COLLA 2014

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Foreword

The Fourth International Conference on Advanced Collaborative Networks, Systems and Applications (COLLA 2014), held between June 22-26, 2014 - Seville, Spain, continued a series of events dedicated to advanced collaborative networks, systems and applications, focusing on new mechanisms, infrastructures, services, tools and benchmarks.

Collaborative systems became a norm due to the globalization of services and infrastructures and to multinational corporation branches. While organizations and individuals relied on collaboration for decades, the advent of new technologies (Web services, Cloud computing, Service-oriented architecture, Semantics and Ontology, etc.) for inter- and intra-organization collaboration created an enabling environment for advanced collaboration.

As a consequence, new developments are expected from current networking and interacting technologies (protocols, interfaces, services, tools) to support the design and deployment of a scalable collaborative environments. Innovative systems and applications design, including collaborative robots, autonomous systems, and consideration for dynamic user behavior is the trend.

We take here the opportunity to warmly thank all the members of the COLLA 2014 Technical Program Committee, as well as the numerous reviewers. The creation of such a high quality conference program would not have been possible without their involvement. We also kindly thank all the authors who dedicated much of their time and efforts to contribute to COLLA 2014. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

Also, this event could not have been a reality without the support of many individuals, organizations, and sponsors. We are grateful to the members of the COLLA 2014 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that COLLA 2014 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in the field of collaborative networks, systems and applications.

We are convinced that the participants found the event useful and communications very open. We also hope the attendees enjoyed the charm of Seville, Spain.

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Table of Contents

Towards a Collaborative System for Delivery of Remote Mine Services

Craig James[1], Weidong Huang[2], Kazys Stepanas[1], Eleonora Widzyk-Capehart[1], Leila Alem[1], Chris Gunn[1], Matt Adcock[1], Kerstin Haustein[1]

[1]CSIRO, Australia; [2]University of Tasmania, Australia

{craig.a.james, kazys.stepanas, eleonora.widzyk-capehart, leila.alem, chris.gunn, matt.adcock, kerstin.haustein}@csiro.au; tony.huang@utas.edu.au

***Abstract*—While work has been done to support remote collaboration, and many remote access products exist, these efforts often need stable connections and high bandwidths, or have a mix of functionality, poor security, or complicated set up processes. There is no singular piece of remote collaboration technology suitable for the remote delivery of high-quality planning and scheduling services to clients at a mining site. To fill this gap, a remote mining engineer (RME) concept has been proposed and a functional requirements analysis has been conducted. Based on the identified requirements, a further study was performed to characterise existing technologies and identify the scope for future work. We report on the method and findings of this study in this paper. The main contribution is the identification of a suitable collaboration tool for developing RME.**

Keywords-Remote collaboration; Remote expert services; Tele-operation; Screen sharing; Remote mining engineer

I. INTRODUCTION

Mining companies (service requestors) employ engineers for critical roles in on-site planning and operations, but access to skilled staff willing to work in remote locations is difficult [7]. Mining engineering firms (service providers) can retain top-level personnel in metropolitan areas but they require frequent trips to remote mining locations to maintain effective communication with service requestors. This results in high travel burdens and service costs, and lengthy, inefficient exchanges over email or phone calls to ensure the services requested are delivered.

Individually, remote communication technologies such as tele-conferencing, Skype, desktop sharing, telephony, and email services do not address the following key challenges in the open cut mining environment:

- Quality of service – effective remote communication relies on clear reception of as many cues as possible (text, tone, gesture, facial expressions).
- Low bandwidth – broadband communications in remote areas is still very poor.
- High security – need to protect integrity of data and control systems where downtime from malicious intrusions can introduce high production penalties
- Usability – available remote technologies are difficult to set up, configure and maintain.

There is a body of work in the areas of tele-assistance/tele-collaboration to improve collaboration between personnel in remote and metropolitan areas (e.g., [2][3][8][9][11]). However, much of this work involves the use of bandwidth or display formats unsuitable for mines [10].

A Remote Mining Engineer (RME) concept has been investigated in the literature [1]. Based on this work, we intended to develop a RME system with the following objectives:

- Facilitate collaboration between staff inside the service provider and between staff of the service provider and the service requester.
- Reduce the need for staff of the service provider to be present remotely without compromising the quality of services provided.

This system would combine existing (text, voice, visualisation and data sharing) and innovative communication technologies (tele-presence, tele-collaboration, tele-assistance, and immersive environments) to improve collaboration and communication over long distances between on-site and off-site personnel. More specifically the system will rely on the following technologies:

- Tele-presence to enable a sense of physical presence with remote personnel.
- Collaborative workspaces to share manipulation of notes and sketches.
- Communication technologies (video and audio).
- Visualisation technology to share 2D and 3D data.

In the remainder of this paper, we briefly introduce the work done for the requirements analysis first in Section 2. We then present the method in Section 3 and results of our research in Section 4. Finally the paper concludes with a summary and future work in Section 5.

II. BACKGROUND

Remote service delivery is becoming increasingly popular in modern business activities. This is mainly due to the requirements of reducing operational cost and increasing

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production efficiency. In this section, we briefly review the background information of our study.

A. *Model of Remote Service Delivery*

Previous studies revealed that service providers often follow a common business model to deliver remote mine services to their clients (e.g., [1]), illustrated in Figure 1.

A business case is started by a request from the client. This activates a range of work routines by the service provider, such as project initiation, site visit, internal task assignment, task progress report and check-up, task collaboration and discussion, document exchange and task re-assignment. Depending on the request context, the service can be executed by one or more personnel either collocated or in different locations. Communication methods include: face-to-face, video, audio, text messaging, emails, and data sharing via physical media.

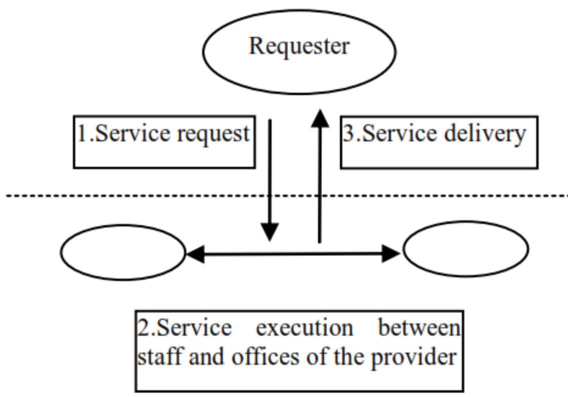

Figure 1. Business model.

B. *Requirement Analysis*

Observation-based user experience design methods were combined with scenario-based software design techniques for requirement analysis. Meetings were conducted with the client manager to understand high-level expectations and identify typical work procedures and scenarios [6]. On-site observations were made of how work is actually carried out by engineers, followed by focus group and individual interviews to elicit and analyse user needs.

C. *Key Requirements*

The results of our requirement analysis highlighted three key challenges in developing a remote collaboration system, namely:

- Bandwidth limitations.
- Security concerns.
- Usability issues.

Seven user cases were identified as key requirements when implementing a solution for delivering effective services remotely. These user cases are:

- Communicate through text, audio and video.
- Send contact requests and also accept / reject.
- Manage the system and user configuration.
- Share full screens or application windows.
- Manage different parts of the collaboration tool over different screens.
- Share electronic whiteboards and annotate.
- Transfer data over the network.

III. Research Method

Based on the requirements obtained, it was decided to make most use of existing technologies for the RME design and development. A scoping study was conducted to identify the best suitable technologies to inform the design of the RME system.

There are a large number of tele-collaboration products on the market that offer a range of services that had the potential to meet some of the requirements for delivering services to remote clients.

A broad product survey of 56 candidates was conducted. These candidates were then further examined to provide a recommendation on an initial system satisfying some of the requirements, and highlighting scope for extensions or replacements needed to satisfy all of the requirements.

The scoping study narrowed the list down to eight, which were then tested against more prominent limitations and user cases required. This resulted in two candidates that satisfied some of the limitations and user cases required.

Adobe's Connect Pro [4] and Cisco's WebEx [5] were the final two. Connect Pro was felt to be more suitable as it was more stable and handled 3D content better. A summary of this process follows in the next section.

IV. Results

Using the research method described in the previous section, we adopted a three-step process for our study: broad review, narrow review and user-case testing. These steps are presented in detail as follows.

A. *Broad Review*

The first step was to survey collaboration tools, deciding on the best one usable for mining engineers to work remotely. A list of 56 possible products was complied.

With the wide variety of products it was necessary to narrow the key collaboration features that would be needed. These features, in order of importance, were:

- Audio communication.
- Sharing of application snapshots.
- Annotation over application snapshots.
- Sharing of 3D applications (using OpenGL).
- Sharing control of applications.
- Video of participants.
- Ability to transfer files.
- Recording.
- Having a tool to schedule meetings.

Many products were also eliminated in this phase because they did not have sufficient security facilities, or could not deal with network firewalls.

B. *Narrow Review*

This list of products was reduced to eight, based on the product documentation. The products in this shortlist, included: JoinMe, YuuGuu, MeetingPlace, GoToMeeting, Mikogo, TeamViewer, Connect Pro, and WebEx. These products were then installed and tested.

The first five were eliminated because they did not have appropriate audio and/or video facilities. The sixth was eliminated because it had problems with annotation over OpenGL.

C. Use-case Testing

The remaining two products, Connect Pro [4] and WebEx [5] were investigated in more detail with a full set of test cases based on the user requirements. It was found that these products were very close in features offered. The main difference was in the way they responded when annotation modes were selected:

- In Connect Pro, participants drew on a static snapshot of an application (see Figure 2).
- In WebEx, participants could annotate on a dynamic view of an application (2D or 3D).

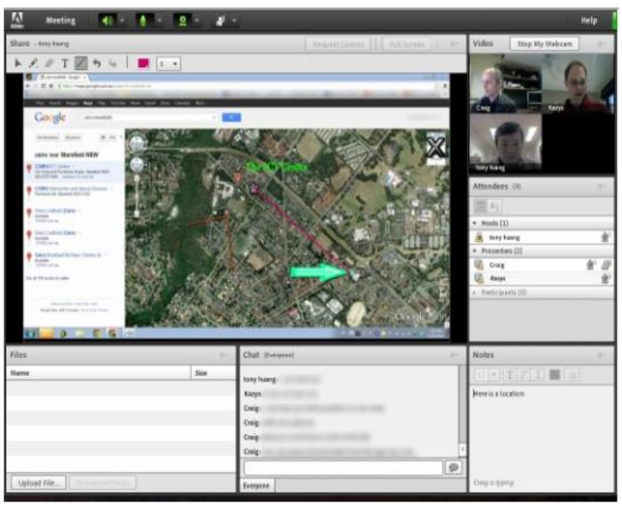

Figure 2. Connect Pro used for sharing and annotation.

The second approach seemed more powerful, allowing for indicators, such as animating lines or pointers, to continue operating in a scene. However, the live annotation feature in WebEx was sometimes unreliable with 3D applications, having annotations disappearing in many situations, lending a preference to Connect Pro's approach.

D. Bandwidth Testing

Connect Pro was then tested against reduced bandwidth conditions. For this test, a bandwidth-throttling program was installed at one end of a high-bandwidth network to simulate low-bandwidth conditions.

It was assumed that reliable audio communication was essential for any collaboration, so this was taken as a measure of usability. If the audio became unusable, the condition failed. Tests were repeated for different combinations of features, to find the minimum bandwidth that sustained features while still permitting bi-directional audio. The results are shown in Table 1. As can be seen from this table, for all features to be functional, the minimum bandwidth is 400 Kbits/s.

Google Earth was used as the shared application, as it uses OpenGL for its 3D rendering. During the tests, audio was considered unusable if parts of the audio stream were missing or if latency was so large that conversations were not possible. It was observed that as the bandwidth was limited, the audio latency would increase. This may be due to packet retransmission within the TCP/IP communications mechanism. During two-hours of the bandwidth testing session the overall upload and download data transfer was greater than 1 Gigabyte each way. This may illustrate that the overall throughput allowance must be fairly high regardless of bandwidth.

TABLE I. BANDWIDTH TEST RESULTS

Bandwidth (Kbits/s)	Audio	Video	Sharing	Annotation	Experience[1]
100	Y	N	N	N	Poor
150	Y	N	N	N	Good
200	Y	N	Y (low)[2]	Y	Good
250	Y	N	N	Y	Good
300	Y	Y	N	N	Good
350	Y	N	Y (low)[2]	Y	Ok
400	Y	Y	Y (low)[2]	Y	Ok
450	Y	N	Y (high)[3]	Y	Good
525	Y	Y	Y (high)[3]	Y	Good

[1] – Subjective experience rating; poor, Ok, good.
[2] – Low refresh frequency OpenGL application (Qt sample).
[3] – High refresh frequency OpenGL application (Google Earth).

It should be noted that Connect Pro did not automatically detect bandwidth and adjust any features. These had to be turned on and off by users.

E. Results Summary

Connect Pro was chosen for the more explicit and stable approach of sharing and annotating over an application. This approach also left the presenter with the ability to interact with other windows on the desktop when annotation was enabled.

V. SUMMARY AND FUTURE WORK

In this paper, we have presented our approach towards the design and implementation of the RME system. This approach makes use of the existing the technologies for knowledge development and for system design. First, 56 candidates were compiled and compared based on their functionalities and application requirements. This resulted in 8 products being identified for further testing in a simulated mining office environment. In the end, Connect Pro was the winner that was considered to be the best suitable system to meet our specific user needs and to inform the design and implementation of the RME system. We are currently working on possible new functions in addition to what was available in Connect Pro.

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For future work, we plan to start the full system development life cycle based on the identified user requirements and design recommendations. It is hoped that end users will be fully involved in the process and their needs will be fully addressed whenever possible. We also plan to experiment and incorporate some additional technologies into the RME system. These include augmented reality, remote gestures, remote fault diagnosis and virtual presence.

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Interorganizational Relationships, Interorganizational Process Redesign, and E-Integration in the Supply Chain: A Social Exchange and Transaction Cost Perspectives

Cheng-Hung Chuang
Department of Information Management, Chia Nan University of Pharmacy and Science, Tainan, Taiwan
e-mail: stanleyjazz@gmail.com

Ing-Long Wu
Department of Information Management, National Chung Cheng University, Chia-Yi, Taiwan
e-mail: ilwu@mis.ccu.edu.tw

Shwu-Ming Wu
Department of Human Resource Management, National Kaohsiung University of Applied Science, Kaohsiung, Taiwan
e-mail:mingwu@cc.kuas.edu.tw

Abstract—**Supply chain is complex and dynamic in its inter-firm nature and thus, an Internet-enabled integration for supplies and customers, namely e-integration, is key to its final success. However, although there has been a high adoption rate of e-integration, the level of realized performance is low. Most firms choose to automate only the processes of that firm and its partners in an isolated manner or to automate outdated existing processes between partners. To effectively implement e-integration, interorganizational process redesign (IOPR) is necessary for the processes with both suppliers and customers. The process redesign is here defined as an important mediator for the final e-integration success. Moreover, the nature of the redefined processes is strategically founded on the structure of interorganizational relationships (IOR). Social exchange and transaction cost issues are widely used to define IOR in the supply chain. Based on these concepts, this study thus proposes a research model to examine a firm's e-integration through the mediator of IOPR with both suppliers and customers from the drivers of IOR. The important findings confirm the mediator of process redesign and the drivers of IOR.**

Keywords-Supply Chain, E-Integration; Interorganizational Process Redesign; Interorganizational Relationships; Social Exchange Theory; Transaction Cost Economics.

I. INTRODUCTION

Supply chain management (SCM) mainly concerns an integration of various key business processes between partners to effectively provide products/services that add value to customers and other stakeholders [28]. SCM is complex and dynamic in nature. The enabling role of IT, in particular for the Internet technology, is an important concern in the supply chain [36]. This results in a new concept for being able to effectively coordinate supply chain partners using this technology. Frohlich [8] referred to this new concept as "e-integration," and discussed how upstream and downstream partners could be broadly integrated in the entire supply chain using this technology. The key issue is the high adoption rate of supply chain technologies but low realized performance [35].

The major reason for this may be that most firms choose to automate only the processes of that firm and its trading partners in an isolated manner or to automate outdated existing processes between participants [6]. To effectively implement e-integration, it is necessary to first redesign the entire supply chain processes across organizational boundaries, including suppliers and customers [1]. In other words, e-integration is closely associated with interorganizational process redesign (IOPR), which is defined as an important mediator to successfully realize e-integration [5,21]. In this current study, we define IOPR to include process redesign with upstream suppliers and with downstream customers [7,8].

The nature of the redefined processes with suppliers and customers is strategically founded on the structure of interorganizational relationships (IOR) [7,24]. Supply chain relationships not only concern social exchange issues, but also involve the economic issues implied by a contract [15]. Social exchange theory (SET) has been used to examine the development of IOR from a non-profit perspective [9]. A summary for the research of SET in the IOR has identified trust, commitment, reciprocity, and power/relative dependence as the main determinants [3,16]. Transaction cost economics (TCE) intends to explain the governance structure of contractual relations for different markets by analyzing the transaction cost of trading activities from a profit perspective [37]. Such purpose for mitigating market uncertainty has been widely used as the basis of the analysis of interorganizational issues [13]. Market uncertainty is therefore the main determinant of TCE issue in IOR.

In sum, this study proposes a research model to examine a focal firm's e-integration implementation through the mediator of interorganizational process redesign from the initial drivers of IOR. However, few studies have considered the basic role of IOR to IOPR with suppliers and with customers in a supply chain.

The rest of this article is organized as follows. First, a review of literature provides the basis for defining the research model. Next, we describe the research design for measurements and sample design. We then discuss hypotheses testing. After that, findings and discussions are presented. Finally, this article provides conclusions and suggestions from the results.

II. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Based on the above discussion, Figure 1 provides a pictorial depiction of this research model. The followings sections discuss the theoretical foundation of this model and the development of hypotheses.

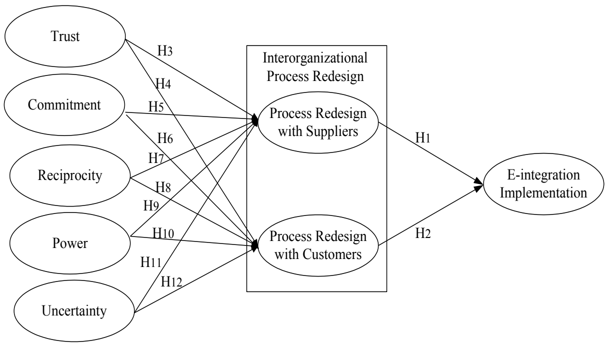

Figure 1 Research model

A. *IOPR and E-integration*

Many studies on the e-integration issue have questioned whether or not the Internet-enabled supply chain actually improves partners' performance [8]. The evidence suggests that there is a need for this to be accompanied by a fundamental organizational change of suppliers and customers so as to be consistent with the focal firms' business processes [29]. In other words, there is a need for the focal firms to first redesign the entire supply chain processes with their suppliers and customers to effectively implement e-integration [13]. Afterward, the IT automation is further deployed to enable the new processes rather than the old ones [12].

Earlier studies have revealed that EDI together with reengineering of the interorganizational processes can improve the initiatives of participated external firms and the benefits of all firms in the overall supply chain [10]. Further studies have also noted that EDI must involve organizational changes in partners' business processes to realize the potential efficiency provided by this technological innovation [33]. Additional studies have also argued that those who have already implemented the SCM philosophy with EDI would have to follow a path of BPR and indeed reengineer the interorganizational processes with their partners [30].

The following develops relevant hypotheses. Researchers indicated that it is important for organizations implementing e-integration as a means of creating a more integrated supply chain to be associated with the need for a structural change of their processes in a cross-organizational level, including upstream suppliers and downstream customers [22,29]. Supplier integration with their processes is especially important in terms of a long replenishment's lead-time, frequent deliveries, and reduced buffer inventories with trading partners [8,24]. Next, tight integration with customer-side processes, such as organizational buyers or channels, shows the importance of connecting to many potential benefits, such as sale forecasting, production planning, and customer relationship management. Studies have showed how the inventory replenishment, customer service, and delivery costs can all be improved significantly by redesigning the processes of the distribution channel partnerships [2]. Accordingly, two hypotheses are proposed.

H1: The process redesign with suppliers has a positive effect on e-integration implementation.

H2: The process redesign with customers has a positive effect on e-integration implementation.

B. *IOR and IOPR*

Many scholars have argued that implementing SCM generally must be associated with an important concern with IOR across trading partners [3,13]. In particular, the main activity for implementing SCM lies in process redesign/integration among partners [15]. Since IOPR is dynamic and complex in nature, analysis of the redefined processes with suppliers and customers requires an understanding of the fundamentals of IOR. IOR not only incorporates social exchange issues, but also involves the economic elements explicated in a contract [15,34].

SET in the supply chain has been defined differently for various research purposes. Some studies have proposed two elements in SET, trust and commitment, that are needed for maintaining relational stability in the supply chain alliance [16,39]. Other studies have modeled how justice/reciprocity and power/relative dependence in SET affect long-term orientation and relational behaviors toward partners [9]. Additional studies have focused on mutual adaptation between partners for developing strategic alliance based on trust and power in SET [11]. Given these theoretical foundations of SET in the supply chain, we thus comprehensively define four main dimensions in IOR, trust, commitment, reciprocity, and power.

Further, TCE has been considered to examine the economic issues in building supply chain relationships [38]. TCE refers to the concept of what kind of institution (firms, markets, franchises, etc.) minimizes the transaction costs of producing and distributing a particular good or service. Often these relationships are categorized by the kind of contract involved. TCE constitutes two situational conditions (i.e., asset specificity and uncertainty), two beliefs about human behavior (i.e., opportunism and bounded rationality), and one transactional condition (i.e., frequency) [37]. Since this study mainly concerns IOR building for the partners, we thereby consider two situational conditions for their connection and importance to this issue, that is, asset specificity and uncertainty.

Basically, asset specificity refers to the extent to which a party is "tied in" in terms of its investment made in a two-way or multiple-way business relationships. From this definition, asset specificity is similar to the power/relative dependence in SET. This line of thinking for reducing market uncertainty with suppliers has been widely used as the basis of the analysis of interorganizational activities [13]. Specifically, many studies have pointed out that market uncertainty prompts firms to establish and manage relationships in order to achieve stability, predictability, and dependability in their relations with partners [29,39]. We thus define market uncertainty as an important dimension in IOR.

The following defines the five dimensions of IOR and relevant hypotheses. Trust is defined as "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other party will perform a particular action important to the trustee, irrespective of the ability to monitor or control the other party" [19].

Specifically, in a buyer-supplier relationship, high trust facilitates more open communication and the willingness to take risks between partner firms, thereby generating greater knowledge and appreciation for each other's contribution to the relationship [16]. Trust with suppliers exerts a positive effect on supply chain proximity, that is, suppliers are really concerned with the success of buyer firms [25]. Accordingly, trust would drive partner firms with upstream suppliers and downstream customers to redesign their business processes in a consistent way to reach the common goal [15]. Therefore, two hypotheses are proposed.

H3: Trust has a positive effect on the process redesign with suppliers.

H4: Trust has a positive effect on the process redesign with customers.

The concept of commitment from Morgan and Hunt [23] is defined as "an exchange belief of partners that an ongoing relationship with another is so important as to warrant maximal efforts at maintaining it; that is, the committed party believes that the relationship endures indefinitely". Several studies have argued that commitment can improve communications and better coordinate buyer-supplier relationships [14,26]. This literature has given impetus to the deployment of BPR in supply chain, that is, between upstream suppliers and between downstream customers, for assuring commitment in their alliance [13,17]. Accordingly, two hypotheses are proposed.

H5: Commitment has a positive effect on the process redesign with suppliers.

H6: Commitment has a positive effect on the process redesign with customers.

Social relationships are formed and maintained because the partner firms offer reciprocal benefits to one another over time [18]. More importantly, the motives of this reciprocity emphasize cooperation, collaboration, and coordination of key business activities among partners for their common goals [9]. Moreover, reciprocity in the supply chain relationships can facilitate information sharing between trading partners [13]. For the upstream side, reciprocity can help suppliers to build virtual business networks, so suppliers can have better access to up-to-date information. Similarly for the downstream side, customers/buyers can acquire better customer services, purchase more easily, and obtain the newest product information. Accordingly, two hypotheses are proposed.

H7: Reciprocity has a positive effect on the process redesign with suppliers.

H8: Reciprocity has a positive effect on the process redesign with customers.

Power is indicative of a dependent relationship on its focal firm in a partnership. In IOR, there is an emphasis on the necessity for mutual and symmetric dependence structure to foster long-term relationships, whereas asymmetric relationships are associated with less stability and more conflict [3]. When there is greater power symmetry in the IOR, there is more interdependence between suppliers and buyers. To be able to exercise a power relationship in the supply chain, especially within the symmetry structure, the redesign of interorganizational processes is an important precursor to assure that the supply chain is taken as a whole, as a set of interrelated activities rather than as pair-wise activities [7]. Therefore, two hypotheses are proposed.

H9: Power has a positive effect on the process redesign with suppliers.

H10: Power has a positive effect on the process redesign with customers.

Since SCM aims at building a mutual understanding of a partnership to facilitate the exchange of various components and products with suppliers and customers, the partnership is clearly in the position to reduce uncertainty within an unpredictable market [28]. Moreover, the firms facing market uncertainty have a greater incentive to adopt IOS for improving information exchange and collaboration between their trading partners [28]. The motivation for reducing market uncertainty suggests that an attempt to integrate supply chain activities by using Internet technology to support collaborative behaviors must be accomplished by re-engineering interorganizational business processes [29]. Thus, two hypotheses are proposed.

H11: Uncertainty has a positive effect on process redesign with suppliers.

H12:Uncertainty has a positive effect on process redesign with customers.

III. RESEARCH DESIGN

A. Instrument

A survey was conducted to collect empirical data, and the research design is described below.

1) Basic Information: This part collects information about organizational characteristics including industry type, annual revenue, number of employees, and experience on process redesign and e-integration, as well as respondent characteristics including work experience, education level, gender, and position.

2) Elements of IOR: This part consists of five elements:trust, commitment, reciprocity, power, and uncertainty. Moreover, IOR is defined with two target dimensions for this study, relationships with upstream suppliers and downstream customers. The measurement items for trust are adapted from the instrument developed by [16,39], including five items for each dimension. The measurement items for reciprocity are adapted from the instrument developed by [13,27], including four items for each dimension. The measurement items for power are adapted from the instrument developed by [31], including four items for each dimension. The measurement items for uncertainty are also adapted from the instrument developed by [31], including four items for each dimension.

3) IOPR: The IOPR for the entire supply chain signifies the integration of key business processes between a focal firm and both its upstream suppliers and its downstream customers. IOPR has two dimensions with both upstream suppliers and downstream customers. The measurement items for IOPR are adapted from the instrument defined by [8], each containing four items. The processes for the upstream suppliers include procurement, scheduling, inventory, and demand. The processes for the downstream customers consist of marketing, order, service, and demand.

4) E-integration Implementation: The e-integration implementation is defined as the extent to which a focal firm establishes IT capabilities for the consistence of data and the rapid transfer of supply chain related information across trading partners. There are two dimensions for this instrument, data consistency and cross-functional applications integration. The measurement items for them are adapted from the instrument defined by [32], including three items and four items respectively.

B. Sample design

To qualify for this study, firms must have extensive experience with technology investments and the management of supply chain systems. Thus, it is assumed that larger firms would be more likely to have these types of experience. We selected a study sample of 1200 manufacturing firms, including high-tech and traditional manufacturing, and 300 service firms, including retailing, banking, and software service, from the 2012 list of firms published by the Taiwan Stock Exchange Corporation. Top managers, including CIOs or supply chain executives, are the persons most likely to be familiar with these issues. Both executives were therefore selected as the respondents.

C. Scale Validation

Initially, a pretest was conducted for the scale. The scale was carefully examined by selected practitioners and academicians in this area of research including translation, wording, structure, and content. These comments were used to revise the scale in order to guarantee initial reliability and content validity. Once the questionnaire had been finalized, we sent 1500 questionnaires to sample subjects. A total of 285 questionnaires were returned, and after deleting incomplete and invalid responses, there was a sample size of 269 responses - an overall response rate of 17.93 percent. CIO and supply chain executives are the main respondents for this survey and occupy a larger proportion, 37.92% and 27.88%, respectively. Among them, 72.5 percent of sample firms are high-tech manufacturing and 26 percent are service industries, including retailing, banking and so on. Sample respondents indicate 37.9 percent of CIOs and 27.9 percent of supply chain executives.

D. Measurement Model

Partial Least Square (PLS) is a structural equation modeling (SEM) technique that uses a nonparametric and component-based approach for estimation purposes. PLS has a minimal demand for sample size and residual distribution [4]. We used PLS for this analysis. Firstly, a measurement model is defined to assess reliability, and convergent and discriminant validity for the scale. Further, a structural model is used to perform path analysis.

The testing results are below. Cronbach' α values are all larger than 0.8. Item loadings range from 0.71 to 0.86 and are significant at the 0.01 level. Composite construct reliabilities range from 0.84 to 0.95 and average variances extracted (AVE) range from 0.57 to 0.67. The results indicate that all constructs have high degrees of reliability and convergent validities. The square root of AVE for each construct is larger than its correlations with all the other constructs. Thus, all constructs also meet the criteria of discriminant validity.

PLS does not provide a significance test or confidence interval estimation. We re-sampled 1000 times with Bootstrapping analysis to obtain a stable result for these analyses. Next, path coefficient (β) was used to indicate the relationships between variables and coefficient of determination (R^2) for endogenous variables was calculated to assess the predictive power of this model.

IV. HYPOTHESIS TESTING

Figure 2 shows the testing results of the structural model. Most hypotheses (11 hypotheses) are significantly supported at $p<0.05$ or 0.01. In contrast, Hypothesis 10 is not significantly supported. Specifically, both the process redesign with suppliers and with customers played a critical role in determining e-integration implementation ($p<0.01$, β=0.40 and 0.35). They jointly explained 36% of variance for e-integration implementation (R^2 =0.36). Thus, hypothesis 1 and 2 are supported. Trust had a positive effect on the process redesign with suppliers ($p<0.01$) and with customers ($p<0.01$) (β=0.34 and 0.33). Thus, hypothesis 3 and 4 are supported. Commitment was a notable determinant of the process redesign with suppliers ($p<0.05$) and with customers ($p<0.01$) (β=0.20 and 0.24). Thus, hypothesis 5 and 6 are supported.

Reciprocity was reported as an important antecedent of the process redesign with suppliers ($p<0.01$) and with customers ($p<0.01$) (β=0.26 and 0.29). Thus, hypothesis 7 and 8 are supported. Power showed a positive impact on the process redesign with suppliers ($p< 0.01$), but a non-positive impact on the process redesign with customers (β=0.30 and 0.10). Hypothesis 9 is supported, but Hypothesis 10 is not supported. Uncertainty had an influential role in determining the process redesign with suppliers ($p<0.05$) and with customers ($p<0.01$) (β=0.19 and 0.26). Thus, hypothesis 11 and 12 are supported. Moreover, these IOR related variables jointly explained 42% and 44% of variance for the process redesign with suppliers and with customers, respectively (R^2 =0.42 and 0.44).

Next, we examined the argument of the mediating effect of IOPR in the research model. We can compare the results by testing the original research model against a competing model with the addition of two extra direct relationship structures for suppliers and customers from IOR to e-integration implementation, each relationship structure including five paths (five variables in IOR) [32]. The difference between the R^2 values was non-significant. This indicates an important mediating role of process redesign in influencing e-integration implementation from the initial driver of IOR.

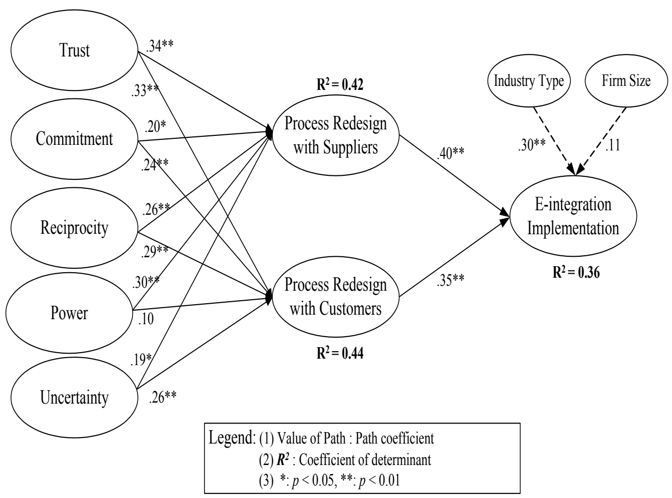

Figure 2. Result of the structure model

V. FINDINGS AND DISCUSSIONS

According to Figure 2, five defined variables in IOR are all important precursors of the process redesign with suppliers. However, four defined variables in IOR have the same important role in determining the process redesign with customers but the power variable does not have this role. In general, IOR has a high predictive power on both the process redesigns with suppliers and with customers (R^2 =42% and 44%). The reasons behind this are discussed below.

In an interorganizational relationship, a high level of trust would foster open communication and the willingness to take risks for a focal firm and its trading partners, thereby generating greater information sharing for each other's contribution to the relationship. This, in turn, would facilitate the need for the process redesign with suppliers and with customers for information flow integration.

Relational commitment in alliances brings about mutual respect for buyers and suppliers and reduces the need for competition from rivalries, that is, integrating processes and activities for trading partners to sustain collaborative relationship. Thus, commitment would drive focal firms to integrate and redesign information, physical, and financial flows with suppliers and customers.

Reciprocal benefit is a motivator or facilitator for cooperation, collaboration, and coordination among trading partners [27]. This would create the need for a focal firm to integrate and redesign processes and activities with its trading partners. In particular, trading partners will be more likely to enjoy information sharing if focal firms share information with their suppliers and customers (information feedback).

In contrast, power is related to the process redesign with suppliers and is not related to the process redesign with customers. Customers (channels or business buyers) are always in a position to take advantage of the buyer-side market to select their partners. Thus, focal firms have less bargaining power over their customers and the dependency relationship between them is imbalanced. It is opposite for upstream suppliers. This can cause upstream suppliers to develop a high level of information sharing with focal firms.

Uncertainty in interorganizational interactions is much greater since two organizations that have different business objectives and stakeholders are involved in a transaction. Focal firms need to develop long-term relationships with suppliers and customers to minimize market/environmental uncertainty. Accordingly, uncertainty can create a need for focal firms to integrate and redesign their business process with suppliers and customers to minimize the transaction costs.

Next, both the process redesigns have a critical role in determining the implementation of e-integration with a high explanatory power (36%). The process redesign with suppliers and with customers can create a unique form of alliance that is difficult to copy or imitate for competitors and eventually develop superior firm performance in terms of a successful implementation of e-integration. Indeed, previous studies have argued for the importance of business processes as a mediator to drive business performance regarding IS-related deployments such as knowledge management. This finding is particularly significant in the supply chain.

VI. CONCLUSIONS AND SUGGESTIONS

Firstly, when focal firms and their partners are planning to implement e-integration, the development of IOR should be the initial step for building a conceptual agreement. Important considerations for the dimensions of IOR with upstream suppliers are, listed in the order of their effect: trust, power, reciprocity, commitment, and uncertainty. Important considerations for the dimensions of IOR with downstream customers are, listed in the order of their effect: trust, reciprocity, uncertainty, and commitment. Further, interorganizational process redesign is the next step in preparation for building new processes that facilitate cross-partnering IT deployment.

There are also implications for researchers. First of all, we approached e-integration implementation by defining two distinct process redesigns, that with suppliers and that with

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customers. Few previous studies have proposed a similar structure for implementing e-integration. This approach can provide differentiated understanding for different types of trading partners regarding focal firms in executing their BPR. The process redesign with suppliers and with customers could thus be solved more clearly and effectively. Further, we comprehensively considered the dimensions of IOR from the perspectives of SET and TCE. This would increase the explanatory power of IOR for the mediator of interorganizational process redesign. Both of these unique features are thoroughly discussed in the research model.

Although this research has produced some interesting results, a number of limitations may be inherent. Firstly, the response rate is lower than desirable, despite the various efforts to improve it. This may be because the respondents lack relevant work experience in the interorganizational process redesign and e-integration implementation. However, the response sample demonstrates no systematic non-response bias. Next, the questionnaires were distributed only to focal firms, which must answer many questions about the status of their suppliers and customers. However, the answers to these questions would be more reliable if the suppliers and customers could provide the answers themselves. Finally, since senior managers of larger firms are always busy, some of the questionnaires may have been completed by subordinates, and so the data may have some biases or inaccuracies.

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Enablers of Optimal Work Systems in Industry

Review, Framework and Likert-scale Survey for Improving Intra-Organisational Communication of Finnish Case Companies

Seppo Väyrynen, Kari Kisko, Henna Filppa, Mirja Väänänen
Industrial Engineering and Management
University of Oulu
Oulu, Finland
emails: {seppo.vayrynen, kari.kisko, henna.filppa, mirja.vaananen}@oulu.fi

***Abstract*— The paper constructs a work systemic framework for more detailed communication analyses and developments. This aims to promote effectively desired and prevent undesired outcomes in companies. In the empirical part the paper piloted new measuring scales and presents their application in surveying the perceptions of the work systems of real industrial organisational cases (N=6). The tentative scales seemed to be consistent, reliable (Cronbach's Alpha) and able to show differences both between companies and groups of employees within companies. As far as both research and practice, finally, recommend new kind closer and synergic connections between issues of communication developments, quality management, productivity, well-being at work and human resources management. These would be useful as far as ICT-enabled collaboration is developed, too. The review section of this paper reveals that actually the author team has for 15 years implicitly emphasised human-centred communication as far as its studies are concerned. Participatory human-centred approach has been an essential feature of almost all Research and Development (R&D) related to achieving an optimal system for production, services, and products. Though R&D has been aiming to cover and analyse a wide variety of as well tangible and intangible work systems issues, opinion now is that the author team's should have been dealt more explicitly already earlier.**

Keywords-human communication; human resourses (HR); Likert-scale; perceptions of own work; quality management.

I. INTRODUCTION

A work system comprises a combination of people, technology, and tasks within a space and other work environment (tangible and intangible), and the interaction of these components within a managed goal-oriented organisation with its processes (Figure 1). Holistic ergonomics aims to optimise work systems, as far as performance and effectiveness, including in a key role people without detriment to their health, safety, or other factors of well-being at work. In other words of the work systems standard, optimisation may be evaluated based on measures of three categories (1) health and well-being, (2) safety, and (3) performance (the quantity and quality (Q) of production with minimal non-conformities) [1][2]. According to this holistic thinking, the factors of both well-being and productivity at work comprise a lot of synergy.

This paper is interested in the above interactive system and particularly in the creation of a contextual framework for communication needed to run the manufacturing and services of six Finnish industrial case companies, and generally later in other companies. Together with The Finnish Work Environment Fund, these companies are funding this study, which is being conducted at the University of Oulu.

We see Communication (C) as an essential factor of work system interaction that operates between and within system components (Figure 1). The following definition of communication guides the current study: "the act or process of using words, sounds, signs, or behaviours to express or exchange information or to express your ideas, thoughts, feelings, etc., to someone else"[3]. In general, in intra-organisational work systems, and even more so in cross- and inter-organisational contexts, the channels and flow of Information and Communication (IC) are essential for effective businesses and the individuals within them. Such communication is today more and more enabled, aided, mediated and supported by Technology (T). Though we focus predominantly on face-to-face communication, ICT should be more explicitly taken into account in the work systems. T has been considered to bring both pros and cons to communication. This study tries to promote the pros of T in terms of its potential to improve both the quality and quantity of communication. For instance, the Health, Safety and Environment ICT (HSE ICT) relates a lot to communication while fulfilling the tasks of reporting and the collection of data, data storage, information processing, and distribution of information to decision makers inside the organisation [4].

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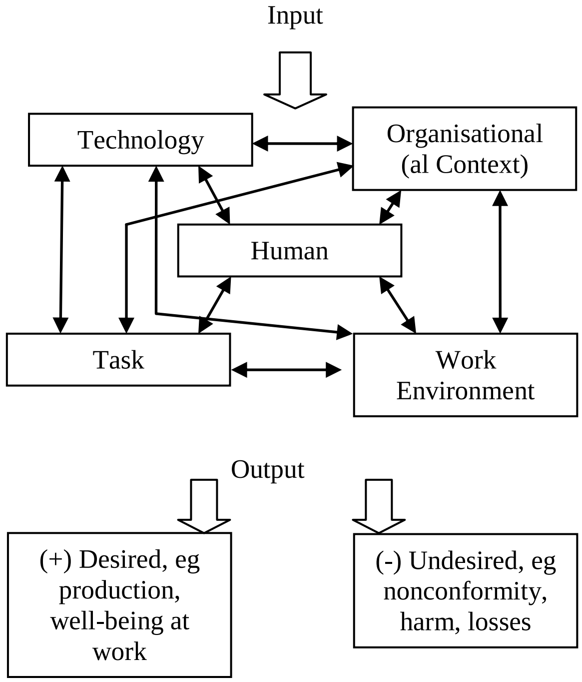

Figure 1.The balanced work system model [47], modified to represent the outcomes as well, i.e., desired and undesired results at work [2].

II. BACKGROUND

Industrial expressions of the role of communication at work can be typically mentioned, eg., as follows:

First, according to Reason [5], communication problems fall into three categories:

- System failures, in which the necessary channels of communication do not exist, or are not functioning, or are not regularly used
- Message failures, in which channels exist, but necessary information is not transmitted
- Reception failures, in which channels exist, the right message is sent, but it is either misinterpreted by the recipient or arrives too late.

Second, Hugnes and Ferrett emphasise the role of communication to be as follows: ”The safety culture of an organisation is the product of individual and group values, attitudes, perceptions, competencies and patterns of behaviour that determine the commitment to and the style and proficiency of, an organisations health and safety management. Organisations with a positive safety culture are characterised by communications founded on a mutual understanding of the importance of safety and by confidence in the efficacy of preventive measures. [6]" Third, an increasing trend within current work organisations is moving jobs at multiple sites. It means that employees are mobile, visiting many distributed sites with face-to-face communication situations, while at the same time frequently using mobile ICT as an essential tool during their work tasks and shifts. That these people predominantly work alone is generally understood to be a challenge to manage well. One such example of this business situation is short-haul truck driving. ICT innovation proposals related to improving communication within the supply chain partners of this mobile and distributed work system have been studied by Reiman, Pekkala and Väyrynen [7].

Fourth, it is worth to mention that Saari showed in his analysis that disturbances in the information processes of a work system and human communication comprise an important factor behind accidents at work [8].

Fifth, Glendon, Clarke and McKenna [9] concluded, that in highly demanding or busy work situations such as safety critical situations, communication factors typically include ones of language, hierarchy, authority, avoiding conflicts, fears, attitudes, behaviour styles, rigid role differentiation, the complexity of the tasks, the impersonality of the media, communication via IT or within team where each member can see and hear each other, among others. These factors have typically been studied in relation to aviation incidents or crashes, flight simulator training, and medical care.

Sixth, to guarantee an optimal communication in a work system, in addition to the intra- and intergroup interactions of employers, managers and supervisors, and employees, communication with external stakeholders is also important. Fluent and frequent contacts to and between internal and external stakeholders can be provided only by increasing the role of communication technology. Dul et al. show a lot of strategic and wise visions for ergonomics and human factors related, eg., to various stakeholders affecting and affected by modern businesses. They speak quite much about communication generally; but according to our opinion, not as such within work systems, as our study aims [10].

Figure 2 shows the key contextual issues of this study collected for the description, analysis and evaluation of the framework of communication in the companies. Eight cumulative issues are reviewed in more detailed way in Table 1. Related issues covered in the past papers by the authors of this study include the following:

- Implementation of telemedicine [11]
- Utilizing employee’s knowledge in metal industry [12]
- Developing mobile communication services for the elderly [13]
- Case describing a collaboratively-developed software application for improving service quality [14]
- Increasing hospital staff participation into the development processes [15]
- Participatory design science approach on the optimum work system [16]
- Short haul drivers’ two-way assessments of prerequisites and communications contributing employee and customer satisfaction [7]
- Regional workplace development in the context of sociotechnology and knowledge [17]

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- Multifaceted analysis of truck transportation's work system by drivers and stakeholders [18]
- Microinnovations [19]
- Managing well-being at work [20]
- Concurrent engineering activities using videophone communication [21]
- User-centered development of video telephony for servicing [22]
- Video-based ergonomic development of work system cases [23]
- HSEQ integrated (asset) management in process industry network [24]
- Communication in high tech product development projects [25]

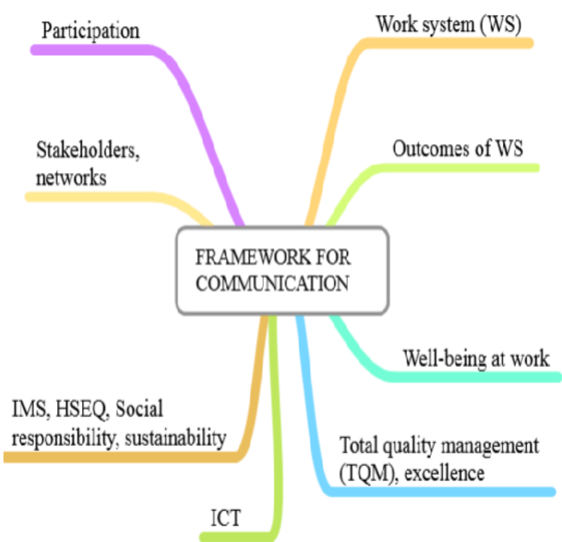

Figure 2. Key effective issues chosen for the description, analysis, and evaluation of a framework for communication.

Lessons learned from all the above, we define the scope of our whole study called Kitkaton Kommunikointi (KIKO), in English Frictionless Communication (FriCo), focusing explicitly consciously on communication possesses the potential to reveal many means of enhancing interaction within a work system, for the benefit of management, workforce, and stakeholders. According to the review above, our assumption is that too much of communication issues are thought to be implicit in our former studies. That is why we see that a lot of inductive study related work communication at the field is needed, too. This later part of our study relies on ethnography and user-study-style observational and other methods of contextual [61] data collection. More explicit picture of the practice and quality of communication and evidence of the importance of the quality of communication enables to understand, model, measure, promote, and manage generally better within the work system.

TABLE 1. A SHORT DESCRIPTION WITH REFERENCES TO KEY ISSUES CHOSEN FOR THE DESCRIPTION, ANALYSIS AND EVALUATION OF A FRAMEWORK FOR COMMUNICATON.

Most relevant general academic and practical back-grounds	Main points, messages, or results.	Referenc e(s)
Work system (WS)	People, technological tools tasks, work environment, and interaction of these components within an organisation.	[1][47]
Out-comes of WS in general	Work systems' optimization may be evaluated based on measures of categories (1) health and well-being, (2) safety, and (3) performance (the quantity and quality conformity).	[1][33][34][2][23]
Well-being at work	Means safe, healthy, and productive work in a well-led organisation by competent workers and work communities who see their job as meaningful and rewarding.	[48]
(Total) Quality Manage ment (TQM), Excel-lence	•Production process, products, services, system, continuous improvement •Safety and productivity as integral inherent parts of quality •Employee and supplier participation	[49][50][43][42]
Participa-tion	Involving people as employees, consumers and citizens, in development, individuals and organisations, driving forces of potential benefits comprise involvement in process, motivation, competence and confidence.	[51][22][55][56]
Stake-holders, networks	Especially employees, customers, owners, partners, business networks, community, citizens, regulating society, i.e. affecting, affected, involved organisations and individuals.	[52][17][53][57][58][59][60]
HSEQ, Social responsi-bility (SR), sustain-ability	Products and services satisfy requirements for quality and excellence, responsible organisations have also to be concerned about the well-being of their employees, their work environment, impact of operations on the local community, and long-term effects of their activities and products.	[35][54]
ICT	Developments in computer technology, telecommunication technology and media technology have given rise to new interactive activities such as social media, gaming, and to an explosion of information transfer. People's lives have become more and more dependent on ICT and virtual networks. ICT developments have brought about many changes in work organisation and organisational design, including more focus on teamwork, the rise of virtual organisations, remote work including working from home, fading borders between occupational and private life, and increased complexity of networks.	[10][47]

Lasswell, the US scientist, once described that every act of communication is ultimately an answer to one aspect of the following question: Who (says) What (to) Whom (in) What Channel (with) What Effect [26]. We find this understanding of communication quite straightforward and rudimentary. While it may be useful in other cases, it appears less useful for the current study. The objectives of this study are of a much more multi-disciplinary and diverse nature than are encompassed in Lasswell's understanding about communication.

The objectives of the KIKO study are as follows:

- To develop the interaction skills of the supervisors and employees of the case companies.
- To study the case companies' communication and find those factors which contribute to or detract from purposeful interaction and operation.
- To identify interaction challenges in the case companies to create new solutions and operation models, and to try to formulate an approach to an innovative procedure for enhancing individual and organisational communication being applicable in other companies ("KIKO R&D service package" as a recommendation of a good practice).

As a part of the preliminary actions of the whole KIKO study, a literature review and a field survey of employees' and supervisors' opinions and perceptions was required. The literature review is presented in the introduction and background. That is why the following additionally objective for starting the KIKO needed to be fulfilled: describing and measuring the starting points generally, and especially clarifying the perceived situation and conditions of the case companies by a questionnaire directed to the supervisors and employees.

III. MATERIALS AND METHODS

The current study is comprised of activities divided into three work packages (WPs):

- WP1:Training and evaluating communication skills in a special laboratory using the consultative approach.
- WP2:Observing and developing the communication practices and culture between employees and supervisors within the case companies (e.g., in workshops, manufacturing lines, sites, offices, R&D spaces, etc.)
- WP3:Identifying and analysing the communication pros, cons and challenges of each case company based on WPs 1 and 2. Based on the results and conclusions of the WPs1 above, the case companies are arranging collaborative workshops with researchers, and thereby creating new solutions, operation models, and management practices to improve the current practises (see design science, [16][27].

The current KIKO study utilises the consultative psychological approach, and relevant methods of ergonomics, quality management, and organisational development (mainly in the fields of ethnography and participatory development, and design).

The study will be carried out with six companies or company units that represent significant Finnish companies in the fields of technology [28] and energy (electric power distribution). KIKO was and is being conducted during 2013 and 2014. Not only is the Federation of Finnish technology industries interested in research on optimal work system in companies [29], so are the European metal, engineering and technology industries [30].

In the initial phase of the study before the WPs, an examination of the literature and a survey on the perceptions of the features of the work systems were carried out. The former is briefly presented in the introduction and in the discussion chapter of this paper. The latter, a field questionnaire, was comprised, of background information questions and allowed free space for writing respondent's own views and opinions. In the main part of the questionnaire, the satisfaction part of the questionnaire, a 5-point Likert scale was used. Each respondent was asked to give his or her opinion (i.e., "how much do they agree" with the presented opinion or work system conditions description) on the statements presented (see Appendix). The potential choices consisted of "1 equals strongly disagree" to "5 equals strongly agree". The employees (blue-collar workers and clerical employees) and supervisors (managerial staff and experts) were asked to fill in the number 1, 2, 3, 4 or 5 according to how they felt about their work system and communication within it.

The questionnaire was directed at the entire staff (employees and supervisors) of all the participating case units. The questionnaire was introduced by first stating that it would takes less than 10 minutes to complete.

The field survey was predominantly conducted utilising a web-based questionnaire, but some of the respondents who did not have access to web were given a paper questionnaire. The questionnaires were distributed to the employees and supervisors of the participating companies. Of the distributed questionnaires, a total of 448 was delivered back to the researches, as follows:

- Case I, bigger company, total response rate 77%, employees (N=220) and supervisors (N=21)
- Case II, bigger company, total response rate 55%, employees (N=15) and supervisors (N=9)
- Case III, smaller company, total response rate 100%, employees (N=8) and supervisors (N=2)
- Case IV, smaller company, total response rate 61%, employees (N=48) and supervisors (N=10)
- Case V, smaller company, total response rate 51%, employees (N=32) and supervisors (N=7)
- Case VI, bigger company, total response rate 49%, employees (N=41) and supervisors (N=18)

The statistics software package (SPSS 22.0) was utilised both for a wide variety of basic descriptive purposes and in trials to predict developed dependent variables using various independent variables.

The dependent variables of the study were as follows: (i) Perceived holistic well-being, (ii) Perceived satisfaction with communication, and (iii) Perceived satisfaction with IT-mediated communication. The sums of the variables comprised: (i) statements 1,2,6,7,12,14,15,16, 17,18,20,21; (ii) statements 3,4,5,10,11,13,19; (iii) statements 8,9,22 (see Appendix). The modelled and piloted tentative sum indexes (i.e., the corresponding averages of the sums) for i, ii, iii were calculated separately for the employees and supervisors, the different case companies, and then analysed and checked in terms of their reliability using Cronbach's Alpha (i.e., the consistency or repeatability of the measures collected from the questionnaires). The Cronbach's Alpha for every statement sub-group on the questionnaire was estimated and compared with the recommended limits of statistical significance in the literature [31][32]. In addition, we put into trial whether indexes (i), (ii), and (iii) showed differences as far as case companies (i.e., case I-VI, bigger or smaller) and staff categories (employee, supervisor).

IV. RESULTS

First of all, a general view on the distribution of opinions about the perceived work system and own role and contribution there were revealed, i.e, ratings generally and as far as all interesting sub-groups.

The appendix shows all questions about the level of accomplishment and choices assigned toward each subject matter in question (averaged opinions on statement / ratings on 5-point Likert scale, x± standard deviation (sd)), by employee and supervisor, and total average opinion based on agreement levels given to all the 22 statements in all case companies.

The values of the piloted sum indexes varied in the way presented in the Table 2.

TABLE 2. THE THREE SUM INDEXES (i) PERCEIVED HOLISTIC WELL-BEING (ii) PERCEIVED SATISFACTION WITH COMMUNICATION AND (iii) PERCEIVED SATISFACTION WITH IT-MEDIATED COMMUNICATION. THESE INDEXES WERE CALCULATED SEPARATELY FOR THE EMPLOYESS AND SUPERVISORS, THE DIFFERENT CASE COMPANIES.

Case	i	ii	iii	total
Case I	3.5	3.6	3.3	3.5
Case II	3.8	3.9	3.5	3.8
Case III	3.7	3.7	3.8	3.7
Case IV	3.3	3.4	2.8	3.2
Case V	3.5	3.8	3.4	3.5
Case VI	3.6	3.7	3.2	3.6
Supervisors	3.8	3.9	3.6	3.8
Employees	3.4	3.6	3.2	3.4
Bigger comp.	3.6	3.7	3.3	3.6
Smaller comp.	3.5	3.7	3.3	3.5

Figure 3 shows averaged scores by staff category and case company. Cronbach's Alpha for every chosen statement sub-group of the questions, i.e., tentative measuring scales, was estimated and compared with the recommended limits in the literature:

Alpha for i= 0.87 (Good), Alpha for ii=0.72 (Good), Alpha for iii=0.62 (Acceptable)

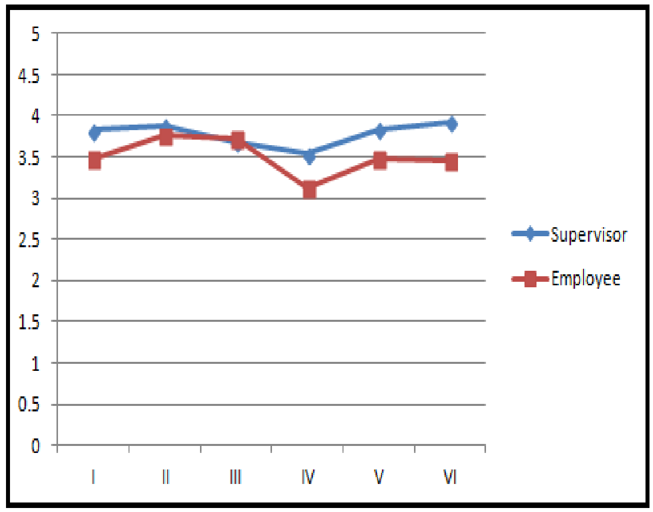

Figure 3. Average Likert-scores for employees and supervisors in case companies.

V. DISCUSSION

Our results of the current pilot empirical study indicate that choosing communication as a study issue, and the probable one in need for enhancement, seems to be right. Effective communication needs to be recognised as an integral capability in every organisation. Methods for the measuring, managing, and developing in a participatory, and business-tailored way should be further developed. The literature review shows Health and Safety (HS) communication to be frequently emphasised in an important British textbook on management and workforce [6]. In Finland, this emphasis would be important, and not only HS, but also Environment and Quality (EQ), and other outcomes, and enabling work system features as well. According to our opinion, KIKO-related multi-disciplinary R&D studies seem to have their relevant place.

An optimal work system approach has a lot of similarities with quality prize models(excellence models) like European or US ones [33][34], as far as taking care of the both enablers and results of the good practises of work and inc business. Communication might not only be in relation with more or less directly measureable issues – it is a value as such, a part of human and social assets.

Our past emphasis on the concept of participation is quite near, we think, to the concept of collaboration. Both concepts are probably highly correlated with communication. In a tentative modelling of communication at work, we try to present key issues, at least as thinking about our emphasis on this paper. The issues relate closely to the work system, management, quality assurance,

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integrated management [35] and finally, “well-being in work system”. This probably quite new term sounds to be feasible. We think we can continue, with our field company partners, using this preliminary choice. To be more comprehensive, we think some elements have to be added to our questionnaire to cover full enough the work systems in companies such as collaborators of this study.

To sum up thoughts we found in international literature, our future steps should especially include more issues linked with the modelling of well-being in the work system, or Quality of Work(ing) Life (QWL) [20][36][37][38], lean management [39][40][41], and emerging views of ICT (the variety of communication channels, ambient, mobile technology, moving multi-site jobs, remote work, embedded, Enterprise resource planning (ERP) systems, “social media”, video). QWL (Quality of Work(ing) Life) is, in addition to Quality of Products and Services and Quality of Work Force, defined together to form Quality [42]. This conclusion by Dzissah et al. correlates positively quite much with our study’s prerequisites and models through the work system and communication are not emphasized by them. The later actual work packages of the KIKO study will most probably further contribute as far as many issues and results, and conclusions, of the current questionnaire part, first phase of the whole study.

As far as the work system is concerned, our assumption is that qualitatively (and quantitatively) enhanced communication has power to increase desired and correspondently decrease the undesired outcomes of the work system. We hope to get more evidence of this. In any case, we suggest that more means to improve communication like ones to improve quality are to be developed and implemented. In our introduction, we did not consider much able to be learned from Lasswell’s older questions (i.e., Who (says) What (to) Whom (in) What Channel (with) What Effect [26]). Instead, we felt that answering the set of questions why, who, when, where, what, and further how (i.e., so-called the five Ws and one H, see Hutchison [43]) might be more useful. That is why the latter questions are often seen the important first steps towards quality developments, excellence and integrated management, and now being well-being in the work system included.

Glendon, Clarke and McKenna [9], suggest looking at even more and specific topics within industrial organisations, such as the hierarchy, team structure, team performance, centralisation degree of the teams and networks, attitudes, and the quality of communication. The latter strongly relates to the roles and systems of ICT in company and individual levels, too. More precisely, Glendon, Clarke and McKenna encourage us to study the aspects in the following way: with adequate dissemination of top-down communications…, but also bottom-up communications… ease worker relations… reduced status distinctions operate through encouraging communication, sharing ideas, and promoting greater concern and trust among workers [9].

Referring to the literature, we conclude that our current review and questionnaire support, generally, our own past socio-technical holistic emphasis: as far communication developments, we recommend synergic design, development and implementation approach [44][45][46] [10]. Further, our past and current concepts, give an approach to apply the contextual design [61] for developing ICT systems useable for supporting collaboration within companies.

This paper focuses on general and Human Resource (HR) management, assessment and developments of well-being at work (system), total quality and further productivity and safety issues, i.e., to achieve more desired and less undesired outcomes within work system contexts. Other later coming papers based on the same KIKO study will provide broader views on these multi-professional and – disciplinary research and development issues of communication in companies.

As far as our pilot questionnaire, generally, and new Likert-style scales constructed specially, we found them useful as a starting point for enhancing communication R&D, e.g., in later sections of the KIKO project. Tentative three scales based of the chosen sub-sets of statements proved to be consistent and reliable measuring scales and applicable to surveying real industrial case organisations. Of course, the pilot scales need further trials with more case organisations, and careful evaluation.

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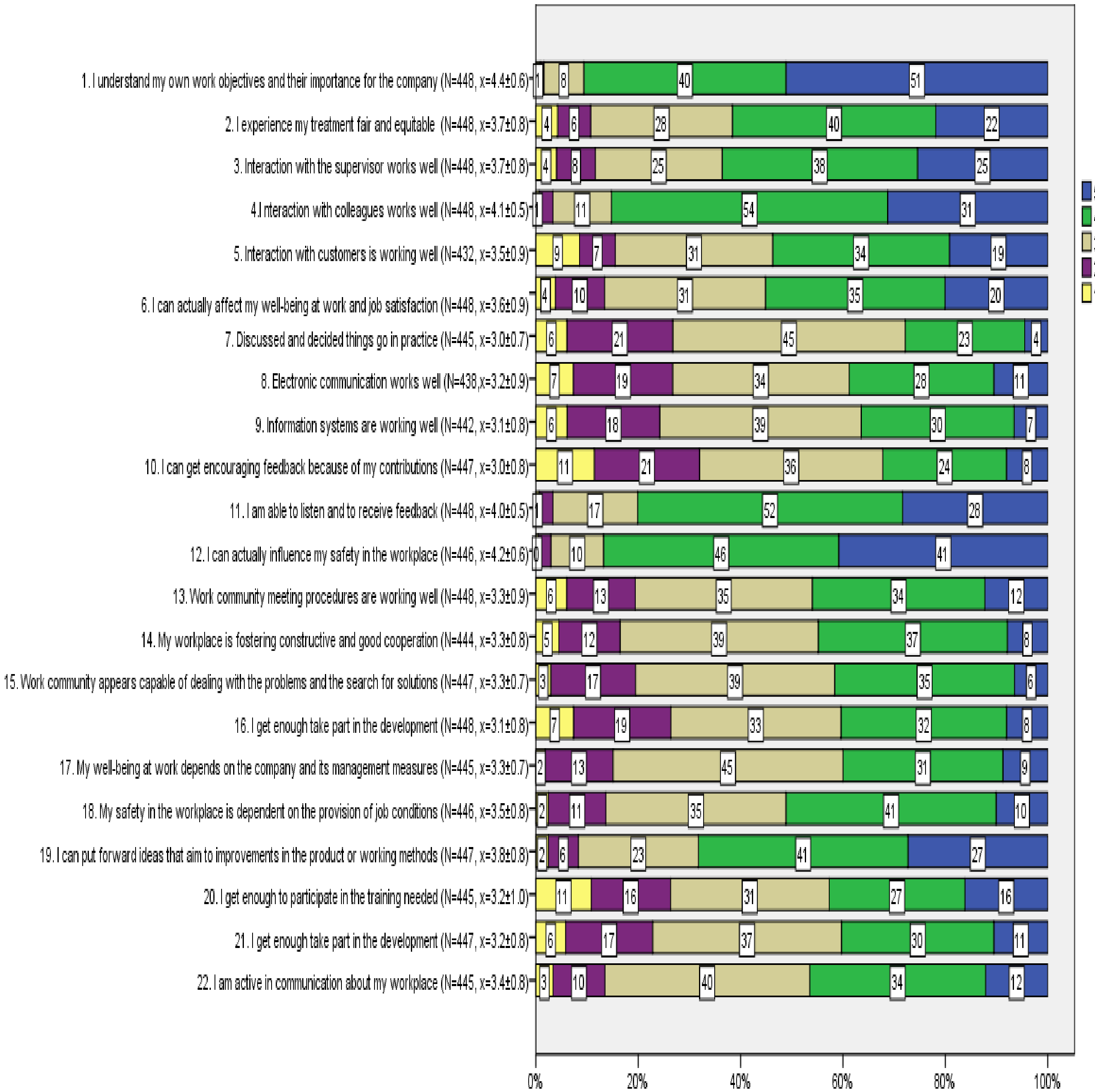
Appendix. Statements amounted 22, and basic descriptive statistics for each one. Distribution of the ratings in percentages on 5-point Likert scale are colour-coded (see right side of the figure).



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CLPMtool - Collaborative Learning Project Management Tool for Moodle

Marcelo Augusto Rauh Schmitt
Instituto Federal do Rio Grande do Sul
Porto Alegre, Brasil
marcelo.schmitt@poa.ifrs.edu.br

Liane Margarida Rockenbach Tarouco
Universidade Federal do Rio Grande do Sul
Porto Alegre, Brasil
liane@penta.ufrgs.br

***Abstract*—Collaboration is an essential element of teaching-learning process. Nevertheless, it does not happen without the presence of coordination mechanisms. Considering that information technology is relevant in supporting group coordination, a software that promotes and assists the coordination of collaboration was developed. The software is based on a coordination framework that permits the definition of flexible collaboration scripts. The students are the authors of their collaboration models. This paper describes a tool (CLPMtool) that was created as a plugin to be attached to Moodle learning management system (LMS). It can favor collaborative learning by organizing group work respecting the particular characteristics of each learning scenario.**

Keywords-collaborative learning; project management; scripts.

I. Introduction

The promotion of collaboration towards learning is considered an essential educational procedure. According to Johnson et al [1], cooperation, compared with individualistic efforts, tends to result in higher achievement, greater long-term retention of what is learned, more frequent use of critical thinking and meta-cognitive thought, more accurate and creative problem-solving and more willingness to persist in working. For Soller [2], collaborative learning brings benefits to the cognitive process, encouraging students to ask questions, to explain their opinions, articulate their reasoning and reflect on their knowledge. Fischer et al [3] emphasize that collaborative learning prepares students for the challenges of contemporary society.

For Henri et al [4], collaborative learning is not a learning theory, but a journey towards the progressive construction of knowledge. According to Bostrom et al [5], collaborative learning is a strategy that encourages students to work together in order to accomplish shared learning outcomes. Qi et al. [6] consider that collaborative learning refers to methodologies and environments in which learners engage in a common task where each individual depends on and is accountable to each other. Resta et al [7] use the definition that collaborative learning is a process where two or more people learn together.

One can notice common characteristics in the published writings of the authors who were previously quoted. For all of them, collaborative learning is a practice that demands an active participation of the student in his own knowledge building. The apprentice is the main subject of his development because he learns while he is eliciting his ideas as part of a group, listening to other explanations, reformulating rationales, and contributing to others' development. He is not someone to be taught, he is the leading figure of the whole learning process. According to Stahl [8], in collaborative learning, the teacher becomes a facilitator of knowledge building, supporting and directing its construction. Schneider [9] employ expressions like “facilitator”, “manager” and “orchestrator” when he is referring to the teacher's role. Resta et al [7] accentuate that the teacher is a facilitator instead of a “sage on stage”. Henri et al [4] express this change in the roles of teachers and students by emphasizing that the collaboration journey is characterized by more egalitarian relationships between all learning actors.

Stahl et al [10] sustain that learning happens through interactions among students. They learn by expressing their questions, pursuing lines of inquiry together, teaching each other and seeing how others are learning. Morishima et al. [11] summarize, in a simple formula, the benefits of using a collaborative learning environment through the expressions "learning by teaching" and "learning by observation". Collaborative learning is indeed a process, a pathway, a dynamics of new knowledge construction and validation.

Collaboration depends on coordination. According to Henri et al [4], to coordinate is to effectively manage activities, people and resources for a particular purpose. They affirm that collaboration requires the coordination of the activities of the members of a group, and coordinating the resolution of a problem is to split it into subtasks, to assign responsibilities, and to utilize resources. For Lewis et al. [12], coordination is the act of working together harmoniously, which consists in overcoming conflicts. The organization and management of activities of both large groups and small groups should be facilitated so that learning happens in harmony and efficiently. Kim et al [13] consider that correct coordination work allows group members to have accurate mutual understanding about their tasks and team, and consequently, to successfully achieve their final goal.

Researchers who study such subject attest the need do coordinate collaboration. Collaboration and coordination are inseparable concepts when related to learning. Computer Supported Collaborative Learning (CSCL) literature presents coordination as an imperative element to build harmonious and productive collaboration [14]-[17]. The distribution of learners in a group and the assignment of a task to them do not guarantee that learning-effective collaboration will occur [18]. Collaboration is not a trivial activity. It implies interdependence among participating students, and such interdependence necessarily demands coordination of actions [19].

Hermann et al [20] affirm that coordination is central for the quality of the problem-solving process and its outcome. According to Henri et al [4], collaboration necessitates the coordination of group activities. Malone et al [19] sustain the idea that it is easier to notice the need for coordination when it is absent. Coordination absence may lead to unclear task assignment, lack of time management, redundant work and resources, unshared resources and dissatisfied students [13].

Due to the essential role of coordination in collaborative learning, it is important to develop technological solutions to support it [13][17][21]. Considering the benefits brought by collaborative learning and the fundamental need of coordinating collaboration, we have sought to develop a coordination framework suitable for learning context and a tool that implements this framework. The coordination model was introduced in a previous paper [22]. While that paper described the proposed coordination framework, this one describes the tool that was deployed.

In Section II of this paper, the coordination scheme is discussed, showing the necessity of a collaboration script but proposing self-constructed models. Section III describes the software developed. Conclusions are presented in Section IV.

II. Collaborative Learning Coordination

A. *Flexible collaboration scripts*

Given that coordination plays a key role for the success of the collaborative learning process, it is necessary to promote it. One way to promote it is to create explicit mechanisms that force people to organize their work. Even unconsciously, students and teachers structure the way they interact over collaborative activities. They define long term and short term goals, organize intermediate tasks and determine the necessary resources to achieve their objectives. But if we want to promote coordination, we cannot rely on the initiative of individuals. We need to support coordination of collaboration.

Many researchers advocate the use of collaboration scripts [23][24] as a method of conducting the collaborative process. Coordination is established by a script that rules the activities of the group members. However, the use of default scripts, to some extent, deviates from the idea of true collaboration because it can disrupt the natural process of solving a problem [25]. Heinze et al [26] assume that either an unguided approach to coordination or a very structured one can lead to undesirable effects in a learning community. Schneider [9] reaches the same conclusion when he addresses projects and implementation of pedagogical scenarios. According to him, teachers have to find a balance between student freedom, which is necessary for intellectual development and motivation, and certain guiding principles, which are indispensable to keep collaborative tasks running. According to Dimitriadis et al. [27], there is a growing concern of CSCL researchers on how to design coordination mechanisms and maintain the flexibility of scripting. The effectiveness of using scripts is a highly controversial topic [28]. Haake et al [29] have found no general advantages in the usage of scripts concerning acquisition of knowledge.

One of the greatest challenges regarding the coordination of collaborative learning is to establish a balance between the freedom of students and the power of intervention of teachers. The responsibility of the coordination of activities in collaborative learning is not an exclusive assignment of the teacher. Carell et al [30] affirm that while the definition of the task and its presentation can mainly be carried out by teachers, the plan of the collaboration process has to be developed by the students themselves as opposed to being delivered to them. Even though the primary objective of a collective work is usually given by the teacher, the steps to accomplish this goal are usually defined by the group members. Intermediate tasks are defined, with deadlines and products. Often, the group needs to review the process of knowledge collective construction and decide for new directions. This more refined planning of how collaboration will take place is essential. Without it, the attainment of the ultimate goal is uncertain.

The creation of subtasks permits that students initiate their planning by defining more abstract phases and make successive refinements of these phases, creating, each time, more specific definitions. Collaboration is a cyclic process [31] and this kind of top-down task definition makes explicit this constant renegotiation. Every renegotiation conducts to new tasks. These mechanisms should not be considered as inhibitors to the collaboration process since the preparation of the collaborative work carried out by those who will collaborate facilitates the accomplishment of the intended goal. Those who plan will have a better understanding of what was planned and, as a rule, a stronger commitment to the activity.

Considering that learning is essentially a social process [32], collective planning itself is an opportunity to learn and to develop learning skills. Those who are not capable of planning an activity by them will do it with other's help and will acquire a new knowledge. During task definition, students interact, new concepts may be internalized, and common ground is created facilitating project development.

If the use of scripts can be an obstacle for collaboration to prosper, it is reasonable to consider the use of a computer system to support a coordination schema that produces multiple collaboration arrangements not restricted to a particular model. Students should be able to structure collaborative process with a high level of autonomy. They should be able to dynamically build their own collaboration model. The teacher, on the other hand, should be authorized to intervene in those situations that he diagnoses as prejudicial for learning. A tool whose purpose is to facilitate the coordination of collaborative learning must make students the leading actors of the process, promoting the emergence of a reflexive, critical, argumentative and autonomous thought on reality. At the same time, it must create conditions for the teacher to monitor the process and

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to realize the best moment for imperative course corrections, aiming collaborative learning.

B. Proposed framework

As students need to organize how they will collaborate to learn [4][14]-[19], one could carefully observe coordination mechanisms used in corporate groupware as an alternative to support collaborative learning. Project Management Tools, found in corporative groupwares, may help to make learning management systems more efficient on issues related to the coordination of collaboration due to the fact that they pay special attention to coordination aspects of collaboration, such as problem organization, task assignment, deadline setting and activity progress tracking.

Schmitt et al [22] proposed a coordination framework. The main characteristic of that framework is to allow students and teachers to create collaboration scripts (or models) tailored to specific learning scenarios. It has two basic assumptions: students have an active participation in the organization of collaborative learning and project management tools can be used to support the coordination of collaboration in educational contexts. Through project definition and task organization, students and teachers coordinate collaboration and create a script that is more adequate for achieving specific goals.

III. CLPMTOOL

A. Reasons to deploy a Moodle plugin

Currently, learning management systems are used both in distance learning programs and in on-site classes. In the first case, they are essential means to managing courses, allowing communication among students and teachers, deploying of learning objects (texts, hypertexts, videos, simulations, games, exercises), and organizing courses (registration of students, participation assessment, grades publication). In the second case, they are used as a support tool for the on-site activities, allowing communication at any time, and publishing of learning resources that lead to the consolidation and deepening of what is learned in the classroom. Thus, learning management systems are, increasingly, becoming well know environments to students and teachers.

Stahl [33] asserts that CSCL artifacts must be built, among other things, to support and structure collaboration. Although there are free project management tools that can be used by any community, the dissociation between the learning management system and any tool used to coordinate the collaboration can hamper the learning process. A first case study [22], which used Egroupware [34] as project manager software, revealed that the use of two different environments brings difficulties for students, especially with regard to the process of learning to use a new user interface. This same case study indicated that the intended coordination framework does not occur spontaneously. It is necessary, therefore, that the tool implements components that cause the organization of collaboration, that is, it must provide ways to make it clear to students and teachers the coordination phases that exist to execute collaborative activities.

The reasons given above led to the decision of building a project management tool integrated to a virtual learning environment. We opted for the implementation of a Moodle module since the institutions which researchers belong to use this software. It was also taken into consideration that a large community, present in several countries, could benefit from such module since Moodle is used in more than 83,000 sites, in at least 236 countries.

B. Plugin description

CLPMtool was developed based on the defined coordination framework. The tool consists of five modules (Figure 1):

a) Project Control Module - allows the definition of activities to be undertaken by groups of students.

b) Task Control Module Tasks - allows students and teachers to define and track tasks that comprise the activity.

c) Gant Chart Control Module - presents a graphical view of the development of the activity.

d) Forum Control Module - organizes group asynchronous discussion.

e) Chat Control Module - organizes group synchronous discussion.

The system uses features that are already present in Moodle. The modules that control project, tasks and Gantt charts use Moodle libraries that administer users and groups of the virtual learning environment. Thus, the management of users and groups is carried out by teachers the same way as they do in any Moodle block. The modules that control forums and chats use what is already available inside the environment, integrating everything and organizing groups of students

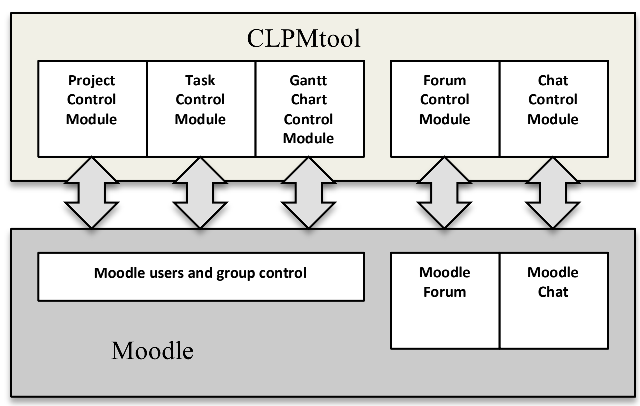


Figure 1 - CLPMtool modules

The plugin is used as any Moodle block. Teachers only have to enable it inside a course and perform an initial setup. This initial setup includes the following actions:

a) Inside the course / outside the block

a. Groups creation

b. Forum creation

c. Chat creation

b) Inside CLPMtool
   a. Initial activity definition
   b. Project deadline definition
   c. Forum and chat association.

Once the block is set, it can be used to assist in the coordination of collaboration. The coordination is accomplished in three phases:

a) identification by the teacher of a basic activity (really important for the student groups to define their projects);
b) definition by the groups of the projects that will be executed;
c) creation and control of task execution.

As proposed in the coordination framework [22], initially, the teacher defines an activity to be developed by the students. The students, in turn, build a collaboration plan in order to achieve the intended objectives. Although the teacher should not be the protagonist of actions, one cannot ignore his responsibility in identifying the skills and the abilities that must be acquired by the students, as well as the means to foster collaboration.

The plugin requires the definition of the activity to occur when the block is initially configured. This definition is a short textual instruction, accompanied by the start and end dates of the activity. It is up to the teacher to create a clear description of his intentions. That description must prompt students to build a collaboration plan. An unclear definition from the teacher may cause groups to make proposals dissociated from learning objectives. A very narrow definition will withdraw from the students the opportunity to establish how the collaboration will occur. In that case the chances to produce among the groups the emergence of argumentative writing, critical thinking, articulation of thought and autonomy will be reduced.

Students will be able to access the block and create their projects as soon as the plugin is setup by the teacher. The plugin is part of an environment already known and used by all students. Once the activity is created, each student will have access to the project of his own group. The plugin integrates in the same environment already known and used by students, the management of the project itself and the communication tools - forum and chat (Figure 2).

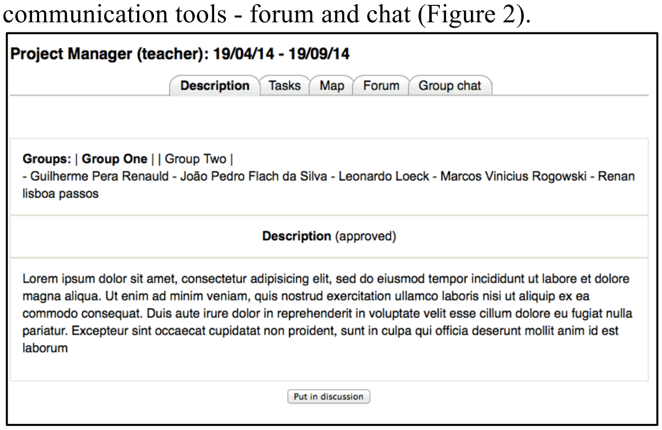


Figure 2 - CLPMtool project definition screen

That strategy seeks to establish a balance between an autonomous attitude of the students and an appropriate mediation of the teacher. The proposed project is a collective construction of students assembled under the mentoring of the teacher.

After defining a project, students detail how the objectives will be achieved. This is accomplished by defining tasks. Figure 3 shows CLPMtool screen that allows the definition of a task. Just like in a corporate project manager, deadlines and responsibilities are set, and the user can register and observe each task progress.

Students build a collaboration model best suited for achieving the intended goals through the proposed tasks. The plugin forces them to be authors of the collaboration script and they perceive themselves as coordinators of the whole activity.

Figure 3 - CLPMtool task definition screen

In addition to the commitment of all involved - students and teachers - collaborative learning requires that group members have a common understanding of the objectives and the planned pathway to accomplish them. Macmillan et al [35] state that for a team to act harmoniously in order to achieve a common goal, this team should have shared information on the situation and on the other group members. In the process of knowledge construction, it is essential that all students become aware of the activities developed by their colleagues [36]. There must be a mental model shared by group members for collaboration to occur [13]. In this context, it is important that students and teachers are able to realize the defined collaboration script and to monitor the fulfillment of activities through time. It is possible to visualize the main plan of actions by clicking over the tab named "Tasks" (Figure 4). From this interface, users may

a) view the collaboration model that was built;
b) track the progress of the tasks;
c) identify each task status;
d) modify each task;

e) edit tasks;
f) create new tasks.

CLPMtool makes it possible to define multiple collaboration models by implementing the proposed coordination framework. Aiming to promote collaborative learning, the software has mechanisms that drive user actions. For the actions of students and teachers to comply with the coordination schema, it is essential that students signal their propositions and teachers their reviews. In the case of project definition, signaling is done by changing the project state: "Students planning the project" or "project set". The current state is shown to the users with the textual definition. The assessment of the proposed project occurs during the planning process or after the students warn the teacher by some communication tool.

Managing a task is more complex. Because of that, we decided to implement a more explicit signaling mechanism, which would be more independent from the communication tools (forum and chat). It includes planning, tracking and assessment of tasks. Table 1 shows the many states that are signaled in order to define, execute and evaluate a task.

Depending on the context, students may perform different actions on the task. CLPMtool allows students to change the status of the task according to the defined coordination framework. For example, a planning task may be delivered by any student of the group to the teacher in order to be assessed. This will make the state and the associated icon to change to "Teacher assessing planning task." The same is valid for a running task that may have a change in its progress status or may be delivered to the teacher for evaluation. On the other hand, the group cannot change a task that is being evaluated by the teacher

It is also possible to follow the evolution of collaborative work through a Gantt chart. This type of chart, as well as the screen that summarizes task states (Figure 4), is fundamental for the group members to acquire the same understanding of what is being held. The coordination of collaboration requires a common understanding about the objectives to be achieved and the responsibilities of the group and of each of its members. Collaboration harmony, also obtained by proper coordination, depends on the understanding of all participants of the proposed dynamic and its progress in time. Graphical views always contribute to the realization of what is aimed and how far the target is.

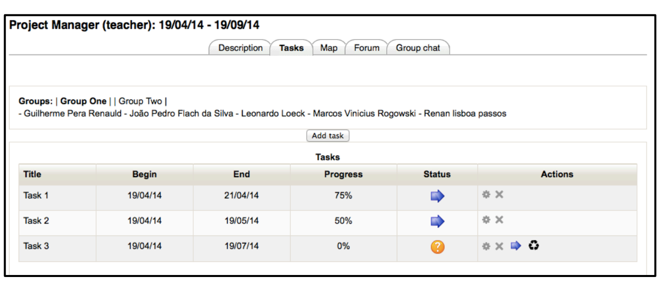
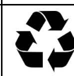
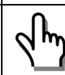
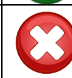


Figure 4 - CLPMtool task tracking screen

Table 1- Sates and icons used in CLPMtool to signal task status.

CLPMtool actions	Icon	Framework status
Students planning a task		Students planning a task
Students ask the teacher if the task is well planned		Teacher evaluating task planning
Teacher accepted task planning and students are executing it		Students executing the task
Teacher did not accept task planning and students are correcting it		Students planning a task
Students considered the task finished and the teacher is evaluating it		Teacher evaluating task execution
Teacher considered the task finished		The end
Teacher did not considered the task finished and students must redo it		Students executing the task

Finally, the plugin allows students to communicate with each other through a forum board or a chat room in the same interface. Communication via the existing tools in Moodle facilitates users exchange of messages. Besides that, the integration into the same workspace indicates to students and teachers the need to communicate in order to define and execute the collaboration model.

C. *Plugin coordination mechanisms*

CLPMtool permits students, with the assistance of teachers, to coordinate their collaborative activities. The various actions of users on the system correspond to the following coordination procedures:

1) *Project description visualization*

The visualization of project description is a coordination activity since they perform those actions during planning and execution phases in order to maintain a common understanding of the project.

2) *Project description editing*

Editing the project description indicates a stage in the process of building the collaboration model. The greater the group autonomy, the lower the participation of teachers in this action.

3) *Project status update*

Updating the project status marks the moment when the teacher believes that the proposal meets the learning objectives. It may also set the need for students to return to discuss their proposals. It is a coordination activity as it corresponds to an explicit indication of project status change.

4) *Task creation*

By adding tasks to the project, students detail the collaborative model that will be used in achieving the main goal. The greater the group autonomy, the lower the participation of teachers in this action.

5) *Task editing*

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When students edit tasks they are articulating and bethinking their proposals. It corresponds to an interaction with the intention of collectively constructing the collaboration model.

6) Task list view

When consulting the list of tasks, students and teachers are trying to better understand what was planned or being planned and how the project is progressing.

7) Task status update

Updating the status of a task corresponds to an explicit communication about progress in achieving the intended objectives.

8) Task removal

When a task is deleted, the teacher is mediating the coordination process and is proposing a change in the collaboration model.

9) Gantt chart visualization

When consulting the project Gantt chart, students and teachers are, once again, trying to better understand what was planned or being planned and how the project is progressing.

10) Forum and chat usage

When using the forum and chat tools, students and teachers are communicating to build a model of collaboration or to carry out the model created.

IV CONCLUSIONS

In order to evaluate CLPMtool, a case study was carried on. Three groups of students used the tool in a PHP course. The logs related to coordination activities produced by the software were analysed and the students were interviewed. All students found the tool useful to improve organization, control and communication in collaborative learning. Data related to task list view, and even Gantt Map view, indicated that students' actions did not limit to produce the requested planning like in the first experiment. Students used CLPMtool to get situated and to control the execution of collaborative process. Logs also revealed the distinct collaboration schemas produced by the coordination model. Those results were presented in [22].

This work, like many CSCL researches, investigates how computational tools can support collaborative learning. Coordination is a constitutive element of the collaboration process intended to produce learning, deserving attention from the community that researches how technology can support collaborative learning. This paper presented software that was developed with the aim of favoring the coordination of collaboration. CLPMtool is a project manager for the collaborative learning in that it combines elements found in corporate groupware (definition of projects and tasks) and features required in the educational context (integration with a virtual learning environment, mechanisms to facilitate the roles of students and teachers, records of users' activities for later analysis). This software was created with the premise that students are active constructors of their collaboration script.

We intend to continue this study in order to propose and develop models and artifacts that better support collaborative learning. Considering that when using project managers, collaboration is organized as projects and tasks, it is important to investigate how the task level of detailing may influence the collaborative activity. One question that still demands investigation is which explicit coordination mechanisms may further favor collaboration. It is also necessary to incorporate the artifacts produced during the collaboration process into the coordination tool. At last, we believe that agile project methodologies can contribute to enhance the coordination framework since there are some similarities between agile projects and projects as an instrument to promote collaborative learning.

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Peer Group Counseling as a Tool for Promoting Managers' Communication Skills in Industrial and Planning Organizations

Heli Kiema, Matleena Mäenpää, Tarja Leinonen and Hannu Soini
Research Unit of Psychology
University of Oulu
Oulu, Finland
{heli.kiema, matleena.maenpaa, tarja.leinonen, hannu.soini}@oulu.fi

***Abstract*— In this study, we focus on investigating and developing communication skills for managers and employees from industrial and planning based organizations that participated in Frictionless Communication (FriCo) project. Our main aim was to explore the effectiveness of Peer Group Counseling – training method (PGC) in promoting managers' communication skills and to find out the possible changes in these skills before and after the training. We used Counseling Response Observation System (CROS) to examine communication skills in 11 managers during the training. In examining the communication skills with CROS, we focused on the periods before and after the training. Communication skills were increased after participating in PGC training. The theoretical background and the training method are presented first, then we describe the methods and measures used in this study and last, the results and conclusions of the study are presented. It seems that the training method (PGC) is effective for improving communication skills. This study points out also the importance of communication skills in working life and for subjective well-being at work.**

Keywords-communication; communication skills; training; counseling; organizations; leadership.

I. INTRODUCTION

The role of communication skills in working life has clearly increased lately and the demand for developing communication skills for managers and personnel overall has risen. Communication and information processes have become vital for success specifically in knowledge organizations. [1] Social relationships and communication are important factors of working conditions in creating functionality to work, engagement and commitment for employees' [2]. Current research also suggests concentrating on the relationship between supervisor and subordinate and developing communication skills in managers [3]. Dialogic leadership brings out the idea that it is more vital to concentrate on the interactional process of supervisor and subordinates instead of individual characteristics of the leader [3][4][5]. The quality of the relationship between supervisor and subordinate can be seen by Leader-member exchange theory (LMX) [6]. The impact of the quality of this relationship has been shown to have great impact for example on employee job satisfaction, well-being, reduced staff turnover and innovativeness [7][8][9]. The baseline of LMX lies in social theory [8] and social exchange theory [11][12].

A growing body of research indicates to a large number of problems related to psychological health in work settings [13][14]. Psychological health problems reflect mostly on job stress and burn out. One important cause for job stress and burn out seems to be related to social interactions and lack of social contact [15]. Social skills and communication skills are associated with two indicators of psychological well-being: reduced symptoms of depression and life satisfaction [16]. Bakker et al. [7] have suggested one option for developing working life and subjective well-being by bringing out the concept of work engagement [17][18]. Even though it has been seen that social interaction is an important factor in creating engagement of employees, there is not much research about this relationship between social interaction and employee engagement. Hayase [18] points out that there is a positive relation between internal communication and employee engagement. Current research also shows that internal communication is associated with commitment, discretionary effort and meaningful work which can all be seen as factors of work engagement [2][18]. When planning the Frictionless Communication (FriCo) project, the baseline was the demand arising from the working life for improving the communication skills of young engineers [19][20]. The impact of engineers' communication skills in adjusting to jobs and achieving career goals seems to be meaningful [21]. Many of the engineers work in leadership positions already at the very beginning of their career, which creates the demand for leadership skills which are not however developed much during university training (see for example [22]).

There is a relationship between social skills and greater well-being (lower level of stress and social skills). The competitiveness depends more on intangible assets that are mostly related to the social interaction of people in organizations and can be identified by psychological and social capital. For competitiveness and creating innovations, there is a demand for qualitative and fluent communication in organization knowledge creation process. Leaders' relational behavior is positively associated with social capital

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in organizations. Social capital includes the feeling of enthusiasm which is positively associated with employee job performance. [23][24]

The field of communication skills and management is still quite new and growing. There is some study to be found on supervisory communication skills but this kind of systematic training like peer Group Counseling –training method (PGC) on communication skills in supervisors or managers is still quite new and infrequent. Zohar et al. [25] bring out a discourse-based intervention for modifying supervisory communication for creating safety climate and improve performance. Guidance-based leadership training program also concentrates on communication skills training [26].

Communication skills' training is not that noticeable in the field of management but in the area of counseling and therapy it is clearly seen as very important. In counseling and therapy sessions the role of communication skills is clearly significant and counselors and therapists are systematically trained in such skills. Most of the theories in the background of this method PGC also lie in counseling and therapy. These skills are needed in building a successful counselor/therapy and client relationship as well as in supervisor – subordinate relationship. [27][29]

This kind of setting is also quite common among health professionals, especially in doctor-patient relationships [29]-[33]. Moore and Wilkinson [29] have shown results of communication skills training for health professionals. In this setting with three trials on 347 health professionals showed a significant positive effect on communications behaviors and the study suggests providing communication skills training for health professionals. One important finding is also that nurses used more emotional speech than untrained counterparts. This result was also seen in patients who also used more emotional terms when interviewed by trained nurses.

Work engagement is an emerging concept in occupational health psychology and it reflects on job resources and personal resources. The concept of work engagement includes a positive, fulfilling, affective-motivational state of work-related well-being that is characterized by vigor, dedication and absorption. Job resources can be divided into physical, social and organizational aspects of the job. Job can fulfill human needs like autonomy, relatedness and competence [32]. In this study we concentrate on the social support of the job resources which support and satisfy the need for autonomy and the need to belong. [35][17][34]

In the project FriCo funded by The Finnish Work Environment Fund, we used PGC training for developing the communication skills of the participants. PGC method has been developed at the Research Unit of Psychology at the University of Oulu [36][37]. The main purpose of the FriCo project was to develop communication skills in Finnish industrial and planning organizations. The communication skills were developed at individual, work community and organizational level and the methods in the project are PGC (individual level), ethnographic (work community level) and participating planning (organizational level). The project develops communication skills in order to create innovativeness in organizations and develop management and leadership that are associated with performance of work community, profitability and subjective well-being.

PGC, also known as consultative method, is based on structured role working, where the participants are given the opportunity to contemplate their own and other participants' experiences of their work issues in emotionally safe and peaceful environments [37]. Consultative method is divided into three phases: orientation, counseling and discussion session and sharing. The phases help the participant to focus on different stages in the discussion and be able to define the concepts of the task of the counselor for the participants. [37] Consultative method is based on multidimensional and process like action [38]. Multidimensionality reflects on a negotiating and inquisitive approach to problem solving. It can be seen in interaction situations that the focus on discussion is on the matter of the client. Consultative method emphasizes the skills in communication that help the owner of the matter to recognize his emotions and knowhow and in that way reach the real problem. Consultative method is developed by peer learning principles [39] [41]. The method focuses on the experiences and expertise of the participants in communication training.

The focus of PGC is on basic skills in counseling and communication. Those skills can be seen as professional counseling and communication skills and those skills can be divided into following items: conducting, listening, dialog, concentricity, reflecting, attending skills, focusing, and agreement. [41][42][43][44]

The approach in this study to counseling and communication skills is based on the Human Relation Counseling Model (HRCM) framework that derives from many formal theoretical points including phenomenological theory and client centered theory [42][44]. HRCM emphasizes a client-centered, problem-solving and helping relationship. The behavior changes and actions (outcomes) can be the result of one or both of the following: 1) the client's exploration and understanding of his or her own feelings, thoughts or actions, or 2) the client's understanding of and decision to modify pertinent environmental and systematic variables [44]. We used the Counselor Response Observation System (CROS) to measure the communication skills of the participants. CROS consists of Counseling Response Coding System (CRCS) which includes the categories reflecting to Ivey's micro skills on counseling and Skilled Verbal Response Scale (SVRS) which consists of seven dimensions of skillful counseling [46][47]. Micro skills in counseling can be divided into verbal and nonverbal skills and in this study and in CROS the focus is on verbal skills: listening, attending and influencing skills [46].

The background of SVRS lies in the definition of helpful verbal responding in HRCM. CRCS categories are derived from Ivey's micro skills. Micro skills model includes combination of a response and its focus and a preliminary model included 12 categories for each response variable (perception check, reflection, specifying question, summary, conclusion, direction, suggestion, self-disclosure, feedback, leading to logical consequences, immediacy, confrontation) and seven categories for the response focus variable (feeling, action, explanation, history, facts, strengths, context). [47]

CROS consists of six SVRS items as presented in Figure1: 1) the counselor speaks of things that the client has not mentioned, 2) the counselor uses open questions, 3) the counselor focuses on exploring the client's problems, 4) the counselor does not share opinions or give advice, 5) the counselor does not act mechanically, 6) the counselor uses specifying questions [46].

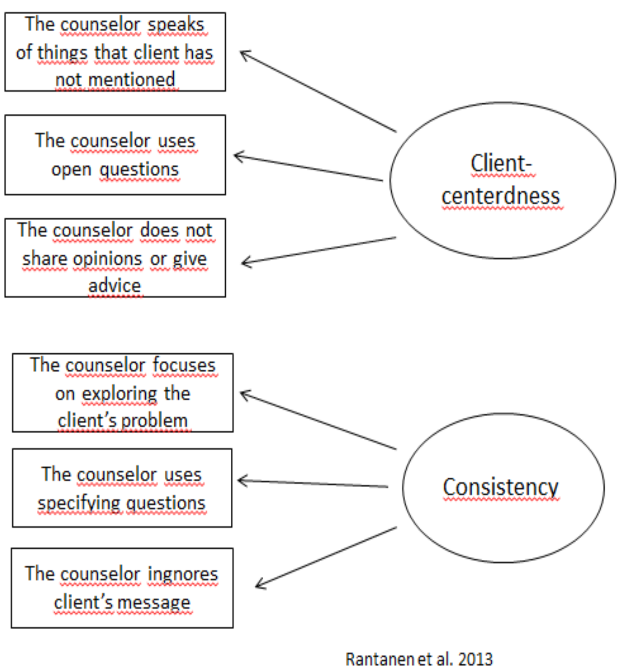

Figure 1. Dimensions of SVRS (Rantanen et al. 2013)

The purposes of the study is to 1) describe the typical communication skills and types of the participants in the beginning of the training based on CROS, 2) present the changes in communication skills during the training and 3) present the participants' feedback about the training and its' effectiveness.

In this study we use SVRS to describe the typical communication skills of the participants and to analyze the changes in communication skills in training. We analyze the written feedback of participants to provide qualitative insight into the effectiveness of PGC as a training method. The study of the role of communication skills in organizations and working life is an important theme today and for the future in occupational health psychology and organizational psychology.

II. METHOD

We present here the methods we use in this study. We begin with participants and then describe procedure of the training method and research design, then continuing on measures and data analysis.

A. Participants

In this study we examine 11 managers and employees who work in industrial and planning organizations and participated in FriCo project. 11 participants take part in the communication skills training. The communication skills' training was firstly planned for managers but we had to replace two of them with other specialists because of time problems. 8 of 11 in training are male and 3 of 11 female. There were no specific selection for sex and the large amount of men is explained by the field of the companies (mostly engineers). PCG training method includes all the participants working in both roles: as subordinate (usually client) and supervisor (usually counselor). The professional status of participant does not play any role in this training design neither does sex.

B. Procedure

The study is executed during the communication skills training with 11 participants taking part in the FriCo project. All the participants work as both supervisor (counselor) and subordinate (client) in the counseling sessions (discussion sessions). The training method in consultative session is based on structured role working when all the participants are required to work as a counselor and a client [37]. We use subordinate-supervisor design in this FRICO project as it is more suitable for the participants coming from industrial and planning organizations. This training in FRICO is planned for managers and that's why we change the counselor- client design into supervisor – subordinate design. That doesn't influence on communication or communication training.

PGC, also known as consultative method, is based on structured role working, where the participants are given the opportunity to contemplate their own and other participants' experiences of their work issues in emotionally safe and peaceful environments

The sessions are all videotaped. The communication skills training session include an intervention during the session. The communication skills of each participant are measured with SVRS scale.

C. Research Design

The subjects are observed in a peer consultation team as presented in Figure 2. A peer consultation team includes a supervisor (counselor), a subordinate (client), a counselor (supervisor) and observers (2-6). PGC training requires working in both roles as a supervisor (counselor) and a subordinate (client) to be able to adapt communication skills. Working in both roles gives important information via practice about consistency and client-centeredness [46]. We examine the whole consultation sessions and SVRS scores are given to all the participants when working in the role of the client.

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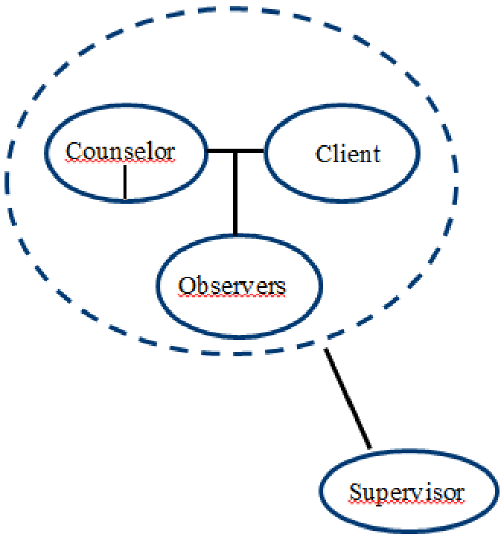

Figure 2. Peer Group Counseling method – roles

D. Measures

1) CROS

We use the CROS to measure the level of communication skills. CROS consists of CRCS and a SVRS, and in this study we focused on SVRS as the aim is to examine the skill level of the participants' communication skills [46]. SVRS focuses on measuring skilled responses of the counselor during a counseling session. The task of counseling is to help the client to explore and understand his/her problem. The counselor can make the most of the counseling session by focusing on the client's message in a personal, consistent and thorough way. Measuring skillful response is based on these qualities. The SRVS consists of six observational items (rated on 4-point Likert scale, 0 = not at all, 1= a little, 2 = somewhat, 3= a lot). SVRS measures the degree of the counselor's ability to help the client to explore his/her problem [45].

2) Data Analysis

We collect the feedback from each participant after each day of training as well as after completing the training. The feedback is collected in the form of open questions and the received qualitative data is analyzed by using constant comparative method (for example [47]). Based on the data it is possible to create an understanding of how the participants experience the PGC method and which facts in their opinion advanced the learning process.

The training sessions are videotaped for later analysis and feedback. A few the participants commented that the presence of the camera had made them feel nervous at first, but during the training recording was forgotten. The actual recordings are however considered to be a good tool for getting feedback and observing one's own action in the communication situations. Based on the comments from the participants a small training group creates a safe and relaxed atmosphere, which makes concentrating on the practices easier. The immediate feedback after the training sessions, as well as discussions and sharing with the other participants and with the trainer is evaluated as the most effective factor for learning the PGC method.

III. RESULTS

SVRS scores in the first training session do not show any typical ways for managers to respond in the communication situations. It can be seen rather that they each are responding in their own typical ways. None of the six dimensions includes into SVRS scale is considered as better as or worse than the others. When comparing SVRS scores in the first training session and in the second training session the results show that most of the participants were able to improve their communication skills during the training (see Table 1). SVRS scores had increased from the first training session to the second training session (session1: mean 10.71 and session2: mean 13.29). It seemed that client-centeredness had improved the most for these participants, which was seen in this training mostly in dimension scenario "counselor speaks of things that client has not mentioned". Unfortunately, all of the participants were not able to attend the second training session and therefore are missing the second scores, but for those who attended both of the sessions it seems that the training method has been effective and we can show preliminary results.

TABLE 1. PARTICIPANTS' SVRS SCORES IN FIRST AND SECOND COMMUNICATION TRAININGN SESSION (11 participants took part in first counseling and 7 participants took part in second counseling session)

PARTICIPANTS	SVRS SCORES1	SVRS SCORES2
1	7	15
2	7	13
3	15	17
6	12	12
7	13	11
8	10	11
11	11	14

p= 0,000, sd svrs1=2,98, sd svrs2=2,21, mean svrs1 10,71, mean svrs2 13,29

We also analyze the feedback from the participants qualitatively using grounded theory. At the beginning of the training the participants report feeling some confusion concerning the PGC method, but as training progressed, the participants started to comment quite quickly that the method felt good in the sense that participating and actual training started immediately. The orientation to the training sessions via a short theory overview (for example concerning the link between the communication skills and work well-being) was appreciated by the participants, but there were however several statements that PGC method could not be adopted via theory or by memorizing: based on the comments, adopting PGC method requires concrete practices, self-involvement as well as ability to reflect and change one's own actions. The participants reported that they gained practical and applicable tools for better communication during the training period. The overall comments concerning the usability of the method in everyday work were very positive.

"The method starts to clear up and sometimes at work I remember to listen more carefully and catch their message instead of offering a solution",

"The method is clearing up and I am already using it at work, it is comforting to know that it is possible to train one's communication skills

"Good experience. I would recommend this to others too. First I thought that there should be more theory included, but later on I noticed that this method is good. I got tools to improve my communication and learned what my strengths and challenges are [when communicating]"

"Practices and watching them [from the video recordings] as well as evaluation have been an educating ensemble, which created an opportunity to see one acting in a communication situation. The skill, how to give feedback has improved during the training."

"Very good practices. It is good to get the feedback concerning the performance right in the middle of practice session."

"Practice, practice, practice and feedback. It is not possible to learn these things via theory sessions. This training model is very good. A half-day training session is convenient and starting time at 12 o'clock is good as well."

"The special feature of this training is that you can't learn it "by heart". It requires assimilation, reflecting one's own action and changing one's personal ways to act. Challenging tasks, which most probably everyone is not capable of handling."

"There could be more practices for each trainee, for example the whole day reserved for the training and each trainee could practice several times a day."

When we further analyze the feedback from the training and compared the data with SVRS scores, it could be seen that those participants who were capable of analyzing their own leader experience and reflect on their own action in the practices during the training, received higher SVRS scores in the second training session. We also notice a correlation between the participants' self-reflection and increasing SVRS scores between the first and the second training session.

IV. CONCLUSIONS

In this study we describe an example of a communication skills training method and show results derived from the project FriCo [20][21]. We show here that our method PGC had increased communication skills for the participants, measured with CROS. These are preliminary results but we can see this training method and the subject of communication skills and organization success as an important area to be investigated in the future. We can recommend PGC as a tool for promoting communication skills in managers within different organizations. The effectiveness of this training demands active participation, commitment and self-reflection. We note the connection between high SVRS scores and self-reflection: participants that had used self-reflection during the training had higher scores in SVRS compared to those that had not used self-reflection. Our previous studies also showed the effectiveness of the method in developing counseling and communication skills (for example [36]). There is a need for further study in examining this method with a larger sample and we can only show preliminary results in this paper. We are also interested in examining the connection between communication skills and well-being at work which would benefit this method and research as well as give important information for the research and study of well-being and the Quality of Working Life (QWL).

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Lookie - A Case Study of a Location Based Collaborative Application

Elina Yaakobovich, Rami Puzis
Department of Information Systems Engineering and Telekom Innovation Laboratories at Ben-Gurion University of the Negev
Email: {elinash, puzis}@bgu.ac.il

***Abstract*—In the age of smartphones, increased online social connectivity, and advanced technological capabilities, collaborative applications often take advantage of crowd resources in an effort to enhance the welfare of the community. Lookie is a collaborative application where users can ask other users to share up to date footage regarding their whereabouts. This paper presents the results of a field trial performed with Lookie, focusing on aspects of user experience, privacy, and participation. Analysis of system logs and questionnaires answered by the field trial participants produced the following key results: (1) users' perceived participation is biased toward their own active deeds, (2) appropriate timing of requests and personalized meaningful request messages improve user experience, (3) most users do not mind helping strangers by taking pictures or answering requests but many refrain from disclosing their location, and finally, (4) users that indicate privacy concerns and feel reluctant to reply to requests, have the same average response ratio as the rest of the community, although, they initiate less interactions.**

Keywords–sharing; location based services; mobile application.

I. INTRODUCTION

Collaborative systems enlist the cooperation of their users to share knowledge and information. Some well known examples of such systems (or applications) include Wikipedia, Yahoo! Answers, Amazon Mechanical Turk, peer-to-peer file sharing platforms and Facebook. Despite the fact that these platforms have their own unique characteristics, they hold a common goal of utilizing the knowledge of their participants and sharing it among community members.

Such applications were thoroughly studied and classified according to nine major dimensions by Doan et al. [1]. The three most important dimensions are:

The contributions of users can manifest in different ways according to the nature of different collaborative applications. For example, in Wikipedia, a contributing user is one who creates and edits Wikipedia pages. On Facebook, a contributing user is one who shares their own information such as photographs, videos and text (i.e. status).

Effort can be distributed among users and owners of the collaborative systems. A recommender system requires some participation of its users (a rank, an opinion), while most of the effort is imposed on the system owner itself (providing recommendations). Wikipedia users are responsible for writing, reviewing and merging all pages, and no effort is required from the system owners.

Roles refer to the type of contribution and how can it be achieved. A contribution can be a thought or perspective, self-generated content or a part of a collaborative artifact. A single user can play multiple roles in each collaborative system.

There are various reasons for users to cooperate. In some cases, cooperation might be beneficial for a user in the future. For example, a user sharing a file fragment in a peer-to-peer system relies on other users to share files with one another, based on their previous sharing history [2]. This consideration of benefit (also, referred to as *utility*) is the foundation behind incentive mechanisms that consider their users to behave rationally, i.e., motivated by maximizing their benefit [3]–[6]. However, human participants rarely act rationally. One Nobel Prize winning paper [7] introduced a behavior different from the expected (when considering utility) behavior in decision making under risk and uncertainty.

Incentives, social ties, and privacy are only a few of the factors that affect user cooperation in collaborative systems. Privacy is known to be a major concern of users, especially in services that include location tracking [8]. Incentives often have contradictory effects when presented to different types of participants. In some cases, monetary reward were found effective for recommender systems [9] and crowd sourcing websites [10]. In other cases, extrinsic rewards, were shown to decrease motivation when performing tasks based on good will [11]–[13]. Intrinsic rewards, such as social ties, within the cooperation community or environment increased workers' performance [14]–[17]. In general, people with a pro-self value orientation tend to respond better to extrinsic incentives, while people with pro-social value orientation tend to better respond to trust and social ties [18]. In order to devise an appropriate incentive scheme for a collaborative application, one must study the user population and apply incentives that facilitate cooperation and discourage free-riding.

In this paper, we study user collaboration through data collected from a two week field trial of a real time collaborative mobile application called Lookie [19]. Analysis of system logs and questionnaires, answered by the field trial participants, indicates that participants recall their own active deeds within the application and tend to disregard requests that they had no opportunity to answer. We can see that personalized meaningful request messages can be regarded as intrinsic incentives improving the experience of responders, while blank or meaningless requests, as well as inappropriate timing, greatly annoy the users. Finally, the study results indicate that users are more sensitive regarding sharing their location than answering queries received from strangers. However, users that feel reluctant to reply to requests have the same average response ratio as the rest of the community, although they initiate fewer interactions. The last result is consistent with other studies that show that privacy concerns have little influence on activity in social networking services [20].

The remainder of the paper is structures as follows: The Lookie application is described in Section II. Section III includes the field trial settings, description of questionnaires, the collected data, and analysis of the results. Findings are discussed in Section IV as well as conclusions and future work.

II. THE LOOKIE PLATFORM

Lookie [19] is a location based Android application. It enables its users to share images from their location upon demand of other users. The application can be easily downloaded and installed through Google Play. Lookie users can request

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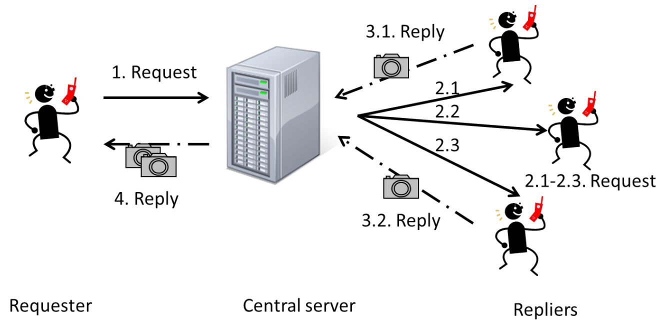

Figure 1. Users' interactions in Lookie

images from other Lookie users. We denote requesting users as *requesters* and responding users as *repliers*, even though each user can play both roles. In this section, we will describe Lookie usage scenarios and the architecture of the application.

A. Interactions

An interaction begins when a requester wishes to see a real time image from a location of interest (e.g., a crowded restaurant). Opening the Lookie application brings the requester to a screen that contains a map showing other online users in their respective (different) locations. For convenience, users that appear on the map are arranged in groups according to their location and zoom level.

Tapping on a group near the location of interest will display a list of users in the group. These users are close enough to the location to serve as potential repliers. The requester can choose one or more user and send a personal text message, ideally mentioning the intention of the desired photo (e.g., "Show me how crowded the restaurant is."). If the request is answered, the user will receive a pop-up message with the photo taken by the replier.

The request that was sent to the potential repliers pops up on each of the replier's phone screens containing the text message. The pop-up contains three options: to accept the message and send an image back to the requester; to decline the request; or to postpone it to another time.

Accepting the request triggers the mobile device's camera. The replier may take a few pictures until she is satisfied with the result. Afterwards, the replier can choose to add personal design details that are supported by the application. She may also add a personal message and set a mood barometer to better represent the atmosphere of the photographed location.

The interactions between application users do not entitle them to any extrinsic reward or compensation. The application is socially oriented in the form of location sharing, community building, and personal touch both in terms of requests and replies. Since requests are sent in real time, and replies are relevant for only a short time period, there is an expectation that users cooperate and serve as repliers in order to ensure that the majority of requests are responded. Without the cooperation of repliers, the Lookie application cannot exist.

B. Architecture

The Lookie application is composed of two main components: the client application installed on the mobile phone of the users and a server mediating all interaction between clients. The client has two main responsibilities: to report and display the geolocation of users and to handle requests and replies.

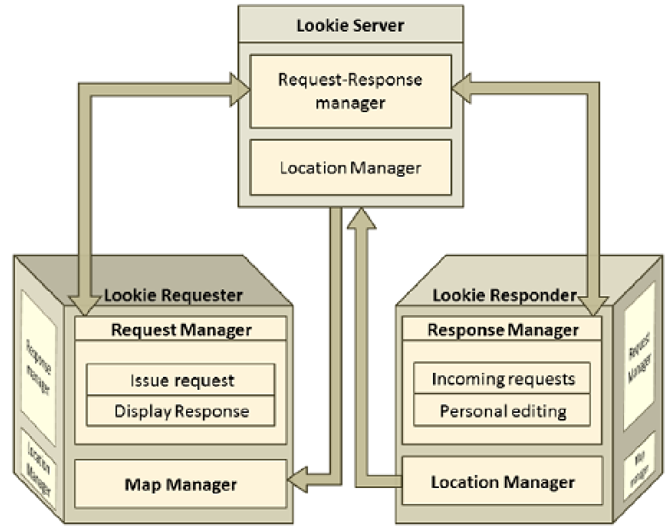

Figure 2. Lookie architectural design

To support the first, the client uses the smartphone's GPS and WiFi connection to determine its location, and sends its own location reports to the server. In parallel, the client is able to poll the server for the updated location of other users in a specific area on the map, which enables the application user to select a potential responder in a location of interest. Second, the client handles incoming and outgoing requests and replies. All outgoing requests and replies generated by the client are forwarded to the server which navigates them to the recipients. Incoming requests and replies generated by other users are transferred from the server.

The server application is the mediator between all Lookie clients. It accepts location reports from clients and updates them on the whereabouts of other users upon demand. In addition, the server manages the navigation of requests and replies between the client applications. This results in all communication being transferred through one main machine which allows us to record all inter-client communication (requests and replies), as well as client-server communication (location updates). The system logs are maintained in a database and are used to analyze users behavior in the performed trials.

A graphic description of these components is available in Figure 2. In addition, Figure 1 illustrates an interaction between a requesting user and potential repliers. The illustration presents a user sending a request (1) to three users in a desired location. The request is forwarded to the central server from which it is distributed to the users (2.1-2.3). Two of the users who received the request take a photo and send it back to the central server (3.1-3.2), which returns the photos to the original requester (4).

III. User Study

A. Lookie Field Trial

The field trial was conducted from March 13, 2011 through March 26, 2011 with 26 participants. The participants were recruited via advertisements around the university campus and on designated student web forums. In parallel, the Lookie application was published on Google Play.

Recruited participants were students at Ben-Gurion University of the Negev, Israel. Field trial held no preconditions for

TABLE I. PARTICIPANTS IN FIELD TRIAL

Demographic	Description
Gender	23 male, 3 female
Age	21 – 29
Occupation	All students, 8 with jobs
Marital status	20 single, 3 married
Total	26 participants

TABLE II. SERVER RECORDED MEASUREMENTS

Name	Description
q_out	total number of queries a user sent.
r_out	total number of replies a user sent.
time_online	total number of location reports a user reported.
q_in	total number of incoming queries a user received.
r_in	total number of incoming replies a user received.
r_out_neg	total number of requests a user did not reply to.
r_out_percent	percentage of replies a user sent.

participation because Android phones were not very popular among students at the time of the trial, and Android users were difficult to find. Table I describes the demographic information of participants. We see an imbalance in gender and in marital status. The limited pool of Android users is reflected in the small number of participants, as well as the lack of participation by females (the lack of female participants is attributed to the lack of females who owned Android smartphones at the time of the trial).

The experiment was scheduled as follows: on December 13, 2011, participants were asked to attend the laboratories, where they received guidance on application installation and basic usage scenarios. At that time, participants completed an initial questionnaire. No requirements were made during the trial regarding the desired number of requests or responses in order to minimize bias in communication resulting from the field trial setup. However, participants were instructed to keep the application online for at least 50% of the field trial period in order to receive the participation fee of 15 EUR. At the end of the trial period, participants were asked to fill out a second questionnaire regarding their experience with the application, and, at that time, they received the payment. Further discussion regarding the questionnaires can be found in Section III-B.

B. Measured Parameters

Because all communication went through a central server, the Lookie server had the ability to save logs accurately representing an anonymized history of past location traces and user interactions, in the form of request-response pairs with time stamps, for analysis purposes. We list the measurements extracted from the server logs and aliases in Table II. All server side measurements are calculated on a per-user basis an are accumulated throughout the field trial period.

Outgoing queries (*q_out*) represents the total number of queries (i.e., requests) a specific user sent during the field trial period. We count a request as a single query sent to the system even if it specifies several potential recipients. We define a request as answered if it received at least one positive reply. Incoming replies (*r_in*) represents the total number of replies a user received to distinct requests, i.e., the number of answered requests. *R_in* accounts only for positive replies and does not account for replies that were declined. *R_in* is always less than or equal to *q_out*.

Incoming queries (*q_in*) represents the total number of queries (i.e., requests) a user received during the field trial. Outgoing replies (*r_out*) represents the total number of replies a user sent an image to. *R_out* does not include declined or ignored requests. Negative outgoing replies (*r_out_neg*) represents the total number of requests a user *did not* positively reply to (i.e., did not send an image). In this measurement we count all declined requests as well as requests the user ignored. The sum of *r_out* and *r_out_neg* is always equal to *q_in*.

R_out_percent represents the percentage of requests a user replied to from the ones she received. We calculate this parameter by dividing the number of replies a user sent by the number of requests she received: $r\_out\_percent = \frac{r\_out}{q\_in}$. *Time_online* represents the total time a user was connected to the Lookie server. We estimate this time using the total number of location reports the client application sent to the server while it was online. Location reports are sent with a constant frequency while the client application is used or runs in background.

1) Questionnaires: During the Lookie field trial participants were requested fill out two questionnaires. The first questionnaire was handed out on the first day of the trial, and the second one was distributed when the trial ended.

The first questionnaire primarily addressed demographic information. This paper does not contain an analysis of the different segments of the population within the field trial but rather presents a general description of the relevant population (see Section III-A). In the first questionnaire the participants were also asked to state their acquaintance with other field trial participants. The specific question is presented in Table III. We will refer to the number of acquaintances a participant had within the test group as *friends*. Lastly, participants were asked to state their preferred hours to receive requests. Users could check one or more of the following blocks of time: 08:00-12:00, 12:00-16:00, 16:00-20:00, 20:00-24:00. The late night and early morning hours (00:00-08:00) were assumed to be a resting period. The specific question is presented in Table III and is referred to as *good_q_time*.

We distinguish between four sets of questions in Table III. First are the number of friends (*friends*) and the desired hours to receive requests (*good_q_time*) which are part of the first questionnaire. The remainder of the questions were part of the second questionnaire which was distributed after the field trial. The second group of questions (*no_res_strangers*, *res_acq*, and *loc_share*) is related to users' privacy concerns. Participants were asked to rank their agreement with the presented statements on a scale from 1 to 5, where 1 corresponds to "strongly agree" and 5 corresponds to "strongly disagree". The third set of questions relates to the user's experience. The participants were asked to rank their agreement with the statements: *filter_req*, *keep_use*, *use_as_requester*, *req_meaningless*, *tnk_snd*, and *tnk_rcv* on the 1–5 scale. The participants were also asked to rank their experience while taking pictures and editing them before sending the responses (fourth group, question *edit_experience*). In this question, a ranking of 1 indicated that a user had a bad experience, and a ranking of 5 indicated a good experience. We omit other questions that are not relevant to current analysis.

Some measurements can be extracted from the system logs (objective source) and from the questioners (subjective user responses). We consider both objective and subjective data in order to distinguish between actual usage and the perception of users about their usage. We extend the discussion about the two in the following sections. The following sections present the field trial analysis and refer to users' activities, characteristics, and experience.

TABLE III. QUESTIONNAIRES

	Label	Question
1	friends	How many of the other participants are you familiar with?
	good_q_time	During which blocks of time would you prefer to receive requests?
2	no_res_strangers	In the future I would not like to reply to people I'm not familiar with.
	res_acq	In the future I would like to send requests only to people I'm familiar with.
	loc_share	I don't mind sharing my location.
3	filter_req	I didn't feel like responding to some requests.
	keep_use	I would like to keep using the application.
	use_as_requester	I would be happy to use the application only to send requests.
	req_meaningless	Most of the requests I received were meaningless.
	tnk_snd	I received many requests.
	tnk_rcv	I sent many requests.
4	edit_experience	How would you rank the editing photo experience?

C. User Participation

As common sense suggests, the number of replies one sends or receives should be strongly correlated to the number of requests she receives or sends respectively. Indeed, we observe a significant correlation between *q_in* and *r_out*, as well as between *q_out* and *r_in*, both at the level of 0.01. No significant correlation was found between *r_out* and *q_out* measurements or between *r_in* and *q_in*.

1) Users' perceptions of their own activities: We asked the participants to estimate the number of requests they sent and the number of requests they received using the *tnk_snd* and the *tnk_rcv* questions. Checking whether the reports of users correspond to the actual application usage produced asymmetric results. We found a significant correlation at the level of 0.01 between the *q_out* and the *tnk_snd* measurements, suggesting that participants have rather similar perspectives on the number of requests they sent. However, we found no significant correlation between *q_in* and *tnk_rcv*.

Surprisingly, a correlation between the *tnk_rcv* and the two measurements *r_out* and *r_out_percent* was found to be significant at the levels of 0.05 and 0.01 respectively. This correlation implies that users do not perceive the actual number of incoming requests as the overall number of requests they received, but rather the overall number of requests they have received and replied to. The more requests the users replied to (out of the requests they received), the more requests they believe to have received.

2) Social ties: Next, we examine the effect of the number of acquaintances a participant had within the test group on the actual usage. We expect that users of pseudonymous applications such as Lookie, would refrain from denying a request that comes from a friend. Therefore, we expect a higher response ratio for users that reported a higher number of acquaintances. In contrast to *r_in* vs. *r_out*, here causality is apparent as prior acquaintances precede the field trial.

The setup of the trial did not allow us to compare the actual response ratio of participants to requests sent by friends and requests sent by strangers. Instead, we compare the responses sent by participants with at least one acquaintance within the test group to responses sent by participants with no reported acquaintances within the test group. We conducted a t-test (independent sample, $\alpha = 0.05$) to determine whether the means of *r_out* significantly differ for two groups of users, one having $friends = 0$ and the other having $friends > 0$. We found significant differences in the means of *r_out*. Users who have at least one acquaintance in the application community, reply more than users who have none.

TABLE IV. FREE RIDERS IN THE LOOKIE FIELD TRIAL

	1	2	3	4	5
use_as_requester	14	6	6	0	0

3) Free riders: Users who do not contribute to the application community, and use its resources are commonly referred to as a *free riders* (as opposed to *good Samaritans* who enjoy mainly serving as contributors). For most applications it is important to quantify the expected (or existing) number of free riders and good Samaritans in order to design appropriate incentives. The Lookie field trial community included six free-riders out of 26 participants (23%) as will be explained shortly.

We employ *use_as_requester*, *r_out*, and *r_out_percent* to quantify the number of free riders and good Samaritans in the trial population. Table IV summarizes the answers participants gave to the *use_as_requester* question. Is it easy to see that non of the participants reported a number higher than 3. Next we will take a closer look at the three groups of replies (participants who answered 1, 2 and 3 to the question). Out of the six participants who answered 3 to that question,five have a reply ratio below 0.15, and on average, the reply ratio is 0.14. If we omit the only participating user (with $r\_out\_percent = 0.7$), the average reply ratio drops to 0.03. Moreover, four of those six participants did not reply to any request they received.

Out of the six participants who answered 2, two did not reply to a single request they received. The mean of *r_out_percent* in this group stands at 0.23 (s.d. 0.18).

It appears as though we found our free riders. However, they do not seem to be aware of it, or more likely did not admit it in the questionnaire. Finally, the last group of users who answered 1, contains no free-riders, and the mean of *r_out_percent* for this group is 0.48 (s.d. 0.19).

We compared the means of *r_out_percent* and *r_out* between the group of users who answered 1 and the groups of users to answered 2 or 3. T-test (independent sample, $\alpha = 0.05$) results show a significant difference between the groups in both measurements. In addition, *use_as_requester* negatively correlates to both r_out and $r\_out\_percent$ with the significance level of 0.05 and 0.01 correspondingly.

T-test (independent sample, $\alpha = 0.05$) results on the means of the *q_out* measurement between the group of free riders (who answered 2 or 3 to *use_as_requester* question) and the group of all other users (who answered 1) show no significant difference between the means of the two groups. This demonstrates that free riders' expected participation patterns of sending requests are no different than the patterns of sending request measured in non-free riders. However, free riders reply significantly less.

D. User Experience

1) Timing of requests: 27% of participants indicated that they didn't feel like answering some questions ($filter\_req \geq 4$). Next we try to find a possible explanation for this negative experience. Accurate understanding of the reasons for a negative experience can help developers of request-response based collaborative applications design systems in a way that will limit negative experience as much as possible. For example, this could be done by implementing a heuristic responder selection mechanism that forwards requests to participants that would not mind or might enjoy answering it.

We found a correlation at the significance level of 0.05

between the *time_online* measurement and the *filter_req* values reported by the participants. This correlation could be attributed to the number of received requests: the more time users spend online, the more requests they receive. Similarly, abundant requests reduce the desire to respond with the required effort and may increase the likelihood of a user receiving an annoying request. We expected that the more requests a user receives, the more requests she would report as unwanted. However, we did not observe a significant correlation between *filter_req* and *q_in*, suggesting that there should be a different explanation to the correlation between the time spent online and the likelihood of receiving an unwanted request.

We hypothesize that the desire to ignore some requests is caused by an inappropriate timing of the requests. Since participants aimed to achieve the 50% online time, this would link the correlation to the *time_online* measurement: Participants turned on the application even if the time was not suitable for replying, thus receiving requests they would rather ignore.

In order to determine what time is considered "inappropriate" we looked into users' reports on desired time for requests, referenced as *good_q_time* in Table III. Once we knew desirable times, we checked the number of requests each user received during a "bad time". We will refer to the total number of requests at an inappropriate time as *bad_q*. The ratio of unwanted requests (*bad_q_ratio*) is defined by $bad\_q\_ratio = \frac{bad\_q}{q\_in}$.

Next we calculated the PCC between *filter_req* and *bad_q* as well as between *filter_req* and *bad_q_ratio*. Both correlations were significant at the level of 0.01. According to these results, the timing of requests is an important user experience factor in applications such as Lookie. We will further discuss the consequences of this observation in Section IV.

2) Responders' user experiences: Keeping the users satisfied with the tasks they are requested to perform is important for the sustainability of collaborative systems. Our results show that unwanted requests reduce the willingness of users to keep using the Lookie application. We found a negative correlation (at the significance level of 0.05) between the *filter_req* and the *keep_use* measurements. However, it appears that unwanted requests do not necessarily translate into reduced response ratio. We found no significant correlation between the *filter_req* measurement and the *r_out_neg* measurement; nor did we find a correlation between *filter_req* and *r_out_percent*.These results suggest that even though a system should refrain from forwarding unwanted requests to potential responders, it may still do, provided there is appropriate compensation (in our case, compensation was likely the field trial payment).

Another interesting result involves the user experience during photo capturing and editing. The personal editing experience was a major user interface design consideration targeted at increasing the fun of replying to requests. We found a negative correlation between the *req_meaningless* and the *edit_experience* measurements at the significance level of 0.01. This implies that users enjoyed the personal editing experience as long as the requests were meaningful. No other correlations were found between those two measurements and other measurements collected. Aside from the well known fact that personalized requests get answered more often, we observe here that they also improve the responder experience.

TABLE V. PARTICIPANTS REPLIES TO PRIVACY RELATED QUESTIONS

	1	2	3	4	5
no_res_strangers	15	3	2	5	1
res_acq	14	5	5	1	1
loc_share	6	5	4	7	4

TABLE VI. PCC BETWEEN PRIVACY MEASUREMENTS

	no_res_stranger	res_acq	loc_share
no_res_strangers	–	.921**	-.471*
res_acq	.921**	–	-.379
loc_share	-.471*	-.379	–

* significance level of 0.05
** significance level of 0.01

E. Privacy Concerns

One of our goals was to understand how privacy concerns affect the participation and user experience within the Lookie application. Table V summarizes the distribution of participants' replies to the privacy related questions (Explained in Section III-B1).

The first two questions relate to communication within the Lookie application. Due to the nature of Lookie, it is important to understand whether users are fond of the idea of sending photos to strangers within the community. The table shows that $\approx 69\%$ of participants in the trial were willing to reply to strangers and not limit their replies only to acquaintances.

The third question relates to user's location sharing. While we have a majority of participants not concerned with replying to strangers, here the population divides to $\approx 42\%$ of users who do not mind sharing their location and $\approx 42\%$ who do. It is therefore important to design location based services in such a way that users could be contacted based on their location, but locations of specific users could not be determined by strangers.

Table VI presents the PCC between privacy measurements. Most correlations were statistically significant. The only exception is the correlation between res_acq and loc_share with a significance of 0.56. This significance of the correlation is almost at the 0.05 level. The cause of this might lay in an unexplored factor that is affected by environmental sources.

Next, we examine the effect of privacy related concerns on participation. We expect users who are more concerned with their privacy to participate less. Three t-tests (independent sample, $\alpha = 0.05$) were conducted to determine whether privacy concerned users issue less requests (*q_out*) on average than users who are not concerned with privacy. The first two groups include participants that responded $1-2$ and $3-5$ to the *loc_share* question. T-test results showed significant difference between the means of the two groups, implying that users who don't mind sharing their location send on average more requests than users who do not like sharing their location.

Similar groups were created according to the *no_res_strangers* and *res_acq* questions. Note the scale of these two questions is opposite to the scale of *loc_share*. Here, users that replied $4-5$ were in one group and users who replied $1-3$ were in the other. Both t-tests showed significant differences between the mean values of *q_out* of the respective groups. Our results support the hypothesis that privacy concerned participants send less requests on average than participants who are less concerned with privacy.

The two measurements, *no_res_strangers* and *res_acq*, negatively correlate with *q_out* at the significance of 0.05 and 0.01 levels respectively. This negative correlation implies, that the more users are concerned with privacy, the fewer requests they send. We believe that these users would abandon the application outside of a field trial. Correspondingly, there is a significant correlation at the 0.05 level between the *loc_share* and the *q_out* measurements. This strengthens our claim that the more privacy preserving a user is, the less requests she will initiate.

Next, we examine the relationship between privacy concerns and replying to requests. We found a significant correlation at the 0.05 level between the *filter_req* measurement and the *no_res_strangers* and *res_acq* measurements. We deduce that the more participants wish to avoid interactions with strangers, the more likely they are to be annoyed by requests. However, previously we noted that higher values of *filter_req* do not necessarily translate into lower *r_out*.

We check the effect of privacy concerns by conducting two t-tests. Again, we divide our population into two groups for every test. The first group consists of users that replied $4-5$ to *no_res_strangers* and the second group consists of users that replied $1-3$. Similarly, two groups were created for the *res_acq* measurement. Two t-tests (independent sample, $\alpha = 0.05$) on the two sets of groups show no significant difference in group means of *r_out* values. We infer that the actual replying pattern of privacy concerned users is not significantly different from the replying pattern of users that are less concerned about their privacy. Though their satisfaction from replying may be lower, their response rates are still high enough on average. For system developers this result would imply that if a low cost incentive exists that may keep these users in the community they can still be a valuable resource.

IV. Discussion and Conclusions

In order to understand the forces driving user participation in collaborative location based applications similar to Lookie, we conducted a two week field trial whose results are presented in this paper. In Section III-C, we presented the analysis of user interactions and perception thereof. Our results confirm that previous acquaintance increases the level of participation in collaborative applications such as Lookie. The implication of these results is twofold. First, in applications such as Lookie, existing social ties should be supported via integration to social networking services. Second, initial deployment of these applications should closely cover socially and geographically contained communities such as schools, colleges, etc.

It is important to determine the intended usage of the application by the members of the target community before deployment, for example, via bus-study questioners. However, asking users about their intended usage may also bring up controversial results as indicated in Section III-C3. None of the free-riders in the Lookie field trial admitted intended usage solely as a requester.

Furthermore, our results indicate that users' perceptions of their interactions de facto within the application is biased as well. Users have rather similar perspectives on the number of requests they sent. However, they perceive the number of incoming requests as a fraction of the requests they actively replied to.

From the perspective of user privacy concerns we see that the vast majority of the field trial participants do not mind responding to requests from strangers. On the one hand, system logs indicate that users who do not like responding to strangers send fewer requests. On the other hand, these users have the same reply ratio as the rest of the community. There are a few possible explanations for this bias. For example, these users could feel obligated to answer an incoming request, similar to other users. Alternatively, their attitude toward requests from strangers may depend on the context. Unkind or even distasteful requests, for example, can easily damage user experience. However, we did not observe a significant difference in the attitude toward Lookie between users with privacy concerns and those without.

While only a small fraction of users feel reluctant to communicate with strangers, a larger number of field trial participants expressed concerns about constant location sharing. A design emphasizing on anonymity could contribute to crowding in those types of users.

In order to mitigate inappropriate timing of requests, we propose an automatic *do not disturb* status should be available for potential responders.

Finally, the results of the field trial indicate that including a meaningful personal message in the request improves the responder user experience. It is easy to understand why helping others, by replying to a request, would be favorable if the requester truly needs help. Therefore, applications such as Lookie should encourage requesters to send more personal requests and avoid using a default request form.

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Enabling Cross-Domain Collaboration in Molecular Dynamics Workflows

Gergely Varga,
Janos Sallai
and Akos Ledeczi

Institute for Software Integrated Systems
Vanderbilt University
Nashville, Tennessee 37212
Email: gergely.varga@vanderbilt.edu

Christopher Iacovella,
Clare McCabe
and Peter T. Cummings

Department of Chemical and Biomolecular Engineering
Vanderbilt University
Nashville, Tennessee 37212
Email: christopher.r.iacovella@vanderbilt.edu

***Abstract*—Molecular dynamics (MD) simulation is used increasingly often for materials design to reduce the costs associated with the pure experimental approach. Complex MD simulations are, however, notoriously hard to set up. It requires expertise in several distinct areas, including the peculiarities of a particular simulator tool, the chemical properties of the family of materials being studied, as well as in general C/C++ or Python programming. In this paper, we describe how MetaMDS, a web-based collaborative environment, allows experts of different domains to work together to create building blocks of MD simulations. These building blocks, capturing domain-specific knowledge at various levels of abstraction, are stored in a repository, and are shared with other users, who can reuse them to build complex simulation workflows. This approach has the potential to boost productivity in chemical and materials science research through separating concerns and promoting reuse in MD workflows.**

Keywords–Simulation; Metaprogramming; Online collaboration; Programming abstractions.

I. INTRODUCTION

Molecular dynamics (MD) simulation has become an important tool in various disciplines, including chemical engineering and materials science, to augment and partially replace the experimentalist approach in materials design. The driving force behind this trend is twofold. First, experiments provide only limited insight to the molecular scale phenomena, and second, the Edisonian approach that relies on experimentation is costly, in particular, when the design space includes a wide range of materials that has to be evaluated. Simulation provides the full spatial and temporal resolution of the system on the molecular scale, providing consider insight into the subtle mechanisms at work, and allows for precise modification of system topology and other parameters, making it possible to use a screening and optimization approach.

Today, several large-scale software packages exist for molecular dynamics simulation. They are conceptually very similar in the sense that they all implement an N-body simulation of a large number of particles and numerically solve Newton's laws of motion, where the forces are computed using functional forms describing the chemical interactions between the particles. These simulators, however, may differ in several aspects:

- the hardware platform they run on may range from desktops to supercomputers and from Central Processing Unit (CPU) to Graphics Processing Unit (GPU) to other specialized hardware;
- their scripting languages may be limited to only rudimentary control structures or could use a powerful language such as Python;
- they may address specific families of chemical compounds (proteins, crystalline structures, etc.) or focus on different chemical properties.

Setting up a molecular dynamics simulation is a notoriously hard task. It needs a user to be familiar with and have expertise in:

- the particular simulator platform, including the syntax of the simulator's scripting language, with the knowledge of how common MD concepts can be carried out using the simulator;
- the specifics of the chemical domain, i.e., how the interactions between the particles need to be parameterized (which may be very different in, e.g., proteins than in ionic liquids);
- the requirements of the particular application domain, e.g., batteries, nanolubrication in hard drives, self-healing paint, etc.;
- and general programming skills to generate input files describing complex systems of particles or to programmatically extract the quantities of interest from the simulation results.

Unfortunately, once a particular simulation workflow has been set up to run on a particular simulator, it is not trivial to retarget it to a different simulator package. There are no common Application Programming Interfaces (APIs), no well-defined abstractions that would allow simulations to be specified in a simulator-agnostic manner. Also, because of the monolithic and ad-hoc nature of the simulation code, code reuse is often merely accidental or nonexistent.

This paper is structured as follows. First, we explain the state of the art of the design-flow of molecular dynamics simulations, highlighting the ad-hoc and often one-shot nature of simulation design. Then, we describe how MetaMDS [1], a web-based metaprogrammable environment, allows for decoupling the roles of simulator experts, (chemical) domain

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experts and end users through abstractions, in a way that they can work in parallel, creating reusable software artifacts and collaborate with each other when building complex molecular dynamics workflows. We present implementation details of the MetaMDS tool and conclude with a case-study demonstrating its use.

II. Approach

Our approach is inspired by Model-Integrated Computing (MIC) [2], a systems engineering methodology that focuses on building domain specific modeling environments, which allow for capturing the concept of the given domain at the level of abstraction that is most appropriate for the problem to be solved, hiding unnecessary level of detail from the end users. MIC focuses on creating Domain Specific Modeling Languages (DSMLs) via metamodeling: describing the DSML's concepts with a generic meta-language (which is, in fact, in itself a DSML). The modeling environment includes model interpreters that analyze the model, check constraints, verify properties, and generate code from the model, automating many of the time consuming, tedious and error prone programming tasks.

Molecular dynamics simulation scripts can be thought of as programs with linear control flow that describe how a simulation is initialized (loading particle coordinates from an input file, enumerating and parameterizing the interactions between the particles, defining a simulation cell, etc.), how the system evolves over time (changes in e.g., temperature, pressure, box size, etc.), as well as when and what quantities are logged or saved to file. We observed that the many of these simulation concepts (e.g., loading the input file, resizing the box, logging the potential energy) are supported in multiple simulators, and while the syntax in which they are defined can be very different, the *parameters* of these concepts (e.g., the *name* of the input file to load, the *dimensions* of the new size, or the *frequency* of the time steps when the potential energy should be logged) are more or less the same.

Therefore, we claim that it is possible to define a simulator-agnostic domain specific language (DSL) that can express these concepts as first class language elements. The end user can describe a simulation in terms of these concepts, instead of writing simulation scripts directly. The simulator scripts can then be automatically generated using a (simulator-specific) interpreter. The interpreter maps the concepts to their equivalent simulator-specific code snippets, and stitches them together to form a script understood by the target simulator.

We further observed recurrent patterns on how the basic concepts are used together, and have identified a number of steps (a series of actions that can be described with basic concepts) that are often present in multiple simulations within the same chemical domain. An example of such step is the initialization of a simulation (reading a data file and setting the parameters of the interactions), equilibrating the system (letting the system evolve at a given temperature for an extended amount of time), and even more complex groupings such as shearing a system to calculate the frictional properties. These simulation steps can be expressed in the domain specific language as a composition of the basic concepts. It is important to note that with our proposed approach no simulator-specific knowledge is required to define the simulation steps, aside from a rudimentary understanding of what needs to be in a simulation. Nevertheless, simulation steps can capture a tremendous amount of domain knowledge about specific compounds in a particular chemical domain. For instance, force-field parameters that define the interactions between the particles can be captured in a simulation step, and reused across several simulations involving compounds within the same family (e.g., dodecane and other length alkanes) or reused when calculate other properties (e.g., coupled to simulation steps that capture either phase coexistence or viscosity). We note that initialization of a chemical system and its interactions can be a difficult, error prone task for complex molecules and thus reuse of validated model parameters via simulation steps should not be an insignificant advancement.

The definition of simulation steps can further increase the level of abstraction at which the end user can define entire simulations. While relying on the simulator-agnostic basic concepts eliminates the need for the end user to have expertise in a particular simulator tool, building simulations from coarser-grained steps allows end users with no detailed knowledge of a specific aspect, e.g., force-field parameterization, to assemble and run simulation workflows. As such, this approach enables and encourages collaboration between those with different areas of expertise.

Naturally, however, several questions may arise regarding a *common* molecular dynamics simulation description language. Who defines this DSL and who creates the interpreters? Which concepts should the DSL contain, and which concepts should be excluded? Is it possible to create a one-size-fits-all set of concepts that meets the needs of *all* possible MD simulations? What parameters should a particular concept have? How does the DSL and the simulator specific interpreters evolve as new simulator tools are developed or existing ones are extended with new features.

Our answer to these questions is metaprogramming. MetaMDS, the platform we have developed, provides a way to define the basic concepts, along with their mappings to simulation-specific code in a simple way. This allows the DSL to be flexible and dynamically updated; either the basic steps, nor the higher level concepts are hard-coded into the MetaMDS tool. Instead, each working group may settle on the set of abstractions that best suit their needs, share them with each other, and use these abstractions as a means of interfacing between team members. That is, the DSL can include multiple methods for defining the same basic operation(s), depending on what is most convenient for the system being studied or for the group using the code. Also, this for composition of concepts into simulation steps allowing for increased flexibility and transparency, where again, groups can assemble basic operations into whatever steps most appropriate for the given system. Again, since the DSL is not hard-coded into the MetaMDS tool, it is trivial to add new routines as they are needed or become available, this makes the tool flexible and able to grow to meet the demands of new users, chemical systems, algorithms, and procedures.

A. *Separation of roles*

We can separate three different types of "actors" in the overall simulation workflow, as shown in Figure 1.

1. *Platform experts* are, as the name suggests, experts in the usage of a simulation platform. They are well versed in the given simulation tool, including the data file format, how a certain task or subtask is implemented, the syntax of the code used to control the simulation, what parameters/routines are needed (and in what order), etc. Examples of such simulation tools include Large-scale Atomic/Molecular Massively Parallel Simulator (LAMMPS [3]), a classical MD simulator that is commonly run on high-performance computing (HPC) clusters, and Highly Optimized Object-oriented Many-particle Dynamics (HOOMD-Blue [4]), a general purpose particle dynamics simulations that takes advantage of NVIDIA GPUs to attain a level of performance on a single workstation.

Of course, the platform expert needs to have a strong knowledge of the basic principles of the field (e.g., chemical engineering), but they need not possess "domain" expertise related to the specific system of interest, as discussed below.

2. *Domain experts* are usually advanced researchers who are experts with regards to parameterizing a particular system and the general methodologies for carrying out the simulations of that system. We refer to *domain* as the solution for a specific problem, e.g., the models and procedures used to simulate grafted nanoparticles or to calculate the phase coexistence of a system. These users may have expertise in a given platform–i.e., how to implement those parameters/procedures in a specific simulation tool–but their domain knowledge should be considered applicable to any tool, as these concepts and parameters are general. In the next section we introduce two domains investigated during development of our tool, in order to facilitate a deeper understanding and better application of the concepts.

3. *Inquiry scientists (endusers)* perform virtual experiments, running simulations to determine the properties and behavior of the system of interest within a given domain. These inquiry scientists tend to be new researchers with limited domain expertise, with most expertise coming from knowledge of related work in the literature. The role of the inquiry scientist is to develop and/or test hypotheses for a system within a given domain, and to gain domain expertise.

Depending on the research, different types of knowledge are required, which is why domain experts are very important. They can design the flow of the simulations, what tasks need to be executed, what model parameters to use, and what properties need to be changed and checked. Platform experts can help implement these procedures correctly in a given simulation platform, noting that different tools may be best suited for different types of research. Finally, inquiry scientists perform the experiments, building upon the models and procedures developed by the domain experts, and codes implemented for a specific simulation tool by the platform experts. While the division between a domain expert and inquiry scientist is often natural due to seniority in a research group, separating-out platform expertise may be less trivial. The roles we have introduced follow the model that has successfully been applied in many experimental laboratories, where centralized microscopy facilities tend to exist, where "platform" experts in those tools (i.e., those that run the microscopy facility) assist domain experts and inquiry scientists in performing their measurements.

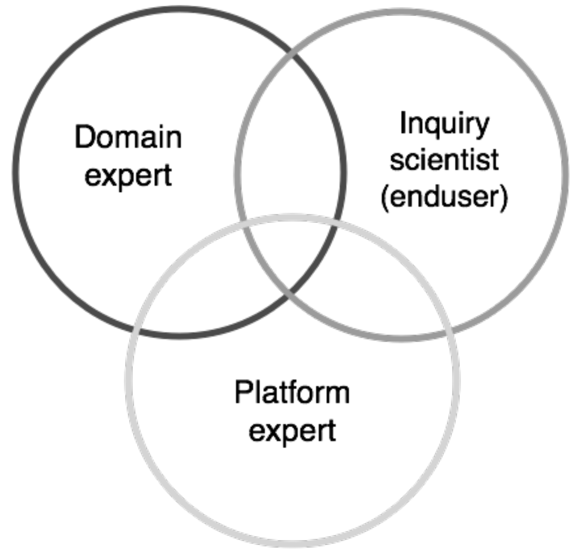

Figure 1. Knowledge domains and their relation. There is a need to know a little bit of everything to accomplish a non-trivial task.

One should note that considerable overlap may exist between these roles. That is, as inquiry scientists become more experienced, they will naturally gain domain expertise and become the domain experts. Also, a domain expert in one area may possess considerable platform expertise and thus can serve as a platform expert for problems outside of his/her domain. Furthermore, to accomplish complex simulations, workflows may need to be developed using multiple experts from different domains or even multiple platform experts if different tools will be used in conjunction. However, by considering the roles and relationships within this context, we can remove the burden that often falls solely on the inquiry scientist, enabling better collaboration and sharing of ideas between experts, which we believe will ultimately augment productivity and quality of the research.

B. Example domains

During the development of the tool, we have examined the protocols and procedures used in the study of two different domains, simulation of the coexistence properties of polymer grafted nanoparticles and the structural and frictional properties of polymer monolayers.

1) Grafted Nanoparticles: Polymers grafted to the surface of nanoparticles, have been used as a means to control the aggregation behavior of nanoparticles, in order to tune the system structure and properties. For example, tuning the graft length can result in transitions from dispersed nanoparticles to string and sheets [5] and properties such as fracture toughness can be increased by many orders of magnitude for polymer grafted nanoparticles as compared to the polymers alone [6]. Understanding how to control the aggregation/dispersion of these systems, via polymer graft length, polymer surface density and nano particle interactions, is of great importance to creating predictive framework for the use of nanoparticles. We have focused on quantifying the aggregation/dispersion behavior of alkane grafted silica nanoparticles, by means of calculating the phase coexistence, as a function of graft properties and relative interactions. In this case, one can consider

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this study to be the intersection of two different domains, grafted nano particle simulation and coexistence calculation, with platform expertise related to the HOOMD-Blue simulator.

2) Monolayers: Self-assembled monolayers have been proposed as a means to lubricate and protect surfaces interacting at the nanoscale, such as those surfaces found nano- and microelectromechanical systems (NEMS and MEMS). Designing lubricants for such systems is not necessarily straightforward, as the behavior may strongly depend on many factors including the chemical composition (and mixtures) of the monolayer molecule(s), length of the molecule, density of the molecules, and surface structure. Several different domains intersect, including domain experts in the ares of (1) monolayer assembly, (2) monolayer simulation under equilibrium conditions, and (3) non-equilibrium simulation (to calculate frictional behavior) with platform expertise related to the LAMMPS simulator.

If we want to accomplish a relatively non-trivial task using the state of the art technologies in MD simulations, there is a need to have knowledge of the three actors: we need the domain knowledge to design the concept of a simulation, we need the knowledge how to implement the steps that we want to run in a specific platform, and last, but not least, we have to create the data file and all the physical/dynamic properties that could be crucial to succeed with our experiments. In our work, we have broken down how a simulation is accomplished from the beginning to the end, creating a universal tool that helps different field-experts collaborate with each other.

Our collaborative tool helps experts to work together and design simulations from ground-up in an interactive way. To use the tool for different simulations from different domains creates the situation for users that the more they use the tool, the less work they need to invest in it. Building a shared library of basic building blocks and using them as basic concepts for different domains becomes trivial in our approach. Of course, in the beginning platform experts need to work very close with domain experts where they are asked to implement those concepts that are needed to be used for the specific simulation. However, using our system's flexible definition engine they can use as many parameters as they want so that certain concepts/blocks can be reused later (e.g., loading a data input file, exporting trajectories of particles, defining interactions between n particles, etc), which will also serve the same goal in a completely different concept (domain). After defining initially the simulation basic operations (which can be also called the shared API), domain experts can start building logically integrated blocks from them (i.e., simulation steps), defining the relevant parameters.

To create a connection between simulation parameters and simulation results, we support *programmable workflows*, meaning domain experts can setup simulations that change their parameters automatically until a certain condition is met, enabling steered simulations and allowing input to optimization schemes – this goes well beyond what is typical in done in state-of-the-art MD-simulations.

Inquiry scientists and platform experts also need to collaborate once a platform is put into use, to ensure proper implementation. As we advance in the development of this tool there are more extra requirements that arise related to an easy-to-use interface, which is able to allow endusers to design complex, yet abstract particle structures and workflows. On the other hand, inquiry scientists can collaborate with domain experts to augment their knowledge and ultimately transition into domain experts themselves.

C. Advantages

The approach we introduced has several advantages compared to today's research habits. First, domain experts do not need to be experts with regards the simulators themselves, in particular, they do not need to know the coding syntax and the low-level tips and tricks of a specific platform; this is increasing important has the number of freely available, full featured simulators continues to grow. Instead, they can focus on their own tasks more directly related to the scientific goals. This is also advantageous, as documentation of freely available, ever developing simulators can often be sparse and difficult to understand for non-experts; this is where the knowledge of platform experts is particularly relevant. Additionally, by working in the MetaMDS framework, domain experts and inquiry scientists can avoid easy-to-make errors, like syntax errors or bad parameter order; this is a very important because researches can wait days or even weeks in queues, waiting for their jobs to execute, wasting considerable research time if a syntax error is made in the final simulation script.

Secondly, we are able to seamlessly keep all the platform-specific code up-to-date while still providing the ability to run using older versions; this allows new versions to be validated to ensure errors were not introduced as a result of the update. Similarly, this allows a standard suite of tests to be performed across multiple different simulators, to ensure consistency in their outputs. Furthermore, different simulators often perform better at certain tasks and worse at others, depending on the numerous factors such as the hardware available, nature of the chemical system, system size, etc. Switching seamlessly between platforms, we can optimize performance and decrease simulation runtime; this enables results to be achieved faster and at reduced cost to the end user (centralized high performance computing resources charge users based on runtime). Our approach focuses on flexibility: extending our system with a new platform is easy and relatively fast (if you have the right platform expert) and can improve the efficiency massively, e.g., by taking advantage of high performance GPUs, and by allowing the examination of systems in new domains (e.g., biophysics simulations).

III. Implementation

MetaMDS is a web application with a complex server-side backend system. We utilized the *JavaScript* scripting language both on client- and server-side. In the browser we built a standalone application using the *backbone.js* framework [7] which is based on the Model-View-Controller (MVC) pattern and is easily extendible and customizable. On the server side we use the *node.js* platform [8] (that is built on Chrome's JavaScript runtime) and *MongoDB*, a document-based, NoSQL database [9] to store our data.

Based on our introduction of our research on how a typical workflow is designed, we created a multi-level data-hierarchy that can provide an easy collaboration between different field-experts. On the top level, endusers interact with

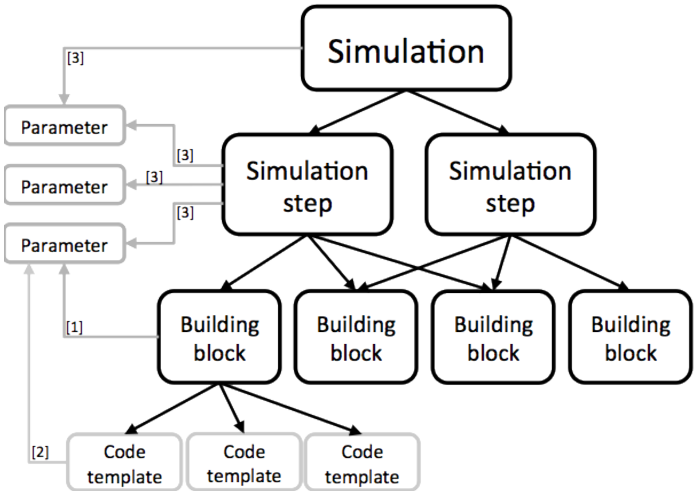

Figure 2. MetaMDS data model. The data structure we use for modeling MD-simulations. Parameter references: (1): Building blocks include parameter definitions; (2): In code templates, code references to parameters; (3): Simulations and simulation steps can set or override parameter values.

a visual programming language that provides them a clean user interface and supports not just importing the pieces of the concepts modeled by the domain experts, but they can build a complete control-flow with branches, conditions (if/else), loops (for/while), return values and of course setting parameter values. While manipulating program elements graphically rather than defining them textually, scientist can design simulations on a high-level, only having to find the suitable parameter-value combinations. Also, they are able to automate simulations (e.g., keep repeating this simulation with increasing a parameter value until a certain condition is met, e.g., *average potential energy* is less than a threshold). Endusers use built-in programming language elements that represent the basic language constructs and additionally use custom elements that were designed by the domain experts. These elements are called in our system *simulation* and *simulation step*.

In Figure 2, we introduce how our data is structured. Simulation steps are well-defined, reusable units that are used to construct simulations. As an example, domain experts can define simulation steps such as *Initialize TNP system*, *Adjust temperature* or *Collect data*. *Simulations* are defined with a limited visual language that doesn't allow control-flow statements, just setting parameter types and values. It is important to note that at this level, domain experts are able to handle the control allowed to the endusers by defining *variable-type* parameters or hardcoding in values. This means that only the data-type of the variable parameter (e.g., integer, double, boolean, string) needs to be defined, where setting the numerical value of the parameters is done one level higher (which can be set as a constant value or variable). With this approach we can provide a very flexible system that allows domain experts and inquiry scientists collaborate in a very unique way, where domain experts provided a specific template to the inquiry scientists.

At the base level of our data hierarchy we use the concept of *basic building blocks*. These blocks are defined by the domain experts on high-level and are implemented by the platform experts. A basic building block contains its basic properties (id, name, description), a list of parameters – where each parameter has its own identifier/name and a thorough description that can be used as a help while assembling higher-level constructs to locate/recognize what is it exactly for – and the actual platform-specific implementations. This implementation contains the actual code in the platform's language using its syntax and parameter notation. These code implementations work as code templates, which are evaluated by the server-side backend system (either before submitting the simulations to the chosen server/cluster, or when users want to download generated code to run on their local systems). After a platform expert has implemented the simulator specific code template to handle the parameters defined by the domain expert, it is used to build up the aforementioned simulation steps. In Figure 2, we highlighted three different types of pointers that point towards the parameters, which need further explanation. *Type 1* pointers mean a definition/containment: we define the descriptors of a parameter in a basic building block, that consists of its name, description, data type, default value, and a simulator identifier. In some cases there are building blocks that express the same concept but, due to simulator implementation differences, have additional parameters that are simulator-specific, thus we need to maintain the last property. *Type 2* pointers show *reference*-type connection: in a code template we need to reference to previously defined parameters (e.g., load $filename$ where $filename$ is a $string$ type parameter). *Type 3* connections are the most advanced references. It expresses that an entity contains a specific parameter with either a value (constant) or indicates that this parameter is a variable. In the variable case we also use the parameter's other properties to perform validations.

In an object-oriented world, we could map the items from our concept to the following entities: basic building blocks as code statements; simulation steps as functions that contain some/several statements; simulations as classes that contain functions and variables defined; our simulation repository as a class library; and the workflows that are built and submitted to simulator servers as programs/applications.

IV. CASE STUDY

In this case study, we demonstrate how MetaMDS and its flexibility can save significant time for researchers. Let's suppose we wish to run simulations with a simple mono atomic fluid. In this case, we wish to determine under what conditions it would be most efficient to run LAMMPS vs. HOOMD-Blue. These two platforms are similar enough to express the same concepts, however their performance vary depending on the hardware and system studied. HOOMD-Blue supports GPU-based calculations, which tend to provide considerable performance over CPUs, while LAMMPS is designed to scale efficiently on large numbers of CPUs. To measure the performance of the different simulators, we use another metric that reflects their efficiency: time-per-step (TPS). We can define this metric as the time needed to perform one timestep during the simulation. The test simulation (*Test mono LJ*) consists of two simulation steps and we had to define 12 distinct building blocks to set up these simulation steps. For a platform expert, implementing these 12 code templates for HOOMD-blue and LAMMPS was accomplished within a few hours (including understanding the concepts we were using here). Only a single simulation needs to be constructed in

TABLE I. TIME-PER-STEP VALUES FOR DIFFERENT SIMULATOR PLATFORMS.

Num. of particles	TPS (ms) LAMMPS	TPS (ms) HOOMD	%
500	0.11736	0.16658	70.45131
1000	0.18470	0.18053	102.30979
5000	0.70105	0.21098	332.27690
10000	1.32672	0.23454	565.66885
50000	6.71378	0.73771	910.08082
100000	14.77878	1.48404	995.84767
500000	108.06365	7.04629	1533.62483

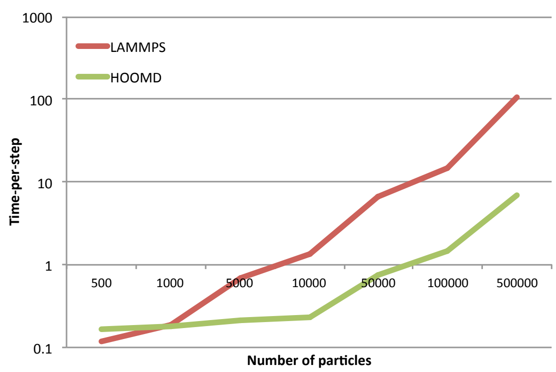

Figure 3. Comparison of the TPS values of different simulators.

MetaMDS, even though we wish to run using two different simulators. Table I reports the TPS calculated as a function of system size, where we note that smaller values of TPS are preferred. Figure 3 shows the graph comparing the two simulator systems tested. There is a clear transition at 1000 particles, for which HOOMD-Blue out performs LAMMPS, where we observe a 3 order of magnitude speed increase by using the GPU-enabled HOOMD-Blue. The first column of Table I indicates the number of the particles in our system, while the second and the third column show the time-per-step values for both simulators we tested (in milliseconds) and the last column shows the performance gain we can have switching from LAMMPS to HOOMD-Blue. While this is a relatively trivial example, the concept is generally applicable to benchmarking more complex systems and algorithms where GPU performance is less significant.

A. Code reusability

Another advantage of the approach used in MetaMDS is code reusability and interchangeability. While the example above focused on a system with only a single particle type, we can reuse the basic simulation workflow for a system composed of two particle types. To accomplish this, we only had to define a new system initialization step that handles two different types of particles. To use this simulation step, we need only to exchange this initialization step in our first simulation instance and then be able to perform simulations using a binary system. The changes are shown on Figure 4. Again, this is a relatively simple example, but the concepts demonstrated are general. For example, a more complex simulation workflow, with many different simulation steps and procedures could be developed and used for one system and then reused for a different system by only changing the step that initializes

Figure 4. Simulation initialization steps for mono- and binary-atomic systems. The rest of our simulation is untouched while we can run different simulations in different domains with very small changes.

the system. This is the general idea that facilitates the collaboration of domain experts; e.g., a domain expert could design the workflow needed to calculate the viscosity of an alkane system, which could then be trivially merged with the system initialized by an expert in grafted nanoparticles to facilitate the calculation of viscosity of grafted nanoparticles. This example also demonstrates the power of being able to present the end user with abstract representations. While the binary system is still simple, two additional interactions were needed to be defined to initialize the system; a simple model of a grafted nano particle [10], would require three more pair interactions, two additional bond parameters, one angle parameter and one dihedral parameter whereas a self-assembled monolayer system requires in excess for 50 additional model parameters. As such, this approach facilitates reusability of not only the general workflow, by e.g., swapping in a different model, but also would enable reuse of models, which is particularly important as system complexity grows.

We performed our tests on a desktop computer with an Intel Core i7 4820K CPU and an NVIDIA GeForce GTX780Ti - 3GB - EVGA Superclocked graphics card.

V. RELATED WORK

Within the MD simulation domain, the objectives of MDAPI [11] are closest to those of our system. MDAPI aims at creating a unified application programming interface that shields the specifics of the particular simulator tools. It is designed for biophysical simulation, where the interface and computational engines are separated, and consequently the API is geared toward the needs of that domain. The most important differences between MDAPI and our work is that a.) MDAPI defines a fixed API, while the set of concepts that serve as the interface between the simulator and the domain expert may evolve over time; and b.) MetaMDS provides two distinct abstraction levels (the basic operations describing the basic concepts, and simulation steps representing high-level operations that capture and hide knowledge specific to the chemical domain), while MDAPI offers only one.

The Atomic Simulation Environment (ASE) [12] is a Python-based tool that can connect to many different simulation codes as *calculators* you plug into the environment. Its primary target is quantum mechanical calculations and thus, it is not directly applicable for most MD simulations. The power of ASE lies in its tool integration capabilities: through the use of the Python programming language it it possible to link different toolkits together, e.g., plotting and visualization libraries, etc.

Etomica [13] is a molecular simulation code written in Java, enabling it to be easily used and distributed via the web. Etomica is similar to our approach in a sense that it defines a molecular simulation API that hides the low-level details of running MD simulations, which allows simulations to be build from predefined pieces. However, it does not offer the flexibility that MetaMDS provides through its metaprogramming functionality. Creating simulations in Etomica requires Java programming expertise: the end users are limited to executing prewritten modules with custom parameter settings.

MetaMDS can be thought of as a science gateway for MD simulators. In this sense, the most closely related tool to our work is the Nanohub [14]. The Nanohub provides a VNC-based interface to a variety of simulation tools hosted as cloud instances. The complexity of the variety of simulators is addressed through simplified user interfaces: the user is only presented with a limited subset of options to help guide the simulations. Most of the modules have a consistent look and feel, so the learning curve is reasonable. Visualization and plotting tools are often built into the GUIs. Jobs are submitted to clusters and the results copied back to the Nanohub space. Unfortunately, Nanohub has its set of limitations. The VNC-based user interface is not very responsive. User-level customization is not supported. The user can only change the parameters that Nanohub includes in its simplified interface. There is no interaction supported between various tools: the output of one simulator cannot be trivially fed to the input of another. Similarly, the primary mode of operation is interactive, since most tools have been developed with education in mind, and thus submitting a large set of jobs is not easily accomplished.

VI. Conclusion

We have demonstrated the design principles associated with our MetaMDS collaborative simulation environment, built upon the ideas of model integrated computing. This tool enables the creation of a flexible "API" for molecular simulation, allow any number of simulation platforms to be run with only a single simulation workflow. Furthermore, our tool provides ways to group common procedures and concepts used within molecular simulations, to enable the reuse and sharing of simulation models and procedures. These common simulation blocks can be pieced together into larger simulation templates to accomplish tasks within a specific domain. This approach enables experts in the simulator platforms to work with experts in a give domain to great simulations for use by inquiry scientists that perform virtual experiments. By their construction, these simulation templates can be used to limit the number of parameters available to end users, to provided an error-free, guided experience. With the flexible simulation parametrization we can also use MetaMDS as tool for teaching both the concepts of simulation and for enabling students to use simulation as a means of understanding molecular level interactions in systems. After setting up several simulations with variable-type parameter values, professors can allow their students or new researchers in their groups to access domain-specific parameter values, enabling efficient simulation of systems within a targeted range of variables. Overall, our tool enables the collaboration between users with different areas and levels of expertise, allows for the seamless integration of different simulator toolkits, and collaboration between end users by creating a platform for the reuse of simulation models and procedures.

Acknowledgments

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Measuring Information Quality in Collaborative Business Intelligence Networks

Jens Kaufmann
Department of Technology and Operations Management
University of Duisburg-Essen
Duisburg, Germany
jens.kaufmann@uni-duisburg-essen.de

***Abstract*—Collaborative business intelligence in the meaning of cross-company data sharing and analysis can be conducted by the use of collaborative business intelligence networks and a peer-to-peer-approach. Despite the pure technological possibility, difficulties exist due to different data schemes and the necessary semantic mappings of them leading to information loss. We propose methods and measures to quantify the information quality of those networks and show first results of a prototypical simulation regarding local and global measures. We further outline research for future work.**

Keywords-Collaborative business intelligence; information quality; quality measures; peer-to-peer networks.

I. INTRODUCTION

Business intelligence (BI) has become a well-accepted and important part of business as of today. The main concept used in its context is the data warehouse (DW) [1]. This is often understood as a central point of structured, well-formatted data that is optimized for multi-dimensional analyses. It can be realized using a single database, but also may be scattered in different systems that all rely on the same scheme [2]. While those solutions are common in companies and their different departments, collaboration mechanisms only have gained attention over the past few years. The understanding of collaborative business intelligence (CBI) is still ambiguous. Some authors propose a definition that combines existing BI systems (i.e., systems for reporting, ad-hoc analysis, data mining, etc.) with collaboration techniques as seen in online social networks (sharing, 'liking', linking, rating, etc.) [3][4]. Others formulate an approach that involves different companies that share data for analyses or even work together on the analyses themselves [5][6].

We understand CBI in the latter way and take a look at the networks used for data sharing and combining. With the assumption that there does not exist a single scheme that is used by all companies involved, rules for matching the data of one company to at least one of the other companies have to be defined. A 'match' in this context is a successful mapping of information about an object in on company's view to a corresponding object in another company's view. It is very likely that in a situation like this no perfect match can be achieved, meaning some data can either not be transferred or received in the way it is supposed to or cannot be matched to the other companies' schemes at all [7]. While different approaches have been discussed to overcome the difficulty of creating matching tables for bigger data structures, the aspect of measuring how effective or well data can be shared, has not been a major topic of research so far in the field of BI.

In [8], the authors propose a peer-to-peer (P2P) network approach to build CBI networks among different companies. An example of practical use is given by a net of universities, exchanging information about research funding. The authors argue that P2P networks provide a maximum of autonomy for every participating partner and that matching tables between partners do not have to be built for every possible connection. Furthermore, the lack of a central scheme reduces dependencies of unanimous verdicts on how to share and organize data. They do not describe how those P2P networks should be organized and do not take into account the different strategies companies could pursue to minimize personal effort regardless of the overall quality of information in the network. To develop global strategies or basic principles that describe, how companies could (or should) choose their matching partners to maximize their and the overall information quality, means must exist to quantify information quality first. Two main problems are therefore identified and dealt with in this paper:

(1) How can information quality in P2P CBI networks be measured?

(2) How do different P2P CBI network structures affect the information quality, regarding the measures mentioned?

Section II will give a brief description of the state of the art in CBI nets. Considerations of quality measurements in CBI nets are discussed in section III, while section IV deals with the possibilities of influencing quality during the CBI net generation. We give a brief overview of first results with a prototypical simulation of P2P CBI nets and close with our plans for future research in Section V.

II. STATE OF THE ART AND PROBLEMS IN CBI NETWORKS

A comprehensive classification and state-of-the-art analysis on CBI has been given in [9]. It shows that most of the publications derive their understanding of CBI from a technical perspective and focus on additional collaborative functions or technologies in existing BI systems. Some approaches, however, give different views on inter-company collaboration and explicitly state that CBI is collaboration in the analysis process or parts of it rather than just communication over private analyses. While some publications only describe the idea of collaboration [6][10], others give more detail on possible implementations or architectures [11]. One of the most often cited publications is [8], where a “Business Intelligence Network” is defined and different architectural approaches are discussed, varying from a central data warehouse accessed by all partners to a completely loose-coupled P2P approach. The authors come to the conclusion that a P2P-based network is most effective for the specific use as a cross-company collaboration tool in BI. As BI systems usually keep most sensitive data about business developments, detailed revenues and other competition-relevant facts, most companies would like to share only parts of their data. The reason they do it at all is to (a) gain insight into the market at the cost of revealing a little bit of their own knowledge or (b) create alliances and/or supply chain partnerships where shared knowledge adds value to all companies’ information base. Nevertheless, those business networks may work on a timely limited or project basis like, e.g., the automotive parts industry sometimes does [12]. Therefore, an easy entry into those networks has to be given as well as an opportunity to keep full autonomy of all shared data. In a BI context, data is often organized in a multidimensional cube, spanned by different dimensions that hierarchically structure attributes to describe data. Publications considering CBI networks or cross-company discussions about data of that type often assume that a common scheme (like a common ‘cube’) is created and used. Then, P2P-based networks can function without any translation schemes between the partners.

A more common and realistic version of dimensions in different systems is given with the example in Figure 1. It shows two versions of a geographical hierarchy. In this example, all attributes in the dimensions are organized in three levels, but that organization is company-dependent, so that different companies may use completely different ‘structures of the world’. For a transfer of data from company A to B it can be seen that (a) the information about Americas loses granularity, (b) aggregations for EMEA and Asia&Pacific are not fully comparable, and (c) information about Antarctica cannot be transferred at all. Because this happens in nearly every DW integration project, different (semi-) automatic matching algorithms between dimensions have been proposed to create a global scheme or a translation table for different schemes [13][14][15]. Depending on the differences between the schemes, translations can be found more or less completely and information can be lost, when one partner keeps data at a higher level of aggregation than another partner.

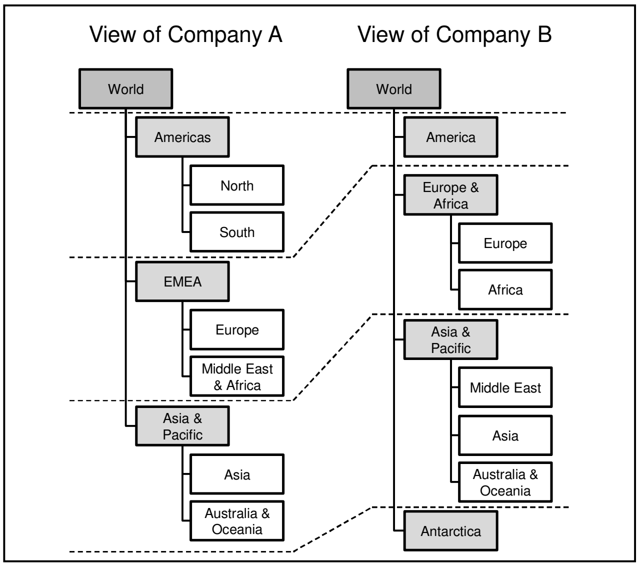

Figure 1. Matching problems between company schemes.

III. POSSIBLE MEASURES FOR CBI NETWORKS

Matching heterogeneous data(base) schemes in general is a well-known problem. Matching algorithms for multi-dimensional data, however, are still under development and improvement; measures have been proposed sparsely as discussed in [15] and [16]. On a dimension level, three properties for a matching were proposed in [7]. The authors use the following terms to describe them: A ‘level’ is meant in a hierarchical way. So the top node of a hierarchy, unifying all underlying elements, is the first level. All of its descendants (or children) form the second level and so on. In the given example, level one is formed by ‘World’ and level two is (for company A) a view of world regions, consisting of ‘Americas’, ‘EMEA’ and ‘Asia & Pacific’. If information of a lower level is aggregated in a higher level, it ‘rolls up’ to the higher level. In the example, the figures of all world regions roll up to ‘World’. The properties for matching now can be described by:

Coherence: If in scheme A level l_1 rolls up to level l_2, then the matching levels to l_1 and l_2 of scheme B must roll up the same way.

Soundness: If there is a matching between levels in A and B, then all elements can be matched.

Consistency: The function defining the roll-up for all members in each level is the same for scheme A as for B.

A *perfect matching* is achieved, if all constraints apply.

In [16], the authors propose the concept of *strictness* to ensure usable mappings for BI systems. Strictness is acquired, if every member rolls up to at most one member of the parent level. This prevents double counting of elements which is crucial for, e.g., summing up revenues. To check for good matches, a *similarity score* based on the Similarity Flooding algorithm [17] was used and complemented by a *match factor* φ that is computed by taking matches of lower levels and elements into account, assuming that a chosen mapping is more likely to be a good match if the lower levels have a high match count, too. Similar ideas can be found when checking for duplicates in XML structures (which can be presented as hierarchical graphs) [18]. All of these approaches target on finding acceptable matches for automatic schema mapping, while only a few consider the measure of the fitting itself a main issue.

For these *local* dimension mappings, i.e. mappings without regarding other existing dimensions and/or partners,

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some of the proposed matching factors or a quantified proportional fulfillment of the desired properties could be used as measures (e.g., 'How many dimensions are sound?' or 'How many percent of elements fulfill the consistency property?'). Taking into account that CBI networks do not work on a one-on-one base only, but do rely on multiple chained scheme translations, *global* measures have to be used to define, whether a CBI net is useful for all (or most of the) participants.

We use the term 'information quality' to describe the possible value of data exchange between partners as data from partners only becomes really useful if it can be matched to the schemes or structures used by a company itself, transferring it from data to information. We acknowledge, however, that the term 'information quality' does not have a single, undisputable definition and refer loosely to the ideas of [19], where information quality is defined by dimensions like ‚accesibility', ‚completeness', and relevancy'. To achieve high rankings on these dimensions, a CBI net must be designed in a useful way which leads back to the question on how to measure the quality of the net.

Figure 2 shows a small net of eight nodes and their connections, i.e., existing translation tables. We assume that a local measure (for simplicity: a function $\alpha_{XY}\rightarrow[0,1]$ with X,Y $\in$ CBI net nodes) has already been defined. α_{XY} is a [0,1]-normalized quality measure, with α near to 1 if X can transfer data to Y with only a little information loss. Due to the use of aggregation functions it can easily be seen that most often $\alpha_{XY} \neq \alpha_{YX}$. α-values are provided for four exemplary nodes and their connections. When considering good routings for data, α-values are complex to handle. Unlike in, e.g., internet traffic routing, α-values cannot be simply multiplied or used to identify a bottleneck as it is not clear, which parts of information get lost at each node.

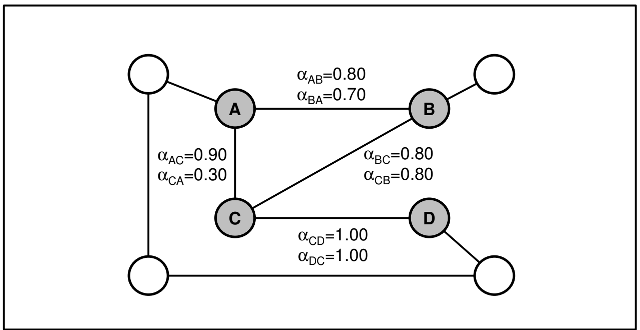

Figure 2. Exemplary CBI net with α-values.

Therefore it is not easily computable, if DCBA would be a 'better' way to send BI data from D to A than DCA (naively assuming that the low α_{CA} is a major problem of the net). To the best of our knowledge, neither detailed local measures for multidimensional data nor global measures for CBI networks have been developed – always considering a high information quality for multidimensional, hierarchical data. We are currently working on measures to overcome the presented issues and bring the following hypotheses up for discussion: (a) valued properties are the amount of directly assignable members and the degree of granularity kept up (because elements carry information and the more detailed they are, the more detailed the information can be presented), and (b) a global measure is crucial to determine a good structure of the whole net and to detect a reasonable relation between 'effort for creating mappings' and 'information quality for all partners' (because local measures only optimize direct connections instead of an information flow via different peers).

IV. Influencing Information Quality in CBI Networks

To effectively influence quality, measures have to be identified. Otherwise, the effect of any means cannot be determined. Also, it can easily be seen that the simplest methods to ensure high quality may be impracticable: For example, if every partner defined a translation to every other, the effort needed to keep those translations running would outweigh the use of the net considerably. Another 'easy' solution is a 'star scheme' of the net, i.e., defining the partner with the most detailed scheme as the center of the net and (only) translating to this scheme. For one thing this would contradict to the autonomy aspect; for another thing it would crucially reduce the robustness of the net. If the center node fails or simply leaves the net, the net is not able to deliver any information. Building a useful net therefore has to take all aspects into account, i.e., quality of and effort for translations, robustness, and autonomy.

To get a first impression on how choosing neighbors in a net influences the overall quality, we created a simplified simulation of the evolution of a CBI network. The settings are as follows: The number of nodes n is set to 10, 20, and 30. The number of new connections each new node makes is varying from 1 to 4, but the same for every node. There exists a value $\beta_{XY}\in[0,1]$ defining the 'completeness' of a mapping, a value $\gamma_{XY}\in[0,1]$, defining the granularity kept (β, $\gamma \in [0.4,1]$), and the assumption that $\alpha=(\beta+\gamma)/2$ is somewhat simple, but sufficient for a first simulation of the whole net. In further work we plan to create comprehensive 'master' dimensions in all nodes and a full simulation of the effect of reduced dimensions with automatic mapping. For simplicity, this time we assume that on a path through the net, γ can be treated as a 'bottleneck'-variable (meaning the lowest γ-value counts for the path, as the loss of levels cannot be repaired) and β only takes a 50%-effect at a query on each node it passes through the net. (An example: If $\beta_{AB} = 0.8$ and $\beta_{BC} = 0.4$, then the calculated $\beta'_{AC} = 0.8*(0.4+(0.6)/2) = 0.8*0.7 = 0.56$, as the 0.6 information loss between B and C only affects 50% of the relevant query data.) Of course, assumptions and values are disputable and more thorough studies will be conducted. Finally, $\delta_{AB} = \max(\alpha_{AB1, \dots,} \alpha_{ABm})$ with 1..m describing all possible connections between A and B and the overall quality is $\Delta = \sum\delta/(n*(n-1))$. With this setting, we evaluated three scenarios for a linear build-up of the net. First, random translations were built, i.e. random β- and γ-values were created. Second, every new node connected to the most connected nodes in the net (on parity to the ones with the lowest index), creating a star scheme. Third, every new node A connected to the best fitting other node(s) B_1, B_2, … regarding α_{BA} (i.e., data reception is valued higher than data delivery). Our findings are presented in Table 1.

TABLE I. RESULTS OF A PROTOTYPICAL SIMULATION FOR CBI NETS (Δ-VALUES FOR DIFFERENT PARAMTER COMBINATIONS)

n	Sce-nario	Number of connections			
		1	*2*	*3*	*4*
10	**1**	0.5423	0.6823	0.7471	0.7794
	2	0.5999	0.7481	0.7552	0.7667
	3	0.5569	0.7292	0.7839	0.8020
20	**1**	0.4969	0.6502	0.7185	0.7506
	2	0.6072	0.7407	0.7510	0.7739
	3	0.5195	0.7262	0.7861	0.8235
30	**1**	0.4678	0.6346	0.7044	0.7386
	2	0.5987	0.7244	0.7318	0.7541
	3	0.4947	0.7205	0.7820	0.8101

They show that higher connection counts lead to better results, which naively seems to be natural. The changes from bad to good quality are quite similar for every net size. When the number of connections exceeds two, scenario three (best-fitting nodes) leads to better results than a random or ‘star’ approach. Considering that not the overall Δ was optimized, but a greedy approach was taken, this is not obvious and provides an interesting basis for further research.

V. CONCLUSION AND FUTURE WORK

We showed that P2P-based CBI networks can provide useful information for autonomous companies in supply chains or strategic alliances. Measuring the quality of translations between partners and defining the overall quality of the CBI net is most important to ensure a reasonable structure of the net. Only a few measures for dimension mappings exist and those cannot be directly transferred to CBI nets. Concerning our research topic (1), we therefore evaluated basic principles for more sophisticated measures. In respect to (2) we showed with a simple prototype that, when entering a net, building ‘easy’ translations does not always lead to an efficient CBI net from a global perspective. Further research will be directed to a comprehensive definition of information quality measurement in CBI nets and recommendations on how to choose directly connected partners wisely.

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Visualizing A Dynamic Web-Based Collaborative Idea Selection Algorithm for Increasing Acceptance in Innovation Processes

Graham Horton
Computer Science Department
University of Magdeburg
Magdeburg, Germany
graham@ovgu.de

David Bobles, Jana Goers
Idea Development and Application Lab
Zephram GbR
Magdeburg, Germany
david@zephram.de, jana@zephram.de

***Abstract* – In order to maintain competitiveness, companies must constantly find new and better business ideas. They use innovation processes for managing idea generation and implementation. This process involves the employees that will be responsible for the implementation of these ideas, and the success of an innovation venture depends on their motivation. Especially during the first idea phase there is a high risk of making an evaluation error, which may reduce acceptance of the result and consequently also motivation. The authors have previously developed the so-called threshold group idea selection algorithm, which although fast suffers from a less-than optimal acceptance by the group. In this paper, we assume that acceptance depends on the understanding of how a selection is achieved by the group. We therefore created a dynamic, web-based interaction design for the algorithm that visualizes the effects of decisions made during the collaborative selection process. We applied basic visualization principles and chose appropriate input devices for different types of collaboration phases. Our findings indicate that the acceptance level of the improved threshold algorithm achieved nearly the same acceptance as the commonly used, but significantly more expensive group discussion method.**

Keywords-Innovation; Dynamic Interaction Design; Idea Selection; Acceptance; Group Evaluation; Collaboration.

I. INTRODUCTION

This Section motivates the research work. An important application, a motivation and the requirements for a solution will be given.

A. Background

Business innovations are crucial for companies to survive. They provide companies with a competitive advantage by reinventing their processes, products, services or business models. Increasing market dynamics creates the need especially for faster innovation creation [25].

Companies waste a lot of money in the development of unsuccessful ideas. An IBM study [7] discovered that less than 1% of the company's ideas are economically successful, while 99% of their innovation efforts are lost in the selection and development process of the ideas.

In order to manage ideas, companies use innovation processes. An innovation process is divided into the Front End and the Back End [22]. The Front End defines the development of an idea from its generation up to a business concept ready for implementation, whereas the Back End develops and brings ideas to market that are ready for implementation. The Front End tends to be unstructured and uncontrolled in contrast to the Back End. This makes it difficult for a company to ensure their innovation successes. These processes are designed and managed by an innovation manager. An innovation manager usually has to manage hundreds of ideas, concepts and projects.

A Stage-Gate process [9] is one common model for an innovation process (see Figure 1.). It divides the process into stages and gates. In the stages, innovation projects are developed. Gates are decision points for whether a project should proceed to the next development stage. The Stage-Gate process was originally proposed for the Back End, but it can also be applied to the Front End. The Front End starts directly after the idea generation and ends with the investment or development decision by management. After that, the development of the projects starts in the Back End.

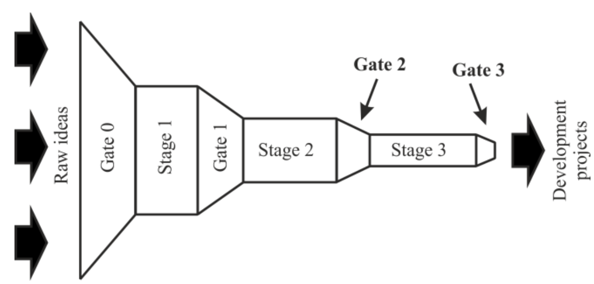

Figure 1. Front End of Innovation Process

For the Back End of the process there are many tools to support the successful development of ideas. The two major differences between the Front End and the Back End are the number and the quality of ideas. The Back Ends needs to deal with few but well defined ideas whereas the Front End needs to deal with hundreds of ideas that are ill defined. Especially gate 0 lacks methods that support innovation managers accordingly to this situation. Decision Maker (DM) need to choose here among hundreds of ideas that are uncertain and ambiguous. They lack time for discussing their opinions in detail [3]. If five engineers had to discuss 100 ideas and each discussion only lasted five minutes, this would cost about 42 man hours, which is too expensive.

The next problem associated with gate 0 is the involvement of the DM. In order to increase the chances of developing successful innovation, the innovation manager needs a motivated team [17] that will engage in a challenging development phase after they have made their decision. If – in their individual opinions – promising ideas were declined or bad ideas were selected, the DM will lose motivation. This may significantly decrease the probability of a successful implementation.

B. Motivation

A group selection method for gate 0 would provide a selection result which is both fast and also achieves a high level of acceptance. Two common selection methods lack either speed or acceptance of selection results:

- **Individual selection.** Each DM is assigned a subset of the ideas and independently selects or rejects them. The overall selection result is then simply the union of the results of each individual DM. This method is very quick and easy to understand, but severely lacks group acceptance [14]. This lack of group acceptance is assumed to be due to the lack of transparency in how the group achieves their overall selection: each group member only evaluates their own subset of ideas and is asked to accept the evaluation of the other group members without seeing or discussing important questions. A discussion is often used for clarifying the selection goal and how they should apply to the selection alternatives.
- **Group discussion.** Each idea is discussed face-to-face. The group then votes to select or reject each idea. With this approach, every DM sees every idea and gets the chance to discuss them with the other DM. This process is fully transparent. DM can follow every discussion and are able to observe how the group reaches their overall selection result. This method delivers selection results with a high level of acceptance, but is very slow and exhausting for the group [14].

Goers et al. [14] proposed a collaborative, computer supported threshold algorithm for combining the advantages of the speed of the individual selection method and the high acceptance rate of selection results of the group discussion. The threshold algorithm achieves a selection in three phases. In the first phase, the ideas are divided into subsets and each subset is assigned to a different DM. These then carry out a local selection and identify the idea, which represents the threshold between acceptance and rejection of ideas within their subsets. In the second phase, DM discuss their threshold ideas, make the selection and identify the global threshold idea. In the third phase, each DM compares their decisions for their own subset from phase one to the newly discussed global threshold idea from phase two, and completes the selection. This threshold algorithm is a trade-off between the pure fast individual selection that lacks acceptance in selection results and the expensive group discussion that generates a high acceptance in selection results. The algorithm combines the advantages of both methods while expending a minimal amount of effort to avoid their respective disadvantages.

The threshold algorithm performs twice as fast as the group discussion and generates less cognitive load. However, it produces only a moderate level of acceptance for the selection results. So, although the threshold algorithm appears to be more appropriate for the selection of ideas in gate 0 than the usually used methods, there is still room for improvement, and our research aims at increasing its acceptance without compromising its speed advantage.

The lack of group acceptance may have many influencing factors such as group behavior or psychological factors. An example could be the trust each DM has in the ability to evaluate alternatives. No process would be able to create a high level of group acceptance if the DM did not trust each other's abilities to evaluate alternatives.

This work examines the influence of process understanding for group acceptance. We assume that low acceptance arises from a lack of process understanding. The DMs cannot trace how their individual decisions or group discussion input might have an impact on the overall selection result. The reason lies in the execution of the algorithm:

- **Number of individually considered ideas.** The threshold algorithm parallelises the selection task in order to obtain speed, thus every DM only evaluates a small subset of the ideas. For all other ideas, the DMs are forced to trust in the selection abilities of the other DMs.
- **Decision consequences on overall selection.** DMs make their judgments individually and as a group. Each decision effects the overall selection. But the DMs cannot track and therefore cannot reconstruct how the overall selection result is produced due to the invisible calculations of the algorithm.

It is thus the limited control over the ideas, the limited visibility of ideas and the non-traceability of the selection process that may cause misgivings and therefore result in the lack of acceptance of the overall selection result.

In 1980, Davis developed a technology acceptance model [11]. It states that a user accepts a technology if two attributes are fulfilled: usefulness and ease of use. A user would accept a technology if he perceives the technology is useful. This includes the perceived quality of result and process understanding. If from the user's point of view, the technology is easy to use, the user is more likely to accept it. That requires the low complexity of the technology as well as the usability. The original implementation of the threshold algorithm did not allow the DM to trace individual decisions and see for themselves how the overall result is achieved. The algorithm gathers their evaluations but did not show them the invisible calculations of the selection. The acceptance of selection results suffers when the calculations are invisible, even if the calculation is simple.

Also, Briggs [6] suggests visualising collaboration processes in order to motivate groups, improve a group's performance and to improve the exchange of information. In the threshold algorithm, DM will see their own subset and their decisions as well as the group ideas and decisions, but have no visualization about the subsets of other decisions makers. This might have led to a lack of acceptance in the selection results for the threshold algorithm.

Human Computer Interaction (HCI) approaches could improve the group acceptance of the selection result. This is a

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discipline that closes the gap between the much higher abilities of computers and the abilities of humans. The threshold algorithm drives the selection process and calculates the overall selection result. It is neither a very complex nor a difficult method, but the distributed and invisible selection task makes it difficult to follow the selection process. HCI is a chance to support the threshold algorithm so that the DMs only need to provide their individual expertise to the evaluation of ideas. The computer then takes care of calculations and transparency issues and saves time of the DMs.

C. Requirements

An improved threshold selection algorithm therefore needs to fulfill the following requirements:

Requirement 1: **Acceptance.** The selection at gate 0 will decide which ideas are worth investing more effort in. The DM will not only be responsible for making a decision but also for developing and even implementing the ideas. A subjectively unacceptable decision in gate 0 will decrease their motivation. However, each DM evaluates only a subset of the ideas and is expected to accept the selection results for the majority of the ideas, which he/she is not even shown. Nevertheless, the process needs to make sure that the group will come to an accepted selection result in order to ensure the motivation for the idea implementation. This acceptance needs to be comparable to the group discussion method.

Requirement 2: **Process understanding.** The original threshold algorithm only allows to trace partial selection as their own decisions and the group decisions. Decisions made by other DM and their influence on the overall selection result are neither traceable nor explained. Even though the selection calculation is simple, the DM cannot follow the effect of their own decision on the overall group selection result and the decisions of other group members contribute to the overall selection result. We assume that a higher process understanding will lead to a higher acceptance of the selection result. The DM need to be able to comprehend how the threshold algorithm comes to an overall selection.

Requirement 3: **Traceability.** The original threshold algorithm does not allow DM to trace the effects of individual and group decisions on the overall selection. But to ensure that the DM understand the selection calculations of the threshold algorithm, they need to trace how their individual decisions or decisions by other DM will influence the overall selection result.

Requirement 4: **Speed.** The threshold algorithm should be able to evaluate hundreds of ideas fast in gate 0 in order to save time of the most valuable resource of a company. So it should keep the speed advantage over the group discussion.

D. Assumptions and hypothesis

We investigated two variants of the threshold algorithm. Both of them are collaborative and web-based computer supported systems. The first variant of the algorithm uses visualization support whereas the second variant works with no visualization support.

The visualization of the threshold algorithm is based on the following assumptions:

Assumption 1: The visualization of the selection process of the threshold algorithm increases the understanding of it.

Assumption 2: A higher level of understanding of the achieved selection results is more likely to make them accepted by the group.

Assumption 3: The visualization support of the threshold algorithm does not take longer than the threshold algorithm without the visualization.

Hypothesis. The threshold algorithm with a visualization of the selection process yields a comparable acceptance to the group discussion. The acceptance level of the threshold algorithm without visualization support is lower.

E. Structure of this study

Our work will be presented in four Sections. The next Section will give an overview of the related work. It will describe our group decision making problem as well as potential solutions in human computer interaction. Little previous work could be found for applying HCI approaches for our specific group decision making problem.

Section III describes the group decision making algorithm and the application of interaction as well as visualization approaches in order to increase the level of group acceptance. Five visualization approaches will be adapted to the specific needs of the selection algorithm as well as appropriate interaction types for different collaboration phases during the algorithm will be developed.

In order to investigate the hypothesis that the new visualization and interaction of the selection algorithm actually increases the group acceptance, Section IV presents the experimental design, findings and their interpretations.

Our conclusions are made in Section V. Here we hope to give some general indicators for which kind of group decision algorithms the applied visualization approaches could increase the level of group acceptance.

II. RELATED WORK

The algorithm delivers a collaborative decision making solution whose performance will be increased by using principles from Human Computer Interaction, Collaboration Interaction and Visualization. This Section describes the link between these disciplines.

A. Characterisation within decision making

The threshold algorithm can be classified in four dimensions of decision analysis methods (TABLE I.) [28]. The first dimension describes the number of DMs that are involved in the decision method. There are decision analysis methods that work for multiple DM. Every DM needs to evaluate at least every idea and provide the method with their judgment. After that the decision method calculates an aggregated result.

The second dimension describes the number of criteria the method is able to work on. The threshold algorithm is a single-criterion method.

The measurement of scale describes the type of judgments the DM uses to evaluate alternatives. The threshold algorithm uses nominal judgments. For a selection of ideas a nominal judgment is sufficient. The nominal judgments are: select or reject idea.

The last dimension describes the decision making result. Either the DM generate a choice, or they are sorting the alternatives according to some qualitative criterion or they are generating a ranking. The threshold algorithm generates a selection, so it generates a choice.

TABLE I. TAXONOMY OF DECISION ANALYSIS METHODS

#DM	Single		**Multi**	
#Criteria	**Single**		Multi	
MoS	**Nominal**	Ordinal	Interval	Ratio
Res.	**Choice**	Sorting		Ranking

B. Characterisation within HCI

In order to make the calculations the threshold algorithm needs individual and group judgments. The requested information cause interaction:

- **Computer-Human interaction**: The algorithm requests individual decisions.
- **Computer-Group interaction:** The algorithm requests group decisions.
- **Facilitator-group interaction:** The selection method is conducted by a facilitator.

Furthermore, the proposed approach will encourage interactions that support process understanding and increase the group acceptance of the selection:

- **Face-to-face Human-Human interaction:** Group decisions need a group discussion about interpretations of the criterion and a consensus where the threshold that distinguishes ideas that are worth putting more effort in and ideas that are dispensable.
- **Human-Computer interaction:** Visualising the individual decision effects on the overall selection result.
- **Group-Computer interaction:** Visualising the group decision effects on the overall selection result as well as the limitations that result from the threshold algorithm rules for the DMs.
- **Facilitator-Computer interaction:** The facilitator conducts the threshold algorithm, supervises the progress and supports the face-to-face group discussion.

Our approach combines a web-based software architecture, dialogue architecture and interface visualizations for the interactions with individuals and a group in order to conduct the threshold algorithm.

C. Approaches for collaboration interaction

Baltes' et al. [2] meta-analysis on computer-mediated communication and group decision making suggests that face-to-face decision making outperforms computer-mediated methods in three key factors (effectiveness, DM satisfaction and time). This analysis investigated only methods that use exclusively face-to-face or exclusively computer-mediated communication (e.g. video conferencing, chat, e-mail). However, our threshold algorithm combines both communication media. Individual phases use computer-mediated interaction and group discussion uses face-to-face communication.

Other findings [24] suggest that especially in situations where a group needs to make a decision under risk, a computer-mediated group discussion performs less well than a face-to-face version. The computer-mediated discussion contained less argumentation than the face-to-face discussion. This emphasises to conduct the group discussion of the threshold algorithm in face-to-face form.

Our approach concentrates on designing a collaboration interaction that involves different individual phases, a group discussion and the collaboration interaction during the whole decision process.

D. Approaches for visualization

Visualization is able to increase the process understanding because it supports the ability to process information quickly, and thus reduces search efforts for information during the process, makes patterns and trends visible and channels the attention of participants.

Gutwin et al. [16] investigated the difference between the visualization of computer systems for single users and for multiple users. The findings suggest that in collaboration systems the effects of the actions of a user needs to be visualized. Applying these findings to the threshold algorithm means to visualize dynamically which actions lead to the current selection state.

Cooper et al. [10] claims that pairwise comparison methods are seldom used in practice because DMs are skeptical about the intransparent calculation of evaluation results. Another finding by Condon et al. [8] supports this claim. Condon's research investigated using visualization for avoiding negative decision behaviour (trying to cheat the algorithm) in the pairwise comparison method AHP. His findings show that a visualized feedback of the effect of the input of DM support the process understanding and by that hopefully the acceptance of evaluation results.

Alonso et al. [1] visualizes consensus by presenting the group a real-time consensus value in order to allow them to follow their level of consensus and build a higher level of consensus. However, the visualization consist exclusively of the presentation of a number and is not focused on creating a higher level of understanding of a decision process.

The aspects of visualization of complex process were investigated by Bobrik [4]. The suggestion is to provide the user with a familiar and recognizable environment, and visualize effects of individual actions on a process-wide level. Different types of HCI during the threshold algorithm could benefit from this. Individual phases could be performed at individual computers (laptop, tablet) while group phases could be performed at a table (multi-touch-monitor, multi-touch-table).

In order to enable quick access to relevant data from a complex, often multidimensional data set, preattentive visualizations [18] are used. Applications are critical systems where a visualization might help to anticipate actions needed before the system gets actually in a critical state. An anticipated selection result would support a DM in coming to a decision due to the visibility of the decision effect.

Gonzalez et al. found that dynamic visualization has a significant impact on decision quality [15]. Especially the use of animated visualization of process steps improved the decision quality.

Brath outlines basic visualization parameters [5] for reducing distractions and channeling attention: length, width, light intensity, texture, colour, conditions, affinity, nearness, connectivity, continuity, symmetry, and many more. These visualization parameters could structure the information and dialogue during the threshold algorithm.

Furthermore Preim et al. [27] describes a visualizing effect for directing the attention of users called preattentive perception. Users tend to focus their attention more to a different element in an otherwise homogeneous group of elements. This effect can be activated when using strong saturated colours, different forms or different frames. This visualizing effect can be used for directing the attention of users. This could be used to create a higher level of understanding of a process.

In decision making methods, visualization is often used for information pooling or information structuring of the alternatives [20] [23]. It supports the overview. But alone it is not sufficient for increasing the process understanding of the threshold algorithm.

Visualizations have been used in education for sorting algorithms [29]. Partially the basic visualization parameters were adapted to the visualization of sorting algorithms. An effective visualization of these algorithms then is able to obtain the same level of understanding as a detailed lecture but in less time. Our approach is also an algorithm. By applying these principles, we hope to achieve a similar improvement in process understanding.

In summary, visualization can support understanding of processes or algorithms and the effects of individual actions on a system. By applying these principles to the threshold algorithm, we hope to increase the group acceptance of the selection.

III. DYNAMIC COLLABORATION INTERACTION

This Section describes the dynamic collaboration algorithm and the application of the performance-increasing collaboration and visualization approaches.

A. *The threshold algorithm*

In this Section, the threshold algorithm introduced in [14] will be described. The threshold algorithm processes $\boldsymbol{M}$ ideas with $\boldsymbol{d}$ DMs. The result is a set of selected $\boldsymbol{S}$ and a set of rejected $\boldsymbol{R}$ ideas. In order to achieve this, the threshold algorithm works in three phases.

Phase 1: Individual selection.

- Input is a set of $\boldsymbol{M}$ ideas.
- The set is split into subsets of size five. Each subset is assigned to a DM.
- Each DM selects which ideas are worth putting more effort in and which are not. Ideas are marked as selected $\boldsymbol{S} = \{\boldsymbol{S}_1, \boldsymbol{S}_2, \ldots, \boldsymbol{S}_d\}$ and rejected $\boldsymbol{R} = \{\boldsymbol{R}_1, \boldsymbol{R}_2, \ldots, \boldsymbol{R}_d\}$ where indices refer to the subsets created by each DM.
- Each DM chooses from his or her own selected ideas the idea which is just good enough to put more effort into $\boldsymbol{T} = \{\boldsymbol{t}_1, \boldsymbol{t}_2, \ldots, \boldsymbol{t}_d\}$. This type of idea is called the personal threshold idea.
- <u>Visualization tasks:</u> Initially, each DM only sees five ideas. DMs must be made aware what the others are doing and understand the implications of choosing a personal threshold idea.

Phase 2: Group selection.

- Inputs are the personal threshold ideas from Phase 1 $\boldsymbol{T} = \{\boldsymbol{t}_1, \boldsymbol{t}_2, \ldots, \boldsymbol{t}_i\}$.
- The group comes together in a face-to-face discussion.
- This discussion is important to reach an overall consensus about the threshold that distinguishes the ideas that are worth to put more effort in and those not. Inevitably, this discussion draws out individual interpretations of the criterion. The group then agrees on their interpretation of the criterion.
- The group decides which of the personal threshold ideas are worth putting more effort into or not.
- The group chooses the idea, which is just good enough to put more effort into from the set of selected personal threshold ideas. This idea is called the global threshold idea $\boldsymbol{t}_g$.
- <u>Visualization tasks:</u> DMs need to determine the meaning of the criterion. After that they need to understand the concept of a global threshold idea. The effects of the group decision on individual subsets of ideas needs to be visible.

Phase 3: Individual reselection

- Inputs are the global threshold idea $\boldsymbol{t}_g$ (a symbol for of the threshold that distinguishes the ideas), the mental model of the meaning of the criterion and the already partitioned individual subset of ideas from phase 1.
- According to the global selection or rejection of the personal threshold idea, each DM needs to reconsider their selection of phase 1.
- If DM $\boldsymbol{i}$'s personal threshold idea was rejected in phase 2 then they need to reconsider their selected ideas $\boldsymbol{S}_i$.
- If DM $\boldsymbol{i}$'s personal threshold idea was selected but was not the global threshold idea then they need to reconsider their rejected ideas $\boldsymbol{R}_i$.
- If DM $\boldsymbol{i}$'s personal threshold idea is also the global threshold idea $\boldsymbol{t}_g$ then they do not need to reconsider either rejected or selected ideas.
- <u>Visualization task:</u> Each DM only sees a subset of the ideas. DMs must be made aware what the others are doing. The consequences of the reselection according to the position of the personal threshold idea compared to the global threshold idea must be understood. Transparency of the reason of the reselection rules is needed.

During the whole selection process, the visualization of the current selection state is needed. Therefore the visualization should be dynamic.

B. *Applying visualization approaches*

In order to solve the interaction and visualization task, four general visualization approaches were adapted.

1: Dynamic application. According to Gonzalez et al. [15], the evaluation quality increases when using a dynamic approach. Since the threshold algorithm needs to process inputs of various DMs, visualising decision effects and the collaboration the application should be distributed and dynamic. All DMs therefore work on a web-based application which is accessible from devices such as laptops, tablets and smartphones.

2: Collaboration. Gutwin et al. [16] claims that in collaboration systems the effects of the actions of users should be made visible. That indicates that each DM needs to understand the decision process and how the threshold algorithm calculates the overall selection result. Furthermore the DM needs to be able to visualize own and other decision effects. Each phase contains an individual view (Figure 2.) that is surrounded by a small representation of the work of the other DMs. At all times, each DM is able to follow the decisions of the other group members (Figure 3.). The current selection result can be identified at all times.

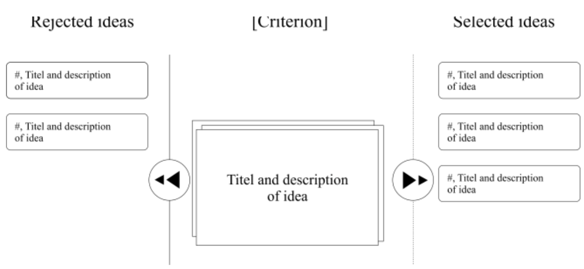

Figure 2. Simulated screenshot of individual view

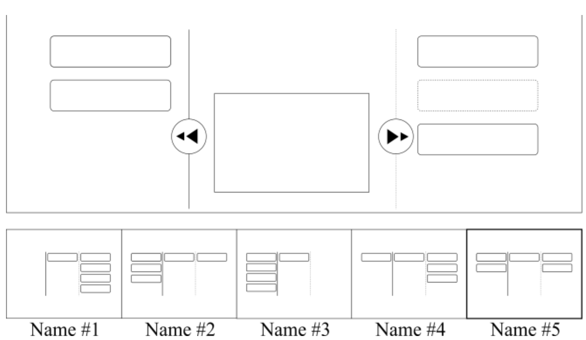

Figure 3. Simulated screenshot of overall view

3: Traceability. The DM should be able to track what the current decision for an idea is. The colours of the container of an idea was used. The colour of the border symbolises the selection information of phase 1. The colour of the filling of the container represents the selection information of the group discussion or the individual reselection. The colour code:

- Green = selected
- Red = rejected
- Orange = threshold

Figure 4. visualizes an example. For the idea in the first container, a decision has not yet been reached. The idea in the second container is a personal threshold idea. The group discussion rejected the idea in the third container, which was a former personal threshold idea in phase 1.

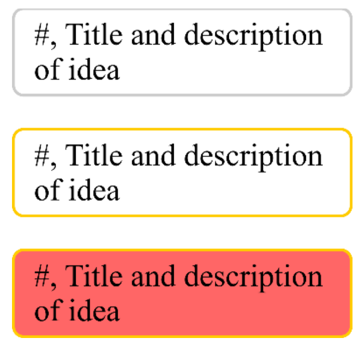

Figure 4. Visualization of decision tracking for ideas

4: Incremental instructions. The three algorithm phases are led by a facilitator. Each phase could only be started on his order. The DMs in individual phases receive their assignments, and in the face-to-face environment the facilitator guides them through the algorithm.

5: Channel attention: Colours and objects were chosen carefully and only according to the interaction and visualization task defined in Section III.A. The decision of an idea is visualized by the colour code described in *3: Traceability*. Every other element is coloured in neutral perceived grey colour tones. This is according to the main rule for preattentive perception [27] (spare use of visualization elements) and therefore allows a targeted direction of the attention of the user.

The colour of elements will change during the process but only piece by piece. This allows the DM to follow slowly the process steps without the need of explanation. For example, in the first phase when each DM makes a decision two parameters visualizes this. At first the position of the element, left for rejected ideas and right for selected ideas. This alone would not allow a preattentive perception, only colours, forms or the change of frames would create a preattentive perception. That is the reason for the second parameter, marking the decision visible by using colours (following the decision colour code, see *3: Traceability*). Every decision the DM creates, the visualization makes the effect visible. So, the DM is able to follow the process steps quickly.

C. *Applying interaction approaches*

For phase 1 and 3, the DMs work separately on a single computer (see Figure 5.). Due to the web-based application, access to the threshold algorithm is open to every device with a monitor and an Internet connection. The input devices could be a mouse, a keyboard and a touch-sensitive monitor. Each DM is technically capable to fulfill the given selection task but also receives impressions about others, their tasks and their progress.

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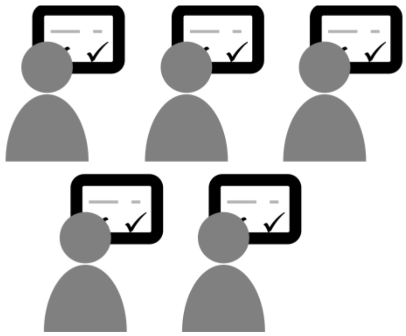

Figure 5. Individual selection computer-support

However, phase 2 of the threshold algorithm is a face-to-face group discussion in contrast to phase 1 and 3 (see Figure 6.), where each DM works individually. But during the group discussion DMs should also be able to monitor group decision effects on their individual subsets. Baltes et al. [2] and Introne [20] suggest conducting group discussions in face-to-face environments. The more familiar the environment for the given task the better for the collaboration result according to Bobrik [4]. So the group discussion takes place in a face-to-face environment but is supported with a multi-touch monitor. This multi-touch monitor presents the DM with the group selection task as well as the overview of the effects of group decisions on their individual subsets. Again due to the web-based application the group immediately receives a response to group decisions.

Figure 6. Group discussion computer-support

IV. EXPERIMENTS

In this Section the results, observations and interpretations of the experiments will be described as well as the limitations of our work.

A. Experimental Design

We designed an experiment to test our assumptions and hypothesis from Section I.D. Our goal was to find out if visualization could be a tool for increasing acceptance of results for the threshold algorithm. Other factors could play an important role in the acceptance of a selection result for a group such as trust in other DM or the influence of a web-based support system. So this experiment should show if further investigation in this matter could be beneficial.

We were also interested in whether the additional visualization meets our requirements from Section I.C.

The following methods were compared:

- **Method M_1: Threshold algorithm without visualization**
- **M_2: Threshold algorithm** with visualization

Furthermore, we compared the results of the experiments for M_1 und M_2 to results of the methods M_3 and M_4 from a previous study [14]. The design of the experiments for M_3 and M_4 were conducted under the same conditions and for the same parameters as the methods M_1 and M_2. One difference of M_3 and M_4 is that they were conducted face-to-face without any computer support:

- **M_3: Group discussion** in which each idea was discussed by the group and reached a consensus whether to select or reject the idea. They pick an idea and discuss whether the idea is worth putting more effort in or not. If they are not in consensus they need to discuss the idea and come to a conclusion.
- **M_4: Parallel individual selection** in which the set of idea was divided into equal subsets. Each DM received one subset and selected and rejected ideas independently. The overall selection result is the unification of all individual selections.

We had 30 participants who were mostly students from the Computer Science department of the University of Magdeburg without any experience in idea selection methods. Inexperienced participants were important, because we will measure the connection between the understanding of a group decision process and the resulted acceptance of the selection. Experience with group decision making method could influence the perception and subsequently our measurements. We divided the 30 participants into six decision-making groups. Three of these carried out M_1 and the other three conducted M_2. M_3 and M_4 were conducted in the previous study with 20 participants. The results were normalized for comparison with M_1 and M_2. This study investigated if an algorithm could be find that enables at the same time an efficient and acceptable selection result in a group.

For the execution of the threshold algorithm we used 25 ideas for attracting new customers to a supermarket. Each decision-making group was instructed by a computer-mediated and face-to-face facilitator. The criterion given to each group was "Could this idea attract new customers to our supermarket?" Students know supermarkets and should be able to make appropriate selection decisions.

Each decision-making group was subsequently asked to fill in an evaluation form and the time needed for the selection was measured.

B. Results and interpretation

In Section I.C, we state the requirement that with the visualization and interaction adaptations the threshold algorithm should not lose its time advantage. The results in 0show that M_2 still performs almost twice as fast as the group discussion. M_1 does not perform quite as well as the threshold algorithm with visualization.

TABLE II. ACTUAL DURATION

in Minutes	M_1	$\boldsymbol{M_2}$	M_3	M_4
Mean	15:40	**13:40**	24:30	6:00
Min	13:00	**12:00**	13:00	4:00
Max	19:00	**16:00**	34:00	10:00

Another requirement of Section I.C was that the DM understand the process and could comprehend the overall selection result. In the evaluation form the participants were asked to respond to the statement: "The selection method is understandable." on a five-point Likert scale from 0 to 4 points. For each measurement and method the total achievable sum and actual achieved sum were built and converted into a percentage. The results in TABLE III. show a value of 82% for the question whether $\boldsymbol{M_2}$ leads subjectively to a higher process understanding, which meets our expectation (see Section I.D, assumption 1).

$\boldsymbol{M_2}$ almost reached the process understanding of $\boldsymbol{M_3}$. Surprisingly the process understanding of $\boldsymbol{M_3}$ is only 90%. It could be assumed that the process understanding of the group discussion should be at the maximum. Nevertheless, $\boldsymbol{M_2}$ performed better than without the visualization and nearly as well as $\boldsymbol{M_3}$.

TABLE III. SUBJECTIVE PROCESS UNDERSTANDING

M_1	$\boldsymbol{M_2}$	M_3	M_4
75%	**82%**	90%	63%

We also wanted to get a more objective way to verify the process understanding results. This is the reason why the evaluation form contained questions in exam-style. Five multiple choice test questions on the functionality of the threshold algorithm were given. The number of correct, wrong and "don't know" answers is shown in TABLE IV. As expected, $\boldsymbol{M_2}$ reaches a higher number of correct answers. Surprisingly was that $\boldsymbol{M_2}$ reached twice as many correct answers than $\boldsymbol{M_1}$. By contrast, $\boldsymbol{M_2}$ made nearly as many wrong answers as $\boldsymbol{M_1}$. $\boldsymbol{M_3}$ and $\boldsymbol{M_4}$ were not investigated in this manner, because in the former study the objective process understanding was not an issue.

TABLE IV. OBJECTIVE PROCESS UNDERSTANDING

	correct	wrong	don't know
M_1	23	25	27
$\boldsymbol{M_2}$	**43**	**23**	**9**

The threshold algorithm with the additional visualization reaches both subjectively and objectively a better process understanding than the threshold algorithm without the additions. This meets our assumption in Section I.D.

Another expectation is that the additional visualization of the threshold algorithm increases the group acceptance of the selection. The participants were given three types of questions. We were interested in the assumed group acceptance, the personal view on the acceptance of the overall selection result and if the threshold algorithm would in general lead to accepted group selections.

At first we were interested in the assumed group view of acceptance. The participants were given the statement "I assume that the group accepts the overall selection result." and were asked whether this statement fits (4 points) or does not fit (0 points) their perception on a Likert scale. For each method the total points from all participants were calculated and converted to a percentage. TABLE V. shows the corresponding values. $\boldsymbol{M_2}$ performed better than $\boldsymbol{M_1}$ and nearly as well as $\boldsymbol{M_3}$.

TABLE V. SUBJECTIVE ASSUMED GROUP ACCEPTANCE

M_1	$\boldsymbol{M_2}$	M_3	M_4
75%	**82%**	86%	74%

Secondly, we were interested in the personal view of the acceptance of the selection result. The participants were asked if the statement "I accept the overall selection result." fits (4 points) or does not fit (0 points) their perception on a Likert scale. For each method the total points from all participants were calculated and converted to a percentage. TABLE VI. shows the results. Surprisingly, $\boldsymbol{M_2}$ reaches even a higher acceptance than $\boldsymbol{M_3}$. It is an interesting finding. It seems that the assumed group acceptance of the selection was underestimated by the group members.

TABLE VI. PERSONAL ACCEPTANCE OF SELECTION

M_1	$\boldsymbol{M_2}$	M_3	M_4
60%	**87%**	84%	60%

Finally, we were interested in the assumptions of the participants whether the threshold algorithm would lead in general to accepted selection results. The statement given in the evaluation form was "I assume that the selection method in general will lead to group accepted selection results." The participants should answer if this statement fits (4 points) or does not fit (0 points) their perception on a Likert scale. For each method, the total points from all participants were calculated and converted to a percentage.

As shown in TABLE VII. a value of 85% is achieved for $\boldsymbol{M_2}$, whereas a value of only 62% is achieved for $\boldsymbol{M_1}$. $\boldsymbol{M_3}$ and $\boldsymbol{M_4}$ were not tested, because the general ability for group acceptance was not an issue in the former study.

TABLE VII. GENERAL ABILITY FOR GROUP ACCEPTANCE

M_1	$\boldsymbol{M_2}$
62%	**85%**

It is an interesting finding: although each DM still only sees one-third of the ideas, the opinion is strong that the selection method would provide a group accepted selection result. This was achieved just by adding visualization support to the algorithm.

The additional visualization for the threshold algorithm exceeded our expectations. Our second and third assumptions are fulfilled. The findings support the hypothesis stated in Section I.D.

C. Other Obserations

In addition to our planned experimental investigations, participants also gave some voluntary feedback:

1: Relevance of the discussion. The discussion was perceived as very supportive for the decision-making task. It improves perspectives on ideas and the criterion. This results in a new research question: How could the threshold algorithm profit more from the effects of the useful discussion?

2: Multiple phases improve decision quality. The multiple views on ideas during the different phases give the chance to reconsider already made decisions. During the process, helpful information and expertise of others changes the participants' views on criteria and ideas. Given the application area, this is not a surprising comment. But we underestimated the impact on the decision quality in the opinion of the DMs. How could we encourage such a thought?

3: Too restricted in the reselection. In the re-selection phase, the threshold algorithm lets the DMs only reconsider in certain ways. That leads to the possible rejection of ideas that otherwise would have been accepted. This is especially true when new information changed the point of view of the DM. In combination with the observation that multiple views on ideas change, the DMs should be able to reconsider all (and not just some of) their already made decisions in the third phase of the algorithm.

D. Limitations

The experiment was carried out using a task that all participants had similar experiences and views. Real-life tasks could be harder because experts may represent different views (such as Marketing, Engineering and Sales), and – in the case of radical innovation projects – have little or no expertise.

The participants were selected for their inexperience in selection methods so that we can obtain an unbiased view on our approach. However, DMs with experience in selection methods might reject the threshold algorithm a priori due to its unfamiliarity.

The experiment was conducted in one room, face-to-face facilitated and in one sitting. By contrast, the threshold algorithm would be able to schedule the three phases on different dates. This change in format could decrease the overall algorithm performance because participants will have forgotten the inputs linking each phase to its successor.

The algorithm was tested with five DMs and 25 ideas. Results may change when these parameters are varied.

The experiments were carried out with a small number of subjects, which limits the statistical basis of the conclusions drawn.

V. CONCLUSIONS

A summary of this work as well as the applicability and open questions for future work are presented in this Section.

A. Summary

The selection of ideas supported by the original threshold algorithm lacked group acceptance in comparison to the group discussion of all ideas. Our approach was to increase acceptance by applying approaches from human computer interaction. The visualization and interaction additions to the threshold algorithm performed nearly as well in process understanding and group acceptance of selection as the group discussion. At the same time, the threshold algorithm was able to maintain its speed advantage.

This result was possible because we were able to improve understanding of the basic principles of the threshold algorithm and at the same time make it transparent how the current selection result is generated by each DM and by the group overall. Our approach applied basic visualization rules, a dynamic web-based application, dynamic visualizations and appropriate media for every DM throughout the whole selection process.

B. Applicability

The threshold algorithm is a collaboration algorithm with changing types of individual and group involvement. This is needed for the performance of the algorithm but causes also intransparencies and misunderstandings. In order to achieve a higher level of acceptance or process understanding, applying visualization and interaction approaches could be beneficial in other scenarios:

- Many group selection methods deal with acceptance issues.
- Methods that divide (decision) tasks into individual and group phases.
- Methods where invisible individual decisions lead to a lack of process understanding for others.

C. Open questions and future work

This investigation demonstrated new perspectives for the threshold algorithm:

- Evaluation errors are dangerous in this selection phase. Especially a false rejection error can lead to high opportunity costs. By making hidden profiles visible in the group discussion of the threshold algorithm the value for applications in business increases. The resulting research question: How could we use the mining of hidden profiles [19] for increasing quality of the group discussion respectively the definition of the global threshold?
- The concept of a threshold is hard to understand for a DM. In the evaluation form, the function of the threshold algorithm was often answered incorrectly. Are there visualization or interaction approaches that are able to support the understanding of this basic element in order to improve group discussion and decisions?
- Each DM still only saw only one-third of the ideas. Making the overall selection during the decision-making process explorable might help to improve the overall group acceptance of the selection. How could

the threshold algorithm benefit by exploring the reasons for others' decisions?

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Adopting Collaborative Business Process Patterns for an Enterprise 2.0 Banking Information System

Antonio Capodieci, Giuseppe Del Fiore, Luca Mainetti
Department of Innovation Engineering
University of Salento
Lecce, Italy
{antonio.capodieci, giuseppe.delfiore, luca.mainetti}@unisalento.it

***Abstract*—The use in the workplace of Web 2.0 tools by knowledge workers has changed companies' operational practices by introducing new collaborative processes. This paper presents the application of a set of "cross-domain" collaborative business processes applied to a model of the Enterprise 2.0 Banking Information System. The case studies presented use collaborative business patterns. The aims are to resolve emerging organizational issues to support the activities of knowledge workers, to increase their productivity and their ability to find the information they need, and to enable collaboration with colleagues. All this is made possible using Web 2.0 tools, without changing their habits and by integrating the knowledge generated within the corporate information systems. In this article, we use the previously presented collaborative patterns in a different application context, to model an Enterprise Banking Information System.**

Keywords: Business Practices; Business Process Patterns; Collaboration; Coordination; Enterprise 2.0, Knowledge Workers.

I. Introduction

The "knowledge worker" [1] is a form of employee, that, in the last fifty years, has become more and more important to companies. The knowledge worker is "a person who works primarily with information or a worker who develops and uses knowledge in the workplace". They are people who can manage multiple tasks all together working in different contexts and having different channels to deliver information [2]. They must manage different parallel "knowledge processes" [3]. These processes may not be codified in formal procedures but could be unstructured or semi-structured and could change continuously. Thanks to the advent of Web 2.0, we can see that there are knowledge processes, which are not coded in formal structures. This is because knowledge workers collaborate using many basic tools at work but they are not checked by traditional information systems. To keep knowledge processes (unstructured) and business processes (structured) coherent is very important at this time; moving from tacit to explicit knowledge [4][5] to be involved in shaping a new kind of information system known as Enterprise 2.0 [6]. To understand the information demand and the different roles in the organizational field we have to have a formal definition of business practice. Researchers, such as Henkel at al. [7], said that enterprise models and business models have adequate tools for the design and maintenance of processes, which require collaboration in agile and flexible networks.

We tried to understand the business process management (BPM) approach in order to solve the modelling issues involved in business practices. Our first goal was to describe the processes that involve knowledge workers in collaboration and coordination. To achieve this we integrated them into the information system and so we obtained efficient (i.e., without waste of resources and time) and effective (i.e., with high quality to meet specific needs) process models. Then we worked to reduce the impact on the overall organization, shaping just the recurring business practice atoms, i.e., patterns.

A pattern-based approach is important both in re-designing processes [8] and for the design of information systems from scratch. The idea of patterns has already been useful in practical contexts and it will be suitable in others [9]. This idea started from the traditional business process design method [10] and from the software engineering field [9]. The use of workflow patterns has been shown in different studies as a solution in modelling business processes [11], to manage collaborative work [12] or, in other cases, to categorize recurring problems.

In this paper, we apply a pattern-based approach to knowledge processes as a key factor in quickly identifying and rapidly applying business practices to support the activities of knowledge workers, increasing their productivity in the networked workplace without changing their habits. The paper presents a case study highlighting the issues related to the modelling of knowledge processes, demonstrating the difficulty of managing tacit knowledge. To address these issues, we used a set of business patterns, which can be useful in modelling collaborative and cooperative activities within business practices.

The paper is structured as follows: the next section reports on key related work in the areas of analysis, description, identification and application of business practices, mainly to address knowledge workers' emerging needs. Section III provides readers with an overview of the methodological approach used to identify collaborative processes. Section IV describes the first case in the banking industry and how it has been modelled using a pattern-based approach. Section V describes the second case in the banking industry and how it has been modelled using a pattern-based approach. Finally, Section VI

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summarizes our key messages and sketches future research directions.

II. RELATED WORK

In this section, we study the explicit modelling of business practice to try to give support to collaborative and cooperative semi-structured processes. In [13] the authors clarify the relationship between information, knowledge and competitiveness by introducing the model of the "knowledge ladder". Based on the knowledge ladder, the terms, fields of action and the maturity model of KM are explained. In addition, the authors demonstrate, with a case study, the conversion of tacit and explicit knowledge according to the SECI model.

Business practices are the most useful practices used to organize internal company processes. Therefore, identifying better practices is really important to achieve efficient and effective business practices, but also for there to be the possibility of reusing knowledge and expertise [14]. Each company should find methods to provide the necessary level of abstraction while modelling daily practices. However, at the same time, companies must manage and preserve social capital through knowledge workers [15].

Knowledge workers can be classified into different categories reflecting what he\she does in the work process in which he\she is involved [1]. Every day, each knowledge worker is involved in different unstructured activities that are information intensive but without technology support. For this reason, there is rapid information overload that has a negative impact on performance. To date, there have been few studies on this topic. Andriole [16] attempts to demonstrate how new technologies enable companies to cost-effectively increase their productivity and their competitive advantage if properly deployed. If a company wants to increase its productivity, it must integrate emerging technologies (first of all from Web 2.0) in traditional business processes [17]. In this way, the information system can allow the knowledge worker to use the right information, in the right format, at the right time. Nevertheless, we must understand that processes are made up of people, and that people will use the technology to improve their work. To achieve this goal, knowledge workers should be provided with an integrated space where they can retrieve all the information and tools they need.

Some research has been carried out in this area. Authors, Jennings et al. [18], propose analysing specific possible lightweight ad hoc processes, known as "micro workflows". By using gestural analysis of human agents within such flexible micro workflows, in combination with social analysis techniques, a new flexibility in business processes can be identified. Thus, the authors wants to better define how people work in companies and how they can use Web 2.0 tools in their daily activities to get better results. Stephenson et al. [19] present business process patterns in order to enhance the design of the public health care business process.

In this context, the main technological areas, through which Enterprise 2.0 is carried out, are social network/community, unified communication/collaboration and enterprise content management.

Cook introduces the concept of the collaboration process in addition to the traditional business processes. It is the way in which a company organizes its work [20]. Collaboration processes have the characteristic that there is collaboration among the participating stakeholders to achieve a common goal. This collaboration takes place through the combination of communication tools, both traditional (e-mail, telephone, direct conversation) and Web 2.0 oriented [21].

Harrison [22] argues that it is necessary to amplify human-driven processes in order to understand how to describe such work formally, then to capture this knowledge in a software tool. This requires changing both business process modelling and information systems. The author analyses the nature of work and explains how information systems can support it in the future. In order to describe human work and the interaction between humans and technology, the identification of patterns can be a useful approach allowing for fine-grained modelling support, as Gschwind et al. [23] point out. However, the modelling tools currently available do not fully support the application of patterns, although, as these authors demonstrate, it is possible to use an approach through which business users receive help in understanding the context through design patterns.

The concept of pattern [9] has been useful in practical contexts and will probably be useful in others. A pattern-based approach has been exploited for many years in the software engineering field but, over the last decade, the concept has been inherited by the business processes area. Some authors [10][11][24]-[28] point out that most of the analysts, who have actually worked on simplifying business processes, have focused on reusing or identifying some process elements from one process that can be re-applied to another, or at least identifying when similar processes are encountered. Our solution, which comes from the methodology of business process patterns, is very helpful in the information systems field and is an important step towards creating a structured and systematic way of managing business practices both in real [27][28] and in virtual environments [29]. The next sections addresses this issue presenting the reuse of patterns identified in different application contexts, to model an Enterprise Banking Information System.

III. THE METHODOLOGY USED

In this section, the methodological approach used to identify collaborative processes is described. The Introduction shows how the adaptive and unstructured nature of knowledge generation processes could become an obstacle to the formalization of business practices on a large scale.

In order to identify and apply the patterns of collaborative processes, an approach that considers the needs of the organization and the best currently available practices for the identification and application of model patterns has to be adopted.

The approach to be followed to identify and apply the patterns of collaborative business processes is divided into six phases:

1) The first phase is characterized by the analysis of the business environment with much attention given to identifying some of the processes and areas that are characterized by both intense collaborative activities among the workers and the need to use Web 2.0 tools. One of the first steps in this preliminary stage will be to identify competence areas of the company and how the employees are involved in various projects. In this situation, it can be seen that the workers are used to working and collaborating with each other. The interactions among the actors are not very often pre-defined, some activities are carried out manually and many others through the use of unstructured communication tools (chat or e-mail), so all the different professionals, who collaborate with each other to achieve common goals, need to be identified.

In this stage, we have to identify the various case studies through:

- “Focus groups” with business leaders and heads of business units;
- A questionnaire.

2) The work continues in the second phase: modelling the business processes detectable within the case used, selected in the previous step through the use of BPMN. A number of processes need to be studied, taking care to analyse both the business practices that are codified and all the activities used every day that are not already encoded or pre-determined. In other words, first of all, all the collaborative practices should be highlighted and modelled.

3) In the third step, the study and comparison of the BPMN diagrams of all the modelled processes starts; to identify new patterns, it is necessary to focus on all repetitive common and atomic “segments” which are in the modelling performed in the previous phase. Particular attention should be paid to collaborative and cooperative activities, where we found a number of practices that have considerable repetitiveness. Each pattern that may be identified must shape typical situations in Enterprise 2.0 and, if they are properly applied, they will provide concrete support to the actors involved in such situations.

Typical situations, into which actors can fall within an organization, are characterized by strong collaboration among them, that contributes to performing a particular task, and intensive use of Web 2.0 tools (such as wiki, blog, chat, etc.) to assist the activity’s progress. So, the identified patterns respond to two fundamental needs: on the one hand to managing the collaboration among different actors that are called to work to accomplish a given task without a pre-defined and pre-structured sequence, and on the other hand, they allow the best use of the typical Web 2.0 tools within the enterprise.

In conclusion, the approach to be used for the identification of design patterns requires the modelling of processes related to three types of activities:

- Activities related to cooperation among workers in order to achieve a specific goal (collaboration activity);
- Activities that require the cooperation of different people with different roles, that are not encoded in the traditional information systems, and for which it is useful to keep track of the messages exchanged in order not to lose information (coordination activity);
- Activities that are repeated many times and for which there is a risk of losing useful information from the enterprise (know-how elicitation activity).

4) Some of the “repetitive segments” detected in the previous step may already be known, so at this stage, it is necessary to verify the existence of patterns similar or identical to the segments identified. In such a case, it is better to use the known solutions that have already been applied and validated in different contexts. Otherwise, these segments can be considered new, such as new patterns.

5) During the fifth phase, the design patterns identified in the third step start to be applied to model and realize a prototype of the collaborative information system. The purpose of this step is to verify the validity of the approach adopted in the identification of the patterns and to apply those patterns in the realization of a collaborative information system. The identified patterns should be used both in the design of the conceptual model of the platform, and in its implementation in order to achieve a development framework that allows:

- Structured and unstructured information flows to be managed together;
- A portfolio of solutions to support unstructured business processes to be incorporated;
- The creation of a workspace focused and customized to the needs of the individual worker.

6) Following the experimentation, in order to verify the usefulness of the use of the patterns in the context of collaborative information systems, the data of the trial (sixth phase, evaluation of design patterns) needs to be collected. The experimental checking of the activities must be conducted by administering questionnaires to the knowledge workers to evaluate the system. The testing must be preceded by a training session targeted at users involved in the identified processes, with the goal of explaining the project and to show the main functions of the system and its areas of use. Once the trial is ended, the users need to meet again in order to give feedback on:

- The potential of the tool and the benefits associated with its use:
- Level of usability;
- Areas of intervention for subsequent improvement;
- Possible extensions to other features.

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Finally, the evaluation data should be subsequently reworked.

IV. Description Of The Circulars Case

A bank circular is a communication sent to multiple recipients to give orders, to advise on provisions, or to transmit information. The creation and approval of a circular follows a particular well-defined process that includes the engagement by multiple actors involved at various stages. Every actor in the process must perform his function within his field of competence and responsibility.

The process is started by the Head of the Central Office, who requires the distribution of a circular to the various editors that are part of the office in order to submit it for the attention of Organization and Quality, which has the power to authorize the circular. Some refusals should transpire thereby giving the editor the opportunity to modify the circular and resubmit it to Organization and Quality through the Head of the Central Office. The process of revision may require more comparisons between the Head of the Central Office and Organization and Quality, at each time refining the characteristics of the circular. Upon the approval of the latter, the process may follow different paths according to the type of circular. For example, some may require the signature of one or more competent structures, others may require a compliance opinion, and others may require both or neither of the two mentioned stages. All these stages become mandatory and essential for the completion of approval. Finally, a positive opinion by the Chief Operating Officer and General Manager is necessary to allow Organization and Quality to publish the circular.

A. Modelling of the Case (TO-BE)

After the preliminary phase characterized by careful analysis of the business practices that are not codified and of all the possible collaborative processes that currently do not meet the needs of knowledge workers, was made the modelling of the process using the BPMN notation. This activity has led to the definition of the process "Circular" that is shown in Figure 1. This highlights the presence of a number of sub-processes that will be detailed below.

This process involves several actors including:

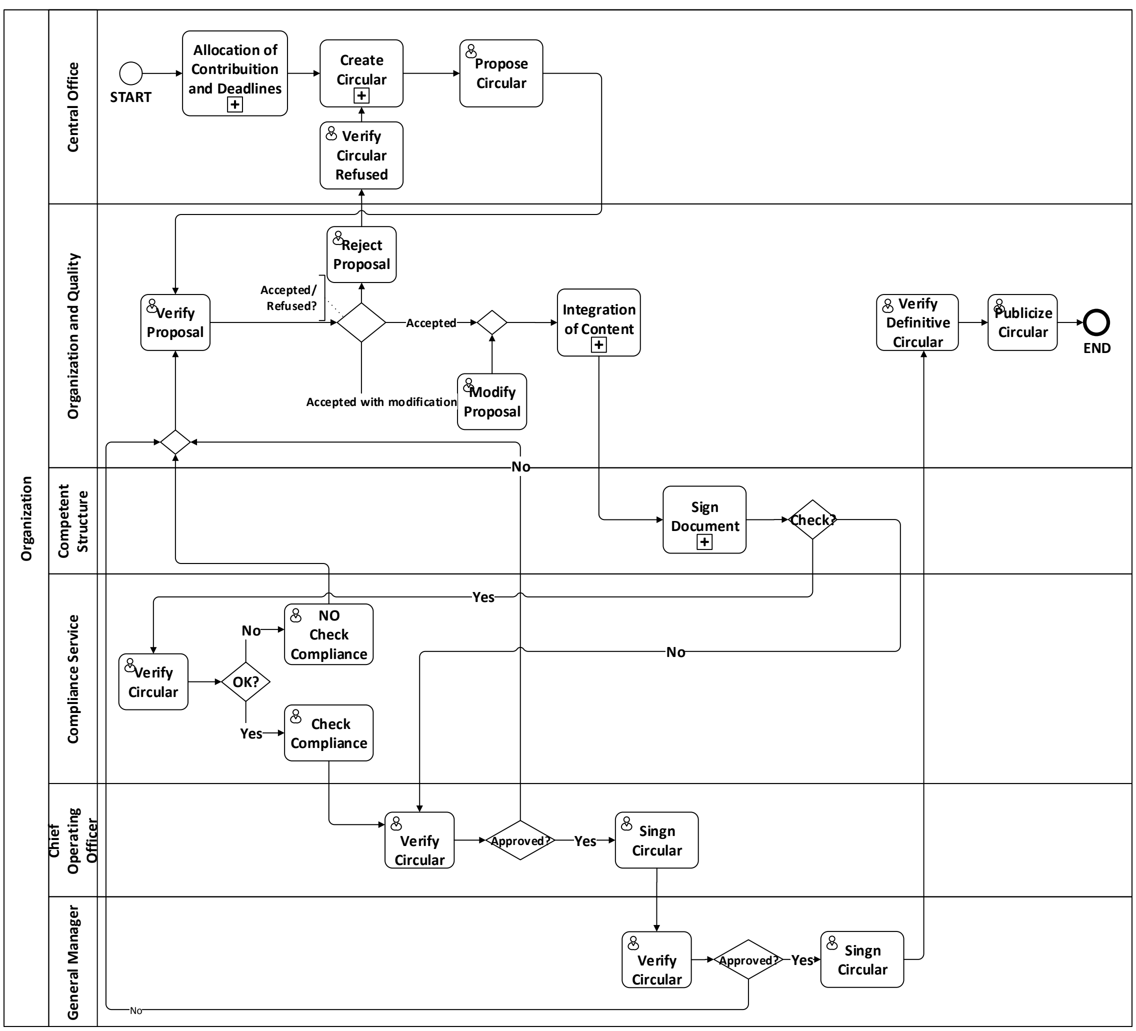

Figure 1. BPMN process design "Circular".

Responsible for Central Office; Editor; Organization; Competent Structure; Compliance Service; Chief Operating Officer; General Manager.

All these actors are strictly necessary to take care of every aspect of the definition, approval and publication of a circular.

1) Secondary Process – Allocation of Contributions and Deadlines

Figure 2 shows the BPMN sub-process "Allocation of Contributions and Deadlines". The sub-process is started by the Head of the Central Office in order to coordinate the contributions and the deadlines of the individual collaborators (editors), who will take part in drafting the Circular. This task ends when the various collaborators finalize their decisions. This sub-process has been modelled using the pattern Deadline Agreement, already published in [27]. This pattern aims to create a model according to which the deadline agreement activity can be performed efficiently, taking into account the different needs of the people involved. Two classes of actor characterize the pattern: the Requestor, who is responsible for the whole activity completion, and one or more Providers, who must provide the required contributions. To agree on the assignment of the work and the internal release date, the Requestor, first of all, defines the date by which any contribution must be provided. Then he/she carries out an initial assignment of work activities; so two collaborative activities ("Work Partitioning" and "Deadline Collaborative Definition") begin. Each of them involves a Requestor and the Providers.

These collaborative activities deal with assigning the work ("Partitions the Work" task) and agreeing the internal release dates for each Provider ("Defines Deadline Date" task) respectively. The two tasks are sub-processes modelled through the collaborative editing pattern.

A Decision Team is made up of the Requestor and the Providers who, using collaborative tools, agree on the assignment of the work and the internal deadline definition. When the Work Partitioning and the Deadline Collaborative Definition are finished, the Requestor, through the "Finalizes Decision" task, formalizes the decisions made and he/she defines the latest date, against the dates agreed with the Providers, as the deadline for the conclusion of their activities. If these deadlines exceed the date defined initially by the Requestor, a new iteration of the two collaborative activities can be carried out.

2) Secondary Process – Create Circular

Figure 3 shows the BPMN sub-process "Create Circular". The sub-process is started by the Head of the Central Office in order to achieve a draft Circular to be proposed to Organization and Quality. The process ends when the various collaborators (Editors) finish submitting their contributions. The secondary process "Create

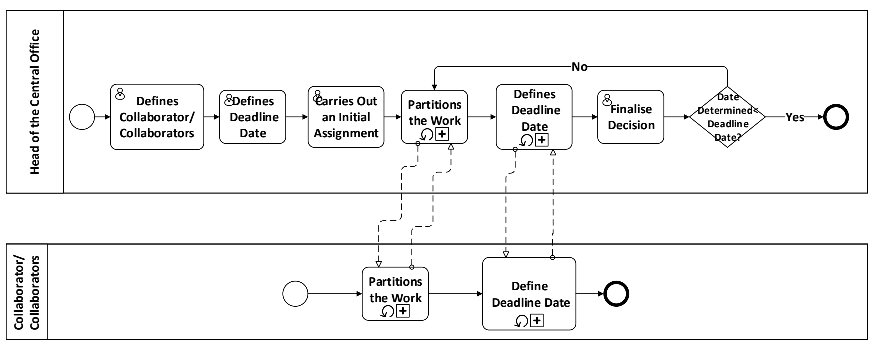

Figure 2. BPMN sub-process design "Allocation of Contribution and Deadlines".

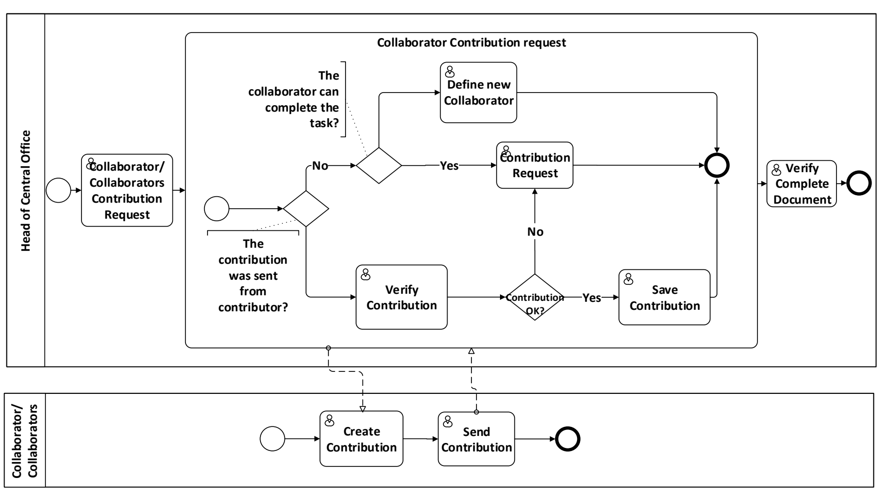

Figure 3. BPMN sub-process design "Create Circular".

Circular" was modelled using the pattern Retrieve Contributions, already published in [27]. This pattern aims to model situations in which the contributions that each actor must provide need to be collected in order to achieve a common goal and aims to solve the problem of retrieving contributions produced by knowledge workers. It takes into account the need to collect the contributions by a pre-defined date in order to have time to elaborate them. The Retrieve Contribution Pattern foresees the involvement of a Requestor and one or more Providers. The Requestor identifies the resources that will have to provide the contributions, while the Providers produce and submit the required contributions. The use of the following pattern involves the use of the pattern/sub-process "Coordinates Enhanced Contributions". This pattern aims to verify and evaluate the received contribution. It allows for coordinating the contributions of other actors. First of all, the system checks whether a Provider has delivered the contribution assigned to him/her. If the contribution has not been received, the system requests the contribution from the Provider. Otherwise, the received contribution is evaluated. It is then registered if it matches quality attributes or, if it does not meet the requirements, the system asks the Provider for a new version.

3) Secondary Process – Integration of Content

The sub-process is started by the Manager of Organization and Quality in order to define contributions and request them from some of the relevant structures. The process ends when all the structures embody all the contents that are within their competences. The figure is omitted because even the sub-process "Integration of Content" was modelled using the pattern Retrieve Contributions, already published in [27], described in the previous paragraph.

4) Secondary Process – Sign Document

Figure 4 shows the BPMN sub-process "Sign Document". The sub-process is started by the Manager of Organization and Quality in order to request the signature from all the relevant structures that have participated in the integration phase of the content. The process ends when all the structures sign the document or on reaching a default deadline. In the latter situation, the principle of tacit consent will be applied. The secondary process "Sign Document" has another internal sub-process called "Send Reminder", which makes use of the pattern Reminder, already published in [27]. This sub-process is started by the Manager of Organization and Quality in order to solicit all the relevant structures that have not already signed the document by a certain time.

V. DESCRIPTION OF THE NEW BANKING PRODUCT CASE

The definition of the products of a bank, or in general of a credit institution, follows a well-defined process that starts from the analysis of the market and ends with the marketing of the product. Every actor in the process is called upon to perform his function within his field of competence and responsibility. The actor that starts the process is the Business Unit that, based on a careful analysis of the market, defines the type of product to be marketed, the target customers to whom it can be offered and the strategic opportunities arising. The prototype of the defined product is subjected to the Organization Unit, who examines the solution by providing feedback to the Business Unit. The Organization Unit, based on the parameters of the product, will execute a plan of simulations by calculating the indices of synthetic cost, comparing them with the thresholds of usury, highlighting some anomalies. The product analysis phase will give the Organization Unit the opportunity to express an opinion on the feasibility of marketing the product. If some conditions and/or fundamental principles are not respected, the prototype will achieve review status and will be referred back to the Business with some suggestions and corrections. The process of revision may require more comparisons between Business and Organization, each time honing the characteristics of the product. Once it has received a positive opinion, the definition of the information content to be included in the information pack and the pre-contractual information provided by legislation concerning banking transparency proceeds. At this stage, the layout and content are defined according to the format of the Bank of Italy. The actors involved at this step of the process are: Legal Advice function, which provides support for the preparation of contractual clauses; the Compliance function, which evaluates its compliance with standards; and Operation Unit, that provides for the creation of documents, inserting the regulatory information and examples in the defined models.

The Operation Unit will perform the activities of "merging" the template shared between the Legal and Compliance functions and the function prototype

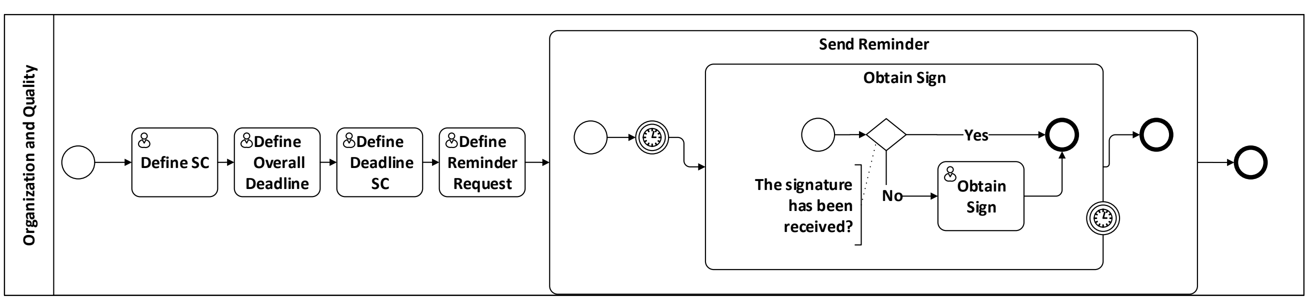

Figure 4. BPMN sub-process design "Send Reminder".

document approved by the Organization. The final validation is delegated to the bodies with executive resolution powers (Board, Executive Committee) that officially approve, unless otherwise specified, the new product, establishing its effective date. With the official resolution, the bank circular, which informs the sales network of the availability of a new product, is drawn up. On the start day for the new product, all of the information and communication platforms will have the necessary documents required by the regulations for Bank Transparency. The disclosure will also reach the third-party brokerage company that distributes institute products.

A. Modelling of the Case (TO-BE)

Completed the analysis phase of the process described above, the modelling of the same proceeds through the BPMN notation. This activity has led to the definition of the process "New Banking Product". This process involves several actors including: Business Unit; Organization Unit; Operation Unit; Legal Function; Compliance Function; Executive Committee.

All these figures are strictly necessary to take care of every aspect of the definition, approval and marketing of a New Banking Product. Figure 5 shows the design process of the BPMN New Banking Product. It can be seen that the process follows a well-defined path that starts from the analysis of the market and ends with the marketing of the product. The presence of some

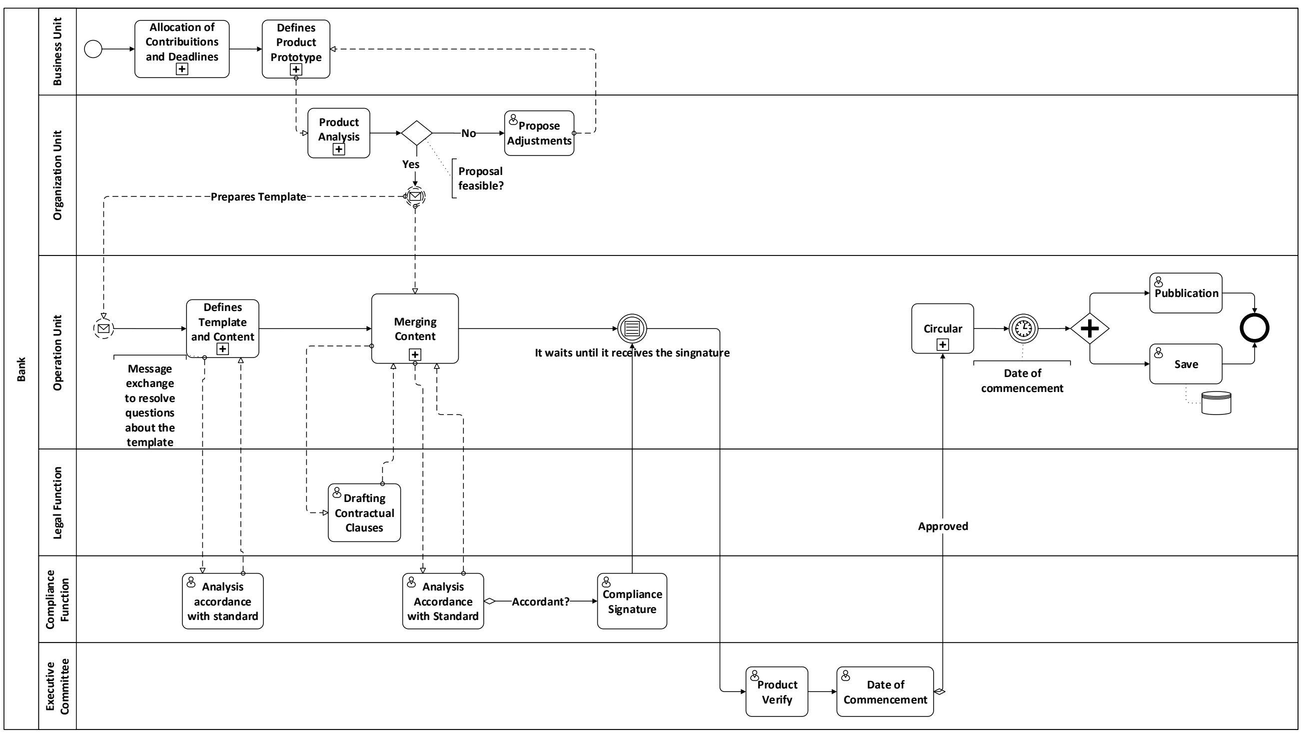

Figure 5. BPMN process design "New Banking Product".

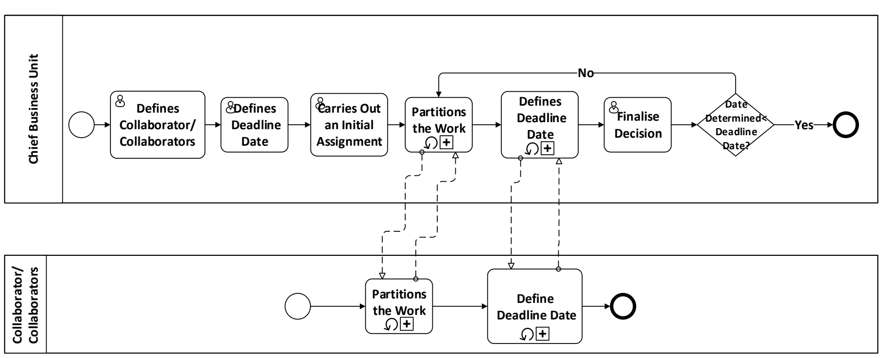

Figure 6. BPMN sub-process design "Allocation of Contribution and Deadlines".

secondary processes, which will be detailed later, can also be seen.

1) Secondary Process – Allocation of Contributions and Deadlines

Figure 6 shows the design of the BPMN sub-process "Allocation of Contributions and Deadlines". The sub-process is started by the manager of the business in order to coordinate the contributions and the experiences of the individual contributors who will take part in the drafting of the prototype of the new banking product. This task ends when the various collaborators finalize their decisions. The secondary process "Allocation of Contributions and Deadlines" was modelled using the pattern Deadline agreement, already published in [27] described in Section IV paragraph 1.

2) Secondary Process – Define Prototype of the Product

Figure 7 shows the design of the BPMN sub-process "Define Prototype of the Product". The sub-process is started by the manager of the business in order to realize a prototype of a new banking product to be proposed to Organization Unit. The process ends when the various collaborators finish submitting their contributions. The secondary process "Define Prototype of the Product" was modelled using the pattern Retrieve Contributions, already published in [27] described in Section IV paragraph 2.

3) Secondary Process – Merging Content

The sub-process is started by the Head of Operations in order to define contributions and request them from some of the relevant structures. The process ends when all the structures embody all the contents of their competences and the Operation Unit merges them. Even the secondary process "Merging Content" was modelled using the pattern Retrieve Contributions, already published in [27] described in in Section IV paragraph 2.

4) Secondary Process – Define Template and Content

Figure 8 shows the BPMN design of the secondary process "Define Template and Content". The sub-process is started by the Head of Operations in order to request information useful in defining the template and content for the definition of the new banking product. The process ends when the template and the content are well defined. The sub-process "Define Template and Content" was modelled using the pattern Aggregate Activity Loop, already published in [26]. This pattern is used in contexts where there is a need to extract structured information from activities carried out with tools, such as Skype, e-mail, MSN, etc., which allow unstructured information to be conveyed.

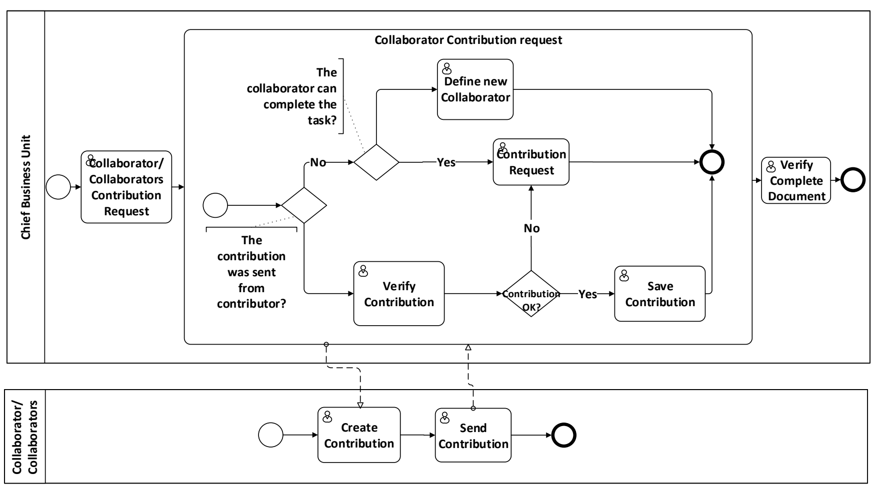

Figure 7. BPMN sub-process design "Define Prototype of the Product".

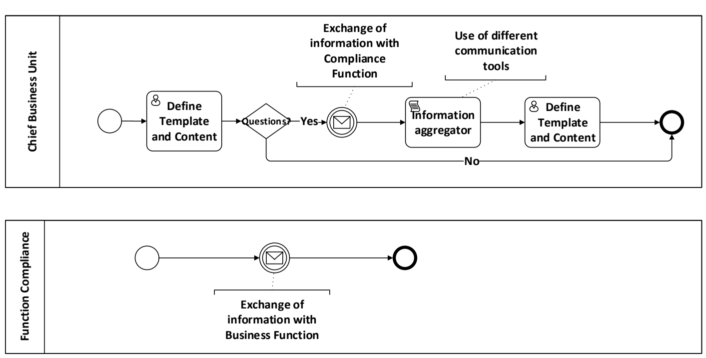

Figure 8. BPMN sub-process design "Define Template and Content".

VI. EVALUATION CONCLUSION AND FUTURE WORK

In this paper, we presented the application of a set of "Cross-domain" Collaborative Business Patterns applied to a model of the Enterprise 2.0 Banking Information System.

We also presented a pattern-based approach to re-designing business practices, which involves knowledge-intensive activities, in order to meet the challenge of providing a conceptual tool to organize knowledge activities and integrate them within business processes. We originally exploited the method of workflow patterns in knowledge processes as a key factor to quickly identify and rapidly apply effective business practices to support the activities of knowledge workers. By using a real case study, in an ICT company, we presented a set of design patterns able to model collaborative activities that readers can find [26][27][28]. Its aim was to resolve emerging organizational issues to support the activities of knowledge workers, to increase their productivity and their ability to find the information they need, and to enable collaboration with colleagues. The patterns previously presented [26][27] were extracted from a case study completely different from the one shown here, in fact the subject of the case study was the collaborative processes of an ICT company. The case studies presented in this paper use collaborative business patterns, to model collaborative processes in the banking sector. The patterns were applied without any modification and the results were immediately usable in the modelling of collaborative bank processes. In this way, it was possible to test the generality of the identified patterns that can be defined as cross-domain patterns.

Moreover, the proposed approach allows companies to identify and design collaborative recurring activities in enterprise practices. Collaboration patterns can coexist with traditional business processes. Compared with the state of the art [19], our approach does not focused on a specific application domain but can be used in several situations where the problem of managing collaboration arises. While the state of the art mainly deals with the sociological aspects of collaboration [30], we identified new collaboration patterns and presented an example of their representation using BPMN.

Currently, an inquiry is underway with several modellers to evaluate the proposed approach. The evaluation will be described in our future work.

Future research will concern, the application of the patterns to other case studies in various fields and to the realization, using the Collaborative Pattern, of a prototype of an Enterprise 2.0 Information System.

ACKNOWLEDGMENT

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Towards an Agent-supported Online Assembly: Prototyping a Collaborative Decision-Making Tool

Antonio Tenorio-Fornés and Samer Hassan

GRASIA group
Universidad Complutense de Madrid
Email: antoniotenorio@ucm.es, samer@fdi.ucm.es

***Abstract*—The promise of online assemblies has been present for years already, and a diversity of tools have attempted to fulfill it. This work aims to reapproach the issue from a novel standpoint that relies on a federated architecture, a real-time collaborative environment, goal-oriented software agents and a consensus-based methodology. Consensuall is a prototype of consensual decision-making collaborative webtool that allows the elaboration, rating and commenting proposals in order to build consensus among a group. The webtool design follows the Agent-Oriented Software Engineering paradigm. Thus, it proposes the use of software agents as complementary automatic participants fulfilling specific roles, as a way to address decision-making common issues. The article presents Consensuall, a prototype of an agent-based collaborative decision-making webtool within the distributed real-time collaborative platform Apache Wave, providing a proof-of-concept of the adopted approach.**

Keywords–Collaborative Decision-making; Apache Wave; Consensus; Agent-Oriented Software Engineering; Multi-Agent System.

I. Introduction

Post-industrial social movements (also coined "new social movements") emerged since the 1960's in the Western societies [1], and, nowadays, have reached a global impact. These movements are increasingly embracing different forms of consensus decision-making as an organizational principle [2]. This is guided by the belief that this model has the potential to empower participants, acknowledge their great internal diversity, and commit to the ideals of participation, democracy and decentralization [3].

Consensus decision-making covers a broad spectrum of implementations [4], and generally it is not understood as a synonym for unanimity, but as aiming to collaboratively reach an acceptable resolution for all the group members. Consensus-driven group assemblies may have multiple lacks and issues, and multiple methodologies have been proposed to address them, successfully doing so for most of them [5]. Still, it is frequently considered that online tools should boost this model, facilitating both scaling up and speed, while not losing its legitimacy and user participation.

The promise of "online assemblies" has been present for years already, and a diversity of tools have attempted to fulfill it. Besides, the emerging Commons-based peer production online communities do not follow traditional hierarchical organizations, and frequently adopt modified forms of consensus decision-making [6]. Popular examples may be found in free/libre/open source software (FLOSS) [7] or Wikipedia [8]. Still, the forms of achieving consensus through online means still have multiple issues and in some cases are rather rudimentary (such as a mailing lists with "+1" in Apache or a simple Discussion page in Wikipedia).

Multiple online group decision-making tools have been built in order to fulfill this gap (see Section II). This work aims to reapproach the issue from a novel standpoint that relies on a federated architecture, a real-time collaborative environment, software agents and a consensus-based methodology. CONSENSUALL is a prototype of consensual decision-making webtool that allows the elaboration, rating and commenting proposals in order to build consensus among a group. This webtool is developed from an Agent-Oriented Software Engineering (AOSE) approach [9], and proposes the use of software agents as complementary automatic participants. Such agents are inspired by the formal (or informal) roles found in offline assemblies, and aim to facilitate the debate and solve certain flaws of the consensus decision-making process.

This work is structured as follows. Section II introduces different decision-making methods and software tools, with a special focus on consensual decision-making processes and applications. Afterwards, Section III explains the adopted methodology, including the concepts of *software agent* and *AOSE* and the technologies used. The prototype design is presented in Section IV, where the concept of the tool, its functionality and the behavior of the designed agents are introduced. Section V presents the developed prototype, showing the use of the tool through an example, and illustrating the agents' behavior with a sequence of their interactions. Finally, Section VI summarizes the contributions and presents future work.

II. Reviewing Consensus Decision-Making

This section explores different group decision-making methodologies and software tools that intend to boost participation and agreement in democratic decision-making and compares them with CONSENSUALL proposal.

A. Group Decision-Making Methods

1) Consensual decision-making: In general, a group decision is a consensual decision if all members of the group are willing to commit to a proposal [10]. Consensus building or consensual decision-making is the collaborative process where a group aims to find a consensual decision. This process may be formal [11][12][4] or informal [13].

As discussed in Section I, forms of consensus decision-making are the preferred by different groups, including FLOSS

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projects [13][8], social movements [14], groups of unrelated experts [11], or many other communities [15]. These groups tend to see the consensual decision-making process as a method to obtain synergistic output, not achievable by single participants [16] and as an extremely democratic and participatory technique [3].

2) Other group decision-making methods: There are other group decision-making methods that attempt to boost participation and agreement further than traditional majority voting. Some relevant examples follow.

- *Liquid Democracy* also referred as *Delegated Democracy* or *Proxy voting* is a decision-making method that enables both direct democracy and revocable, topic-based, transitive delegation [17]. This method has been adopted by some political parties [18] and other groups and communities [19] and has been implemented in several online applications [17][20].
- *Dotmocracy* is a participatory large group decision-making method. Participants can write ideas in paper "dotmocracy sheets" and rate these ideas with the values {"Strong Agreement", "Agreement", "Neutral", "Disagreement", "Strong Disagreement", "Confusion"}, together with some qualitative comments [12].
- *Dynamically Distributed Democracy* is a method to approximate a group opinion when not all members of the group participate. It uses a social network of the transitive relations of trust within the group to calculate the opinion of non participants by the opinion of their trusted participants [21].

B. Group Decision-Making Software Applications

There are different online group decision-making tools. These software tools differ in the target groups and group sizes, the methods they implement (see Section II-A), the collaboration degree, the required level of agreement, or might have a wider or more concrete scope of application. These and other dimensions are considered in the comparison among some of the most important decision-making tools or resources and the CONSENSUALL proposal.

1) E-voting & Polls: There are plenty of software tools implementing majority voting and polls. These tools are used by different kinds of groups for democratic decision-making. Generally, e-voting and polls do not allow a high degree of collaboration, they usually lack discussion support and proposal modification/addition. Among these tools there are voting platforms [22][23] and poll extensions integrated in software platforms such as forums, social networks (e.g., Facebook) or collaborative environments (e.g., Apache Wave). There are also domain-specific voting tools, such as "Date matchers" (e.g., Doodle [24]), software systems to collectively decide appointment dates.

2) Adhocracy: is a participatory platform for democratic decision-making. It targets communities, organizations and citizens [20]. Users can make proposals, add an alternative proposal to an established proposal, comment proposals, and vote proposals with either +1 or -1 vote. The tool implements liquid democracy (see Section II-A), allowing users to delegate their votes for specific topics to a trusted user.

3) LiquidFeedback: is a liquid democracy (see Section II-A) decision-making tool for communities and citizens [17][19]. As in Adhocracy, a user can propose, make an alternative proposal, rate, and comment. It uses preferential voting (i.e., Schulze method [25]) to boost collaboration and avoid rival competitive voting.

4) Delphi: is a formal consensual decision-making method consisting of an iterative process of elaboration and response of questionnaires [11]. This method is commonly used to obtain expert opinions and forecasting, although it can be applied for other purposes [11].

5) Loomio: is an online consensus decision-making tool for communities [15]. It allows users to create topics, to propose and rate proposals with the values {"Agree", "Abstention", "Disagree", "Block"}; comments are allowed during the topic main discussion, the proposal discussion and the rating of proposals, which enhance collaboration to achieve consensus.

Lommio is the most similar to this paper's proposal. However, there are several differences: CONSENSUALL uses software agents interacting within the tool as a way of improving consensus decision-making process. It takes advantage of a real-time environment, together with a federated architecture (see Section III-B); besides, CONSENSUALL enables the parallel discussion and rating of more than one proposal while Loomio only allows the rating and discussion of a proposal at a time, which mimics offline assemblies behavior.

Other general purpose tools are also used for decision-making (e.g., mindmapping, videoconference, collaborative writing). However, those fall out of the scope of this paper.

C. Multi-Agent Systems for decision-making

MAS have been applied to assist decision-making. In decision support systems, some MAS provide information aiding to choose a decision [26]. In the negotiation process, MAS may help to obtain favorable deals [27]. However, these systems focus on decision-making scenarios such as business negotiations and domain-specific decisions. Moreover, within these negotiation systems (as in market environments) parties are usually considered competitive, rational and self-interested (i.e., following Rational Choice Theory (RCT) [28]). CONSENSUALL is a general-purpose decision-making tool, and designed for a collaborative context with group aims and emotional links among members, far from a RCT approach.

III. METHODOLOGICAL APPROACH

This section introduces the methodological approach of the proposal. Explaining its AOSE perspective and technologies.

A. Agent-Oriented Perspective

The software has been designed and developed with an AOSE perspective [9].

Software Agents are software systems that possess: *autonomy*, *social ability*, *reactivity* and *pro-activeness* [29].

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AOSE is devoted to the development of Multi-Agent Systems (MAS). AOSE uses software agents and their interaction as the basis for the specification of its systems. It is frequent in AOSE works to follow a Model-Driven Engineering (MDE) methodology [30], which implies the use of intermediate languages between the conceptualization and the implementation of models, facilitating the model description and replicability.

The introduction of agents in order to extend the decision-making tool is one of the main contributions of CONSENSUALL. In offline consensual decision-making, many issues are addressed by specific participants that play a formal (or informal) role, through interventions in the assembly [4]. This inspires the conception of automatic participants (agents) addressing specific roles within the system.

On top of the use of agents, the use of Agent-Oriented design has been a useful tool to conceive the prototype. Objects as agents (also used as Actors in the prototype design), roles, goals and actions, have been helpful abstractions for the design purposes.

B. *Technologies*

The INGENIAS [31] methodology, a software development methodology for MAS, have been used for the design of the tool. It adopts a MDE approach with two basic components: a modeling language and software tools. A metamodel specifies the INGENIAS modeling language. It defines the available concepts and relationships, together with their properties and constraints. Within this framework, an agent is mainly characterized in terms of its goals and the capabilities it has to accomplish them. Besides, agents participate in interactions with other agents to achieve global goals.

Thus, CONSENSUALL follows an Agent-Oriented perspective, using the metamodels provided by the INGENIAS tool, i.e., an intermediate graphical language to design the tool.

The webtool CONSENSUALL has been conceived as an *app* running on top of a FLOSS federated real-time collaborative platform, being Apache Wave [32] or Kune [33]. Wave is a technology that was initially developed by Google (and known as Google Wave [34]), and later transferred to the Apache Foundation and released as FLOSS. The Wave Federation Protocol [35] is the first protocol for full federation of contents in multiple servers with real-time transparent synchronization among them. Kune is a Wave-based federated collaborative platform which integrates social-networking features, and is under the umbrella of the Comunes Nonprofit [36].

The Wave technology allows the development of *Gadgets* or applications embedded into conversations [37] and *Robots* or automatic participants [38] that can perceive changes in gadgets and conversations and participate in them. CONSENSUALL takes full benefits of the potentials of this technology: the decision-making space where users and agents interact by building, rating and commenting proposals is implemented as a Gadget. Finally, agents are implemented as Wave Robots.

Gadgets and Robots have been developed using Java and the Google Web Toolkit (GWT) [39], which allows the automatic generation of JavaScript code from Java code.

IV. THE WEBTOOL DESIGN

The proposed prototype has been designed using the AOSE methodology INGENIAS [31]. This section explains such design using the INGENIAS "Agents", "Interactions" and "Goals and Tasks" viewpoints, illustrated with INGENIAS metamodel diagrams in Figures 1, 2 and 3.

A. *Concept*

CONSENSUALL is a prototype of a collaborative consensus decision-making tool. It is inspired in offline consensual assemblies but takes advantage of online real-time collaboration provided by its technology (see Section III-B). The decision-making webtool, developed as a Wave Gadget [37], can be introduced in any part of a wave document or wave conversation and is conceived as a generic tool for any Wave [32]/Kune [33] community.

The proposal introduces software agents (see Section III-A) as a way of extending the decision-making webtool. These agents, automatic participants in wave conversations [38], interact with the user and the webtool as other participants: posting comments, adding or rating proposals. This feature is inspired by the roles and interactions in offline assemblies to solve some of the most common issues in the consensus seeking process. Two agents have been developed to prove the appropriateness of this approach: a "consensus seeker" agent and a "participation seeker" agent; the definition of these agents (Section IV-E) and an example of their interaction with the users and the tool (Section V-A) are detailed below.

B. *User and Agent Participants*

The introduction of software agents as an extension of the decision-making webtool is one of CONSENSUALL's main contributions. This inclusion of agents in the tool provides a modular solution to address a variety of issues in decision-making processes (see Section VI-B for other interesting new agents). Thus, each group may invite the agents they find useful and could develop new agents to solve their problems without modifying the decision-making tool.

Both software agents and users have been considered to play the *role* of Participants of the tool (see Figure 1). These participants are able to perform different *actions*, described below.

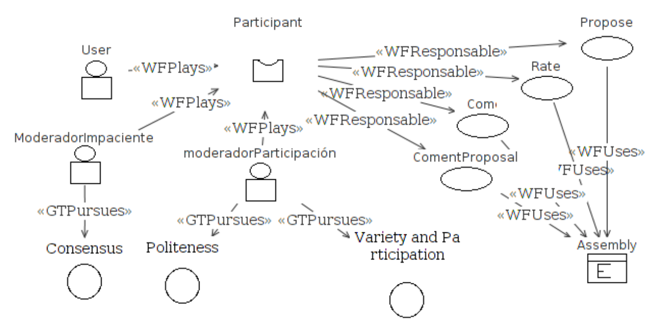

Figure 1. INGENIAS diagram of the Agent viewpoint in Consensuall

C. Actions

Consensus decision-making is a process that involves deliberation, to make proposals, rate these proposals and reformulate or make new proposals [10]. In CONSENSUALL, each participant, (either user or agent) can post a general comment, make a proposal, comment proposals and rate proposals. These interactions are depicted as the *actions* "Comment", "CommentProposal", "Rate", "Propose" in Figure 1. These actions facilitate the deliberation (performed through messages and comments in the real-time collaborative environment) and allow the easy creation and rating of proposals.

The diagram in Figure 2 shows the design of the interaction triggered by one of these actions ("Proposal") in an INGENIAS "Interaction" viewpoint. That figure shows that a proposal interaction contains an initiator participant and many participants that collaborates in the interaction, meaning that a specific participant (either user or agent) makes a proposal and the others receive it and interact within this conversation ("ProposalConv").

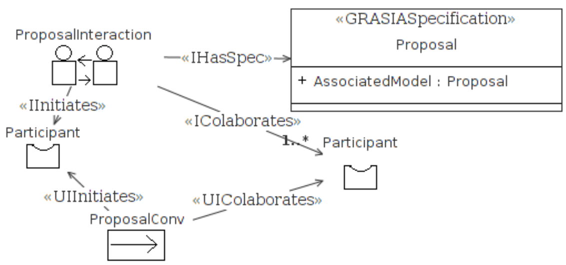

Figure 2. INGENIAS diagram of the "Interaction" viewpoint within a Proposal interaction.

The mentioned action *Rate* deserves special attention, and thus it is discussed in the following subsection.

D. Proposal rating

The possible ratings users can give to proposals have been chosen to facilitate consensus building. Similar to the options provided in Loomio [15] or dotmocracy [12], CONSENSUALL provides 5 rating options: *"Agree"*, *"Do not care"*, *"Do not agree"*, *"Block"* and *"Not decided yet"*. This set of options allows users to express their opinion about an specific proposal better than with a binary rating used by other tools. Among the rating options, distinguishing the block or veto [4] (different than "Do not agree") is a desirable feature in consensus building, since without it, a user cannot express that consensus has not been obtained yet. That is, a proposal is considered blocked just if one or more participants select the "Block" rating. A proposal with no Blocks is considered a valid resolution even if it contains "Do not agree" ratings, as by default consensus does not require unanimity. It should be noted that, as consensus is a collaborative process where opinions change, the ratings can be modified at any moment.

E. Proposed Agents

Two agent prototypes have been implemented to illustrate the interest of this resource in decision-making tools. One of the agents pursues the achievement of consensus while the other aims to encourage participation and good manners (Figure 1). The development of other interesting agents is discussed as future work (Section VI-B).

1) Consensus seeker: The "consensus seeker" agent (*ModeradorImpaciente* in Figure 1) aims to obtain consensus. To improve the odds of obtaining its goal, this agent writes a generic comment to participants *blocking* a proposal (see Section IV-D), in the case that such participant is the only one blocking the proposal. The design of this behavior can be observed in Figure 3.

2) Participation seeker: The "participation seeker" agent (*ModeradorParticipacion* in Figure 1) aims to boost participation in the decision-making process and to keep a polite discussion. In order to increase participation, it makes generic comments encouraging users that have not participated yet to vote and comment. In order to keep a polite discussion, it blocks proposals which have either rude words or orthographic mistakes, explaining in a proposal comment its reasons for blocking. When the "participation seeker" agent is asked to unblock a proposal by the "consensus seeker" agent, the former may tolerate orthographic mistakes (and thus it will unblock if requested) but will not tolerate rude words (and thus it will remain blocking until they are removed). See Figure 3 for a design diagram representing this behavior.

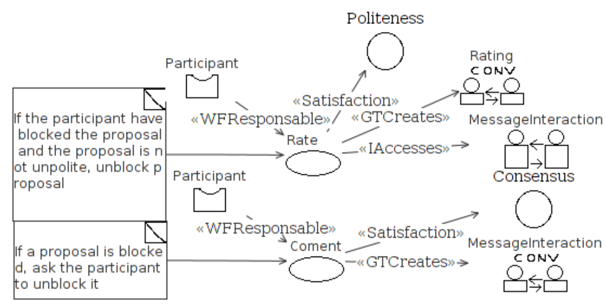

Figure 3. Part of the INGENIAS diagram of the "Goals/Tasks" viewpoint.

F. Agents and Webtool integration

Both Wave Robots (agents) and Wave Gadgets (decision-making webtool) are aware and react to changes in Gadgets state. Considering this, the integration among the agents and the decision-making tool is done through a shared data model of the state of the consensus decision-making process. Being aware of the data model and being able to perceive and create changes in the state, robots can, for instance, interpret a new proposal when it is inserted, or insert a proposal by themselves. Similarly, the webtool can also perceive when an agent performs an action and it may refresh its displayed information.

V. THE PROTOTYPE AT WORK

The presented design (see Section IV) has been implemented in an available working prototype [40]. This section presents the prototype, showing an example where the users and agents (Section III-A) interactions are explained.

A. Example of use

This section explores the users and agents interactions with the decision-making tool.

1) Starting: To start a decision-making process using CONSENSUALL, the prototype has to be included in a wave document/conversation as a gadget. In order to do so, its URL [40] has to be inserted in the Gadget Selector pop-up of any wave document/conversation. Participants of the wave can then invite agents as if she was inviting any other user (these agents must be previously registered with their own username in any Wave server).

2) Proposing: To insert a proposal, participants should provide a title of the proposal and a description. Once a proposal is done, participant can rate it as discussed below. The proposal insertion dialog is located in the upper part of the GUI (see Figure 4).

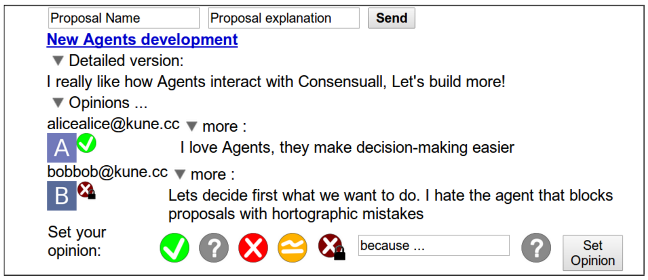

Figure 4. CONSENSUALL User Interface of a new proposal

3) Rating and commenting a proposal: Participants can rate and comment a proposal. Participants should select their rating to the proposal and may insert an optional comment. Figures 6 and 7 show ratings and opinions by one of the agents.

4) General comments: Comments can be added in the wave conversation as it is usual in waves. Figure 5 shows a comment done by "Consensus seeker" agent reacting to previous user interactions in Figure 4.

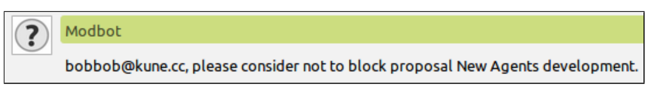

Figure 5. "Consensus seeker" agent asking a user not to block a proposal.

B. Agents interaction

This section presents an example of a non-trivial agent interaction and is illustrated by image captures of the prototype. A description of the behavior of the developed agents can be found in Section IV-E. Both "consensus seeker" and "participation seeker" agents are used in this interaction example.

The interaction starts when a participant makes a proposal with orthographic mistakes. This triggers the following sequence of agent interactions:

1) "Participation seeker" agent, in order to achieve the goal "politeness"(see Figure 1), blocks the proposal, writing a comment in the proposal requesting to rewrite it.
2) "Consensus seeker" writes a comment (analogous to comment of Figure 5) asking "participation seeker" not to block the proposal (as it is the only participant blocking it).
3) "Participation seeker" agent unblocks the proposal after "consensus seeker" agent's message and changes its comment to the proposal (see Figure 7).

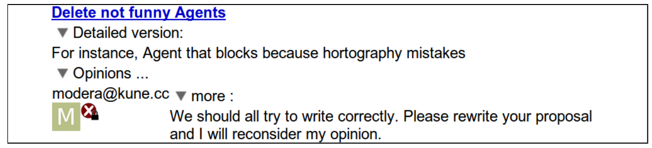

Figure 6. "Participation seeker" agent blocking a proposal.

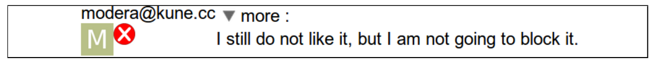

Figure 7. "Participation seeker" agent rating a proposal.

Direct communication among agents, such as the shown message asking other agent to unblock the proposal, could be enhanced by the definition of an *agent communication language* for the proposal domain. This feature is considered as future work (Section VI-A).

VI. CONCLUDING REMARKS

A. Conclusion

The article presented CONSENSUALL, a prototype of a collaborative consensual decision-making webtool. CONSENSUALL provides a decision-making environment where users can elaborate, rate and comment proposals. Additionally, the application allows the introduction of software agents as automatic participants to address common consensus decision-making issues, inspired by the roles adopted in offline assemblies.

The webtool has been designed with an AOSE [9] perspective and software tools (INGENIAS). The use of such tools and methodology have facilitated the development, providing useful concepts and abstractions for the design and conception of the application.

The technology used fits the needs of CONSENSUALL approach. Apache Wave [32] provides a real-time collaborative environment that favors collaboration, needed in a deliberative decision-making process. Wave Gadgets [37] facilitate the development of webtools that may be inserted in wave conversations and shared among participants, and thus it is suitable to build the decision-making prototype. Wave Robots [38] allow the development of software agents as participants, as the article shows with two examples. Their easy development and insertion in the environment makes them a valuable option for a modular improvement of the application.

The results state the feasibility of the proposal, constituting a proof of concept for the future development and research identified in the next subsection.

B. Future Work

The most obvious future research lines point towards scaling consensual decision-making [8][41] and exploring the implementation of different forms of consensus [4] or even other decision-making methods (see Section II-A).

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As proposed above, the tool may be extended by the development of new agents, that can be identified in collaboration with users and communities. Examples of some other agents may be: elaborated versions of the two proposed agents; an "egalitarian participation moderator" that points out unbalances in participation (i.e., low participation of female participants or minorities) and encourage the group to solve this issue. The development of an *Agent Communication Language* (for instance, compliant with the FIPA ACL standard [42]), as proposed in Section V-B, would allow interesting interactions among agents.

Some additional improvements, such as its GUI or wave integration or the use of visualization tools, may transform this prototype in a usable webtool for standard users, allowing to make experimentation in real communities. Thus, this would allow further exploration of the potentials of the CONSENSUALL consensus decision-making webtool and its associated software agents, allowing to asset the adequacy of the tool and agents to improve the desired characteristics of consensus decision-making such as democracy, diversity, quality of the decision or required time.

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