framework is based on our review of related work that revealed common components. Applications (sources) generate awareness information, which is communicated over certain media. They are bound to a central entity (by middleware) that manages the information flow. Application specific interfaces are necessary to connect them to the medium (very often computer networks). Users activities using these applications are of interest to other users. These consumers access this informa-
tion using applications that are bound to the framework too. In our case the central entity is the Awareness Model. We assume the collaborative editors used by the groups are physically integrated. The TL accesses the AM through a portal application. The collaborative editor is seen as one of the sources along with its characteristics in the TL’s Source Superset. The TL adds it to his Focus and chooses details such as when to be notified if certain events occur in the editing session, how often and so on. This is an example of choosing the relevancy and frequency of information based on the displayed characteristics. Being on a low bandwidth connection, the TL chooses text-based notifications only. Though all events from the editing session are communicated, the AM would relay information to the TL based on her preferences. The TL being aware of the status could communicate with the groups through email/telephone/IM or even the editor application itself assuming it has such capabilities. We assume the editor communicates details such as, which changes were made by whom, when and so on making it part of the Information Content. The TL should be able to view this information as it occurs, or later. For e.g. the TL should be able to query to see all the changes made by a particular group member. The editing groups know they are connected to the AM through their Awareness Map views. They know that the TL is aware of their activities. Thus there is mutual awareness. Let us assume that one of the groups engages in a videoconference with another group as part of the process. The user TL could expand his focus to include this source if necessary. The TL may not be able to access the session but may be able to access a text transcript that is recorded and stored in the AM after the conference. The AM is not meant to be a data bottleneck; rather it is analogous to a lens over the awareness capabilities of the group bringing into focus the pertinent aspects. Users may have direct lines of communication with the source for actual data transfer.

5 Validation and Future Steps

Further work involves completing the model specification. The model will be validated with realistic collaboration scenarios and refined. Evaluating how useful the model is in enabling the users to tailor the quality factors is essential. Mechanisms used in integrating the information, displaying sources, supporting user browsing and querying based on the quality are being developed. Also providing context-sensitive awareness based on the user’s sphere of activity, profile and the current state of the project is of interest. Another interest is evaluating the model in scenarios where there exists a certain level of awareness in the group, with intervals requiring a “heightened awareness” as in emergency rooms and call centers [5]. Among the multiple foci that a user has, some could diminish in “strength” when not important and others could come into prominence during such periods. The Awareness Map concept will be developed completely and a proto-type implemented.
6 Conclusion

Heterogeneous sources of awareness and media have a significant influence on the quality of awareness in groups. We examined the major issues in empowering users with the ability to tailor the quality of awareness and established the need for integration of sources at the information level. We proposed a generic unifying model to provide the composite picture that awareness is. We aim to demonstrate the utility of the model in tailoring awareness quality, simplifying the integration process and dealing with changes in group work.

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Reduction Over Time: Easing the Burden of Peer-to-Peer Barter Relationships to Facilitate Mutual Help

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Abstract. A peer-to-peer complementary currency can be a powerful tool for promoting exchanges and building relationships for coordinated activities. \textit{i-WAT}\textsuperscript{1} is a proposed such currency usable on the Internet. It is based on the WAT System\textsuperscript{2}, a polycentric complementary currency using \textit{WAT tickets} as its media of exchange: participants spontaneously issue and circulate the tickets as needed, whose values are backed up by chains of trust. \textit{i-WAT} implements the tickets electronically by exchanging messages signed in OpenPGP\textsuperscript{3}.

This paper proposes an extension to the design of \textit{i-WAT} to facilitate mutual help among people in need. In particular, we propose additional "reduction" tickets whose values are reduced over time. By deferring redemption of such tickets, the participants can contribute to reduce the debts of the issuers, as well as to accelerate spending. Applications of this feature include a relief to disaster-affected people.

A reference implementation of \textit{i-WAT} has been developed in the form of a plug-in for an XMPP\textsuperscript{4}\textsuperscript{5} instant messaging client. We have been putting the currency system into practical use, to which the proposed feature will be added shortly.

1 Introduction

1.1 Peer-to-Peer Complementary Currency

One of the issues of activity coordination is \textit{incentive-compatibility}\textsuperscript{6}, roughly restated as the goal of the coordinated activity being accomplished by collection of selfish behaviors. Because it necessitate fair exchanges of resources among participants, the medium of exchange must take an important role.

Money is a well-known medium of exchange, but its scarcity has caused a lot of problems. \textit{Complementary currencies}, or alternative forms of monetary media, have been proposed and tested to achieve an autonomous, sustainable local economy even in short of money. There have been successful cases, such as experiments in Wörgl in 1932 (stamp money\textsuperscript{7}), in Comox Valley in 1983 (Local Exchange Trading System\textsuperscript{8}) and in Ithaca since 1991 (Ithaca HOURS\textsuperscript{9}).

Many of those outcomes are short-lived, however, because most of the existing currencies are dependent on the qualities of their administrations. It would thus benefit the
autonomy and sustainability of economy if we could design an administration-free (or peer-to-peer) complementary currency.

We proposed \(i\)-WAT\[1\] in year 2003 as such a currency usable on the Internet, based on the WAT System[2]. The WAT System is a system of polycentric complementary currencies using WAT tickets as its media of exchange. A WAT ticket is like a bill of exchange, but without a specified redemption date or place. \(i\)-WAT implements the tickets electronically by exchanging messages signed in OpenPGP[3]. It has been put into practical use since June 2004.

1.2 Reduction Over Time to Accelerate Spending

It is known among the practitioners of complementary currencies that reducing the value of the exchange medium over time accelerates spending. The stamp money experiment in Wörgl in 1932 is a well-known example. It was based on the idea of stamp scrip introduced by Sylvio Gesell in [10], who believed exchange media must also deteriorate as the exchanged goods do (for this reason, Reduction Over Time is dubbed ROT hereafter).

A user of stamp money needs to paste a stamp every week on the back of the note, or the note becomes invalid. Users are motivated to spend the scrip before another stamp is required. The stamp is a tax for storage of exchange medium. It is a suitable way to implement ROT in a centralized currency system.

1.3 Contributions of This Paper

If ROT is to be implemented for decentralized currencies, a different approach needs to be taken. We have applied the notion of calendar money[11] by Arthur Dahlberg, which has a schedule of reduction printed on the note.

We have realized that this has potential effects of not only promoting exchanges, but also providing participants with means to support peers by sharing debts among one another.

This paper describes WAT/\(i\)-WAT concisely, and proposes an extension to the design of \(i\)-WAT to realize the above concept. It shows that the extended design is incentive-compatible by a casual analysis.

2 WAT/\(i\)-WAT Currency System

2.1 The WAT System

Overview The WAT System[2] is a complementary currency designed by Eiichi Morino, a coauthor of this paper. It has been used broadly as a means for mediating bartering, since its introduction in August 2000.

A WAT ticket, a physical sheet of paper resembling a bill of exchange, is used as the medium of exchange in the system. A lifecycle of a WAT ticket involves three stages of trading as illustrated in Fig. 1:
1. Issuing – the birth of a WAT ticket
   A drawer issues a WAT ticket by writing on an empty form the name of the provider (lender) of the goods or service, the amount of debt\(^4\), the present date, and the drawer’s signature. The drawer gives the ticket to the lender, and in return obtains some goods or service.

2. Circulation – ordinary exchange
   The person to whom the WAT ticket was given can become a user, and use it for another trading. To do so, the user writes the name of the recipient, as well as their own, on the reverse side of the ticket. The recipient will become a new user, repeating which the WAT ticket circulates among people.

3. Redemption – the return of the WAT ticket
   The WAT ticket is invalidated when it returns, as a result of a trade, to the drawer.

**Distinctive Features of the WAT System**

*Autonomy*  Anyone can spontaneously become a member of the WAT System with a sheet of paper if they follow the above protocol.

*Compatibility*  A WAT ticket is compatible with any other WAT tickets in the world, so that the currency system is operable globally, as long as the drawer can be credited.

*Extensibility*  The protocol illustrated in Fig. 1 defines the WAT Core, the essence of the WAT System. An extended part can be defined for a new currency based on the WAT System, stating, for example, the region, group and duration in which the tickets are usable, as well as the unit in which the debt is quantified.

\(^4\) Typically in the unit kWh, which represents cost of producing electricity from natural energy sources.
Table 1. *i*-WAT messages

<table>
<thead>
<tr>
<th>message</th>
<th>sender</th>
<th>receiver</th>
<th>function</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;draw/&gt;</code></td>
<td>drawer</td>
<td>recipient (lender)</td>
<td>draws an <em>i</em>-WAT ticket.</td>
</tr>
<tr>
<td><code>&lt;use/&gt;</code></td>
<td>user</td>
<td>recipient</td>
<td>uses an <em>i</em>-WAT ticket.</td>
</tr>
<tr>
<td><code>&lt;accept/&gt;</code></td>
<td>recipient</td>
<td>drawer and user</td>
<td>confirms readiness to accept the <em>i</em>-WAT ticket once it is validated.</td>
</tr>
<tr>
<td><code>&lt;reject/&gt;</code></td>
<td>recipient</td>
<td>drawer or user</td>
<td>rejects an <em>i</em>-WAT ticket.</td>
</tr>
<tr>
<td><code>&lt;approve/&gt;</code></td>
<td>drawer</td>
<td>user and recipient</td>
<td>validates an <em>i</em>-WAT ticket, and approves the transaction.</td>
</tr>
<tr>
<td><code>&lt;disapprove/&gt;</code></td>
<td>drawer</td>
<td>user and recipient</td>
<td>denies an <em>i</em>-WAT transaction.</td>
</tr>
</tbody>
</table>

* depending on whether the ticket has just been issued or in circulation, respectively.

Security In case the drawer fails to meet their promise on the ticket, the lender assumes the responsibility for the debt. If the lender fails, the next user takes over. The responsibility follows the chain of endorsements. The longer the chain is, the more firmly backed up the ticket is. Therefore the length of the chain of endorsements represents the extent of trust the ticket has gained.

2.2 *i*-WAT: the Internet WAT System

Overview *i*-WAT is a translation of the WAT Core onto the Internet. We have made a reference implementation available to the public, which has been used mainly by the members of the WAT System.

In *i*-WAT, messages signed in OpenPGP (*i*-WAT messages) are used to implement transfers of an electronically represented WAT ticket (*i*-WAT ticket).

An *i*-WAT ticket contains the identification number, amount of debt and public key user IDs of the drawer, users and recipients. Endorsements are realized by nesting PGP signatures.

Table 1 shows the types of *i*-WAT messages. All *i*-WAT messages are signed by the senders, and are formatted in the canonical form[12] of XML[13] with nested signatures. The messages cause state transfers of a ticket as illustrated in Fig. 2.

Changes from the WAT System Upon translating the WAT Core onto the digital communication domain, we have made the following changes from the state machine of a WAT ticket:

1. Trades need to be asynchronously performed. Intermediate states, such as waiting for acceptance or approval, are introduced.
2. Double-spending needs to be prohibited. The drawer is made responsible for guaranteeing that the circulating ticket is not a fraud. This means that every trade has to be approved by the drawer of the involved ticket.

The semantics of this design and the trust model of *i*-WAT are discussed in detail in [14].
Fig. 2. State machine of a WAT/i-WAT ticket

Protocol

Issuing – the birth of an i-WAT ticket (Fig. 3)
1. The drawer sends a <draw/> message which contains the public key user IDs of the drawer and lender, identification number and amount of debt. This message becomes the original i-WAT ticket after the protocol is completed.
2. The lender sends back the content of the message as an <accept/> message.
3. The drawer sends an <approve/> message to the lender.

Circulation – ordinary exchange (Fig. 4)
1. The user adds to the i-WAT ticket the public key user ID of the recipient, and sends it to the recipient as a <use/> message. This message becomes a valid i-WAT ticket after the protocol is completed.
2. The recipient forwards the content of the message to the drawer and user as an <accept/> message.
3. The drawer verifies the ticket, and sends an <approve/> message to the user and recipient.

Redemption – the return of the i-WAT ticket (Fig. 5)
1. The user sends a <use/> message to the recipient, who equals the drawer.
2. The drawer verifies the ticket, and invalidates it as the debt is now redeemed. The drawer sends an <approve/> message to the user.
3 ROT: Reduction Over Time

3.1 Concept

We make a generalization to the value of a WAT/i-WAT ticket such that it is expressed as a tuple \((V_0, V_m, f)\) presented by the drawer, where \(V_0\) is the face value (initial value) of the ticket, \(V_m\) is the minimum value, and \(f(t)\) is the differentiation (derivative) of a function of time \(F(t)\) such that \(f(t) \leq 0\) for all \(t\) (an extension to allow \(f(t) > 0\) is conceivable, but it will be discussed elsewhere). The effective value \(V_t\) of a ticket at time \(t\) is given by the following equation:

\[
V_t = \max\left( \int_0^t f(t) dt + V_0, V_m \right)
\]
This is a generalization to introduce an additional type of tickets called *reduction* tickets, whose values are reduced over time, limited by a minimum value. For regular WAT/i-WAT tickets, $f(t)$ is a constant value zero, and $V_0 = V_{\text{initial}}$.

Reduction of the value of a ticket means that the drawer’s debt is reduced. The cost of reduction is first admitted by the lender who credits the drawer, and then shared among the endorsers as illustrated in Fig. 6. The amount of the total reduction is manifested to the drawer upon redemption. By deferring redemption, participants can help easing the burden of the drawer.

### 3.2 Incentive-Compatibility of the Design

We show that the design of *reduction* tickets is incentive-compatible by a casual analysis.

**Lender’s Reasoning** The lender may not want to accept a *reduction* ticket because they know that its value will decrease over time if they save it. They can be motivated to accept the ticket, however, if they know that the drawer is in need, such as in a case of aftermath of a natural disaster. They know that they do not have to take all the burden by themselves; they infer that, by the same reasoning as theirs, it is likely that those people around them are also willing to accept the ticket. Therefore the ticket is accepted, and spent as soon as possible to satisfy the need of the lender themselves.

**Endorser’s Reasoning** All participants, if they are aware of the situation of the drawer, will be motivated to:

1. defer redemption of the ticket to support the drawer, and
2. spend it as soon as possible to avoid much reduction of its value and to satisfy their own needs.
We predict that a *reduction* ticket will typically circulate at high speed until its effective value reaches the minimum value $V_m$.

**Drawer’s Reasoning** There is a risk that circulation may be stalled for an $i$-WAT ticket by negligence of the drawer in their role for approving transactions. However, we can show that it is to the drawer’s own benefit to maintain the liveness of their tickets:

1. If one is late to respond, or tends to fail to answer requests for redemption, they will lose trust from others. Then it will become more difficult for them to have their tickets accepted for future trades.
2. If one is quick to respond, and accepts requests for redemption with certainty, they will gain more trust from others. Since their tickets become easier to use, they may attract more load. But it will become easier for them to draw tickets at will in the future, and initiate trades spontaneously to obtain goods or services.

### 3.3 Protocol

*Reduction* tickets can be incorporated to the system with minimal changes to the existing $i$-WAT protocol.

Since it is unrealistic to assume that the clocks of all participating computers are synchronized with precision, the time is ultimately measured by the computer of the drawer.

The timestamp of the drawer’s or user’s signature (depending on whether the trade is issuing or circulation) defines the effective value of a *reduction* ticket, to which the recipient either agrees or disagrees. The drawer (or their software agent) is responsible to check that the timestamp belongs to the past for them when they approve a transaction.
3.4 Applications

Applications of reduction tickets include relief to disaster-affected people. We are sure that everyone is hurt by the tsunami which swept the coastlines of Southeast Asian countries on December 26, 2004, killed an unprecedented number of people and took means of life away from literally millions.

We have made a proposal to ccTsunami[15], which is an open forum on the Internet for discussing and implementing programs to support the tsunami-affected places with complementary currencies. In the proposal, i-WAT tickets are issued by an NGO which promises to exchange the tickets with WAT tickets issued by the disaster-affected people, so that people in need do not need to use computers.

4 Ongoing and Future Works

4.1 Implementation

We have been developing a reference implementation of i-WAT as a plug-in for wijia, an XMPP (Extensible Messaging and Presence Protocol)[4][5] messaging client. Although we cannot quantify the number of users because of the nature of the WAT System, many who have experienced the physical WAT System are using i-WAT despite of technical difficulties they may be suffering. We are in a continous process of improving the ease of use of the system.

Implementation of the proposed ROT feature is in progress. It will be included in the bundled plug-in for the new version of wijia to be released in March 2005.

wijia is available at http://www.media-art-online.org/wija/.

4.2 Formal Analysis

We are working on a more formal analysis to show that the ROT feature is incentive-compatible. A partial result shows that an equilibrium is achieved when the scheduled minimum value of a reduction ticket is zero. Although this is compatible with everyone’s benefit, it may cause a moral hazard such that the drawer issues as many tickets as they want. We are pursuing an operational design which mitigates this hazard.

4.3 Future Work

Once the new implementation is ready, we will experiment on actual usage of the ROT feature to verify the prediction that the reduction tickets typically circulate at high speed until their effective values hit the minimum.

5 Conclusions

This paper proposed an extension to the design of i-WAT to implement reduction over time, which has potential effects of both promoting exchanges and providing participants with means to support peers, by sharing debts among one another as a form of currency. The extended design is shown to be incentive-compatible by a casual analysis. The implementation will be available to the public shortly.
References

Identity Management for Electronic Negotiations

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Abstract. Using the Internet as the medium for transporting sensitive business data poses risks to companies. Before conducting business electronically, a company should take preventive measures against data manipulations and possible data misuse. One initial step could be obtaining certainty about the true identity of a potential business partner responding to a request or tender. In this paper we report on the development of a concept for identity management to introduce trust for electronic negotiations.

We describe the character of electronic negotiations and give an example for a possible use-case scenario of our concept. For this we choose the most complex type of negotiations in the business domain, which are interactive bilateral multiattributive negotiations. Based on a general application architecture for such negotiations developed in a research project, we show the necessity of security provisions and introduce a security concept for identity management. We argue that the development of authentication and authorization services for the identity management of business partners involved in a negotiation are not only crucial but also an enhancement for electronic marketplaces.

1 Introduction

Electronic negotiations are of increasing importance in today’s e-business applications, especially since integration is becoming a major consideration in the forming of business processes. For achieving effective procurement and supply chain management, seamless integration in processing complex transactions is required [1]. Supply chain decisions within in organizations depend on the results of negotiations with the potential partners of a transaction. Supporting these negotiations electronically, and supplying their integration with internal applications, allows major progress in internal and external business process integration as well as decision support and the facilitation of supply chain management.

Consequently the nature of electronic negotiation applications has become strongly inter-organizational. Negotiations and contracts form the economic links between organizations as elements of the information chain emerging during the process. Next
to research-oriented aspects business application requirements have become relevant. The interface nature of electronic negotiations implies social and legal, but also organizational (business processes and documents) and technical (application integration) aspects [2]. Research and application development has already been done in this area, often focusing on auctions and tenders. But whereas in the 1990s electronic negotiations have largely been a domain of stand-alone applications, today, also with focus on EDI and supply chain transactions, their inter-organizational aspects become prevailing [3–6].

True integration between organizations and their applications requires seamless electronic data exchange in order to enable the exploitation of process optimization and the resulting competitive advantages. But due to the inter-organizational character of electronic negotiations in the business domain combined with the use of the Internet, organizations are becoming more exposed to malicious acts than in pre-electronic times. Consequently, a simple adoption of negotiation processes to the Internet is subject to manipulation and data misuse. Numerous security issues can arise. Addressing these issues is prerequisite for electronic negotiations. In this paper we focus on one specific security service, which is identity management.

In section 2 we explain the concept of electronic negotiations focusing on the B2B domain. A negotiation may be conducted in form of an auction, tender, exchange or bilateral considering either one or several attributes at the same time. As an example of the most complex type of negotiations we describe interactive bilateral multiattributive negotiations, as those are the most common [7]. We then discuss an application architecture for this type of negotiations and introduce and analyze the main security aspects within this context, concentrating on identity management. Based on our analysis, we develop a concept for this security service. It provides authentication of the business partners involved in a negotiation and access control through authorization. Furthermore, we show how security related information can also be used to support the implementation of business policies. We conclude with related work.

2 Electronic Negotiations

2.1 Negotiations in the course of a market transaction

For all types of business, markets and marketplaces provide information to the trading partners, enable establishing of binding agreements and execution of the agreed [8]. Traditional and electronic markets show various similarities. Conceptually an electronic market is an application based on electronic communication services that supports the market coordination of economic activities. It is an inter-organizational application system and supports at least one phase of a market transaction. In those virtual markets, market partners can perform either parts of transactions or complete transactions electronically. The full cycle of a market transaction can be best described with a model including the following phases [9] as depicted in figure 1:

**Information phase**, where the relevant information concerning products, market partners etc. is gathered.
Fig. 1. Roles of the applications during a transaction

Intention phase, where offers concerning supply and demand are submitted by the market partners

Agreement phase, where the terms and conditions of the transaction are specified and the contract is closed

Execution phase, where the agreed-upon contract is operationally executed

Service phase, where support, maintenance and customer services etc. are delivered.

A negotiation can be defined as a decision-making process by at least two parties. It is performed until an agreement is reached or the process is terminated without reaching an agreement by one or all the partners involved. Its basis is the interactive exchange of information in form of issuing and adjusting offers back and forth to specify the contract particulars. Usually the objective of this process is to reach consent and establish a legally binding contract between the parties concerned, which defines all agreed-upon terms and conditions next to regulations in case of failure of their fulfillment as well as any further possible details [9]. The number of parties involved in this process and its temporal and logical conditions varies depending on the type of negotiation taking place. It may be initiated between the trading partners directly or through the intermediation of an electronic marketplace, which is one out of several possible realizations of electronic markets in general.

During an electronic market transaction an ad-hoc information chain is formed between the market partners. This information chain may be looked at as a temporary network, that is built dynamically and lasts until the transaction is terminated [10, 11]. Within such a dynamic business web, the applications supporting the information and intention phases can be hosted by an electronic marketplace. Components concerning the execution and service phases can be found with the partners’ internal (ERP-) applications. The processes during the agreement phase are handled by an independent application. This application is the decentralized integration point, where all data services are dynamically joined together (figure 1).

2.2 An Application Architecture for Multi-Attributive Negotiations

In the MultiNeg Project [12] an electronic negotiation support system for bilateral, multi-attributive negotiations has been developed. The key objectives for the development have been the design of an architecture suitable for different industries, company sizes and products and a communication interface design that allows the integration of inter-organizational with intra-organizational applications. The functionalities are conceptualized for usage in a decentralized deployment and are based on open standards. Thus they allow the seamless electronic integration of internal and external business processes.

The architecture has three application layers, which are the Business Object Framework...
Layer providing the metastructure for negotiating, the Negotiation Layer and the Communication Layer. Each layer is represented by a major component in the application architecture (figure 2):

**Business Object Framework Layer** supports the management of the application’s business object framework containing the specific object and document structures.

**Negotiation Layer** supports the process flow of interactive, bilateral multi-attribute electronic negotiations.

**Communication Layer** supplies the communication functions required by the other two layers. It handles incoming and outgoing messages and provides authentication and encryption functionality. It also supplies workflow functionality to manage the negotiation process flow with internal or external, human or electronic agents.

### 3 Security Aspects and Requirements

Due to its availability and flexibility, the Internet is used as the communication platform for dynamic business webs as described above. However, this design decision has undesirable side-effects, since the Internet is an open and anonymous network, security issues can arise. These issues can be attacks such as masquerading, or spying out confidential data etc. These threats strike at the very foundation of all transactions, which is trust. Trust is of vital importance for all communities, since it builds the basis for any kind of interaction [13]. Non-existence of any security measures leads to a lack of trust which will significantly impede the widespread acceptance of any e-business application. Therefore we introduce security services for the given dynamic business web:
Authentication: In general authentication can be classified according to the purpose desired. Either mechanisms to prove or verify the authenticity of a claimed identity (entity authentication) or the authenticity of a message (message origin authentication) are needed. In the following our understanding of authentication will always be in the sense of entity authentication. The aspect of authentication is crucial in dynamic business webs, since they tend to involve much less stable business relationships. Business partners do not necessarily know each other before starting business conduction. Therefore they need reliable authentication services to build up trust, which is key to concluding business transactions.

Authorization: This means the granting of rights, which includes access based on access rights. For instance, the access to product inventories of the parties involved in a negotiation within the application should be controlled.

Data confidentiality: All messages exchanged between business partners in the course of transaction should be private. It should not be possible for an unauthorized third party to eavesdrop on negotiation details.

Non-repudiation: The purpose of the non-repudiation service is to provide evidence of a particular event or action. Non-repudiation is essential for e-business applications. Without it business partners can later deny any involvement in concluded negotiations.

In this paper we address authentication and authorization services and develop an identity management framework.

4 Communication Services

To enable full electronic business conduction the applications used by all parties involved in an electronic transaction need to be coupled. The internal systems and applications such as ERP-systems of buyer, seller, electronic marketplace and negotiation system can form an integrated, but still flexible information chain. Consequently in MultiNeg we developed several web services in order to build up information chains in a flexible manner.

4.1 Description of the Services

The developed service components may be coupled with electronic marketplaces, but may also be used stand-alone. They can provide a faster process flow and at the same time also increase the quality of the exchanged information. To achieve this goal the close integration of the negotiation system into the information chain coming into being is mandatory. For designing such communication services the security aspects as described above need to be taken into account besides the consideration of handling the variety of existing syntaxes and semantics.

By combining web service technology with the principles of decentralized, distributed processing, the application components can be dynamically coupled each time individually precisely as needed for performing all business transactions possible. Within the so created information chain transactions can be executed by application components
especially combined for each phase. The components are distributed among the parties involved. Figure 3 depicts the overall architecture of an evolving dynamic business web. A certification authority (CA) has to guarantee the authenticity of public keys within the

![Diagram of Dynamic Business Web](image)

**Fig. 3. Dynamic Business Web**

presented scenario. For this purpose it issues digital certificates for business partners, the marketplace and the negotiation system. These certificates are trusted by all parties concerned. Possessing a digital certificate is optional for business partners. However, not to have a certificate may cause implications regarding business processes. These implications will be detailed later.

Business transactions are initialized on the electronic marketplace and are transferred to the independent negotiation system through web service interfaces. Within the project various web services have been conceptually developed and prototypes are operational for the integration of an electronic market in general, the negotiation system and the internal systems of the partners.

These web services enable a consistent, syntactic and semantic inter-operational data exchange from the initialization of the negotiation to the frequent information update until the final transmission of the signed contract document. The services are [9]:

**Init Negotiation Service:** It transfers the data for the initializing of a negotiation to the negotiation application.

**Inventory Visibility Service:** Through this service product descriptions can be enhanced with up-to-date inventory stock information.

**Tunnel Inventory Visibility Service:** This tunnel service has two functions in the integration scenario. It communicates with the inventory visibility service of the supplier via the marketplace. At the same time it aggregates the inventory stock data for
transmission to the negotiation system. Assuming several suppliers offering such inventory services, this visibility service is able to combine the web services of all suppliers aggregated into one front-end information.

**Catalogue Update Service**: This service provides the updating process of a catalogue. Using the product identification numbers the marketplace’s backend generates an up-to-date catalogue extract and transmits it to the negotiation systems.

**Contract Transmission Service**: The transaction information of a successfully concluded negotiation is supplied by the negotiation system to the partner’s internal systems through this service.

### 4.2 Identity Management

The core task of identity management is to answer the question "who can do what when". This simple question depicts the two core tasks of identity management, namely authentication and authorization.

Due to the lack of physical contact in online environments, such as dynamic business webs as described above, there exists an inherent uncertainty which may hamper business transactions. One sound approach to overcome this shortcoming would be the introduction of an intermediary. An intermediary is a third party who facilitates a deal between two other parties by providing certain services. There are good reasons for having intermediaries, c.f. [14]. For instance, intermediaries may offer value added services, such as aggregation, matching, facilitation, and also trust establishment. The latter service is often carried out by a so-called "trusted third party". The term trusted third party is used to describe a security authority or its agent, trusted by other entities with respect to security-related activities. Since business partners have to trust the marketplace, the marketplace itself is a perfect candidate for acting as a trusted third party offering authentication services.

The first step is the authentication process[15]. In our scenario the marketplace supports two authentication mechanisms:

**weak authentication schema**, such as Login/Passwords. The reason for supporting weak authentication schemes is to lower the barrier for entering the marketplace.

**strong authentication schema**, such as challenge-response identification based on digital certificates. By doing so the marketplace asserts the validity of the certificated issued by the CA.

Both authentication schemes can be realized using the Transport Layer Security technologies(TLS/SSL), which is the only current ubiquitous cryptographic infrastructure [16]. In our scenario server, i.e. the marketplace, authentication is compulsory, whereas client, i.e. company A, authentication is required only in case of strong authentication needs.

After a successful authentication the marketplace issues an assertion for company A. An assertion conveys information about authentication acts performed by different parties. The assertions in our scenario are issued by the marketplace and contain detailed information about the authentication process, e.g. time and schema. Furthermore they are digitally signed by their issuer.
Company A can use the assertion to prove its identity to company B. The latter has two options to verify the integrity and the authenticity of the assertion. It can verify the attached signature itself or forward the assertion to the issuer, who is here the marketplace. The choice between these options may depend on the specific circumstances of a particular business scenario.

In contrast to authentication services, authorization services have to be decentralized, since each (business) party is the only one able to grant access to its own resources. As a consequence, there is no single policy decision point. We detail a possible authorization scenario with help of examples. We focus on the Init Negotiation Service and the Tunnel Inventory Visibility Service.

For sake of better comprehensibility, we assume that company A is interested in negotiating for products offered by company B. The Init Negotiation Service runs on the marketplace and uses the web service interface of the negotiation system to transfer all data necessary for a negotiation. It includes the catalogue data as well as the assertion of company A. The assertion has been issued by the marketplace during the authentication phase, thus it enables company B to find out more about the identity of company A. As described before, the negotiation system can be customized by its users. Companies can exploit this functionality even further and may derive negotiation strategies from assertions. Company A could perhaps define different classes of negotiation partners. The specific class depends on both the authentication schema stated in the assertion and the experiences gained in past negotiations. Consequently, the class of a business partner reflects the level of trust extended towards that partner. It may influence specific negotiation settings like payment conditions or special price offers. In case company B just uses login/password to authenticate itself towards the marketplace, company A could have defined the policy of not accepting payment by invoice after delivery.

The Tunnel Inventory Visibility Service described above offers authorization in addition to aggregation and anonymity services. This is achieved through setting up policy decision points in order to define access rules for different negotiation partners or types of partners.

Again we consider the scenario where company A and company B are involved in a negotiation. We assume that company B wants to add some new items into the ongoing negotiation. For this purpose it makes use of the Tunnel Inventory Visibility Service, which expects to get company B’s assertion. Access to sensitive information, such as price and availability of goods, can be controlled on the basis of that assertion. For example, in consequence company A could set up individual catalogues for its business partners.

5 Related work

Research in the field of support for electronic negotiations concentrates around the implementation of negotiations protocols [5, 17], application of agents [18, 19] or the communication flow [20]. Even though the need for security has been part of recent conceptual design discussions [21, 22], present designs require enhancements for the provision of user authentication beyond password control [21, 23] in order to grant successful implementation of an identity management concept.
There has been some remarkable industrial effort in the field of identity management aiming at developing standards for single sign-on mechanisms for the Internet. The most known among them is Liberty Alliance [24]. Although the architecture developed by Liberty Alliance is sophisticated, it is not suitable for B2B scenarios, since it mainly focuses on providing single sign-on mechanisms [25] for B2C scenarios.

6 Conclusion

In this paper we presented a web-based system, offering different services for enabling electronic negotiations for business partners. Our approach is integrative and flexible due to its modularity. Each component can be used either stand-alone or in conjunction with other components. In order to increase the creation of dynamic business webs, it offers both the possibility to use standard services and the possibility to customize them. These possibilities allow business partners to adjust parameters according to specific needs. Especially flexible are the security services, where involved parties can decide themselves how much security they need. Within the security context we focused on identity management for different services. For that purpose we developed an approach which is centralized regarding authentication and decentralized concerning authorization. Business partners want to rely on existing authentication services offered by a trustworthy party, which could be a marketplace. In our approach we support different authentication schemes. Selection and acceptance of the proper authentication schema is up to the business partners. For authorization, which is based on authentication, we concluded that only a decentralized solution can meet the needs of business partners. They are responsible for setting up access control rules themselves. For that purpose respective the services are configurable by their users.

References

A Conception Of Multiagent Management System
Of Dispersed Market Information – E-negotiations Area

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Abstract. The conception of multiagent system (MAS) as a tool aiding dispersed market information management in e-negotiations area was proposed in this article. The results of the conducted surveys concerning among other things identification of the application areas of intelligent software agents in the enterprises are also presented here. Attention was paid to the role of business negotiation in market information acquisition. Software environment Agent-Builder enabling elaboration of the simulating model of the proposed conception of the system was also described in the present article.

1 Introduction

The electronic markets develop mainly due to technology and computer technology advances. Particularly important here are: electronic data interchange (EDI), the Internet – the global network, and especially World Wide Web network service and electronic mail [5], [8].

Market information is a set of all data, information and news, also informal information and news acquired through direct contacts, which is essential to prepare market strategy and market operations, including operations on international markets. Ability to compete effectively and maintain own position on the market may be secured for the enterprise by an efficient system of market information. Thus, there are initiatives undertaken that aim to develop new access technology to dispersed and heterogeneous market information. Despite the fact that contemporary IT technology (Information Technology) offers great opportunity of quick and easy access to vital information from the point of view of business operations [11], finding required at a given moment information on the Internet is still troublesome to some managers and is a complicated and time consuming process.

One of the interesting conceptions is the application of intelligent software agents operating on behalf of the users [2], [3], [10]. Their task is among other things to search in many sources for information that meets set in advance criteria, and at the same time to draw conclusions on the basis of this information and formulate further search goals. Intelligent agent – as a concluding system – influenced by external impulses makes logical, precisely determined decisions. A group of cooperating software agents makes up a multiagent system. In accordance with the MAS systems
pragmatism even already existing information-decision making system can be treated as environment in which agents carrying out particular tasks are inserted [4].

The Internet has become communication medium and has created possibility of electronic business management. Its development lets us assume that greater and greater part of economic life will take place by means of the internet technology. Economic globalization forces constant communication of market participants and thus frequent negotiations.

Results of the survey conducted in Polish enterprises were presented in chapter 2. The aim of the survey was to show whether business negotiations are treated as a source of market information, and if they are supported by electronic media and what tasks would Polish managers delegate software agents to perform.

The conception of multiagent system, which is to show possibility of market information management in an enterprise was proposed in chapter 3.

2 Market Information And Business Negotiations Aided By The Internet

Business negotiations are the important source of market information acquisition. Being treated as the communication and information exchange processes, they give the enterprise opportunity to complete knowledge of the other, negotiating, side [9]. Connection of the contemporary enterprises by means of informatic networks, but first of all of production and cooperative ties causes that aiding negotiation processes - perceived as information-decision making processes - becomes an important task of the enterprise’s informatic system. Business negotiations may take place on the Internet on the virtual B2B (Business to Business) markets, where auctioning mechanism is not enough. Sides have to use more advanced e-negotiation technologies in order to fix not only prices but also delivery conditions, technical details, guarantee conditions, payment terms and many more aspects of the agreement. Acquisition of reliable information is the basis to create loyalty, which in turn means, that there is a possibility of negotiations in new areas – among other things in the company-client relationships.

Within the confines of the research conducted at Częstochowa University of Technology, Management Faculty, in the Department of Management Information Systems, connected with the application of multiagent system and integrators of information flow in market information management in the enterprise, there was the survey “E-negotiations in Polish Enterprises” conducted. The subject of the study were the enterprises applying in their operations internet business model and mixed business model – traditional-internet one. The survey was conducted among four groups of respondents – presidents, members of the board, middle-level managers and employees. The total number of respondents constituted 172 people. The surveyed enterprises included:
- 31 employing more than 500 people,
- 14 employing 251-500 people,
- 44 employing 51-250 people,
- 49 employing 11-50 people,
- 34 employing fewer than 10 people.
  The majority of 117 constituted the enterprises with 100% of Polish capital. The remaining enterprises were:
- 27 with the majority of Polish capital,
- 24 with the majority of foreign capital,
- 4 with 100% of foreign capital.

With respect to the type of operation the biggest group of all the enterprises constituted service companies – 61, then production companies – 42, trade companies – 31, production-trade-service companies – 15, trade-service companies – 14, production-trade companies – 9.

The survey consisted of two parts and included 23 questions altogether that concerned business negotiation aiding and market information acquisition by electronic media, the Internet in particular. The results of the two questions directed to respondents are presented below. The questions were connected with the perception of the software agents’ role and business negotiations, as the sources of market information (Fig. 1, Fig. 2).

It follows from the chart presented in Figure 1 that one of the most burdensome and important at the same time activities for managers responsible for business negotiations in Polish companies is – according to the respondents – collecting information about prices of competitive products (7.6 points in 10-point scale). It is acquisi-
tion of information on prices of competitive products that they would assign an intelligent software agent to perform these duties. Thus, there exists a real need to automate this activity and if at all possible quick implementation of such a solution. However, the respondents would be less willing to allow the software agent to select their negotiating partner (5.1 points).

The result of the second answer is connected among other things with classical methods of the other side’s credibility verification. Nevertheless, it should be stressed here that the respondents assigned substantial significance to every activity represented in Figure 1. It justifies the necessity of the intense research in the area of software agents application in social organizations, especially with regard to market information acquisition.

The second of the presented in this paper questions concerned perception of the role of business negotiations in Polish companies. The results received presented in Figure 2 indicate that the most important role of negotiations is maintaining or winning the competitive advantage (6.6 points). However, the two following positions are connected with the notion of information. Negotiations are as follows: the tools of organizing information exchange with the environment and the source of information of the environment (comparable significances – 5.9).

The most important role in enterprises is still played by traditional “face-to-face” negotiations where negotiators meet directly. This concerns particularly negotiations of very important or strategic for enterprises contracts. Undoubtedly, it is still the most interactive way of communication between the negotiating sides.

However, the analysis of the conducted survey and interviews justify necessity of work on application aiding managers in running e-negotiations, particularly in relations on electronic, B2B markets.

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**Fig. 2.** Perception of business negotiations functions in Polish companies. Source: own analysis.
3 Proposed Model Of The System

One of the conceptions of a system aiding market information management in the e-negotiations area is its realization in the form of multiagent system. The proposed in the work model will comprise of two mutually cooperating groups of software agents (so called agencies):

- First group – its task is to acquire, analyze and make market information available to manager, aids manager in preparation to negotiations phase,
- Second group – its task is to aid manager in the terms of transaction negotiations; it takes over the task of offers evaluation and working out initial compromise.

The above mentioned groups include three basic kinds of agents:

- Interface agents – their task is to facilitate man interaction with the system and presentation of the work results in accessible form.
- Coordination agents – they analyze introduced by man tasks and divide them into elementary tasks.
- Information agents – they realize elementary tasks, delegated to them to carry out by task agents (they take and store data from the available information resources, collect information acquired in the process of negotiation, take over tasks of offer exchange and working out initial compromise); they return results of their operations to Interface Agents.

General architecture of the first group of agents presents Figure 3.

Information agents take over tasks of collecting, analyzing and making market information helpful in preparation to negotiations with clients and suppliers available to manager. They also take over tasks of offers exchange – so called packages. Offers, that is lists of items to negotiate and their weights are sent as KQML (Knowledge Query and Manipulation Language) language commands. Items to negotiate are among others: price, quantity, quality, delivery terms and conditions, payment conditions, guarantee, discounts. Packages are subject to evaluation, and worked out by Information Agents possible compromises are presented to managers to accept or modify with respect to the weight of particular negotiated items. If the agreement is accepted, Information Agents cease their operation and the final part of the negotiations concerned with signing contract and accounting is taken over by man. In the case of lack of acceptation however, Information Agents work out compromise again or their operating is interrupted. Thanks to application of Information Agents and the possibility of holistic packages comparison by managers there exists a chance of Pareto-optimum compromises achievement [9].

The proposed in the work model was elaborated in the AgentBuilder environment of Acronymics Inc. The research of the simulating model was divided into three stages:

- formulating, describing and assigning tasks to software agents,
- multiagent system implementation – elaborating system’s ontology, establishing concluding rules of particular agents, negotiating protocol and communication with database,
- elaboration of coordination method among agents,
- simulation and verification of the proposed model.
Where:

**JDBC Agent** - software agent for database service.
**HTTP Agent** – software agent carrying out function of information acquisition from websites.
**E-Mail Agent** – software agent for electronic mail service.
**FTP Agent** – software agent for file transfer service.
**Auxiliary Agent** – for communication with other software agents in KQML language.

Fig. 3. General architecture of the first group of agents. Source: own analysis.

At present the research focuses on the second stage – MAS system implementation. Initial simulations concerning contract negotiations among software agents representing two sides of negotiations are being carried out – Figure 4.

The criteria for evaluation of negotiated packages is value of their usefulness function described by the formula (1):

\[
\sum_{i=1}^{m} \sum_{j=1}^{n_i} u_{ij} x_{ijk} = U(p_k).
\]

Where:

- \(U(p_k)\) – \(p_k\) package usefulness,
- \(k\) – number of packages,
- \(i\) – item to negotiate,
- \(j\) – j option for i item to negotiate,
- \(u_{ij}\) – partial usefulness of j option for i point to settle,
- \(x_{ijk}\) – binary variable indicating if j option of i item is present in \(p_k\) package,
- \(m\) – quantity of items to negotiate,
- \(n_i\) (i = 1……m) – quantity of vital items to negotiate.
4 Summary

Acquisition of up-to-date market information is one of the crucial factors influencing management efficiency of contemporary enterprises. Enterprises possessing proper, efficient information will not perceive external environment as a barrier in their development, but rather as a stimulus to innovative operations. Due to this fact a higher efficiency level of market information management should become a goal to pursue. The fulfillment of this postulate requires a new model of information system to be designed, characterized by elasticity, autonomy and reactivity to changes occurring in the enterprise’s environment. Its monitoring is a process of constant following and search for market changes, sending offer inquiries, etc. Changes happening in the enterprise’s environment often generate surplus of information [4]. Not all the enterprises are able to make the proper use of this fact. Efficient system of market information largely conditions creation of the market offer by the enterprise, and also influences maintenance or gaining of competitive advantage on the market. Moreover, enterprise management often requires real-time reaction, which means receiving information about an economic event the moment it happens and immediate dispatch of feedback information.

Business negotiations are an important source of market information – which is clearly visible when analyzing negotiating processes from the perspective of their full “life cycle”. Information is generated at various stages of the negotiating process.

The proposed in the paper conception of multiagent system aims to show possibility of market information management through improvement of enterprise’s business negotiations with other, present in its environment subjects. This is particularly important because there are often multisided negotiations run in enterprises.

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Improving Supply Chain Operations performance by using a collaborative platform based on a Service Oriented Architecture

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Abstract. Every new technology promises to solve a lot of problems inside companies and to achieve unforeseen performance improvements. Nowadays, Service-Oriented Architectures begin to be promoted as new balsam where companies may realize their visions and put all their new strategies in practice. Initially focused on intra-organizational integration efforts, they begin to be used when supporting inter-organizational business processes engineering in networked organizations. Although these kinds of initiatives in most cases are lead by major companies, the INPREX project (Spanish acronym for Interoperability in Extended Processes), here presented falls out this category. By contrast, this is an undergoing initiative leaded by a Small and Medium Enterprise (SME) and founded by a local government in Spain. In this work, we introduce the IDIERE Platform which has been designed for supporting three major requirements of networked enterprises: openness, flexibility and dynamism when deploying and executing distributed business processes.

1 Motivation

Collaborative Networks (CN) are enabling new ways of conducting business transactions and functional alignment between their members [7]. As organizational form, they tie together two or more companies that had understood the benefits of conducting win-win partnerships coming from such collaborative environments ([2], [6]).

When adopting this emerging approach, extended functionality needs to be designed and deployed to reach such levels of interaction. Collaborative, Extended or Distributed Business Process are terms used to name a set of activities that, in such context, need to be carried out in order to accomplish some commonly agreed business goal.

New technologies, mainly those related to the Internet are enabling the deployment of global business processes and facilitating, at the same time, the interoperability of the information systems in which they are supported [8].

The INPREX Project is an undergoing initiative founded by the Ministry of Education and Science of the Spanish Government. One of the main objectives is the de-
ployment of a platform (called IDIERE) that, taking advantage of web services and their orchestration, enables the engineering, deployment, execution and monitoring of distributed business processes in a network of companies surrounding one SME stamping firm in the automotive sector, located in Valencia, Spain.

In this work, we are going to present the architecture and main components of the platform and how it has been used to improve the coordination and information visibility in a distributed business process inside a network of companies surrounding a stamping firm in the automotive sector.

The paper is structured as follows: Section 2 depicts how the service-oriented architectures support Distributed Business Process Management. Then, in Section 3, the IDIERE Platform is presented, that is, its architecture and the software components that implement the architecture. In Section 4, how it has been applied for improving a Production Planning Business Process and, finally, in Section 5, we state some conclusions that we are gaining when developing this project.

2 Distributed Business Processes Management and Service-Oriented Architectures (SOA)

2.1 Introduction

Relaying on emergent Internet technologies, Service-Oriented Architectures (SOA) [3] are allowing to conceive the Internet not merely as a communication channel but also as support of more complex activities tied, for instance, to purchasing, personnel recruiting or customer service support.

Business process management’s requirements and the Internet are moving towards a third stage of evolution [9] where the applications that support business processes are conceived as a single user graphic interface (based on web browsers) but whose functionality is composed of computational capabilities on the client side combined with a set of invocations to third-party provided services ([1]).

The main changes provided by SOA are:

• The capability of narrowing down the gap existing between the modelling and the operational phases of the business process engineering, by means of intermediate languages like Business Process Execution Language (BPEL) to link the business process modelling world and the web-services world. BPEL is explicitly designed to work with Web services and provide coordination and integration of business services into higher-level business processes.

• The emerging web-services technologies (mainly XML, SOAP, WSDL, UDDI and BPEL4WS) supporting the service-oriented architecture are wide-spread and well-accepted by service-oriented tools.

• Web Services allow a loose decoupling between process’s functionality and executors [4] so they provide a higher dynamicity
When these concepts are applied to collaborative networks (CN) they gain additional advantages related to information sharing policies and visibility. SOA-based applications orchestrate and compose invocations of computational capabilities by means of service interfaces. This mechanism allows companies to keep as independent as they want by only providing the information that could improve the global performance of the CN.

Based on those principles, has been proposed [4] that web services interfaces are able of encapsulating activities, or sub-processes, of a business process definition, and then, support composition and execution of their instances.

2.2 Web Services extended

The term Web Service is used by various groups to describe widely differing concepts. From a technological perspective, they have been defined as [11].

A Web service is a software system identified by a URI [uniform resource identifier], whose public interfaces and bindings are defined and described using XML. Its definition can be discovered by other software systems. These systems may then interact with the Web service in a manner prescribed by its definition, using XML based messages conveyed by Internet protocols.

By contrast, in a more business-related context, web services are also considered as pieces of business functionality that companies provide (offer, rent or sell) to third parties by using Internet-related technologies.

Despite the technological complexity that may be related to this technology, most companies can be able of start providing services in a short period of time. This has caused that service offering rate had increased quickly but without much order.

Although web services are not distributed objects [10], applying object oriented computing principles may help when engineering software applications based on SOA. Looking for such order, some attempts in the right way have been carried out [5] where an extension of web service’s concept has been proposed in order to create an upper-level entity which provides a unique access point for a set of web services belonging to the same domain.

2.3 Supporting distributed business processes

Distributed business process can be conceived as a set of activities which are assigned to different members of a CN in order to be accomplished to achieve a common goal. When modelling this kind of processes, is not always possible to keep the same abstraction level for each activity/role. In fact, depends on how much detail can be gathered. More, initial steps in process modelling always begin with a more or less clear picture but without so much detail.

In the scope of this work, these two interrelated concepts will be introduced:

“Definition 1: an Execution Unit is a work package that may be composed of a single activity, a sub-process or a whole process and that could be assigned to some executors which have the proper knowledge and capacity to accomplish the task for the global process”
From the information flows management perspective, the execution unit can be seen as a computational function \((ws)\) which maps some Data Inputs into Data Outputs through some internal logic not accessible by others (in a black box way).

This led us to the concept of service and service provider. If each execution unit is wrapped under some interface that can be located and consumed by third parties, it is possible to consider it as a service that may be provided by some service provider.

Then, service providers or executors can be defined as follows:

**Definition 2:** executors are those service providers (organizations or their resources) that are capable of accomplish some execution unit for the global process by providing and consuming third-party services.

And relying on SOA principles, it could be convenient to add:

“...by means of web services interfaces and a supporting data model.”

We consider executors as some extension of the object web service concept. They represent a conceptual unit that will be used as functional/computational building block when assigning some execution unit for accomplishment. They have the following structure (See Figure 1):

- **Data Model layer:** this data model is specific for the business domain within which executor works and it’s devoted to provide the interoperability foundations from the information flows perspective.

- **Internal Logic layer:** the data model represents the external interface to be exposed in terms of information. If some additional computation is needed or existing system must be integrated, the internal logic layer is the mechanism to be used.

- **WS Layer:** the internal logic may use several mechanisms to feed up the data layer, even web services. Despite this, this layer is devoted to provide a set of web services that will be offered to external applications. This layer is also dependable of the executor’s interaction scenario.

There is no one single definition for executors. Instead of this, like when defining classes in Object Oriented Programming, it could be better to define as many types as needed.

Then, it’s possible to consider as executor to all organizational resources that may provide some services to a global process by means of their WS interfaces. In this sense, whole organizations, organizational units, systems, machines or devices (which can be used for human interaction) being able of run web services instances may fall under this definition.

![Fig. 1. Executor’s Architecture](image-url)
In order to completely define the execution model, we must create the execution units (eu) which represents the atomic building blocks used to compose inter-organizational business processes. Each eu represents a complete piece of work that will be assigned to executors in order to be accomplished.

The proposed Execution Model is based on execution units’ assignment and monitoring to different executors. This facilitates a loose coupling of execution units and the corresponding executor, enabling either early or late binding (at process runtime) between them (See Fig. 2).

**Fig. 2.** The Execution Model assigns EU to executors and maps business representations with process interfaces at runtime

3 The IDIERE Platform

The IDIERE Platform relays on SOA capabilities in order to automate business process execution and monitoring. The platform provides a set of components allowing users to be involved in several business process instances of execution.

The principle is straightforward: it works as any business process system does but, at the same time, it provides different levels of automation when needed. Such levels of automation are supported by corresponding web services interfaces.

IDIERE Platform is the information system that supports distributed business process management capabilities by providing a set of components that allows creating and maintaining a centralised set of repositories of processes, executors and exchanged messages in each process’s instance.

3.1 The IDIERE Architectural View

The IDIERE Platform, is based on a traditional client-server architecture that is deployed over the Internet. Inside the platform it’s possible to identify:

- **The IDIERE Server**: it supports two major phases: process engineering and execution. It allows defining collaborative business processes structure, storing them in a common repository, registering executors, assigning execution method and executors to individual activities or sub processes, monitoring delegated activities, deploying a set of indicators for performance measurement.
− **Client-side:** in terms of users, there would be a set of nodes which may be connected to the platform in order to notify each assignment’s status. Each node represents the instantiation of one executor for each process instance. Correspondingly, each deployed thin client, will act as Task Manager for the system (in the traditional workflow sense) but having some extended functionality.

Initially, we have defined three different kinds of users that will access the platform that is, users that will interact with the platform in order to: manage processes, accept or reject assignments, or status reporting. The types of user identified are:

− **Organization:** this user initially will act as any company that provides some service to a process. By means of its Task Manager, it will provide a service interface that may be located and accessed by the server some eu accomplishment. When Workers users are present, work items can be delegated.

− **Workers** are nodes belonging to an Organization. A Worker is a Task Manager also but with a simplified functionality in terms of capabilities for delegating tasks or accepting offers, for instance. Organization is able of adding their workers by registering them into the system. Once this process has been completed, tasks can be delegated to these nodes to be internally processed.

− **Individual:** finally, it represents individuals not belonging to any organization but, once registered, may conduct transactions inside the platform.

### 3.2 The IDIERE Software Architecture

Major components of the platform are shown next (software modules, applications and databases) and how they are interrelated.

![The IDIERE Architectural View and its Major Components](image)

**Fig. 3.** The IDIERE Architectural View and its Major Components

On the server-side, the architecture is mainly composed of:

- **A Business Process Modelling Tool:** it’s devoted to model business processes in a graphical way. Definitions are stored in three repositories:
  - **A Centralised Business Process Repository (CBPR)** which will store business process definitions. This repository can consider processes appearing in reference mod-
els as SCOR, or in standard documents as the ISO series; business processes defined by a user as a template and finally business processes induced from web-services by an inducer tool.

- A repository with all the business object documents that will give support to the definition of information and control flows.
- The Network model configuration module is devoted to configure all those topics related to the network deployment. That is, the organization model, executors’ permissions or additional parameters.
- The Business Process Engine is responsible of executing and monitoring processes’ instances. Consequently, it considers the enterprise models released by the business process modelling tool and it is able to execute and monitor them. By assigning each execution unit to the corresponding executor.
- Web Services Portfolio within which all active web services definitions that may be used to compose a business process will be registered. There will be three kind of services: sub-contracted with third parties (outside of the CN), internally deployed (owned by the core members) and additionally those services that the CN will able to provide to third parties to be consumed.
- The inducer engine is capable of inducing business process templates from existing web-services definitions.

4 Case Study: an SME stamping firm in the automotive sector

4.1 Business scenario

The IDIERE Platform has been deployed inside a network of companies surrounding an SME (which is a 1st-tier Supplier, and high level sub-assembly supplier, for one Original Equipment Manufacturer (OEM) in the automotive sector. The company is responsible for its own logistics and independently chooses its own suppliers (2nd-tiers), the components of its products, etc.

The network, as it is now, has a relatively low degree of synchronization and collaboration. Generally, although the production plans of the company that is directly connected with the demand are those who launch the supply chain’s production, certain information that needs to be drawn upstream is held up and sequentially the cycles of planning and production decrease, and therefore the delivery time of the final item is significantly affected.

Currently, this information flow is relatively restricted. The SME receives OEM’s demand planning and makes its production plans and attendant orders to 2nd-tiers according to it. But when small-scale changes and variation in demand coming from the OEM arrive, SME’s production plans and order needs change, but the sub-tiers are not informed on time and thus do not have the time they may need to change their own planning, if this is possible.
4.2 Proposed solution

We have applied the IDIERE platform principles in order to achieve a successful reengineering of the Production Planning Process (PPP).

After conducting a BP Analysis, PPP was identified as the most critical and conflictive one. Due the company’s raising trend of outsource part of their production activities, more information visibility and co-ordination of such activities was needed.

Three kinds of executors were identified and their services modeled:

1. Productive: they transform some inputs (raw material or components) into outputs (components) by performing of some activity (stamping, painting, welding or similar). Finished or semi-finished goods are packaged in specific containers.
2. Transport: this kind of executor moves containers between productive executors.
3. Warehouse: they stores finished or semi-finished goods

Fig. 5. Organizational resources have been modeled as executors

Once executors have been modelled, supporting services were developed for each kind of executor. Then, there is a set of services belonging to each one of them. For instance, productive executors are able of notify stocks, capacities, enact their Bill of Material, receive demand, put orders and so on.

Table 1. Supported services (non exhaustive)

<table>
<thead>
<tr>
<th>Executor</th>
<th>ServiceName</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Productive</td>
<td>NotifyDemand()</td>
<td>It allows knowing which the demand for some reference is.</td>
</tr>
<tr>
<td></td>
<td>NotifyStock()</td>
<td>It returns stock of some reference</td>
</tr>
<tr>
<td></td>
<td>BillOfMaterial()</td>
<td>It returns those references which compose other one</td>
</tr>
<tr>
<td></td>
<td>Capacity()</td>
<td>Notify agreed capacity about some reference based on signed contracts</td>
</tr>
<tr>
<td>Warehouse</td>
<td>Input()</td>
<td>Register receptions of material</td>
</tr>
<tr>
<td></td>
<td>Output()</td>
<td>Register material consumptions</td>
</tr>
<tr>
<td></td>
<td>Stock()</td>
<td>Notify availability</td>
</tr>
<tr>
<td>Transport</td>
<td>Load()</td>
<td>Load some package into the transport</td>
</tr>
<tr>
<td></td>
<td>Unload()</td>
<td>Unload packages</td>
</tr>
<tr>
<td></td>
<td>Move()</td>
<td>Move them between executors</td>
</tr>
</tbody>
</table>
After that, we modeled the production process of each reference (almost ninety) as a business process within which each activity (stamping, welding, and painting) is associated with the corresponding executor and its services.

By using this set of services we provided the SME with a complementary module running in the platform: a collaborative planner who checks SME’s plans feasibility after analyzing the information gathered from each executor and, complementarily, traces plan’s execution.

5 Conclusions

In this work we have presented advances in the work carried out within the INPREX Project. We have introduced the IDIERE Service-Oriented Platform, and have defined the main components that implement it. The project looks for a low-cost, flexible and extensible platform that companies can use in order to design and execute inter-organizational business processes by composing a sequence of services invocations.

We strongly rely on Service Oriented Architectures as a medium for enabling Small and Medium Enterprises get involved in this kind of initiatives. By adopting standards related to the Internet (Web Services stack for Communications, current initiatives like OAGIS for content and BPMN/BPML for modelling) we have composed a framework that is open, flexible and dynamic.
Regarding the project, it could be convenient to point out that currently there are a lot of initiatives concerning business process management by using web services composition, but real undergoing implementations being carried out by SMEs are not so usual. Currently, we are at the development stage of major components.

Acknowledgments

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References

A Workflow-based Environment to manage Software-Testing Process Executions

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Abstract. This work describes a workflow-based environment that manages the execution of software-testing processes. Testing processes require that human and computer resources be handled as dedicated resources, previously scheduled for testing activities, with no overlapping. Two striking features of this environment are: a) the efficient handling of resources by taking into account the capabilities offered by resources required by testing activities, and b) it provides a broader view of all execution steps in a software-testing plan. Hence, it enables a better planning of software-testing process executions, as well as of human and computer resources involved.

1 Introduction

Quality assurance in software products has increased the interest on software testing processes. New software development life cycles have stressed the importance of starting testing as early as possible in the software development life cycle [18]. It also demands increasingly efficient tools and techniques for the description and management of testing processes, as well as qualified staff to execute them, with various profiles.

Testing software means running it in an effort to find errors [6,11]. Testing a software product implies the definition of the Software Test Plan (STP), which defines a sufficiently encompassing number of test cases. According to [11], an STP should describe: (1) the computing environment in which the tests will run, (2) the capabilities required from the testing team, and (3) the sequence of test cases execution, as well as the procedures to handle errors. To properly execute STP, software testing centers are composed of appropriate computing and human (testers and test engineers) resources. Test engineers define and manage the execution of STP, and create the corresponding test reports. Testers develop the individual test cases, according to their competences. For a better management of the testing process, test centers usually split each STP in blocks of test cases, referred to as test activities, which are distributed among testers.
Independent test activities may be allocated to different testers, enabling a parallel execution of these activities, and, consequently, saving STP elapsed time.

To properly manage a test center, there must be a deep understanding of its main characteristics: (1) resources are limited; (2) many of these resources need previous configuration or set-up before use; (3) tests described in the STP must be run in a predefined sequence; (4) distinct test sequences from the same STP can be executed in parallel; (5) unexpected results in a specific test may abort the test, a sequence or the entire test plan; and (6) delays caused by software development teams can significantly impact in all schedule planning of tests of the test center. As a result, the test manager should be aware of (a) which test plans are being executed and at which test activity each test plan is, (b) which resources are currently allocated and which are free to be utilized; (c) what the future resource schedule is; (d) which test plans are waiting to be run; (e) the average time taken to configure a computing system for the execution of a test; and (f) which test plans are waiting for developer feedback before resuming execution. All this information is important to achieve the optimized use of (limited) resources, agility in test execution, as well as to identify bottlenecks in the process. To achieve such level of control, it becomes necessary to provide adequate tools that allow test engineers or process managers to manage its execution and use of resources.

An important aspect that software testing processes share with production processes [24] is the need of full and exclusive dedication of human and computing resources to their respective test activities, during the whole process. The Enterprise Reference Architecture CIMOSA\(^1\) (Computer-assisted Industry Management - Open System Architecture) states that “Enterprise Activities of a particular enterprise define elementary tasks to be performed in the enterprise which consume inputs to produce outputs and need allocation of time and resources for the full duration of their execution”. In other words, neither the tester nor the computing system allocated to run a test can perform other activities concomitantly. Workflow management systems (WFMS) are targeted at handling the execution business process activities [8,12]. However, workflow technology fail to provide support for handling human and computing resources as resources in production-processes [4].

This paper presents a workflow-based environment for the management of the software testing processes, which regards human and computing resources as production-process resources, in the context of the CWf-Flex project. The main contributions of this environment are: (1) the efficient management of resources for the execution of test activities in view of the competences required; (2) efficiency, reliability and an encompassing view of the entire course of the STP by a workflow automation standpoint; and (3) the use of open-source software tools and solutions.

\section{A Motivating Scenario}

In 1999, our University and a major IT company launched a partnership which established a software test center (STC). This center has been able to identify the specific needs of this kind of process, like the need to work with limited resources with varied

\footnote{http://cimosa.cnt.pl/Docs/Primer}
capabilities. As indicated by the characteristics already mentioned, workflow technology presents an advantageous solution to all these needs.

Between 1999 and 2000, an experiment was made in this test center, using a WfMS to support test management. The WfMS chosen was Changengine [9], and the following evaluation of the advantages and disadvantages of using a workflow approach showed that WfMS did not provide two important characteristics in a test process: the support for human and computing resources as production-process resources and the STP as single execution instance for each process model. Before the effecting of an STP, the computing system to be used must be configured with the proper operational system and a clean software environment. This is necessary in order to ensure the detection of errors happening strictly in the software being tested, and not errors in anything unrelated with the test specification. When identifying bugs and non-conformities, it must be possible to isolate and replicate the error, not only by the testing team but also by the development team. This is essential to ensure the quality of the testing. Since it is impossible to cover all possible hardware and software configurations at the same time in a test center, a prior setup time is frequently needed to reconfigure the machines before running a different set of tests.

A study was also conducted to identify if the standards for the description of workflows and the modeling of production-processes met the requirements of a software test center. The result was the proposition of the conceptual reference CWf [4,20], which merges the WfMC interface 1 [22] with the CIMOSA standard [24] in the description of production-processes. For the design of CWf models, a UML-extension was proposed to support CWf additional concepts: Workflow Activity Diagrams WAD [5]. The CWf-Flex project is a direct evolution of the union of these research efforts.

3 Environment Architecture and Description

The main goal of the CWf-Flex project is to specify and implement an open, flexible environment for the description of software-testing process, and management of executions, providing support for definition and management of human and computing resources. This environment is composed of three parts: (1) design module, (2) formal description model and (3) execution environment. The design module allows to model testing processes using WAD (Workflow Activity Diagram) [5] WAD is an extension of UML-Activity diagrams and aims at supporting CWf designs. The prototype of the design module [21] is able to generate a corresponding XML specification from a WAD test process modeling.

The formal description model is the standard by which the two parts (description and execution) communicate. A test process specification is made by using XPDL [23], with extensions proposed by CWf [4], in the form of a XML-Schema named XCWf. The main extensions present in XCWf are: (a) capability and capability-set, which may be associated to activities (required capabilities) and resources (available capabilities), (b) the definition of machines as a resource type, and (c) definition of synchronous transitions for the synchronized start of parallel activities or sub-processes. Inherited from CIMOSA, XCWf introduces the synchronized start (S-AND-split) as an additional routing construct besides AND-split, AND-join, OR-split and OR-join. An XCWf+XPDL
Table 1. Table 1 Partial Use Case Description

<table>
<thead>
<tr>
<th>Use Case</th>
<th>Actor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insert Project</td>
<td>Test Engineer</td>
<td>Loading of the XPDL+XCWf (text file) specification. Process and resource consistency is verified.</td>
</tr>
<tr>
<td>Schedule Activities</td>
<td>Test Engineer</td>
<td>Allocates and schedules testers and computing resources for every activity of a new project. These resources should fulfill the capabilities required by the activities. This scheduling takes into account the work calendar and availability of the human participants. The activity scheduling must abide by the sequence of their execution, as defined by the XML specification.</td>
</tr>
<tr>
<td>Execute Project</td>
<td>Test Engineer</td>
<td>Enables the execution of the process. Activities which can be executed are inserted in the allocated participants worklists.</td>
</tr>
<tr>
<td>Review Project</td>
<td>Test Engineer</td>
<td>This interface is provided to enable the managing of the test process itself. Its progress can be checked at any time during execution, and the engineer may view which activities are scheduled, which are ready to execute, currently running or complete.</td>
</tr>
<tr>
<td>Review Worklist</td>
<td>Tester</td>
<td>Displays the worklist, informing which test activities are ready to be executed and which are currently being executed.</td>
</tr>
<tr>
<td>Review Schedule</td>
<td>Tester</td>
<td>Displays the schedule for human and computing resources according to their planned activities.</td>
</tr>
<tr>
<td>Execute Activities</td>
<td>Tester</td>
<td>Either sets an activity for execution or notifies that it is concluded. The environment evaluates the specification and enables the execution of the subsequent activities.</td>
</tr>
</tbody>
</table>

specification complies with XPDL using the XPDL extended-attributes option. This allows an XCWI+XPDL specification to be executable by an WIMS according to the XPDL, Interface1 of the WfMC reference model [8]. S-AND-split can be roughly simulated by the use of AND-split plus a set of deadline constraints. In fact, this solution does not guarantee the simultaneous start of activities.

The execution environment, described in the remaining of this section, is a workflow engine that enables the management of software testing processes. Its striking feature is the ability of effectively allocating human and computing resources, besides implementing the typical routines of a STC.

3.1 Overview of the Workflow Execution Engine

Table 1 presents use cases representing the main functionalities of the execution workflow engine. The maintenance of the STC basic data-sets and of human and computing resources is not shown. Only information pertaining directly to the process is kept by the environment, such as work schedule, capabilities (for human resources) and basic configuration (for computing systems).
Activity scheduling is a crucial functionality, since it supports the resource allocation planning activity. In the current prototype it is performed manually by the test engineer, but an automated allocation tool is under consideration, based on the M-DRAP approach [3]. M-DRAP is a multi-agent resource allocation approach where every single resource is managed by an intelligent agent, which, in turn, negotiates its commitments to test activities with the other agents. The data model for the execution environment was designed so as to easily perform this extension, such that only very exceptional cases would require the assistance of a test engineer during scheduling.

3.2 Execution Engine Data Model

The execution environment data model extends the model presented in [14] in two ways: a) it provides support for the extensions proposed by the CWf reference model, and b) to persist data related to the work calendar of human resources, their capabilities and the resource activity schedule. Figure 1 shows the class diagram with the main abstractions. Human and computing resources, with their respective capabilities, are represented by the Human, Machine, Capability and Configuration classes. They represent the work force and computational infrastructure the STC has at its disposal.

When a specification is loaded, objects referencing the control flow are created in the Process, Activity and Transition classes. Each activity is associated to one or more Capability, to reference the required set of capabilities from a Human, and to one or more Configuration to reference the required system configurations. Each configuration corresponds to a different machine that will be employed in the activity. There is a special type of activity, named route activity, with no association to Capability and Configuration. It serves only to describe the control flow when its description is not possible in common activities. The activity schedule is established through the Schedule class, where the period in which the activity will be executed is defined, also associating: a Human with all required capabilities, and one or more Machines corresponding to each configuration.

During a process execution, the ProcessHistoric and ActivityHistoric classes store all state transitions of Process and Activity, including the starting states when a specification is loaded. The TransitionHistoric class stores the actual passage of the process through a transition in the model. The state diagrams adopted for Process and Activity are described in [8,12]. Activities ready to be executed are made available to their respective participants through their worklists, taken from the activity states and scheduling, which are stored in Schedule. Every time an activity is completed, the execution environment checks what are the next activities to be executed, according to the corresponding specification. Each process has its set of relevant data, visible to the execution environment, to select which paths are enabled on an Or-splitting activity.

3.3 Implementation Architecture

A client-server architecture has been adopted, where the client is a Java-enabled Internet browser, and the server side is composed of three tiers: presentation, business rules and data persistence. The J2EE technology has been used in the development of environment as a whole. The presentation and business rules layers are enclosed in the
Web server, along with the Java Server Pages (JSP). The presentation layer is based on the Model-View-Controller standard. The WebWork\(^2\) framework has been used in this layer, mainly because it offers better functionalities for the validation and conversion of types when compared to other solutions. For the business rules, the Hibernate\(^3\) framework was adopted because it provides abstraction mechanisms for database access, which allows an easier migration among data persistence tools. The use of these frameworks has made possible a better standardization in the source code, and also allowed greater efficiency and quality in the development process. For the data persistence layer, the PostresSQL\(^4\) DBMS was chosen for both its transaction support and level of conformity to the SQL standard.

![Partial Class Diagram](image)

Figure 2 shows a typical Web page, the commitments of a tester, with the visual standard adopted. The upper menu in the screen belongs to the browser being used. The left side menu presents a hierarchic structure consistent with the modeled functionalities, and allows the easy access to the different system functions. These menus options may vary from user to user, depending on the logged users profile. Through this menu, all data relevant to the STP may be retrieved, including test plans being executed and completed, and resource commitments to the STP (by reviewing participants schedules and worklists, etc).

### 3.4 Innovative aspects of the Execution Environment

The implementation solution presented here fulfills the needs identified in section 2 above. It is a system that offers an efficient management of the test processes and the commitment of resources to these executions. In order to do that, the environment enables the resource scheduling for the entire process even before it starts its execution. Such scheduling takes into consideration testers capabilities and work calendars and previously scheduled activities of other STP. This permits test engineers to predict the involvement of the work force with test activities, to size up their test teams and computational infra-structure and to properly plan the growing of the test center. Besides, it guarantees the simultaneous start of activities, when specified in the model.


\(^3\) [http://www.hibernate.org/5.html](http://www.hibernate.org/5.html)

\(^4\) [http://www.postgresql.org/docs/](http://www.postgresql.org/docs/)

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Fig. 1. Partial Class Diagram
4 Related Work

[13] presents many WfMS development projects using open-source software, which supports XPDL at various degrees of conformance. Our approach, based on [4], looks at resources as production-process resources, which is not supported by the [23] and [16] specifications. Likewise, it is not supported by either other open-source projects such as YAWL [1] or commercial tools such as AQdevTeam [2].

TestDirector [15] is a leading workflow-based tool that addresses the management of software testing processes. It support resource allocation, permitting to view resource skills, assignments and load rates. Our approach works with exclusive use of resources by activities and not with load rates. Testlog [17] is a tool that permits the definition of resources similar to our approach: testers, hardware platforms, test configurations, etc. In addition, it permits the assignment of resources to test cases. However, it supports neither the testers capability description nor resource scheduling, as opposed to what our approach proposes.

[19] introduces a multi-agent approach for the modeling and scheduling of resources in activity coordination. Two types of resources are discussed, schedulable and not schedulable. An abstract resource model and four basic operations for its manipulation are presented: identification, reservation, acquisition and release. Even though the schedulable resources are adequately typified, the authors do not explore them fully.
They state that even in a process with a previously defined order, the agents will manage their appointments and execute activities at their own discretion. Our solution keeps the global scheduling of activities and supervises their execution, according to the test process specification, which is essential to the execution of testing activities.

[7] presents a WfMS for grid computing, named GridFlow, and addresses the workflow scheduling problem using a fuzzy timing technique. Similar to [3] approach, GridFlow is an agent-based resource manager, but oriented to grid resources. Grid computing means the execution of multiple parallel tasks with maximum resource utilization. [7] states that WPDL [22] is sophisticated and too generalized for grid computing. Resources have different capabilities and should be allocated properly in our approach, as opposed to GridFlow. However, the fuzzy timing technique can be useful to improve our resource management.

5 Conclusions

This work has detailed the research made in the context of the CWf-Flex project, for the specification and implementation of the execution environment. The characteristics and problems of test process management were described, and, in particular, the necessity to adequately support human and computing resources, especially during test activity scheduling. Besides that, it also references the adoption of the XPDL standard for workflow description, along with the extensions proposed by [4], such as the procedures for test process specifications exchange. The environment was developed using only open-source software tools, which allows its portability to different operational systems. The addition of new modules is to be considered for future versions. The main contributions are (1) the previous scheduling of resources to the activities, even before the execution of the test process, (2) the consideration of the capabilities of testers when selecting activities for them, (3) the control of collisions in the schedule, and (4) the beforehand knowledge of resource commitment in the test center.

The project’s current stage is the installation of the environment in an STC, with the intention of assessing requirements compliance, accessible use and the quality of generated productivity information. Apart from that, the implementation of the [3] dynamic resource allocation approach in the project core, as well as a method for the definition of workflow processes, with resource allocation, is being considered in a near future. This method will be based on the description and execution environment specification and the formalization of the description model.

Acknowledgment

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References

Using Timed Model Checking for Verifying Workflows

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Abstract. The correctness of a workflow specification is critical for the automation of business processes. For this reason, errors in the specification should be detected and corrected as early as possible - at specification time.

In this paper, we present a validation method for workflow specifications using model-checking techniques. A formalized workflow specification, its properties and the correctness requirements are translated into a timed state machine that can be analyzed with the UPPAAL model checker. The main contribution of this paper is the use of timed model checking for verifying time-related properties of workflow specifications.

Using only one tool (the model checker) for verifying these different kinds of properties gives an advantage over using different specialized algorithms for verifying different kinds of properties.

1 Introduction & Related Work

In recent years, interest in business process automation has raised. One reason for this is that the concept of web services allows integrating web-based applications using open standards.

Developing a large system using web services starts with specifying the flow of control and information between these services - the workflow. This task should be done by domain experts. Different business process definition languages have been developed for specifying workflows, the most important ones are BPML, BPEL4WS, XPDL and UML2 activity diagrams. An increasing number of software tools abstract from the syntax of the business process definition language, allowing the business process analysts who specify the workflow to use a graphical notation (for example BPMN).

It should be possible to eliminate errors (like deadlocks or missed deadline constraints) in a workflow specification at specification time. Model checkers are sophisticated tools that are able to find exactly this kind of errors for a given system. What remains to do is to translate the workflow specification and the requirement we are interested in into the input language of a model checker.

Our paper shows how this "translation" can be done. Similar approaches were proposed by several other authors: [1] starts with an informal description of a business process. This description is being translated into the input language of the NuSMV model checker which can check basic properties like liveness and reachability. [2]

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checks various properties of business process specifications modelled in Testbed, a framework for business process reengineering. The business process specification can be defined by business process analysts using the Testbed tool, while the model checking must be done outside the tool by model checking experts. A follow-up paper [3], identifies some patterns of properties for business process specifications. Queries about these patterns are transformed automatically into an LTL formula, allowing people who are not familiar with the details of model checking to test properties of the business process specification based on these patterns. [4] translates business process models defined in the XPDL language into the input language of the SPIN model checker in order to check their properties.

In all these publications, the properties than can be checked by a model checker, depends on logical order between activities, not on their timing. Other than these existing approaches, we take into account time-related properties (deadlines etc.).

We give an example for checking very different workflow properties: structural correctness, resource constraints, deadlines and dependences between different activities. In the overview below, we will refer to algorithms that allow to check these different classes of properties. The main contribution of this paper is to exploit only one tool for checking the different properties instead of using one algorithm to check the structural correctness, a second one for verifying the deadlines and other ones for reasoning about deadlocks, reachability or resource conflicts.

Scheduling of activities under resource constraints is a well-studied problem in operations research, known as Resource Constraint Project Scheduling Problem (RCPSP). The general problem - finding a feasible schedule for a set of activities such that the time for completing the project is minimized - has shown to be NP-hard [5], therefore different heuristic algorithms have been suggested for solving it [6]. Finding resource conflicts in a given workflow is much easier than solving the RCSP. [7] presents an algorithm to find such conflicts. (Our example workflow is based on the example used in this paper.) This is done by simply finding the earliest starting time and the latest completion time of each activity. However, the dependencies between the activities are not taken into account which leads to many false positives. Our model checking approach gives a more accurate result than [7].

[8] discusses the use of timed automata for solving the scheduling problem, which is also the key idea for our model-checking approach. [9] has expanded the net diagram technique PERT to ePERT which can be used for workflow specifications.

Structural correctness can be verified using graph analyzing techniques [10, 11], which require the use of special-purpose nontrivial algorithms. Graph analyzing techniques can also be used for answering "basic questions" about reachability and dependence between activities (“Will a receipt be sent for every order?”, “Is it guaranteed that no receipt can be sent if the ordered item is out of stock?” etc.)

With our model checking approach, such specialized algorithms for checking specialized requirements (resource constraints, structural correctness etc.) can be substituted by using only one tool that can be used for verifying different kinds of properties.
2 Definitions

2.1 Workflow Specification

The Workflow Management Coalition defines a workflow as the computerized facilitation or automation of a business process, in whole or part[12]. A Workflow Management System (WfMS) is defined as a system that completely defines, manages and executes workflows through the execution of software whose order of execution is driven by a computer representation of the workflow logic.

In order to be processed by a WfMS, a workflow has to be specified in a formal language that can be executed by computers. This language must define the order of activation of activities and the information flow between them.

Before we give a formal definition of a workflow, we have to introduce the basic concepts:

An activity is a description of a piece of work that forms one logical step within a process[12]. Activities are scheduled by a WfMS. Their execution order is specified by transitions. In the simple case of a (sequential) transition between activities, one activity completes and the thread of control is passed to another one, which starts. To be able to define more complex business cases, we further need the control structures AND-split, OR-split, AND-join and OR-join, with the usual semantics [12].

We define a workflow specification as follows:

Definition 1 A workflow specification is a 4-tuple $(N, n_0, f, T)$, where:

- $N$ is a set of nodes which is defined as the union $N = A \cup C$, where $A = \{a_1, \ldots, a_n\}$ is a finite set of activities and $C = \{c_1, \ldots, c_m\}$ is a finite set of control nodes. Each control node is either an AND-split, an OR-split, an AND join or an OR-join, which is denoted by the type function $\text{type}: C \rightarrow \{\text{as}, \text{os}, \text{aj}, \text{oj}\}$.
- There are two distinguished nodes: The start node $n_0 \in A$ and the end node $f \in A$.
- $T \subseteq (N \setminus \{f\}) \times (N \setminus \{n_0\})$ is a set of transitions between the nodes, where:
  - If $(a \in A) \vee (a \in C \land \text{type}(a) = \text{as}) \vee (a \in C \land \text{type}(a) = \text{os})$, then there exists one and only one node $b$ such that $(b, a) \in T$. (These nodes have exactly one predecessor.)
  - If $(a \in A) \vee (a \in C \land \text{type}(a) = \text{aj}) \vee (a \in C \land \text{type}(a) = \text{oj})$, then there exists one and only one node $b$ such that $(a, b) \in T$. (These nodes have exactly one successor.)

The usual semantics apply: The workflow starts in its start node $n_0$. During a workflow execution, activities are executed with respect to the transitions between them. Split nodes allow us to specify concurrency and alternative and join nodes allow us to specify synchronization between incoming flows. Finally, the workflow execution stops when the final node $f$ is reached.

To illustrate a workflow, we use a simple graphical representation with these symbols:

The name OR-split in [12] is a little bit misleading: XOR-split would be a better name, because one and only one transition to the next node is selected.
Split nodes have at least two outgoing transitions (arrows), while join nodes have at least two incoming transitions. Outgoing arrows from an OR-split node can be labeled with a short text describing a decision being made in the OR-split that leads to the selection of one of the outgoing arrows.

Figure 1 shows an example workflow taken from [10] and [7]. It shows a business process model for expense request payments with an option to differ between payment in US-$ or in Australian $.

2.2 Structural Correctness

While def. 1 defines the syntax of a workflow specification, it does not say anything about its semantics. Not every workflow specification that can be constructed using definition 1 makes sense when the semantics for splits and joins is considered. An example is shown in Fig. 2: Only one of the activities 2 and 3 will be performed after the OR-split, but the following AND-join would wait for both activities being completed. Even if the end node will be reached anyway via activity 1, it is very unlikely that this is the behavior intended by the person who has specified the workflow. For this reason it is reasonable to call such a workflow specification structurally incorrect.
We will see later in this paper that structural correctness of a workflow can be decided with our model checking approach. In fact, this is even possible without much reasoning about possible sources of structural conflicts. We just have to take into account that the result of structural incorrectness is that either a possible execution exists that does not reach the end node or there are still "uncompleted things to do" when the end node is reached. This leads us to:

**Definition 2** A workflow specification \( w = (N, n_0, f, T) \) is structurally correct if

- every workflow execution reaches the end node \( f \) after a finite number of transitions.
- when the end node is reached, all other activities that have been started before are completed and there are no remaining join nodes waiting for incoming transitions.

Because of the limited space in this paper, we omit the formal definition of "a workflow execution" and "taking a transition", but it should be intuitively clear what those phrases stand for with respect to transitions and the semantics of split- and join-nodes\(^2\). Def. 2 simply requires that every sequence of nodes and transitions finally reaches the end node \( f \) after a finite number of transitions, and there are no remaining join nodes waiting for an incoming flow when the end node is reached. Infinite loops, AND-joins waiting for an incoming flow infinitely long and similar problems must not occur. Sadiq and Orlowska [13] have identified five types of possible structural errors in a workflow specification. For all five types of errors, the workflow specification will be identified as not being correct using def. 2 or it is already disallowed by the requirements for unique predecessors and successors in def. 1.

### 2.3 Timed Workflow Specifications with Resource Constraints

Activities can require human, material or machine resources, for example a director who has to sign a bill (human resource), a vehicle to transport heavy goods (material resource) or write-access to a database (machine resource).

\(^2\) The only point that needs some clarification is that activities after an OR-join should *not* be activated more than once if more than one incoming flow reaches the OR-join. In this point, the semantics used in this paper differs from the one used in [10]
Often, these resources cannot be shared between different activities: When a workflow is executed, only one activity can access a resource exclusively.

This leads us to another possible source of incorrect workflow specifications: When one activity needs a resource that is occupied exclusively by another activity, the workflow is deadlocked and cannot proceed. In real life, we can formulate the previous sentence even more strictly: If the other activity occupies the required resource exclusively until some deadline is reached, the workflow cannot be completed in time and hence does not fulfill its purpose.

To find out whether such a situation can occur, we need to know something about the usage of resources by the activities and about the duration of the execution of activities.

**Definition 3** Let $R = R_1, \ldots, R_n$ be a set of resources, which cannot be shared between different activities. For each activity $a \in A$, $r(a)$ is the set of resources needed by this activity.

**Definition 4** The minimum time (expressed in some time unit like seconds, hours or days) that will be needed to execute an activity $a \in A$ is denoted by $m(a)$, the maximum execution time will be denoted by $M(a)$.

We call a workflow specification with the information about minimum and maximum execution time of its activities a *timed workflow specification*. This information about timing is rather simple, but it has been shown to be sufficient for answering basic
questions about deadlines and resource conflicts (for example by applying the Critical Path Method [14]). Additional elements like an interrupt construct can be added if necessary.

In Fig. 3, we add information about timing and resources to the graphical representation of the sample workflow. For each activity \( a \in A \), \( m(a) \) and \( M(a) \) are given as an ordered pair \([m(a),M(a)]\) above the activity box, the set \( r(a) \) is given below the box. Empty sets \( r(a) \) are omitted. We have taken this example from [7], with small modifications.

3 Model Checking of Timed Workflow Specifications

3.1 The Model Checker UPPAAL

To verify properties of a workflow specification, we use the real-time model checking tool UPPAAL [15]. We show how to translate a workflow specification into a timed automata specification that can be processed by UPPAAL.

An UPPAAL model is a set of timed automata, clocks, channels for handshake-synchronization, variables and additional elements. Information about the syntax for UPPAAL models can be found in [15]. Here we describe some elements only.

Each UPPAAL model is a set of processes (timed automata) which are depicted as states (circles) and transitions (arrows) between them.

For each automaton, one state is marked as initial state (two concentric circles). A graphic representation of an UPPAAL process can look like Fig. 4:

![Fig. 4. Simple graphic representation of a process in UPPAAL](image)

States can have the attribute "committed", depicted by the letter C inside the circle. If a state is marked as "committed, no time may pass in this state, and it must be left immediately (i.e. no interleavings with non-committed states in other automata are allowed).

When a transition is taken, clocks can be reset. (In Fig. 5 the clock named clock1 will be reset to 0 when the transition from "idle" to "logging in" is taken), and global or local variables can be manipulated. (In Fig. 5, a variable named active is changed when the transition from "logging in" to "transferring data" or from "abort connection" to "idle" is taken).

Note that the meaning of an arrow in the UPPAAL model is different from the meaning of an arrow in the graphical workflow representation. Also a circle in the UPPAAL model does not stand for an activity like the rectangle in the graphical workflow representation does. Instead, one UPPAAL process (depicted by some arrows and circles) stands for an activity.
Synchronization between different processes can take place using channels. When a transition is taken, a channel can be written into (written as `channelname!`). To achieve a handshake-synchronization, the corresponding reading operation (written as `channelname?`) can serve as a so-called guard of another transition which can not be taken unless reading from the channel is actually possible. If a channel is defined as urgent channel, the reading operation must be performed as soon as possible, i.e. immediately and without a delay. Fig. 6 shows a synchronization between a server process and a client process:

![Diagram of Fig. 6. Using channels for handshake-synchronization]

Conditions on clocks or variables can also be used as guards for transitions. This means that a transition cannot be taken until some condition (for example an equation for some variable) holds. Finally, invariants can be added to a state. We will use invariants of the type "$\text{clock} \leq m$" which means that the system is not allowed to remain in this state for more than $m$ time units. In Fig. 7, the transition will be taken when the clock named `time` is in the interval $[2,4]$ and the value of the variable `active` fulfills the equation `active == 1`.

![Diagram of Fig. 7. Guards and invariants]

idle  logging in  transferring data  abort connection

<table>
<thead>
<tr>
<th>state 1</th>
<th>time &gt;= 2, active == 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>time &lt;= 4</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 5. clocks, variables and an urgent location

Fig. 6. Using channels for handshake-synchronization

Fig. 7. Guards and invariants
3.2 Workflow Elements in UPPAAL

Using the elements introduced in the last section, we can define templates for the different kinds of nodes in a workflow specification (as defined in def. 1). Urgent channels are used to model the transitions between the nodes.

**Start Node**  The start node process does nothing else than writing into a channel `letstart` and setting the variable `running` (which stands for the number of currently running activities) to 0:

```
letstart!
running := 0
```

![Fig. 8. Start Node](image)

**Activity Node**  The UPPAAL process for an activity node waits until it becomes activated by being able to read from a channel `in_channel`. When it is activated, it sets a local clock to 0 and increments the variable `resource`. The variable `running` (the number of currently running activities) is incremented. After staying in the next state for at least `mintime`, but not longer than `maxtime`, the process comes to an end which it signalizes by writing to the channel `out_channel`. When the channel can be read by another UPPAAL process, the variable `running` (the number of currently running activities) is decremented.

**AND-Split**  When activated (by the ability to read from `in_channel`), the UPPAAL process for an AND-split writes repeatedly to the channel `out_channel`, thus being able to activate more than one following node. For AND-splits with two incoming flows as used in our definition, this happens twice.

**OR-Split**  Other than the AND-split, an OR-split process writes to the channel `out_channel` only once, thus only one following node can be activated by reading from this channel.

**AND-Join**  An AND-join process tries to read from two channels, `in_channel1` and `in_channel2`, and proceeds if and only if both of them are readable. (Note that it is not required that `in_channel1` is readable before `in_channel2`. If `in_channel2` is the first of the two channels being readable, it just "waits" and the reading operation can be performed after `in_channel1` became readable as well.)

**OR-Join**  An OR-join process tries to read from two channels, `in_channel1` and `in_channel2`. It proceeds if it can read from one of them.
The UPPAAL process end stands for the end node. This process will reach the status named \textit{finished} at the end of the model’s execution.
3.3 Translating Timed Workflow Specifications to UPPAAL Models

In the previous section we have shown how the general elements of a workflow specification can be expressed as UPPAAL models. To "translate" a special workflow specification into an UPPAAL model, we make use of UPPAAL templates. The UPPAAL models of workflow nodes given in the last section are regarded as templates. This means that the names for variables, clocks and channels in the UPPAAL model are placeholders (called parameters in UPPAAL). To define an instance of an activity, we use this template with parameters as follows:

$$\text{Activity}(\text{processclock}, \text{mintime}, \text{maxtime}, \text{resource}, \text{in}\_\text{channel}, \text{out}\_\text{channel}), \text{where}$$

- processclock is a placeholder for a local clock variable,
- mintime and maxtime are placeholders for numeric constants,
- resource is the placeholder for a name of a single resource (For the sake of simplicity, we assume that each process uses at most one resource from the resource set $R$. By adding more placeholders, we can easily expand our model to the general case.)
- in\_channel and out\_channel are placeholders for urgent channels,

To instantiate the model for an actual workflow activity from the template, the placeholders are substituted by actual variables:

$$\text{IssueCheck} := \text{Activity}(\text{clock9}, 4, 6, \text{r8}, \text{a6\_channel}, \text{a10\_channel});$$

(compare Fig.15 with Fig.9). The activity "File Payment Request" can be defined as:

$$\text{FilePaymentRequest} := \text{Activity}(\text{clock11}, 1, 2, \text{r10}, \text{a10\_channel}, \text{a11\_channel});$$

Note that synchronization between the both activities can take place using channel a10\_channel, which replaces the parameter out\_channel in the "Issue Check" activity, but in\_channel in the "File Payment Request" activity.

Instances of control nodes can be built from the template in the same way. If a workflow specification is given according to def. 1, the translation to the UPPAAL model can be done automatically. For each node, an instance of an UPPAAL template will be generated. This means that in general, only one line of code will be added to the UPPAAL model for each node in the workflow specification\(^4\). Split nodes with $n > 2$

\(^4\) plus declarations of used variables, channels and clocks and the information about the fact that the instantiated process is part of the system.
outgoing transitions or join nodes with \( n > 2 \) incoming transitions can be transformed into a sequence of \( n-1 \) split/join nodes with two outgoing/incoming transitions.

The complete UPPAAL model of our example workflow can be downloaded from ebus.informatik.uni-leipzig.de/~laue.

### 3.4 Checking the Correctness of Timed Workflows

Having built the UPPAAL model of the workflow, we can use the model checker to verify the required properties. The property specification language used in UPPAAL is a subset of Timed Computational Tree Logic (TCTL) ([16].) Properties that could be checked include:

"The end node will always be reached" (part 1 of def. 2):
\[
\text{A}\neg\neg \text{end.finished}
\]
(The state "finished" in the process end will always be reached). This property can be checked to be true for our example workflow.

"When the end node is reached, no activities are waiting for being finished" (part 2 of def. 2):
\[
\text{A}\neg\neg \text{end.finished} \implies \text{running} == 0
\]
This property can be checked to be true for our example workflow. (Note that \text{running} will not be decremented until the outgoing channel can be written into.)

"There are no resource conflicts for resource r10"
\[
\text{A}\neg\neg \text{r10}<2
\]
Can be checked to be true. Note that this requires reasoning about time: There are no resource conflicts, because "Update Account" is always finished when the activity "File Payment Request" starts. (Using the knowledge that "Update Account" and "File Payment Request" are the only activities that use resource r10, we will get the same verification result by checking the property \[ \text{A}\neg\neg \text{UpdateAccount.working} + \text{FilePaymentRequest.working} <2 \]. This makes use of the trick that boolean values like \text{UpdateAccount.working} are converted to numbers (0 or 1). We would not need the variables r1,...,r10, which helps to reduce the state space of the model.)

"There are no resource conflicts for resource r8"
\[
\text{A}\neg\neg \text{r8}<2
\]

The model checker does not only finds out that the property is violated, it also gives a counterexample: a resource conflict between the activities "Signature From Finance Director" and "Transfer Funds to US-Account"

"If a request has been rejected, no check will be issued."
\[
\text{RejectRequest.finished} \implies \text{not IssueCheck.finished}
\]
Can be checked to be true.

"The whole process will be completed in no more than 30 time units"
\[
\text{A}\neg\neg \text{end.finished} \land \text{clock1}<30
\]
To check this deadline constraint, we use \text{clock1}, the local clock of the first activity "Payment Request". It is started at the begin of the whole workflow. This property can be checked to be true. If we replace "30" by a smaller value, a counterexample of a process that needs 29 time units to complete will be given.
3.5 Remarks

**Resource Pools** The approach can not only be expanded to multiple resources (if r(a) has more than one element, the model just needs more placeholders for resources used by activities), it can also be used for checking the usage of resource pools, for example a database that allows up to 10 parallel connections. We would have to check a property like resourcecounter<=10.

**Abstraction** The timed workflow specification can be transformed automatically into an UPPAAL model which can be used as the input of the model checker. However, a complete translation of the workflow specification, preserving all its properties, does not necessarily have to be what we really want: Too many details in the model can lead to too many states the model checker has to examine. Instead of translating a workflow specification while preserving all its properties, it may be a good idea to do some abstraction before by asking which parts of the system are relevant with respect to the property being checked. If we check for resource conflicts for r10 in the example workflow, information about other resources can be ignored. In fact, even only the model built from the very last part of the workflow ("Issue Check", "Update Account" and "File Payment Request") is relevant. Often, this abstraction can be done automatically.

4 Conclusion

The use of only one tool for verifying different kinds of properties (with or without timing information) and the simplicity of translating workflow specifications to UPPAAL models are the main benefits from the results presented in our paper.

We have highlighted reasoning about structural correctness and resource constraints, but using the given approach, various other properties of workflow specifications can be checked as well. This includes the patterns identified in [3] and [17], including existence, absence, precedence and response patterns. In our further research, we will investigate such patterns, including patterns for time-related properties (see [18]). Another direction of our work will be to enable the business architects who are responsible for defining workflow specifications to specify such properties without a deeper knowledge in model checking or temporal logics.

References


5 In general, models with a large number of clocks lead to a state-space explosion in timed model checking. Please note, however, that this is not the case in our model (where each activity adds a clock): When an activity is completed, its clock is not used actively in comparisons and cannot lead to new states.
A Machine Learning Middleware For On Demand Grid Services Engineering and Support

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Abstract. Over the coming years, many are anticipating grid computing infrastructure, utilities and services to become an integral part of future socio-economical fabric. Though, the realisation of such a vision will be very much affected by a host of factors including; cost of access, reliability, dependability and security of grid services. In earnest, autonomic computing model of systems' self-adaptation, self-management and self-protection has attracted much interest to improving grid computing technology dependability, security whilst reducing cost of operation. A prevailing design model of autonomic computing systems is one of a goal-oriented and model-based architecture, where rules elicited from domain expert knowledge, domain analysis or data mining are embedded in software management systems to provide autonomic systems functions including; self-tuning and/or self-healing. In this paper, however, we argue for the need for unsupervised machine learning utility and associated middleware to capture knowledge sources to improve deliberative reasoning of autonomic middleware and/or grid infrastructure operation. In particular, the paper presents a machine learning middleware service using the well-known Self-Organising Maps (SOM), which is illustrated through a case-study scenario -- intelligent connected home. The SOM service is used to classify types of users and their respective networked appliances usage model (patterns). The models are accessed by our experimental self-managing infrastructure to provide Just-in-Time deployment and activation of required services in line with learnt usage models and baseline architecture of specified services assemblies. The paper concludes with an evaluation and general concluding remarks.

1 Introduction

Due to the pervasive distributed computing environment, such as information systems and computational Grid, has enabled a new generation of applications that are based
on seamless access, aggregation and interaction. The dramatic side of the story is a
strong presence of the plea that those decentralized Grids are potentially affected by
number of primitives derived from their anatomy, is that they are inherently large,
complex, heterogeneous and dynamic, globally aggregating large number of
independent computing and communication resources. This had clearly exposed an
essence exigency for a vital change of how these applications are developed and
managed, which has motivated researchers to consider other techniques used by
biological systems to deal with complexity, dynamism, heterogeneity and uncertainty,
which is referred to the autonomic computing.

In particular, autonomic computing research is exploring and developing models
to support distributed systems lifetime management and unpredictability by delegating
many of the systems management, maintenance tasks to the software itself including;
resource management, job scheduling, services failure prediction, load-balancing,
QoS, services reservations, deployment and discovery [1].

A prevailing design model of autonomic computing systems is one of a goal-
oriented and model-based architecture, where rules elicited from domain expert
knowledge, domain analysis or data mining are embedded in meta-systems (self-
management) software systems [2] to provide autonomic systems functions including;
self management, self optimization, self-tuning and/or self-healing. Whilst, such a
rule-based approach is reported to be appropriate for systems self-management with
inherently stable operating rules (and/or policies), it suffers from the lack of support
for variability and evolution of domain operating rules and policies. Thus, requiring at
best a manual rule-base maintenance or at worst software systems maintenance.

Among tremendous machine learning deployment, in which a model consisting
classes and features is to be trained adaptively to preserve data learnt, this model can
can then be used to perform taxonomy against new epochs, another approach of
anticipated properties of system is yet claim more advantages of neural networks in
learning machine symptoms over time.

Motivated by research on unsupervised machine learning techniques, which can
exploit the abundant systems’ monitoring data; this paper advocates for the need for a
machine learning utility and associated middleware to capture/extract and evolve
knowledge models (sources) from the infrastructure operating systems. Such
knowledge/models can then be used by our developed autonomic middleware control
services.

In particular, the paper will present a machine learning middleware service using
one of the well-known neural networks unsupervised learning techniques Self-
Organising Maps (SOM) to nominate classification and clustering applied in an on-
demand home-networked appliances scenario. In which, the SOM service is used to
classify types of users and their respective networked appliances usage model
(classes/features) and services dependencies. The models are accessed by our
experimental self-managing infrastructure to on-demand and Just-in-Time deploy and
activate required services in line with learnt/extracted usage models and baseline
architecture of specified services federations/assemblies1 and discovering and
activating additional services on-demand. Other types of supervised learning
algorithms like regression, decision trees, Bayesian learning, reinforced learning and

1 Discovering of the services through anticipating the required services for each group of users
and reserved services for them
many others demand more analyzing to achieve prospected goal with minimum error; this would ultimately claims manual procedures and testing until reaching those goals, which in return requires managed centre administration. The paper will finish with some concluding remarks and outlines further works.

The remainder of this paper is divided as follow: Section 2 outlines the motivations for the work including related work. Section 3, describes the intelligent connected home machine scenario based on demand services. Section 4 introduces an application of classification method to support on demand grid service binding, activation and reservation. This is illustrated though a simplified scenario of a SOM-based middleware service for an intelligent connected home machine in section 5. Sections 6, presents an implementation for services and job schedule services using simple example. The last section is the conclusion and future work.

2 Motivations and Related Work

Many applications of the autonomic computing model in grid computing settings have been widely reported by major IT players including; Sun Microsystems, Hewlett-Packard and IBM as a way forward for a highly automated computing systems [3]. By creating hardware and software that can diagnose and solve network problems, thus improving high-availability while reducing IT operation costs [3].

A plethora of publications are now available ranging from a description of the general benefits of autonomic computing, case-studies to design models, to tools and techniques for design, deployment and management of autonomic computing software systems.

Much research is now underway adopting the using of machine learning to support different tasks of autonomic grid computing such as self-management, self-configuration, self-protecting, and other general QoS improvement. For instance, M. Chen et al. [4] report on their application of the C4.5 decision tree algorithm and data mining to categorize causes of failure in large Internet sites such as eBay. Many of researchers have recognized the importance of using autonomic system for path failure as one cause of services failure and to improve the QoS. G. Candea, et al. [5] presents an Automatic Failure-Path Inference (AFPI) as an application-generic and automatic technique for dynamically discovering the failure dependency graphs of componentized Internet applications. They focused on applying AFPI to applications built on Java 2 Enterprise Edition middleware. AFPI-generated f-maps correctly omit dependencies that appear in the static call graph but do not result in observed fault propagation at runtime. The accuracy of applying autonomic system using machine learning or data mining algorithms for large, distributed, and dynamic application environments is one of the critical problems. M. Chen et al. [2] present a dynamic analysis methodology that automates problem determination in these environments by 1) coarse-grained tagging of numerous real client requests as they travel through the system and 2) using data mining techniques to correlate the believed failures and successes of these requests to determine which components are most likely to be at fault. They implemented Pinpoint, a framework for root cause analysis on the J2EE platform that requires no knowledge of the application components. In large scale system, there is an expectation for large number of failure services; this produces the
demand for failure management system. M. Chen et al. [6] present a new approach to managing failures and evolution in large, complex distributed systems using runtime paths. They use the paths that requests follow as they move through the system as their core abstraction, and their “macro” approach focuses on component interactions rather than the details of the components themselves.

In our approach, we use Self-Organizing Maps (SOM) to underpin autonomic middleware services, in that, in this research, to do the classification process among groups of consumers according to the usage services. If the middleware gets this classification, then it can predict the required services for a group of consumers according to their assemblies. The middleware acts to reserve and prepare the required services for the consumer before prior to the demand request; this will add synchronization of service usage. Of course the reservation services may not require one, but the accuracy and responsiveness of the system will increase with the learnt services usage by consumers, which will in turn increase the training process for the system. Job schedule also gets benefit from classification services, because the middleware can anticipate the peak load and then manage the job schedule according to it.

3 On-Time Intelligent Connected Home Scenario

Grid computing requires a range of management processes and services for making the middleware or broker interactive with the services/infrastructures and applications faster. On-time services are another way to reduce the interaction between the consumers and the devices by adjusting them to give better and fast services to the consumers. Such processes and services to work fast and reliable need an autonomic services or management services to run inside the middleware. Such services will be one of the core units for the middleware in doing the automated jobs for the Open Grid Services Architecture (OGSA) [13]. Taking benefit from the concept of service-oriented model of the grid, the consumer should consider his requirements in advance before invoking the demanded services to reduce the unnecessary invocation process, and hence reduce the response time, or in other word is to create an advanced on demand services request. A service reservation is much more agreeable in this case, which is responsible to organize the consumers’ requests in advanced. Such service can be integrated as one of the middleware core services. The middleware needs to be more specific in the provision of the services required, clustering and classifying consumers should be yield, and this method of classification is much applicable in our

2 Efficient performance in grid computing requires mechanisms for managing the load balance, recover services failure and discover most suitable services for the consumer, and improve QoS. Most of these things can be done using instrumentation inside the middleware. This instrumentation needs to be autonomic to tune the reaction of the middleware against different types of changes, and force self-configuring, self-optimizing, self-healing, and self-protecting Middleware needs to get readings from the services or targets.

3 Our approach for services reservation and job schedule depends on using one of the intelligent classification methods for the system’s users.
case while the target of hypothesis is instantly unknown until the final trained model is built.

To elucidate the idea of on-time or on demand services based on user usage classification, connected home devices scenario is adopted. The intelligent connected home machines are the next generation of the home devices, which depend on local and remote services to be available on-time. Each such device may use remote grid services. Each consumer can use a number of services (we will use name services instead of devices). Of-course there are a number of consumers sharing approximately the same devices each time, we tried to classify these consumers according to their usage devices. Reasoner is the intelligent services inside the middleware responsible to do the autonomic stuff, which will be clustering in this case according to the consumer’s usages. Figures 1 and 2 demonstrate this idea.

The scenario starts by training the machine learning service with the consumer’s devices usage. The sensors inside the connected homes starts collect information for the new consumers and store it in the logger. This information is used by the machine learning service (inside the reasoner) to classify the new users to one of the classified groups. The benefit after classifying the users into group is to anticipate the required services by each consumer beforehand. These anticipating results are fed to the service reservation system with the required information. This system determines the required services, time of operation, required resources, dependency and other things required to run the service for each consumer and send it to the job schedule system. The jobs schedule system at this stage is responsible to do schedule of the services, anticipating the load on each service, and recover the fault tolerance problem before occurrence. Job schedule system is responsible to arrange services readiness before requesting in order to reduce the response time and give better QoS.

Because currently existed grid architecture model lacks classification services, we are proposing a SOM-based classification service to underpin our unsupervised machine learning middleware service. There are many others types of unsupervised learning methods that can be used to do this job, like Support Vector Machine (SVM) [15, 16]. For us, we tried to start with SOM because it is widely used in such problem, and it works efficient with such applications [11, 17]. In the future, SVM will also be tested to reach to the best method of consumers’ classification.

The data collected from the middleware repository has rich information to be processed, and starting with the definition of self-organizing map method as a vector quantization method which places the prototype vectors on a regular low-dimensioned grid in an ordered fashion [14].
Fig. 1. Illustration of the connected home case study.

Returning to our scenario of using home machine devices, the input data is presented as XML, which can be used in the future with heterogeneous, decentralized and distributed environments. On the other hand, XML can be used to store a large amount of data with small size, and the RAM can easy work with it, therefore we thought in the future XML will be useful to represent the huge amount of data. Figure 3, presents a sample of the XML for the input data that is used to train the system for different cases (i.e. type of devices, category, and time of work).

```xml
<?xml version="1.0" standalone="yes" ?>
<!DOCTYPE categories SYSTEM "categories.dtd">
<categories>
  <category ID="1">
    <categoryName>Entertainment</categoryName>
    <categoryDescription>Playing</categoryDescription>
    <device>
      <deviceID>2</deviceID>
      <deviceName>Audio center</deviceName>
      <deviceDescription>Music</deviceDescription>
      <timeFrom>10</timeFrom>
      <timeTo>12</timeTo>
      <deviceStatus>On</deviceStatus>
    </device>
    <device>
      <deviceID>11</deviceID>
      <deviceName>Play Station</deviceName>
      <deviceDescription>Playing TV Game</deviceDescription>
      <deviceStatus>OFF</deviceStatus>
    </device>
  </category>
</categories>
```

Fig. 3. XML Schema for the input data.

4 SOM Implementation

The concepts of the SOM are out of the scope of this paper, and there are many references on the using of SOM in different applications [9,10,11,12,14].
User’s classification using SOM will be services used by the middleware to do the autonomic work for the grid. The intelligent middleware will be responsible for services reservation, job schedule, and other services which will be described in future papers, like fault tolerance and load balance. The SOM services as web services will be one of the core service of the middleware in doing the autonomic jobs for the Open Grid Services Architecture (OGSA). In our approach we depend on doing consumers’ classification using SOM will be part of the middleware which will achieve prediction services over the data repository mined out from consumers usage to the grid in order to tune other middleware activities like service reservation, job schedule, fault tolerance and load balance. Actually the classification service is a part of the autonomy inside the middleware has prioritised role over all other components.

The SOM toolbox for Matlab is an effective software tool for the visualization of high-dimensional data. It converts complex, non-linear statistical relationships between high-dimensional data items into simple geometric relationships on a low-dimensional display [18].

The SOM is initializing using either random or linear initialization. For train the map, SOM uses sequential or batch algorithms by using som_make function, the resulting visual map exhibits the neighbourhood between the neurons and the input training samples updating Best Matching Unit (BMU). The quantization error could be measured using som_quality function which supplies two measures: average quantization error and topographic error. A schematic diagram at Fig 4 [10] illustrates SOM cycle processes, SOM model delivers logic decisions from the visual maps taking benefit from labelling feature in som_autolabel and som_addlabels functions, hence we can build a programming model achieving SOM method and outputting decisions from calculating BMU for a given data vectors using som_bmus function and other related useful functions provided by the toolbox.

VS.Net is used to develop a complete environment for getting training data, scaling data, learning SOM and get the classification results, and simulate the inputs later based on using Matlab function as ASP. This environment will be developing to be one of the middleware services.

Fig. 4. Using SOM in preparation-survey –cycle [based on 10]
4.1 Data Collection

In order to produce experimental data for the automated classification of users and their home devices’ usage models, which will be used by our autonomic middleware for the intelligent connected home a simulation software has been developed using VS.Net and Matlab.

Data format for SOM is a main concern to prepare the samples in proper iterations, and then it will be easy to construct them and build the data structure, which is a Matlab SOM struct using som_data_struct function included with the SOM toolbox for Matlab. Data pre-processing needed can be either simple linear transformations, normalization or logarithmic scaling especially when the divergence of ranges of data is too high, this is done using som_normalize function. After that, the scaled data is used to feed the training system of the SOM.

Different types of categories are selected to represent the different types of home-machine categories, each one of these category contains a number of home-machine devices or services. 0 and 1 are selected to represent the status of the devices as "OFF" or "ON" respectively.

5 Results of SOM Classification for Connected Home Machine

The visual results of the experiments are obtained using an implemented machine learning middleware service. Matlab SOM library [14] is used to implement such experiment. Figures 5, 6,7 and 8 show SOM-based classification results of the our input data generated from Matlab, which represent a simulation of our self-managing middleware for intelligent home networks. The results represent classification for different type of users and devices. Figure 5 shows many correlations between device usages, which are obtained after the training phase which included 1000 input sample data and 10 trainees (devices consumers). Sample of these correlations are described in the following points:

a. Lights and PlayStationII correlates as shown in Figure 5.
b. Video and Coffee Machine correlates as shown in Figure 5.
c. Video CD and Fans correlates as shown in Figure 5.
d. Vacuum cleaner and Washing machine correlates as shown in Figure 5.

Figure 6 represents U-Matrix distribution of labels for the connected home devices. Figure 7, shows shaped U-Matrix with coloured regions exhibiting 7 clear clusters of the map. The critical analysis of this approach depends on selecting and scaling the correct data for training the system.

At runtime, the machine learning middleware service using the training data (user and device classification) can classify log in users according to known users/devices (one of the seven classified region). Each of which is for instance specifies the user types and their uses model such as device usage order and time of usage. One of the applications of such a user device usage model is used for our autonomic services reservation and provision services.

SOM prevail some shortcoming when large quantity of good quality representative training data required training the maps, possibly misleading visualisation when neurons close together in output space represent similar input patterns. The SOM
toolbox comes with some error measures: som_quality which measures quantization and topographic error of SOM, som_distortion which measures SOM distortion and som_distortion for elements of the SOM distortion measure.

6 Implementation of Using SOM Service with On Demand Services Scenario

User classification scenario based on devices usages is used to implement the idea of on demand services as described in section 3. The SOM service is used to find the pattern for each user. SOM is design as web service to be integrated with the core functions of the middleware. The new user is sort to one of the classified groups, then the system send a notification to the service reservation system with this new user and the estimated required service that should be prepare by such system. For example,
Figure 9 demonstrates a list of devices required by user ‘Wael’. Also it shows the new users who enter to the system, in this case ‘Wael’ and ‘Taleb’. This information regarding the new users with their requirements is sent to the job schedule services to manage the execution of such services. For example, figure 10 presents the notification of execution service (device) light for user ‘Wael’. It also describes the time of execution for this new users. The system predicts the time for the execution for each service based on gathering information through dynamic instrumentation. Of course, the consumer has the right to change this time or even the service to adjust the system and make it suitable for his requirements.

The software for the services reservation, notification and job schedule for connected home machine has been implemented using VS.Net.

Fig. 9. Service Reservation

Fig. 10. Job schedule & notification services

7 Conclusions & Future Work

Autonomic computing is addressed to be one of the methods that are used to manage the grid environment. User classification is here proposed to enhance job schedule and services reservation processes based on automated way. Machine learning is used to do the autonomic staff. SOM is suggested to be used to do the classification staff as a service that can be attached later to middleware core services. VS.Net and Matlab functions are used to develop the environment for the user classification process starting by creating the random data as XML or text format, scale the data, train the
map and then predict the type and pattern of the new user. The goal of predicting the new user is to determine the required reservation services. Connected home machine devices scenario is adopted to demonstrate the idea of classifying Users according to the devices usage.

Job schedule will be used to complete the scenario of services reservation, and then manage the load. SOM technique is also used to do the middleware self-management process. Other types of machine learning (like SVM [16, 17]) will be tested in the future to do the classification process. For the future, this environment will be developed to be as a web services that can be added to OGSA middleware services.

The idea of autonomic monitor will be develop in the future stages to predict the type of data that is needed by the autonomic services. Also, it will be used to reduce the amount of unnecessary data that is transfer from the target to the log file system.

References

Short Papers
A Workflow Model For Integrating IC Design and Testing

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Abstract. This paper outlines the challenges facing the domain of automated testing of mixed-signal integrated circuits and how these can be tackled by enhancing communication between the design and test engineers. An abstract workflow model is introduced for seamless interaction of design and test teams, thus enabling faster work-flow and a greater redundancy in the correctness of communicated specification data. The latter is embedded into a system-level model and completely integrated into the process. A data-sheet integration methodology is briefly introduced with several application-level requirements and integration guidelines. The goal is to reduce the time for developing and running test programs, which is a major cost factor in the reducing life-cycles of mixed-signal devices. The paper emphasizes obstacles in current settings and suggests workarounds.

1 Introduction

Decreasing the time required for testing an integrating circuit is vital for any semiconductor company. Developing the (automated) test programs and running tests from simulation and prototype to production phases are major investments in terms of working hours and automated test equipment utilization. A multitude of factors should be considered in order to increase the effectiveness of such a design and test process. Several are mentioned in this paper, defined as “challenges”.

There is a consensus among the test community to increase abstraction in dealing with such obstacles. This refers to a clear need for a system-level approach, which will be described and elaborated on in the following chapters. As complexity is growing in circuits, that have analog and digital modules combined onto a single chip or System-on-Chip, we need to increase the abstraction in dealing with these designs by the same margin.

Various methods have been proposed and experimented with considerable success. Nevertheless, most of the issues touched upon are still in research phase and hopefully the work outlined in this paper can provide support for implementation guidelines.

1This paper addresses the preconditions and work-flow issues deriving from a more comprehensive work on increasing abstraction for automated test generation for mixed signal integrated circuits and devices.
1.1 Challenges

The demand for mixed-signal integrated circuits is increasingly growing. Within the next five years the number of transistors per cm$^2$ is expected to rise from ~40 to ~180 million, a factor of 4.5 times, [1]. This will directly impact the complexity of these devices. Even though the packaging of such chips has evolved with the introduction of ball-grid-array and quad-flat-package, [2] the increase in pin-count is expected to be none higher than from current ~1500 to less than 3000 external pins, a factor of less than two times. The ratio of the two clearly outlines a need for increasing abstraction in the (automated) test of these circuits.

An ever-occurring challenge in manufacturing an integrated circuit is the communication between the design and test engineers. With the emergence of complex mixed-signal designs, effective communication is critical for a successful work-flow, considering the shortening life-cycles of such products. Nevertheless, passing specification-related information from designers to test personnel is often realized through simple tools like e-mails or verbal communication. The specifications tend to be static files, with multiple versions going back-and-forth. In such manner, information can easily get distorted or even lost.

Conclusively from the above, the concept of design-for-test (DfT) is often mentioned but more seldom implemented in its intended form – to enable testing of product functionalities at all levels and phases of the design.

Several other specific complexities exist in the domain, such as modeling the input-output relations of mixed-signal designs and their building blocks, dealing with noise under low-power requirements and increasing clock rates. Additionally frequent (test)signal passing through the analog-digital and digital-analog divide requires propagation of analog signals through digital modules and vice versa, introducing complex, but promising results. The latter problems and proposed methods for overcoming are not explicitly described in the following sections, thus they would draw the focus from the abstractive perspective offered.

2 System-level Work-flow

There is a need for an abstract model of the design consisting of functional blocks, also referred to as the basic blocks, [3]. The model should be developed in parallel with the actual design, which would enable the design and test engineers to tackle arising problems as soon as possible. This interaction is the starting point of an already established DfT process which is ideally maintained throughout the whole life-cycle of a product. Following Figure 1, a re-iteration of a model-based design approach proposed in [4], proposes the workflow model, some aspects of which will be discussed in the following chapters.
The above Figure 1, originally developed for the design of an aircraft control system, points to similar efforts in various engineering disciplines.

The model outlines the roles of both the inter-actors (design and test teams), with the actual (specification) data being communicated, used directly in generating a system model of the design. The system model consists of functional basic block models, which carry as many parameters with tolerances as required for a particular propagation and/or measurement in a certain phase of the test-run. In addition they should be identifiable within the signal paths through indexing or describing previous and following basic blocks, to preserve observability and controllability for all relevant parameters. Certainly a pre-analysis of the entire model needs to be conducted beforehand, to identify those parameters. Such methods, proposed in [5], lay the groundwork for actually pursuing an automatically generated test (program) for a mixed-signal circuit. As the design and test process phases are iterated, simulated and prototyping carried out, the goal is towards a dynamically updated specification, hence keeping a keen eye on all of the changes, however marginal, are being added into the information set. Such electronically supported method adds a higher redundancy into dealing with critical design data, while removing irrelevant overhead data from the communication.

Therefore the described work-flow contributes toward inter-human communication supported by a virtual information system, enabling to speed up the process and achieve human fault elimination – a cause for far too many project failures and missed deadlines.

3 Data-sheet Integration

A specification or data-sheet of a design is to-date viewed as the means of describing the overall functionality and characteristics of a device, including operating conditions, electrical parameters, thresholds, etc. While it maybe sufficient, in terms of automatic test generation for relatively simple devices, such data-sheets carry less advantages for the test team. It is too extensively considered a marketing tool, rather than a possible tool in product validation.
Our starting point is the specification of a mixed-signal design. A problem often facing the interaction of the design and test teams is the presentation and format of the product specifications. These specifications are not always delivered to the test team in a consistent format. This is drawing additional time resources from the test engineers to manually transfer ratings, electrical and performance characteristics and other information from the data-sheets to the test program.

The terms “specification” and “data-sheet” would in this case refer to the same collection of data, necessary for a DfT process. We expect this data to include information on the system model, basic blocks and sets of blocks, possible signal paths, etc.

We propose creating a unified data-sheet format to be followed from the beginning of the design phase to the product delivery and throughout the product portfolio. In an actual corporate environment this would entail first carrying out a data-sheet uniformity analysis, to determine the mappings from current setting to a standard format. The format alone is of little use to the automated test process. The format and the software should ideally meet all of the following criteria:

1. A widely accepted, customizable structured data format (XML).
2. Easy insertion and extraction of data.
3. Interface with modeling, design, simulation and test environments.
4. Standard representation:
   1. web: HTML
   2. print: PDF
5. Quick comparison of files by any parameter(s)

Point 5 in the list outlines an important requirement to promptly create a comparison chart of similar products. When data-sheets are given solely as PDF-documents, this is not easily done, as extracting text and data from a portable document can be a tedious task. Using an approach to generate this from XML files makes the process not only faster but also customizable.

The use of a database back-end is not recommendable as it makes the process dependent on yet another component. Implementing the software to support both local and remote data-sheet repositories is a sufficient solution.

The use of XML carries another major advantage, as it can be interfaced with little effort with the design and test environments. Using a centralized repository for data-sheets enables the test engineer to obtain the latest changes in the specification automatically, which increases positive redundancy in the communication between the design and test engineers. An automatic notifier for latest changes would also keep both sides up-to-date. A fact, that XML has evolved to become the de facto standard for communicating customized information, ultimately makes it a logical choice. Future work will include applying this concept to a fairly simple mixed-signal design, consisting of 4-5 basic blocks, to evaluate the approach.

Following Figure 2 depicts the proposed data-sheet approach.
The above Figure 2 also visualizes the idea of application level integration and targeting less complexity in the IC automated test development process. A strong advantage for selecting a non-proprietary format for data-sheets is the possible adoption among the academic community. Several (free) tools exist to process such files, such as Xerces, DOM, XML::Parser for Perl, etc - bringing out the easy-to-handle properties of the proposed format.

The following structure shows a sample XML-file, describing basic blocks of a model with the name, classification and index of the block, together with required parameters and tolerances. A simplified version of an actual XML-based system model specification, it introduces a much needed hierarchical structure. With browsers supporting navigating through XML by enabling to open and close sub-levels, it is convenient for understanding the architecture, sequence and specific parameters.

Example XML-file describing basic blocks within a model, identified by name, class and index. Parameter set is "closed" in the second block (LPF).

```xml
  <MODEL>
    <BASICBLOCK>
      <NAME>AMP</NAME>
      <DATA>
        <INDEX>1</INDEX>
        <CLASS>Analog</CLASS>
        <PARAMETERS>
          <PARAM_1>Gain</PARAM_1>
          <PARAM_1_VALUE>2.3</PARAM_1_VALUE>
          <PARAM_1_TOL>0.1</PARAM_1_TOL>
        </PARAMETERS>
      </DATA>
    </BASICBLOCK>
    <BASICBLOCK>
      <NAME>LPF</NAME>
      <DATA></DATA>
    </BASICBLOCK>
  </MODEL>
```
4 Application Level

Without referring to any COTS products, using already established modeling, design, simulation and measurement environments to implement the design and test flow introduced in the previous chapters, carries several advantages both for academic institutions and corporations. These tasks include:

1. Parametric input from the specification
2. Modeling and simulation of basic blocks
3. Input Signal Propagation, Output Measurements
4. I/O with the DUT (switch matrix control)
5. Results acquisition, analysis and storage

Refer back to Figure 2 for some inter-connections between the above-listed tasks. Re-using environments capable of handling the above tasks would enable to leverage the existing competence of applications at a site, rather than vesting resources in developing an additional design and test software for the purpose.

5 Conclusions

Though this paper targets work-flow improving for a particular domain, namely the automated test generation for mixed-signal integrated circuits, the author is confident, that the actual concepts introduced are applicable to several others. With quality and reliability counting for a major portion of a products overall success, increased and more efficient interaction between design teams and quality assurance (testing) teams becomes inevitable. In an ideal view, the two processes should have more and more overlaps with both providing feedback and input into one another.

Utilizing a set of existing and future technologies and applications to bring this interaction to life, enables for any entity with such needs to begin experimenting and re-defining their work-flow models promptly.

References

A Web Services based Communication Services Framework for Collaborative Work

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Abstract. This paper considers the problem of integrating communication services that support group collaboration systems. Past experience has shown that heterogeneous communication services are extremely difficult to be integrated into collaboration environment and extended to meet continuous changing requirements. This paper aims at proposing a common, interoperable framework based on Web Services technology for integrating communication services in a collaboration environment. This framework allows the implementation of reusable communication services components that can be plugged into the collaboration system and be invoked on demand according to communication requirements of collaboration applications. Based on this framework, a prototype system called Rich Media Collaborative Workplace is developed. This system provides an integrated collaborative workplace with benefits of increasing productivity, saving cost and improving efficiency.

1 Introduction

In today's extremely competitive environment, success of business is the result of collaboration of corporate groups. Efficient collaboration relies on effective communications. With the information technology revolution, computer supported collaborative work (CSCW) [1] system becomes the popular tool to support people work together anywhere and anytime to solve a common problem. A typical CSCW system integrates the control and presentation of heterogeneous types of data channels, such as text, image, audio and video, to enhance the quality of distributed collaborative work. From the perspective of communication services, CSCW system has a broad range of requirements. In the last decade, enterprises focus on building communication infrastructures in order to meet the ever-increasing requirements for intra-enterprise and inter-enterprise communications. In this perspective, enterprises have brought together various communication technologies and applications to facilitate and improve the collaboration. Hence at present most collaboration systems must adapt a heterogeneous communication environment, which are not designed in the approach of a unified communication subsystem. It will bring substantial benefits to users if we can build an integrated communication services environment for collaborative work system, which combines various communication services as well as other collaboration applications into a single easy-to-use environment. Therefore, it is
important to create a more general framework to integrate wide range of communication services into a collaborative work system.

In this paper, we define such a common, interoperable framework based on Web Services [2] technology for integrating communication services in a collaboration environment. Based on this framework, we developed a Rich Media Collaborative Workplace system, which integrates various communication services including instant message, email, telephone and audio conference in a heterogeneous environment.

The remainder of this paper is organized as follows: Section 2 introduces the motivation of building a Web Services based framework of communication services for collaborative work. Section 3 describes the communication services framework for collaborative work. Section 4 introduces the implementation of Rich Media Collaborative Workplace system as the prototype. The conclusion is given in section 5.

2 Using Web Services to Build a Communication Services Framework

2.1 Collaborative Work Model

To achieve a goal with a collaborative approach, people need to cooperate towards a common purpose, to coordinate for organizing themselves and to communicate for exchanging thoughts. These three concepts, cooperation, coordination and communication, consist the 3C model (Figure 1) for collaborative work [3]. They surround the working group, which is the centric role of this model, to provide desired services for collaborative work.

Cooperation services provide means for a group of people working together towards a common purpose. It support users with the mechanisms and means they need in order to perform their collaborative tasks within dislocated working groups. Members of groups could be spatially separated from each other. The inter-member
cooperation is implemented by means of groupware, which are combinations of software and hardware that efficiently support group people in their collaborative works. There are two essential factors for successful cooperation: well-understood goal and organized process. They are ensured by communication and coordination services.

Coordination services provide means for organizing working group members and bringing them order. Coordination service is accomplished by one entity (known as the coordinator) disseminating coordination context to group members to complete a task corporately. From previous research work [4], we can that the ability of group members to reach and maintain a superior coordination relies on the efficiency of communication service. And the performance of coordination can be improved by increasing the potential of using communication services.

Communication services provide group communication facilities to working members for transmitting and exchanging information. These services include: text-based instantaneous exchange of messages (Instant Message Service), individual electronic mail exchange (E-Mail Service), peer-to-peer voice-based conversation (Telephone Service), prearranged or ad-hoc meeting for discussion (Conference Service), etc. Communication services are important for collaborative work. Working group members must share information as widely as possible. Effective communication helps members understand how their works fit the objective and perform collaboration work in order. Otherwise, individuals in a working group tend to work independently, often in conflict with one another.

Thus, we can say that communication is the foundation for collaborative work. It is the basic element and provides support for cooperation as well as coordination.

### 2.2 Challenges to Communication Services

Development of communication services in collaborative work environment is evolving quickly. At the same time, challenge of heterogeneity to communication services also comes out. In the last decade, computer supported communication improved the performance of collaborative work by enabling working group to collaborate in ways of distributed cooperation. Therefore, there are a large number of communication systems are built to meet the ever-increasing user requirements. In these systems, there are various communication technologies and applications exist to facilitate and improve the collaboration. This situation brought the big challenge of heterogeneity to communication services for collaborative work system [5]. The heterogeneity is represented not only by the variety of hardware, operating system platform, programming language, but also by the diversity of underlying communication protocol, software architectures and models. This heterogeneity is the barrier to services interoperability and usability. It causes different perspectives and needs for cooperation and coordination services, which leads to incompatible design specifications for collaboration workspace solutions. Hence, developers of collaboration systems usually face this complex problem which must be efficiently solved. It is desired to build an integrated communication services environment for collaborative work system, which is easy to combine various communication services as well as other collaboration applications into a single easy-to-use environment.
2.3 Using Framework as a Solution

Above subsections indicated the heterogeneity challenge of communication services for collaborative work, which brought the complexity problem to developers of collaboration system. Managing this complexity in collaboration system development is essential for the success of the system. Here we propose to use a Communication Services Framework (CSF) to support integration of communication services in the development and implementation of a collaboration system. The CSF makes it easier to integrate sophisticated communication services supporting collaborative work. The CSF seeks to abstract the developer from the specifics of the underlying communication services platforms, applications and protocols. It eliminates the need for the developer to fully understand the detailed operation, configuration and integration of communication services in a collaborative environment. Thus, making use of the CSF can simplify the design, development and implementation of collaboration system. Developers can use it to accelerate the development process, leading to shorter time, lower cost, higher product quality and stronger competitiveness. To achieve this, the framework should have the following features:

- Integration solution for consolidation of heterogeneous hardware, software and protocols.
- Flexibility architecture for combination different communication services to meet various requirements.
- Standard-based interface for interoperation between different technology vendors.

2.4 Web Services: the Best Choice

We proposed our new concept that is to combine different communication services into a collaborative environment using an integrated communication services framework above. This framework should have following capabilities: integration, flexibility and standardization. From those perspectives, Web Services [2] seems to be the best candidate for this framework.

Web Services is a standard technology of integrating Web-based applications using a set of open standards (XML, SOAP, WSDL and UDDI) over an Internet protocol network. Web Services provide a way to describe and publish application’s interfaces to allow client applications invoke them. It supports different applications from different sources to communicate with each other. Following benefits from Web Services make it as the best choice to be used to build the communication services framework for collaborative work.

- Web Services is a simplified solution to integrate applications regardless of the device, platform and protocol that they use. Web Services works with standard Internet and Web protocols such as TCP/IP, HTTP and XML. The Web infrastructure is widely built in a significant number of companies for collaboration system. People have had sufficient knowledge and experience in using and managing it. So Adopting of Web Services can potentially improve collaborative process efficiency and reduce IT implementing cost.
- Web Services is designed as a flexible solution with loosely coupled feature. By adopting XML protocol, Web Services allows applications written in different lan-
guages on different platforms to communicate with each other in a standard way. So it is an ideal technology to orchestrate various information exchanging processes for supporting collaborative work.

- Web Services is based on industry standard protocols with universal support. The full life cycle of Web Services are covered by standards including describing, publishing, discovering and invoking. It makes Web Services to support the development of interoperable applications across a wide array of environments. The open standards help to reduce technology cost and increase service quality by wide choice of suppliers.

3 Web Services based Communication Services Framework

With the framework concept and benefits of Web Services, we propose a Web Services based Communication Services Framework (WS-CSF) to support integration of communication services in the development and implementation of a collaboration system. Figure 2 shows the five-layer architecture of WS-CSF framework. They are transport layer, access layer, collaborative presentation layer, mediation layer and communication middleware layer. The WS-CSF allows the implementation of reusable communication services components that can be plugged into the collaboration system and be invoked on demand according to communication requirements of collaboration applications. In this framework, communication services are wrapped into an independent component to hide the complexity of underlying communication networks, platforms and protocols. This component exposes a defined set of Web Services interfaces to use supporting communication services, such as message, telephone and conference services.

![Fig. 2. WS-CSF Framework](image-url)
**Access Layer:** This is the application interface layer for end users. This layer provides user interaction interfaces with the collaboration system. It contains different kinds of application endpoints to participate collaboration sessions, such as computer, telephone and PDA. Since different application endpoints have their own signaling and media protocols for participating, we abstract them as an access interface between access layer and transport layer.

**Transport Layer:** This layer is the carrier component to interconnect other layers. It provides capabilities to reliable transmit information from a source to single or multiple destinations. This layer comprises a collection of transportation networks, such as IP network, Public-Switched Telephone Network and Mobile network. Each network is responsible for supporting a communication service to meet a specific requirement.

**Collaborative Presentation Layer:** This layer provides a collaboration portal to end users for the aggregation of different collaboration services. It is a container of various collaboration applications for collaborative work. The main concerns of this layer are the representation of collaborative information and integration of various collaboration methods. It takes care of visualizing the collaboration service interfaces to the user in a way that is adapted to the application endpoint that the user is used. Users can customize the layout of their collaboration portal. With this layer, it is easy to integrate various collaboration services into a consolidated workplace. These services can be installed and removed dynamically by using service configuration facilities.

**Mediation Layer:** This layer is the mediator between collaborative presentation layer and communication middleware layer. It brokers interconnections and bridges communication services requestor and provider between these two layers. The purpose of introducing this layer is to conceal the heterogeneity of communication services by offering a unified interface. The main component of this layer is a Web Services Bus. This bus offers an enhanced environment for conducting dynamic communication services invocation with Web Services. It receives service requests from requestor (i.e. applications in collaborative presentation layer) and dispatches requests to corresponding service providers (i.e. servers in communication middleware layer) to accomplish a communication process.

**Communication Middleware Layer:** Below the mediation layer, the communication middleware layer provides the core communication facilities to access supporting communication services. It contains the engines of communication services. This layer comprises a group of service server that is responsible for providing a specific communication service. Each service server offers capabilities to collaboration applications for accessing underlying communication resources. These capabilities are exposed as Web Services interfaces to be invoked through Web Service Bus in mediation layer. The service request conveyed in Web Services message is mapped to specific protocol by service server and transmitted into transport layer.
4 Implementation of a Prototype System

Based on WS-CSF, we have built a Rich Media Collaborative Workplace prototype system that is used for worldwide collaboration work. This system integrated following communication services into a single collaborative workplace: synchronous communication for real-time interaction including voice-based (telephone) and text-based (instant message), asynchronous communication for users not available simultaneously (email), pre-scheduled and ad-hoc voice conference and white board. Figure 3 shows the system architecture of Rich Media Collaborative Workplace.

![Rich Media Collaborative Workplace Architecture](image)

We built a converged IP network based communication infrastructure as the transport layer. In this infrastructure, we construct a SIP-based VoIP network to provide voice communication capability for users. Session Initiation Protocol (SIP) [6] is an application-layer control protocol for creating, modifying and terminating communication sessions with one or more participants. The SIP proxy and SIP/PSTN gateway create a VoIP domain, which is bridged with traditional voice network, for voice terminals to perform voice communication. Additional servers including media server for voice mixing and LDAP server for user information storing provide supplemental functions. The converged transport layer offers diversity data and voice channels for user to access this collaboration system. Users can use computer, mobile phone, PSTN phone, softphone and SIP phone to access collaboration services.

We implemented this system using a flexible componentized architecture, which makes it easy for using, managing and extending. The system provides a collaboration portal to users to aggregate different collaboration services into a single workplace. It is built based on a portal server which contains various collaboration portlets [7] for each collaboration services. Users can customize their collaboration portals by adding and removing collaboration portlets and changing the layout of their workplace portal. With the power of portlet administration tool, the system administrator can easily integrate various communication services into workplace by dynami-
cally installing and uninstalling portlets. In addition to existing Domino portlet for email and Sametime portlet for instant message, we developed two kinds of portlets for telephone call control and conference services. These two portlets are built with Web Services adaptor for encoding and decoding request to SOAP [8] message. Through the SOAP connection on mediation layer, the collaborative workplace portal can invoke Web Services provided by service servers in communication middleware layer. We implemented two communication middleware servers by leveraging Parlay Web Services technology [9], which is a set of standard APIs that enable third party to access resources of communication network. After receiving request routed from mediation layer, communication service server translates the high-level commands to signaling messages of underlying protocol (i.e. SIP messages) and sends them to corresponding collaboration clients or feature server through transport layer.

With this system, we provide an easy-to-use web interface for users to perform collaborative work. In addition to text message and email, users can start voice conversation and conference by a single-click through workspace portal. Figure 4 shows the scenario of using this system. We can see that a user invite another user into a voice conference by choosing an option of context-aware menu through clicking people’s name. And the conference status can also be seen in a popup window.

Fig. 4. Usage Scenario of Rich Media Collaborative Workplace
5 Conclusion

For years, computer supported communication services have been converged into collaboration systems. It is changing the way how workers interact and perform collaborative work. By adopting enhanced communication services, companies can improve efficiency of collaboration and increase productivity for business growth. In this paper, we presented a Web Services based Communication Services Framework (WS-CSF) to support integration of communication services in the development and implementation of a collaboration system. This framework has five-layer architecture to solve the heterogeneity problem in a collaboration environment. Under the WS-CSF framework, various communication services can be integrated into a single collaboration workplace to meet various communication requirements. Based on this framework, we have developed a prototype system called Rich Media Collaborative Workplace. This collaboration system provides an integrated collaborative workplace with multiple communication channels including instant message, email, telephone and audio conference. It can benefit users by increasing productivity, saving cost and improving efficiency.

References

A Framework for Designing Collaborative Tasks in a Web-Environment

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Abstract. We present a framework that considers both the collaboration activities as well as the tools involved combining the artifact and process oriented approaches of knowledge engineering. Following the framework stages, we designed an Asynchronous Learning Network with a collaborative environment that enables structured collaboration between group members. Hundred and fifty (150) university students divided into teams of ten members each performed two collaborative tasks within a university course. As a preliminary evaluation we classified the messages sent by students within the discussion forum. Feedback on uploads increased significantly in the second assignment indicating that students besides performing their own task also took part in other group’s tasks creating a cooperative group that produced a collaborative outcome. We discuss the suitability of the framework for the design of Collaborative Environments for knowledge sharing and raise a few topics for further research.

1 Background

The field of Computer-Supported Collaborative Learning (CSCL) focuses on how computers support learning processes performed by a group of people working on a given task. The needs and demands for collaborating with peers & colleagues that are located distance apart are increasing. Hence, it is an important goal for any educational institution to improve the students’ performance in collaborative situations.

In the latest years we have witness the growing amount of implemented CSCL environments. However, only a few are based on defined frameworks that support the development of CSCL. Most groupware frameworks or toolkits attempt to cover a variety of domains, thereupon not being able to provide the most suitable solution for a specific domain. The domain of education in particular, requires specific mechanisms to address issues such as theory of learning, culture, evaluation and those related specifically to teaching-learning collaborative processes [1]. Littleton and Hakkinen [2] state that lately the interest in the field of collaborative learning has shifted away from considering just the outcomes and products of collaborative work, towards analyzing interactions as a mean of gaining insight into the processes of collaborative learning. The aim of such analysis is to identify what constitutes a productive collaborative activity.

The term collaboration implies that people engage together on a given task. Collaborative learning may be defined as situations in which particular forms of interaction among people are expected to occur, which would trigger learning
mechanisms, but there is no guarantee that the expected interaction will actually occur [3]. Collaborative learning involves cognitive and social-interaction processes. In fact, collaborative learning is not one single mechanism: peers do not learn because they are two, but because they perform some activities (reading, building or predicting) that trigger specific learning mechanisms (induction, deduction, compilation and others). Collaborative learning includes the activities/mechanisms performed individually, since individual cognition is not suppressed in peer interaction. In addition, the interaction among subjects generates extra activities (explanation, disagreement, mutual regulation, etc.) that trigger extra cognitive mechanisms (knowledge elicitation, internalization, reducing cognitive load and others) [4].

The advantages of collaborative learning in higher education encourage teachers and researchers to implement collaborative learning in virtual environments. Regardless the adopted approach many studies attempted to measure the effects of web collaborative learning. Lehtinen et al. [5] state that there is ample evidence to suggest that Web-based collaborative learning has significant advantages in comparison with the face-to-face (FTF) traditional approach as well as with the individual Web-based learning approach. He quotes a long list of experiments from the last decade that seem to corroborate the assumption that Web-based collaborative learning raises academic performance. Other advantages include: a dramatic increase in (high education) student participation rate Nachmias et al. [6]; enhanced student satisfaction from the educational process, combined with higher motivation and involvement; better combination of self-reflection and interaction among students [7] and developing group spirit and a sense of belonging to a community among individual learners – one that is missing in individual on-line learning methods [8].

There are numerous existing learning approaches. Hiltz & Benbunan-Fich [9] distinguish between the different types. The passive approach to learning assumes that students learn by receiving and assimilating knowledge individually, independently from others [10, 11]. On the contrary to the passive approach, the active approach presents learning as a social process, which takes place through communication with others. In between the passive and active learning is the interactive approach described by [11] and Alavi [12] who claim that the student acquires knowledge by formulating ideas into words and these ideas are built upon through reaction and response to others. Collaborative learning is defined as a learning process that emphasizes cooperative efforts among faculty and students. It stresses active participation and interaction by both, students and instructors [11, 13]. The collaborative learning approach is considered an interactive approach. It can be treated as a method that encourages students at various performance levels to work together toward a common goal [14]. Harasim [15] indicates that collaborative learning is fundamentally different from the traditional direct-transfer or one-way knowledge transmission model in which the instructor is the only source of knowledge or skills. In collaborative learning, instruction is learner-centered rather than teacher-centered and knowledge is viewed as a social effort, facilitated by peer interaction, evaluation and cooperation. Therefore, the role of the teacher changes from the transferring of knowledge to students to being a facilitator in the construction of the student's own knowledge[9].

Collaborative learning can be characterized by the level of collaboration as its being exercised during the learning process. The continuum ranges between students sitting together, on one pole, and autonomous collaboration groups, on the other. In this study we have defined cooperative groups that implement different tasks, linked to each other that generate a one collective outcome, made of different parts.
The synchronous environment is mainly used for lecturing or training tasks. Harasim et al. [16] reviews a variety of on-line CL models based on the group interactions enabled such as seminars, students workgroups and learning circles, peer learning groups and networked classroom. All the models include a certain involvement of a controller/tutor and all are based on peer interaction. Since synchronous environment imposes the time constraint of being together at the same time on the net, it is usually complemented by an asynchronous environment. The Asynchronous Learning Network (ALN) is a teaching and learning environment located within a Computer-Mediated Communication (CMC) system designed for anytime/anyplace use through computer networks.

Any web collaboration environment enables interactions between learners and tutor through (mostly asynchronous) web based tools. Defining the web collaborative learning environment through the tools included is known as the tool based approach. Among the prevalent web-based collaborative learning tools, Clark [7] describes the following: e-mail, forum, private conference, gated conference (also described as a question and answer protocol), video and internet conferencing (chat).

Another approach classifies collaborative learning environments into document-centric or session-centric. Systems based on the document-centered approach focus on the management of documents and objects respectively. These documents and objects are classified (e.g. task, address, date etc.) and access rights (i.e. write and read permission) are assigned. Electronic mails can be considered a special case of document management. These systems usually offer the users a number of different views on the data collection dependent on the object's attributes. Some of these systems support special co-ordination tasks such as defining dates for group meetings or task delegation among group members. Besides context-neutral tools (such as Lotus Notes or Microsoft Exchange, that must be adapted according to customers requirements) there are systems developed especially for the purpose of learning (so-called web-based training systems for computer-based distance learning). Tools that are based on meeting-focused concepts (session centric approach) concentrate on the support of synchronous communication at different locations [17]. Services normally allow textual, graphical and audio information exchange. Typical functionalities are text chat, audio and video communication, multi-user graphic programs, and application sharing.

We have presented in this section prevalent approaches to web–based collaborative learning and research support for its advantages. However, we cannot deduce from the research, which is the most effective approach to the design of web collaborative learning environments. This is due to the fact that all these studies are embedded in very specific contexts, rely on different research methodologies and the collaborative approaches implemented strive towards different aims. The question is not just how to implement collaborated activities via the web medium in the educational domain, but rather when one comes to implement a collaborative activity what are the tools that should be used to evaluate the success of the collaborative process. Furthermore, how do we measure success and effectiveness?

A collaborative e-learning framework should enable a systematic approach for the development of web based collaborative learning environments including the technological, educational and social processes involved. The present study is a first step towards defining a general framework that will enable to characterize a collaborative learning process within an electronic environment.
2 Defining a General Framework for Collaborative E-Learning

Cambridge Advanced Learner's Dictionary defines framework as a supporting structure around which something can be built or a system of rules, ideas or beliefs that is used to plan or decide something. TEPCEL is an acronym for Technological, Educational and Process oriented Collaborative E-Learning Framework. It is composed of five stages: (1) objectives definition, (2) collaborative features settings, (3) collaborative assignment definition, (4) collaborative tools definition and (5) evaluation (see Figure 1). Each stage is characterized by a set of attributes that enable the design and later evaluation of the collaborative learning environment. The first four stages refer to the design process while the fifth is the evaluation process. Since the evaluation is performed during the implementation process (formative evaluation) as well as after the implementation has finished (summative evaluation) there is no point in defining a separate implementation stage.

The TEPCEL framework enables to design synchronous as well as asynchronous collaborative learning environments. It combines several approaches including the tools, outcome and process, document centric, and session centric approaches into one integrated framework. This kind of integrated approach is crucial since many studies have shown the importance of each approach in collaborative learning. Choosing just one approach may lead to limited results.

For each stage, TEPCEL provides a set of attributes with possible values. For each attribute (O) denotes that one value should be selected and (O+) denotes that at least one attribute should be selected. There is no intent to provide a finite set of attributes and values. Both may be updated to enable TEPCEL to be an evolving framework for the design and evaluation of collaborative e-learning activities. Stages 1-5 provide a detailed description of the attributes per each stage of the TEPCEL framework (Figure 1).

Stage 1 - Objective Definition

This stage defines the goals for collaboration. The following attributes should be defined.

1-a. The cause for the CL process – (O) Voluntary or mandatory (decided by some authority).
1-b. Expected Collaborative Outcome – (O) Different outcomes; Each participant completes his part; One collective outcome made up of the different parts; The same outcome - the product of mutual effort.

Stage 2 - Collaborative Features Settings

The second stage defines the collaborative features for both the personal attributes and the assignment settings. Personal attributes will be gathered using assessment tools that will be defined as part of the framework.
2-a. **The size of the CL group** – (O+) The number of group’s members, number of subgroups and its members.

2-b. **The duration of the CL process** – (O) Number of days, weeks or months.

2-c. **Document/Session-centric** – (O+) Focus on the management of documents and objects (asynchronous) and/or meeting-focused concepts that concentrate on the support of synchronous communication at different locations.

2-d. **The nature of learners in CL process** – (O+) Learners characteristics such as type of learners (full/part time, profession, status in the organization).

2-e. **The aspects of the learners** – (O+) Personal traits relevant to the CL process (behavioral (i.e.: likes to learn alone/in groups), emotional (confident), cognitive (learning style), informational (level of computer knowledge).

**Stage 3 - Collaborative Assignment Definition**

The third stage defines the collaborative assignment content, educational approach and format.

3-a. **The subject of the CL process** – (O+) The main subject matter learnt, practice acquired or issues or problems discussed.

3-b. **Educational approaches** – (O) Networked Classroom as Course Enhancements, Online Course Delivery, Distance Education and Open Learning.

3-c. **Group Type** - (O) Sitting Groups, Work groups, Cooperative groups, Autonomous collaboration groups

3-d. **The motivation sources of the learners in the group** – (O+) External motivation such as final grade, pass mark, prize; Internal motivation such as research work selected by the students, competition (with no prize or mark assigned but some kind of recognition such as publication at website or mention in class).

3-e. **The nature of the outcomes(s) of the learning process** – (O+) Conceptual understanding or knowledge on the discussed topics, some shared capacity or consensus (such as a solution to a problem or a list of recommendations), a written document or an object (program, prototype or product).

**Stage 4 - Collaborative Tools Definition**

The fourth stage defines the set of collaborative tools to be used within the environment.

4-a. **Available tools and technologies** – (O+) The following is a proposed list of available tools and technologies that enable web collaborative processes. A non-exhaustive list of the proposed technological tools for the collaborative environment may include: conference call (phone), email, message board, discussion forums, news groups, ICQ, FAQ pages, instant messaging, shared virtual scheduling systems, text chat, audio chat over the Internet, video conferencing, application sharing, web based training software, FTP, download function and upload function [17].

**Stage 5 - Evaluation**

5-a. **Timing of evaluation** - (O+) During the process (formative evaluation), at the end of the process (summative evaluation).

5-b. **The intensity of the CL process** – (O+) Number of meetings, their frequency and their length for synchronous collaboration; Number and type of messages for asynchronous collaboration.

5-c. **Evaluation criteria** - (O+) Student participation rate; student satisfaction from the educational process; student satisfaction from the social collaborative
process; Student's feeling of belonging to a community; academic performance; group spirit; student's perceived learning efficacy (for example by adapting the instruction procedure to the learner's individual learning style).

5-d. Evaluation type - (O+) Quantitative or Qualitative.
5-e. Subjects of evaluation – (O+) The individual learners; the group of learners,
5-f. Who determines the type of evaluation? – (O) Decided by the tutor/evaluator, Decided by the tutor/evaluator after consultation with the learners, Decided by the learners themselves.
5-g. Who decides on the evaluation criteria? – (O) Criteria are given/dictated by external circumstances; the tutor dictates criteria; the tutor dictates criteria based on dialogue and consultations with the learners; the learners themselves decide criteria.
5-h. Patterns of interactions amongst the learners - (O+) Division of labor, hierarchical or symmetric relationships, roles, interdependence, negotiation, autonomy of the individuals.

The framework attributes and tools described above enable to define and compare many different environments. They also enable to test the influence of different attributes in a specific environment over time. In the next section we present a case study implementing TEPCEL framework.

3 TEPCEL Framework – A Case Study

We have implemented a web collaboration asynchronous environment based on TEPCEL framework in an undergraduate course for Information Systems Engineering students. The course population consisted of 150 students divided up into 15 groups. Each group was further divided up into 5 dyads. The students had to complete a collaborative task, consisting of two assignments; each assignment was divided into 5 tasks. Each dyad of students selected one of the 5 tasks based on the principle: “first come first served”.

The registration to the groups was conducted as follows: During the process of registering to the course website each student was required to select a teammate. Each new dyad was assigned automatically to the next group that was being formed. Every five dyads formed a new collaborative group. The students were unable to control their collaborative group belonging. As a result in some of the groups the members became acquainted only during the collaborative assignments.

Each group was provided with a private workspace with asynchronous capabilities that contained the following:
- A list of all group members
- A list of five tasks
- Collaborative Assignment description
- A threaded asynchronous discussion forum
- Upload capabilities for draft files and for final assignment submissions
- An automatic email mechanism that sent notifications to the group members each time a file upload operation was performed by one of the dyads requesting for feedback.

The group members used the forum to discuss topics that referred to the collaborative assignments and to add feedback on uploaded files. In both assignments, there was no content intervention by the course instructor. Each discussion forum was
a private workspace and was independently managed by each group, based on students’ initiative. We have instantiated each one of the TEPCEL attributes in our case study. A full description of all the attributes is beyond the scope of this paper.

As mentioned, the collaborative activity was compound of two assignments. Each assignment was divided into five different tasks related to each other. The expected outcome per each assignment was one collective outcome, made up of 5 different parts. Each group had to plan the task, and divide the work among the participants. At the end of each assignment we have analyzed the collaborative interactions within the discussion forum and provided feedback to each group.

Assignment 1 - The objective of the first assignment was experiencing with the phases of a software project life cycle. This type of assignment enabled us to implement 5 different tasks related to each other and produce one collective outcome. Each group received a description of a requested system that was based on multi-modal technology. The implementation of each phase was assigned to one dyad as a task. The first dyad was responsible for performing the exploration phase during which they were required to perform a literature review by searching for relevant articles, existing enterprise systems, track faults within existing tools based on existing publications and provided a detailed report based on their findings. The second dyad gathered and analyzed the user requirements based on the literature review of the first dyad and performed a limited user requirements survey. The third dyad was in charge of the design and functionality of the prototype system. The forth dyad defined and performed the system usability evaluation based on Nielsen’s usability parameters [18]. The last dyad prepared a comprehensive presentation that summarized all parts and presented it to the class in a face to face session. During the assignment, the students collaborated by using the proposed workspace. They have submitted documents to the website by using the upload capabilities and provided feedback and suggestions on their group-mates products by using the discussion forum tool.

Assignment 2 - The objective of the second assignment was to create an interactive lesson on the web. The assignment was divided into 5 related tasks. Each dyad was in charge on the implementation of one task. In addition, it was clearly emphasized by the course instructors that the group members are expected to collaborate. The first dyad was responsible for searching for relevant references and contents to be used when creating the interactive lesson content. Based on the literature review the second dyad was in charge of writing the contents and designing the lessons’ WebPages. The third dyad developed a quiz to evaluate student’s learning performance in that lesson and implemented the DB to store the students’ lesson’s data. The fourth dyad was in charge of the development, integration and implementation of the website. The last dyad planned and preformed functional and usability evaluation testing.

4 Evaluation

The evaluation aims to demonstrate the assessment of the case study performed according to TEPCEL framework. We measured the level of group collaboration within the ALN in the two assignments. We expected that the level of collaboration will increase in the second assignment as a result of acquired experience in the first collaborative assignment. We defined three dependent variables:
1. The quantity and quality of interactions. This dependent variable was assessed by the number of messages per type. All the messages in each private forum were recorded in a database at the web server. We classified the discussion forum messages into one of the five following categories that were defined during the content analysis of the discussion forums: (1) Not Relevant - messages not related to the assignment, such as jokes or messages related to other courses. (2) Collaboration support/request for assistance (3) Encouragement (4) Updates on activity (5) Feedback on upload – messages that provided feedback on the form, presentation, or content of the files uploaded to the collaborative private workspace (6) Administration Messages – after each upload, an event driven agent sent an automatic email to the group members notifying them that a file was uploaded by a certain student, and requested for feedback. The classification of the messages was performed manually by doing log file analysis.

2. Number of uploads per group – The environment enabled the students to upload an unlimited number of working files to the private collaborative workspace. At the due date each dyad uploaded their final submission file to be graded by the course staff. The number of uploads per group was computed automatically by the system.

We expected that students will collaborate more in the second collaborative assignment. We performed Student's paired t-Test, with a one-tailed distribution comparing the two assignments. It is clear that messages types between the two assignments differ in one dimension only: feedback on uploads. The number of messages dealing with comments on uploads (message type 5) increased significantly in the second assignment (p= 0.023). In addition we may see a close to significant decrease in requests for assistance (p= 0.060). This result may indicate that when students collaborate better, they give more feedback on uploads and request less assistance. This result should be studied further.

5 Discussion

The main goal of this study was to define an integrated framework for the design and evaluation of collaborative e-learning environments. We described a case study that implemented a web collaborative environment according to TEPCEL framework. The evaluation aimed to demonstrate the assessment of the case study performed according to TEPCEL framework.

The evaluation was intended to verify that collaboration took place within the collaborative environment designed according to TEPCEL framework. This preliminary evaluation intended to test face validity of the framework, meaning that the framework indeed helps in the design of collaborative learning environments. Further evaluations should compare a collaborative environment designed with TEPCEL with a control environment (collaborative environment designed according to another model) and test the collaboration enabled by both collaborative virtual environments.

The results of the preliminary evaluation on a case study of two collaborative assignments indicate that TEPCEL helped in designing the collaborative e-learning environment for knowledge share. Furthermore, we found significant increase in the interactions about the material uploaded by students in the second assignment. Unfortunately, the order of the assignments could not be counter-balanced, it was defined according to the course schedule. There could be other reasons for the
difference between the assignments in terms of feedback on uploads: a different task, a different time period, the students just may be more experienced with the environment.

Our assumption was that messages classified as “feedback provided on upload” indicate the level of collaboration as students not only perform their own task but either they take part in other group’s tasks and therefore create a cooperative group that produce a collaborative outcome.

The assignments included a variety of Harasim et al. [16] on-line CL models: Learning Partnership and Dyads (which are recommended as an introductory step for students in acquiring online CL skills), Students Workgroups (a task with a distinct pre-defined division of labor, roles, timeline and decision making process within the group), Team presentation and Teaching by the Learners (an important motivational factor for collaboration) and Peer Learning Groups (which enabled the students to complement each other’s weaker points by asking for assistance and advice on various tasks, mainly used in the first assignment).

The collaborative environment was designed according to the TEPCEL framework parameters. TEPCEL is indifferent to the electronic available tools. It will track the interactions done within the diverse tools. However, collaboration is not only depended on the tools and the activity models. In order to design successful collaborative tasks we should relate to the social interactions which take place during the assignment's development. Another approach stresses the importance of personal attributes on the success of the collaboration within ALN environment [19]. TEPCEL relates to the personal attributes as one of the parameters being defined or tested (as pre-defined or evaluated). In our study, students expressed their need for a tutor or leader, a person who is in charge of the assignment timeline. We have noticed that during the second assignment numerous groups have nominated a group chair and defined timeline for each task by themselves. One of the groups that received a low grade on the first assignment due to low collaboration of its members decided on corrective action during the second assignment.

Another interesting factor is the improvement of the collaborative work from which we can conclude that group collaboration requires training. It takes time for students to get familiar with the collaboration concept. Collaboration is not just a tool or an activity but either a process. The collaboration takes place within a technological environment. Therefore, a careful design of the diverse attributes implemented in the environment should take place. Also, a careful planning of the task should be done in order to favor the collaboration between team members. TEPCEL is able to deal with the different factors that influence collaboration through the definition or the testing of the relevant parameters: groupings (groups and subgroups), initiative (for the activity and the evaluation), roles, volume of interactions and its contents, outcomes, various personal attributes and more. We found that TEPCEL enabled us to easily characterize and analyze the collaborative process that took place during the collaborative assignment. The linkages between the messages in the discussion forum serve a role in the nature of the dialogue.

Future work will deal with the development of more measurements in order to analyze the quality of collaboration that takes place within the web-based environment.
References


Abstract. To gain a leading edge in today’s competitive environment, higher education enterprises are implementing and obtaining International Standard Organisation (ISO) 9001:2000 certification for their quality management system (QMS). In this paper, the use of ARIS (Architecture of Integrated Information Systems) methodology to assist in process understanding when implementing QMS is discussed. Introduction of the ISO certified QMS into the School of ABC, XYZ University – the first ever for an academic school in Australia, is used as a case study to illustrate both the notion of a process-oriented HEE and the elegance and power of ARIS.

1 Introduction

Reducing government funding, intense cost pressures, increasing student numbers, rising competition for international students, growing need for self-reliance, demands for greater accountability and quality are changing the landscape for higher education in Australia. Consequently, higher education enterprises (HEEs) are moving away from more traditionally collegial styles towards corporate management styles characterised by high student/staff ratios; introduction of stringent financial planning and spending; centralisation of power structures; increased focus on efficiency and effectiveness of individuals’ and departments’ research and teaching standards; and introduction of information support to gain a leading edge [1].

Most of the corporate management concepts adopted by Australian HEEs centre on business processes and have long been expected to obtain competitive edge for process-oriented enterprises. They include activity-based costing, benchmarking, balanced scorecard and quality initiatives like quality assurance system to ISO 9001:2000 (ISO from now onwards) standards and total quality management model. Relevant literature including the discussion of these activities in the context of a HEE include for examples, Cribb & Hogan [4], Ellis-Newman & Robinson [8], Goddard & Ooi [9], Hafner [10], Lundquist [13], Massaro [14] and Piper [18].

A business process-oriented enterprise is seen to include the following key factors: a process view of the business; structures that match these processes; jobs that operate these processes; management and measurement systems that direct and assess
these processes; and customer focused, empowerment and continuous improvement oriented values and beliefs (culture) that are embodied in all components [15].

In view of this, it is important to understand the concept of process-orientation in the context of higher education as process-orientation paves the way for a number of corporate management concepts, in particular quality management system (QMS) to ISO standards which become prominent in Australia after the introduction of quality evaluation by the government due to lack of community confidence and funding cutbacks.

The objective of this paper is, therefore, two-fold:

- to study the industry specific issues of how the implementation of an ISO quality management system within an academic school serves as a facilitator for a business process modelling exercise; and
- to illustrate how ARIS methodology is utilised in the process of ISO certification

This paper closely follows the case study methodology [25] with elements of formal theoretical process analysis and design being incorporated into it

The contribution of this paper is that it reports on the first ever case of ISO certification undergone by an Australian academic school [16] and puts it into a coherent framework of process-orientation and process modelling.

This paper is organised as follows: Section 2 presents an overview of ISO certification, Section 3 provides a brief description of the ARIS methodology while in Section 4 the case of the School of ABC, XYZ University, Australia and its ISO implementation process are introduced. This is followed by a discussion of the case study findings in Section 5 and an overview of the overall description of the ARIS models developed in Section 6. Section 7 provides further discussions on the case study and finally Section 8 contains a brief summary and conclusion.

2 ISO 9001:2000 Certification

Process is defined in ISO as “a system of activities that utilises resources for the transformation of inputs into outputs” while in classical business process management literature, Davenport ([5], p.5) define a process to be “a specific order of activities across time and place, with a beginning and an end and clearly identified inputs and outputs with a structure of action”. There are definitely similarities between these definitions.

The ISO process-based approach refers to the management of processes and the interactions between processes within the organisation. It emphasises the importance of understanding and fulfilling quality requirements, considering value adding processes, constant monitoring of the results of process performance and ongoing improvement of processes based on objective measurement [19]. Implicit in this approach is the assumption that quality of processes should guarantee quality of outcomes.

Process-based approach makes it easier for employees to share in the construction of the QMS because routine day-to-day tasks are expressed. Involvement of staffs in the process of detailed procedure creation and updating advances user acceptance of this system as well as inspiring staffs to continuously improves and enhances it [21].
The benefits obtained from ISO certification have long been recognised by the manufacturing industry [7]. However, the application of these standards to higher education is a fairly recent trend and is an attempt to respond to the increased pressures to ensure accountability and quality in the industry [2], [3]. It is also used by HEEs to increase their credibility of promoting commitment to excellence and continuous improvement in all its processes to take full advantage of the latest education reform which allows Australian HEEs to increase Higher Education Contribution Scheme (HECS) fees up to 25% of current HECS fees, all of which go directly to the HEEs [17].

It is important to note that whilst the implicit assumption of quality of processes leads to quality of outcomes is often taken for granted by ISO as well as organisations undergone ISO certification, whether this is always the case will be discussed in Section 5.

3 Process Modelling with ARIS

A business process model is a blueprint that keeps a list of relevant interrelated organisational dynamic activities from beginning to end, and their structure and close relationship with other related resources that support them.

ARIS framework was first introduced by Scheer [20] and further developed by Davis [6], Loos & Allweyer [12], and Scheer [22] to amalgamate both business processes and major components of information systems into a coherent integrated architecture for organisational information support which became one of the well-documented classical process modelling methodologies. It is not the purpose of this paper, therefore, to provide a “mini-tutorial” on ARIS modelling but rather we briefly recall the basic concepts of ARIS that are relevant for our discussion.

The ARIS methodology is based on the concept of a process chain model - a collection of value-oriented individual processes [20]. Presenting the overall business process model in one big schema in order to describe the real complexity of underlying business processes reduces the clarity of the model.

Davis [6] suggests decomposing the business process model into three hierarchical layers: conceptual layer, process layer, and procedural layer. Fig. 1 depicts the three hierarchical layers in ARIS model where a value-added process in Fig. 1(a), decomposes into an overall sequential activities of that process in Fig. 1(b) and decomposes further into more specific details of a particular activity in Fig. 1(c).

Davis [6] also proposes the decomposition of conceptual and process layers into several detailed levels to improve clarity of more complex processes. An assignment icon symbol is used as a navigation tool in ARIS to link one process to another process or to another view as indicated by Fig. 1(a).
There are many potential uses of graphical ARIS process models once they are developed. According to Scheer [21] these benefits include among others, storing corporate knowledge in reference models, optimising organisational changes, utilising process documentation for ISO-9000 and other certifications, improving cost calculation and leveraging process information to implement and customize standard software solutions or workflow systems.

4 Case Study Settings

The School of ABC was established in 1988 and is the second largest school out of the eight schools within the Faculty of DEF - the second largest faculty in XYZ University. It offers two undergraduate degrees and six postgraduate degrees. Currently the school is made up of 49 full-time staff: 35 academics, 11 administrative staff, and 3 technical staff. The school also employs approximately 60 sessional assistant lecturers each semester to help run tutorials.

The implementation of the school’s QMS, known as business management system (BMS) is part of the faculty’s BMS and stems directly from the Faculty Operational Plan 2002. The faculty recognises the need for quality assurance program to gain a competitive edge due to the current downturn in information technology sector and rapid technology advances, among other factors discussed in Section 1. The school was chosen to implement BMS because it already has procedures in place for its day-to-day operations.

The eight steps adopted by the school in achieving ISO certification for its administrative and academic processes include: form two units; establish objectives and key processes; develop process maps; document procedures, preliminary audit of documentations, in-house audit of procedure manuals; on-site audit of procedure manuals; and certification of ISO 9001:2000. These steps are depicted as an ARIS procedural model in Fig. 2 using extended event-driven process chain model (eEPC), the central modelling technique in ARIS process layer.

The four types of objects used in the process layers are: events, functions, rules and resources (refer Fig. 1(b)). An event represents the changing state of the world as process proceeds. Function is an activity that is carried out as part of a business that adds business value. A logical Boolean connector (AND, OR, XOR) is used as rules to
segregate and/or join the events and functions. Resources may include organisation, systems, data, knowledge and the like.

Despite the potential benefits of ARIS, the ARIS methodology discussed in Section 3 is not chosen by the school for its ISO process description, instead Microsoft Word is used. We argue that using ARIS methodology is beneficial and in Section 6 we demonstrate how the process description could have been simplified and simultaneously enhanced by ARIS.

5 Case Study Findings

The case study findings reported upon in this paper can be roughly classified into two broad categories.

5.1 Academic versus Administrative Processes

Based on our case study, it is found that nine academic processes compared to 78 administrative are documented by the school staff members. The large discrepancy may be due to the nature of the processes, academic being less structured hence more difficult to procedurised than administrative. This is evident by the fact that the nine academic processes documented tended to be more administrative related for example, new course approval process, staff induction, staff development and the like.

Another reason may be due to the fact that administrative staff members operate in an “enterprise” mode thus more receptive towards change and teamwork environment than academics. Academics tend to value their freedom, incline to be less flexible and
prefer to operate autonomously hence documenting academic processes may be seen as an intrusion into their freedom and privacy. It correlates well with the general observation that academics are less likely to operate in an “enterprise” mode when the current academic reward system is very much based on individual research outputs. Understandably academics tend to gain more if they devote time and energy towards those aspects of teaching and research which tend to be less “formularisable”.

The certification process increased administrative staff members’ awareness of the school’s core processes. They focused on these processes to help enhance the transparency of them and to identify activity owners hence have better appreciation of each other’s roles and tasks.

Since administrative staff members tend to adopt proactive leadership management and facilitated greater communication and teamwork, they have higher coordination level. Academics, on the other hand, have much lower coordination level as they tend to operate autonomously.

5.2 ISO: Processes versus Outcomes

The impact of ISO certification on the school have not been analysed as yet since the whole certification process was completed at the end of 2003. However, following from our discussions with the school management, the specific benefits of ISO certification to the school included streamlined processes by eliminating redundant and duplication activities. In addition administrative staff members have better understanding of the school’s activities, thus are no longer perform activities that are supposed to be done at academic faculty level.

Recall the discussion in Section 2 about the implicit assumption of ISO certification that quality of processes guarantees quality of outcomes. This may not necessary be the case. Efficiency is producing maximum (a given) level of outputs for a given (minimum) set of inputs while effectiveness looks at how well the objectives of the entity are achieved. Efficient processes may not necessary be effective and vice versa. Therefore quality of processes does not guarantee quality of outcomes. As discussed in Seng and Churilov [24], in order for process to be both efficient and effective, mean objectives of the process must be aligned with fundamental objectives of a HEE using Keeney’s value focused thinking [11] where fundamental objectives are specific objectives that an organisation wants to achieve while mean objectives are objectives that help accomplish fundamental objectives. For example, the set of fundamental objectives for a HEE include among others: provide facilities for study and evaluation; give instruction and training; aid advancement of knowledge; and confer degrees, while mean objectives include among others: increase revenue; improve customer service; reduce operating cost; and manage fixed assets. Consequently the implicit assumption of ISO certification should not be taken for granted. On the contrary, it is important that the objectives of the processes identified for documentation be aligned with the objectives of the HEE.

We have just demonstrated the findings of the case study that did not use the power of ARIS. Below we demonstrate how the ARIS methodology can be used to improve process modelling and understanding.
6 Case Study Revisited: an ARIS-based Approach

The School of ABC is made up of both the Academic Unit and Administrative Unit therefore all the key processes are separated accordingly. As part of the ISO certification process, the school produced documentation for 87 processes: nine academic and 78 administrative.

The Academic Unit is in charge of four core processes: Teaching; Research; Curriculum development & review; and Industry liaison as depicted in Fig. 3. The Curriculum development & review process is decomposed into four sub-processes: New course approval; Unit review; New unit or major amendments; and Unit minor amendments as shown in Fig. 3(b). Further, as illustrated in Fig. 3(c), the Academic Unit is responsible for six core processes within its resources management: Recruitment; Staff industry; Staff development & training; Teaching allocations; Mentoring; and Staff performance management.

In contrast, within the Administrative Unit there are five core processes as illustrated in Fig. 4: Marketing; Staff services; Student services; Technical services; and Student support services.

Each of these decomposes further into several other levels of conceptual layer. The Marketing process into two 2nd-level: Publications; and Open day, and two 3rd-level conceptual layers. Staff services process consists of five 2nd-level: Financial re-

![Fig. 3. Conceptual layer of the Academic Unit](image_url)

![Fig. 4. High-level conceptual layer of the Administrative Unit](image_url)
sources; Human resources; Physical resources; Teaching resources; and BMS documentation, 19 3rd-level and 20 4th-level. Student services process comprises of eight 2nd-level: Admission; Enrolments; Timetabling; Assignments; Examinations; Results; Scholarships and Research, 18 3rd-level and 10 4th-level. Technical services process encompasses four 2nd-level: IT support for staff & research student; IT teaching & leaning support; File, web & application servers; and Network & account management, 17 3rd-level and 12 4th-level. Student support services process includes two 2nd-level: English conversational classes; and Online textbook listing, and two 3rd-level.

The processes of the school are modelled using ARIS value-added chain diagrams for conceptual layers, ARIS eEPC for process layer and ARIS function allocation diagram (FAD) for procedural layer. In total 102 ARIS process models are developed. Nine ARIS process models for the Academic Unit: four for Curriculum development & review; and five Resource management and 93 ARIS process models for the Administrative Unit: three Marketing; 33 Staff services; 26 Student services; 28 Technical services; and three Student support services.

The lecture timetabling process is discussed to illustrate the power and elegance of ARIS methodology in enhancing process understanding. This process is chosen because it is one of the “deepest” processes with several levels of conceptual layer (see Fig. 5) and eEPCCs as well as a FAD.

![Fig. 5. Decomposition of the conceptual layer of the administrative process](image)

As depicted in Fig. 6, the high-level eEPC is used to capture the chain of activities that is happening at the lecture timetabling process.
This process is initiated by the arrival of the faculty’s census spreadsheet event and is supported by two 2nd-level eEPCs: check unit offerings and prepare lecture timetable and ends once all the school’s staff are notified of the updated lecture timetable. It is further supported by three 3rd-level eEPCs and one FAD as depicted in Fig. 7 and Fig. 8 respectively.
(b) 3rd-level eEPC for enrolment numbers estimation

(a) 2nd-level eEPC for lecture timetable preparation

(c) 3rd level eEPC for determining unit leader requirements and availabilities

(d) 3rd level eEPC for booking of lecture theatre (refer Fig. 8)

Estimate Enrolment Numbers
P/G Prog Coordinator
Book lecture theatre
Determine requirements & availabilities
enrolment numbers estimated
requirements noted
academic allocation file checked
census file returned
email unit leader for lecture requirements
no changes to requirements needed
Note lecture requirements
requirements noted
P/G Prog Coordinator
academic allocation file checked
check lecture theatre feasibility
lecture theatre determined
email requests to FIT time-tabling officer to key to Syllabus+
Syllabus+ FIT confirmation file received
check lecture requests confirmation
create lecture timetable file
lecture timetable created
lecture theatre booked

Fig. 7. Decomposing from 2nd to 3rd-level eEPCs of lecture timetabling process

(a) 3rd level eEPC for booking of lecture theatre

(b) FAD for checking lecture theatre feasibility

Fig. 8. Decomposing from 3rd-level eEPC to FAD of lecture timetabling process
7 Discussion

Describing business processes with ARIS ensures consistent modelling and elimination of paper versions of documentation. Further storing processes in ARIS repository meets most certification requirement that processes should be available at all times to respective people in the organisation.

During the ARIS modelling, 102 process models are developed. Nine models for the Academic Unit: four for Curriculum development & review and five for Resource management; and 93 for the Administrative Unit: three for Marketing, 33 for Staff services, 26 for Student services, 28 for Technical services, and three for Student support services.

These models act as reference models ensuring the school’s knowledge is not lost and smooth transition of processes due to staff movements or departures. On top of that they facilitate greater process understanding and reconciliation of different viewpoints through ARIS methodology of decomposing complex processes into hierarchical layers. Thus the adoption of such methodology greatly enhanced the level of activity coordination among the people involved.

In addition these models may be modified for other purposes which may include activity-based costing, process improvement and/or design, process benchmarking, simulation, balanced scorecard and the like for improving the school’s decision making processes, quality of processes as well as efficiency and effectiveness of the school’s operations.

Taken together with the findings described above, the “administrative-related” corporate knowledge seems to have higher potential to become explicit while the “academic-related” knowledge seems to have a reasonably high tacit component.

8 Summary and Conclusion

In this paper the process of the ISO certification for an academic school within Australian university is discussed. The concept of a process-oriented HEE developed by Seng and Churilov [24] provides a convenient starting point for addressing the issues of ISO certification in a university. As the ISO set of standards is very much process-oriented on its own, it is rather natural to expect a “better fit” and fewer problems when implementing ISO certification by the enterprise with process-oriented organisational structures.

The competitiveness in the area of higher education puts a strong emphasis on the HEE to adhere to an internationally recognised set of quality standards. As a part of this study, the strategy adopted by the School of ABC in regards to ISO certification was discussed and a number of tangible benefits were formulated. These include streamlined processes, better understanding of the school’s activities, increased awareness and staff member focus on core processes, transparency of processes, and better appreciation of different roles and tasks within the school.

In the course of the school’s ISO certification process, more administrative processes were identified and documented when compared to academic processes. The reasons behind this may be firstly, documenting academic processes is seen as an
intrusion into academic freedom and privacy and secondly, academic processes are less structured than administrative processes and hence harder to procedurised.

Needless to say, having a powerful and flexible process modelling framework and methodology becomes very important when dealing with process-oriented tasks such as ISO certification. In this study we demonstrated how the ISO certification processes can be better managed and documented using ARIS methodology. It is argued that although ARIS was not chosen as a modelling tool for the actual process of ISO certification, the use of this or another sophisticated process modelling tool could have potentially delivered even more benefits to the enterprise in question.

As the whole process of ISO certification was completed at the end of 2003, natural directions for future research include longitudinal studies of the impact of the process of ISO certification on the school as well as research into comprehensive reference models for ISO certification of an academic school and the dissemination of modelled procedural knowledge within HEE.

This research can be extended by addressing potential benefits of academics and administrative staffs within HEE and how process-orientation facilitates quality improvement for students. These issues are partially explored in Seng [23] and require future consideration.

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Other Way of Making Business: A Virtual e-Commerce Community / CVN Platform

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Abstract. This article describes the current problem in the business environment from the department of Cauca – Colombia (South America), and the proposed solution called Project CVN (Spanish initials) “Business Virtual Community - for the department of Cauca - Internet Commercial Platform or BVC”. Based on a markets research, the architecture of the added value conceived by the project is described; these values support advertising, collaboration, B2C, and B2B, activities framed within the virtual environment of the community. Below, the business model proposed for the community and the logic architecture of the software is described. Lastly the experiences and the learnt lessons throughout the implementation of the project are exposed.

1 Introduction

CVN is a Research [12] University [1] and Enterprise [4] cooperation initiative, which adapts the IT (Information Technologies) to the specific commercial needs of the department of Cauca (Colombia). Three aspects of the problem stand out: firstly, the lack of the associability and collaboration among the enterprises; secondly, the distance between costumer and enterprise on account of the deterioration of the communication channels, and finally, the unawareness about the advantages of the use of the IT [1]. There are similar initiatives in Colombia, among others, such as: Plaza Orbita [15] (Orbital Market) that attempts to promote products and services of the city of Medellin (Colombia); De Remate [6], Latin-American leader selling products through auctions, and TAMPU [7] focused on promoting the tourist image of city of Popayán and department of Cauca region (Colombia). Facing the mentioned initiatives, CVN proposes a business concept that brings together the region enterprises, through a virtual environment that offers added value services directed to the advertising, the B2C (Business to Consumer) and B2B (Business to Business), as an alternative to the suggested problem. The CVN will benefit cultural and technological conditions that motivate the associativity and collaboration among enterprises, as well as the formulation of strategies for the promotion of products and services that benefit the effective approach of these enterprises with their customers.
2 Project Development

CVN has been developed as a project in different stages, from the conception of the research idea, going through the markets research, the elicitation of the requirements and the harmonization of the service outline, up to the design of the logical architecture of the software, the business model view and the sustainability – continuity strategies. These stages are described as follow:

2.1 Markets Research

The carried-out markets research intended, first to identify and quantify the regional and national supply - demand over product-services supported on the CIT [9] through the CVN, and second, to establish profiles and entrepreneurial tendencies, that allows identifying opportunities and threats of the environment with the purpose of designing commercialization and sensibilization strategies of the transactions through the Internet.

2.1.1 Hypothesis

The following hypotheses were proposed for the markets research:
1. There is an unsatisfied Internet service and E-Commerce demand in the department of Cauca.
2. There is a lack of knowledge of the business, opportunities, and risks derive from the commercialization through Internet in the department of Cauca.
3. There are limitations and/or technical-economical barriers in the department of Cauca that oppose the commercialization through the Internet.
4. Inexistence of Internet integral solution offers and electronic commerce in the department of Cauca.

2.1.2 Execution

The critical needs of information identified to validate the hypotheses during the execution of the markets research, were:
1. To validate the execution of the project with the evidence that there are enough enterprises which request an E-Commerce alternative such as CVN.
2. To identify the treats and opportunities of the project from a study of the current use of the CIT (Communication and Information Technologies).
3. Finally, to estimate the supply of products and services and its possibilities of commercialization on a national or international market.

2.1.3 Technical Specifications and Sample

The complete sample consisted on productive enterprises and associations from the department of Cauca with a regional, national and international coverage. The sample consisted on 54 enterprises of 12 different business areas. The type of sampling was “Non probabilistic”.
2.1.4 Conclusions of the Markets Research

The conclusions of the research, allowed the designing of the service portfolio and the elicitation of the technical and functional requirements of the CVN. The markets research has focused its study and subsequent conclusions on aspects related to the Internet, specifically: use, experience, problems, shopping, sale, associability, advertising, interest, and/or conditions of entrepreneurial participation in the execution of CVN project. Here, here are some of the main conclusions found:

- The enterprises need a technological platform that permits the association among them.
- The enterprises guess that the CVN is an important E-Commerce project that will permit them to offer an integral solution of products at the customers and advertising through the association among the entrepreneurial members of the community.
- Increased sales, improved knowledge of the market, improved customer service, achievement discounts by amount of purchase, among others are the main reasons that the association of their relationships will bring to entrepreneurial members of the community.
- The CVN added value services platform will allow the entrepreneurial members of the community to promote and to sell their products and/or services on a national and/or international market.
- There are favorable conditions for the execution, continuity, and sustainability of the CVN, in each one of the aspects mentioned above.

3 A Business Model

The business model [11] of the CVN relies on two basic parts: A service model [9] and a sustainability model. Together, they will allow the start up of the CVN as an E-Commerce platform. These two concepts are explained briefly below.

3.1 A Service Model

The service model is conformed by three components: Publicity and collaboration component, B2C Component and B2B Component.

3.1.1 Advertising and Collaboration Component.

Also called “Advertising and Collaboration Virtual Environment”, it is responsible of supporting the approaching between the enterprises and their customers through stimulus strategies related to the promotion of products/services and the cooperation and information interchange among the enterprises. The main on-line services that this component offers are: catalogues of products and services, personalized consumption profiles, search engine, ads, information about events, supply and demand of products and services, information managing, and chats moderated by experts.
3.1.2 B2C Component

Also called “B2C Virtual Environment”, it is responsible of supporting the communication channel between costumers and enterprises, it provides the following on-line services: Shopping Cart, Information recovery and analysis according to the customer’s shopping habits, and auctions-drop/auctions among users of the community. CVN will offer an evaluation of the quality for every service provided.

3.1.3 B2B Component

Also called “B2B Virtual Environment”, it is responsible of supporting the cooperation among enterprises with the purpose of promoting a higher power of the entrepreneurial negotiation, the acquisition of better prices through on-line value services, the addition of the supply/demand of products-services and finally, provides commercial information from Popayán.

3.2 Sustainability Model

It defines the valued cost over the provision of the services of the CVN that will allow in a long term, to guarantee the sustainability of the community (over five years). Two income sources are proposed: the first one consists of memberships that are obtained by those people or customers whom interest is to actively participate in the CVN, and the second one consists of the selling of added valued services that through the profit of the commercial information provide the enterprises with competitive advantages that impulse the capacities of negotiation and communication. CVN proposes 3 kinds of memberships for the users according to their needs. These memberships have been defined according to the identified needs in the markets research (see Number 2.1).

3.2.1 Free Entrepreneurial Membership

This one allows access to the CVN platform for the entrepreneurial members of the community, in order to show them basic services such as: yellow pages, Entrepreneurial Webpage, search about products and services of the CVN, participation in auctions, and drop auctions, among others.

3.2.2 Standard Entrepreneurial Membership

This one allows to the entrepreneurial members of the community, to have access to added valued services such as: electronic chats lead by specialists, Evaluation information gathering that the Customers do about the enterprises on aspects related with: Products and Services, client service, fulfillment and support post-selling; configuration of integral solutions of services for costumers, among others.

3.2.3 Plus Entrepreneurial Membership

Additionally to the free and standard subscription services, this one includes on line support, addition of the supply/demand service for major suppliers and customers,
configuration of integral solutions of services for costumers, and inter-entrepreneurial purchasing orders value, among others.

The second sustainability source, relates to the selling of the added value services such as: advertising (Banners among others), branding, direct and crossed marketing, promotions and customers fidelization strategies that are the result of applied data mining strategies to the CVN platform. Having in mind the offered services and the entrepreneurial interest in participating in CVN, a presentation of the subscriptions behavior in the first year (see fig 1) was carried out as well as a projection of the community utilities in the first five years (see fig 2), in this one we can see that it is evident that in the two first years the community does not present utilities due to the high initial costs that implies to start it, however the outlook improves considerably, after the second year.

![Fig. 1. Number of subscription for the first year](image1)

![Fig. 2. Five years forward](image2)

### 4 A Software Architecture for the CVN Platform

CVN offers a technological platform that permits to support the services model
mentioned above. Fig. 3 shows the logical architecture of the CVN, (it was modeled using the UML Language [16]). This diagram specifically shows the domain layer (following the Application-Domain-Services Architectural Pattern [8]). In this paper we only explain the main software classes that implement some services in the virtual environment of the CVN platform, such as: product/services catalogue, shopping cart, orders, subscriptions, stands, among others.

4.1 Access Control Package

The main purpose of this one consists of providing all those services related to member's access control rules e.g.: user accounts creation and its maintaining, CVN’s services assignment based on a membership model and other commercial considerations.

4.2 Shopping Cart Package

The main purpose of this consists of providing all those services related to remove and store items (here are products and/or services) from and to the shopping cart and the buy order making based on the shopping cart content and others.
4.3 Products and Services Catalogue

The main purpose of this package consists of providing all those services related to facilitate the search and retrieve of structured information from the products and services catalogue, making products and services requests and getting prices, too.

5 Conclusions

Despite the difficult conditions of violence and ground communication in Cauca, CVN proposes an alternative concept of promoting and commercializing the products and services in Cauca, encouraging, at the same time, through added value services, the associativity and collaboration among entrepreneurial members of the community, profiting the initial conditions to consolidate, throughout a virtual environment, an agreement point among enterprises and customers, and finally promoting alternative communication channels. From the Basic aspects in the advance and development of CVN outstands the markets research that allowed dimensioning the expectation of the services that had to be offered to the community; at the same time, it was outlined the strategy of releasing them. Furthermore the CVN has conceived the mechanisms of sustainability and its future regulation in the frame of the Colombian legislation during its start up.

It is important to emphasize the technological support that the CIT offers like support (internet, communication protocols, standardization, software development tools, among others) to the CVN and the maturity level that CIT has at this moment; in addition, there are very good software development tools such as Microsoft .NET Framework and IDEs that offer many benefits in order to develop this kind of E-Commerce platforms. This technological support, finally allows us to contribute in the fortification of the communications channels between enterprises and between enterprise-costumers.

We hope the CVN platform will be turned into a business alternative to Cauca since it counts with a higher availability of the businessmen of the region, a software tool adapted to the requirements of the Cauca region, and an adequate sensibilization that shows the competitive advantages of the usage of the CIT, will guarantee the successful starting up of the CVN.

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## Author Index

Amrit, C................................. 3  
Anaya, V.................................. 56  
Becker, K................................. 66  
Bendiab, A............................... 89  
Bharadwaj, V........................... 18  
Carvalho, R............................. 66  
Churilov, L.............................. 128  
Copstein, B.............................. 66  
Fengel, J................................. 38  
Forgiarini, G............................ 66  
Franco, R................................. 56  
Goori, T................................. 118  
Goren-Bar, D............................ 118  
Gruhn, V................................. 75  
Karam, Y.................................. 89  
Kiełtyka, L............................... 48  
Laue, R.................................... 75  
Liu, J...................................... 109  
Lu, W..................................... 109  
Martinez, L.................. .......... 141  
Mellik, A................................. 103  
Mendoza, M.............................. 141  
Meneguzzi, C............................ 66  
Moreno, J................................. 141  
Morino, E................................. 28  
Murai, J................................. 28  
Naranjo, R............................... 141  
Navarro Varela, R.................... 56  
Niedbal, R.................. ............ 48  
Oliveira, A............................... 66  
Oliveira, F............................... 66  
Omar, W................................. 89  
Ortiz Bas, A............................. 56  
Rebstock, M............................. 38  
Reddy, S................................. 18  
Reddy, Y................................. 18  
Ruiz, D................................. 66  
Saito, K................................. 28  
Seng, D................................. 128  
Tafreschi, O............................. 38  
Yang, B................................. 109