

An empirical study of groupware support for requirements negotiations in distributed software development

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Abstract

This paper addresses groupware support for synchronous Requirements Engineering in distributed software projects. Empirical evidence is reported on the group performance of decision-making groups involved in requirements conflict resolution, in face-to-face and distributed software development settings. Lessons learned from a laboratory study are presented and issues that require further investigation are discussed.

INTRODUCTION

The problem addressed in this research is of computer support to facilitate requirements negotiations in distributed software development environments. The requirements conflicts and tradeoffs, and the challenges that distributed software development brings to effective requirements negotiation are critical aspects of software engineering. We, as software engineers, need to understand them better. This understanding should consider people and performance issues, the group dynamics, human-computer dynamics and the human-to-human dynamics that is intermediated by groupware systems.

Software engineering involves compromises. Software requirements represent the interests of a wide range of stakeholders of the system (which may be conflicting or contradictory) and the final system requirements are inevitably a compromise between them [13]. Although conflict and negotiation have been recognized as critical aspects in managing the requirements throughout software development [12], we lack a good understanding of conflict and its multifaceted nature in software development. While technical approaches to requirements engineering are largely concerned with formal processes for describing, representing and analyzing requirements, the human processes leading to these requirements have not been studied to the extent merited by their practical importance. System development is a complex social phenomenon and the use of research methods that investigate organizational and human behavior issues in RE is important for understanding processes leading to conflict resolution [9].

As organizations move towards more globally distributed structures, distributed software development poses new challenges to an effective communication and negotiation

of requirements (i.e. releasing relevant participants to attend requirements meetings at remote sites has become problematic [1]). Thus the combination of distributed software development processes and the importance of involving all relevant stakeholders in requirements meetings leads to a pressing need for investigations of groupware systems to support such processes. Further, developing an understanding of how stakeholders reach resolution in distributed requirements negotiations demands thorough empirical investigation.

Empirical studies of multimedia meeting systems are important because, although the use of videoconferencing-based systems in organizations is documented (e.g. [8]), we are just beginning to understand groups using computer technology in distributed requirements negotiations [3]. The technological impacts on groups' performance and behavior in distributed requirements negotiations is largely unknown.

What makes it even more interesting is that media effects theories [5,11,13] predict that groups engaged in negotiation tasks perform best in rich communication media such as face-to-face meetings. The reduced richness of social behaviors available in 'leaner' communication medium such as videoconferencing systems or text-based systems is believed to impact the groups' performance.

Thus questions that require thorough empirical investigation in computer-mediated requirements negotiations include "does group performance change when requirements are negotiated through a different communication medium than F2F meetings?". From a socio-psychological perspective, "do stakeholders with different (conflicting) requirements manage conflict differently when physically separated or co-located?", or "Is the human facilitation of these negotiations affected by the communication medium used?".

There is the need for further development in empirical software engineering to address these questions. It is important to determine potential problems or opportunities in computer-mediated distributed requirements meetings and to inform the design of meeting systems to support distributed requirements negotiations and their human facilitation.

This paper reports on our ongoing efforts in investigating the effectiveness of multimedia meeting systems for requirements negotiations in virtual software enterprises.

An exploratory study is conducted in the laboratory setting, to gain a preliminary understanding of the phenomena in a controlled environment. Not only is Software Engineering a young field that benefits from more experimentation, but also complex phenomena such as groups using computers in requirements negotiations are difficult to study in field settings. Reasons for favoring laboratory experiments over other methods in field settings include (1) lab experiments make possible the careful observation and precise manipulation of independent variables (e.g. computer technology), allowing for greater certainty with respect to cause and effect, while holding constant other variables that would normally be associated with it in field settings and (2) encourage the researcher to try out novel conditions and strategies in a safe and exploratory environment before implementing them in the real world.

Our empirical study explored several settings of customer-developer computer-mediated links. The groups' performance in the distributed settings was compared to that of face-to-face groups. Evidence shows not only that groups in computer-mediated communication reached performed as well as the face-to-face groups but also that one distributed setting was particularly conducive to integrative agreements of high quality in the requirements negotiation. The collection of both quantitative and qualitative data provided a rich picture of the use of the groupware and its impact on the group performance and behavior. It enabled us to frame recommendations for the design of multimedia meeting systems and for the design of virtual software enterprises to conduct effective requirements negotiations at a distance.

The paper is structured as follows: A brief description of study design is followed by a summary of the empirical evidence. The study findings are presented as lessons learned in the investigation of a multimedia meeting system in support of distributed requirements negotiations. Implications for software industry practitioners are discussed, limitations of the study acknowledged and future research directions presented.

STUDY DESIGN

The experimental task illustrated the design of a banking management system with limited project resources (development time). Two users (banking employees) represented two different organizational units and had different requirements on the system. Given the time constraint, the fulfillment of all requirements was not possible and that triggered the need for negotiation. Both system users (negotiators henceforth) were presented with a description of their job operations at the bank, which allowed them to negotiate system requirements that would enable the performance of these operations. The task provided priority information for these operations and had integrative potential. Their negotiation was assisted by a

system analyst and a professional facilitator. The system analyst was provided with necessary information to assess the feasibility of implementing the agreed system requirements.

The experimental group settings are illustrated in Figure 1 and featured (1) the face-to-face meeting (F2F), (2) the physical separation of the two negotiators (D1), (3) the co-location of the two negotiators at one site (D2), (3) the co-location of the two negotiators with the facilitator (D3) and (4) the co-location of the two negotiators with the system analyst (D4).

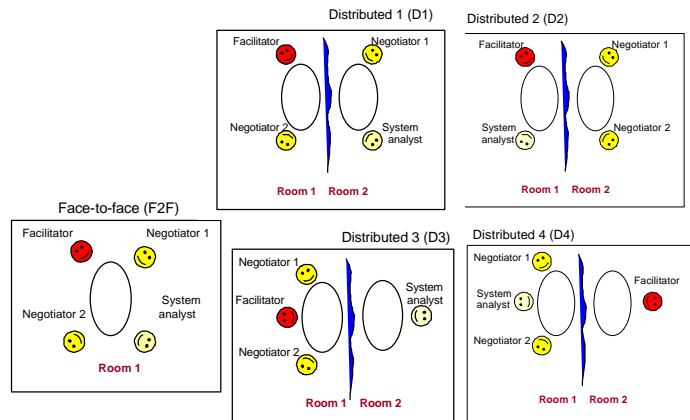


Figure 1. Face-to-face and four distributed requirements settings

Fifteen three-person groups of students from the University of Calgary were randomly assigned to roles and face-to-face and distributed conditions. Each of the three professional facilitators mediated one group in each condition. The software requirements session was presented as a scheduled meeting of 40 minutes. The sessions were ended after 40 minutes and the participants completed a post-session questionnaire. Interviews were held with participants and facilitators.

The computer technology was Microsoft's NetMeeting, with full video/audio and shared files facilities (Figure 2). The participants used noise-canceling microphones. The task was electronically mediated through WordPad within NetMeeting, to reflect the alternatives chosen during the negotiation.

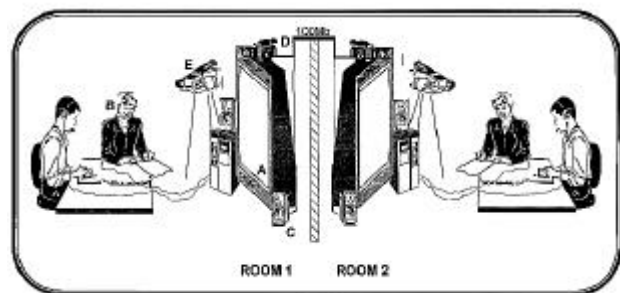


Figure 2. Computer technology in the distributed settings

EMPIRICAL EVIDENCE

Three main aspects were investigated: (1) group performance, (2) interpersonal relationships and (3) human facilitation of requirements negotiations.

The group performance was conceptualized as the *decision quality*, i.e. an objective evaluation of the final agreement in the negotiation. The decision quality illustrated the extent to which the agreements were integrative of the negotiators' most important interests and provided equal benefit in the negotiation. A summary of the results is presented in the box below.

Five different types of agreements were recorded in the study, and arranged on an ordinal scale as follows:

- A: most integrative agreement, optimal feasible outcome;
- B: less integrative agreement; greater benefit for one negotiator
- C and D: less integrative agreements, which compromised critical requirements important to both negotiators, and
- F: no agreement was reached within the allocated time.

Table 1. The distribution of agreements across all group settings

	F2F	D1	D2	D3	D4
Facil. 1	A	A	C	B	A
Facil. 2	F	A	B	B	D
Facil. 3	B	A	B	D	F

The interpersonal relationships were evaluated by the participants' judgment of their partners (except the facilitator) on 13 five-point scales such as: 'polite', 'dominant', 'sociable', 'emotional', and others. *Local* participants were rated as more trustworthy, emotional, argumentative and competitive than those encountered remotely through computer conferencing. A detailed discussion of the results on the decision quality and interpersonal relationships is included in [6]. A discussion of the evidence on the human facilitation of the distributed requirements negotiations can be found in [7].

Here we discuss in detail the lessons learned from this study, the practical implications of its results and recommendations for virtual enterprises to facilitate distributed requirements negotiation sessions.

LESSONS LEARNED

The analysis performed on the decision quality revealed that groups in F2F did not perform better than groups in any of the distributed settings. Further, the frequency of the most integrative agreements (type A) in distributed setting D1 (where the two negotiators were physically separated) was significantly greater than in all other distributed conditions combined, where the two negotiators were co-located (i.e. D2, D3 and D4) (Fisher test, $p=.018$).

Group performance in F2F was no better than in distributed group settings. This finding does not support the predictions of media effects theories [5,11,13]. In this study, the use of a 'less rich' communication technology, i.e. the multimedia meeting system provided in NetMeeting, did not result in a decrease in the group's performance, conceptualized as the decision quality. This indicates that there is a need for better media effects theories that analyze the capabilities of and opportunities offered by newer media such as multimedia meeting systems.

Remote collaboration of the two system users benefited the negotiation. An exploratory approach was taken in the investigation of the physical separation of negotiators. The evidence shows that their physical position in the distributed conditions impacted the quality of the agreement; the remote collaboration was most conducive to the achievement of agreements that incorporated the most important interests of both negotiators and offered equal benefit in the negotiation. The data on the interpersonal relationships combined with the anecdotal data from interviews suggests that the computer-mediated communication enabled an enhanced task-oriented interaction in the distributed settings. This resulted in a more rational approach to conflict resolution and an enhanced ability to stay objective in the negotiation.

Further, the co-location of the two negotiators was found as helpful but not beneficial. Evidence was found that suggests that interaction in close proximity was more intense and interpersonally involving, to some detriment to the negotiation. Participants' comments indicate that face-to-face interaction made them less willing to voice opinions and suggestions, less objective and created feelings of sympathy or compassion for the co-located negotiator.

Human facilitation of distributed requirements negotiations was possible. In Requirements Engineering, the role of facilitator in distributed teams is still subject for discussion and largely under investigated. The three panelists (experienced facilitators) at the ICRE'98 [10] debated the notion of conducting requirements as a distributed team and considered that face-to-face meetings were essential to effectively manage conflict as it arises. In this study, the focused inquiry into the facilitation of both face-to-face and

distributed settings enabled the description of problems caused by the restriction of the communication medium. However, aspects that were beneficial to facilitation in the computer-mediated settings were also found, together with some 'facilitation tools' in the medium itself. A perceived detachment from the group interaction and the slowing down in the computer-mediated conversation enabled an enhanced ability to stay objective in the meeting and assist the group process.

Initial face-to-face contact before the computer-mediated meeting is important. Evidence was found that meeting the collaborators before the videoconferencing was important in getting to know each other, in getting a sense of physical stature and in establishing relationships of trust between the negotiators.

A combination of quantitative and qualitative data collection procedures is important in obtaining a complete picture. In this study, the use of quantitative approaches in assessing the decision quality and interpersonal relationships was complemented with interviews and open-ended items in the questionnaire. The anecdotal data provided information on aspects of the computer – mediated settings that made the quantitative data come alive and provided a rich picture of the complex phenomena. Explanations of the results on the decision quality and interpersonal relationships in isolation from the qualitative data would not have been possible.

Implications for the software industry practitioners. Conflict is endemic in system development, and requirements conflict resolutions and negotiations are aspects least understood in software development. The study findings represent a significant step in building knowledge based on empirical and experimental evidence of what works and does not work, and under what conditions, in distributed requirements negotiations. The computer technology that incorporated real time conferencing capabilities successfully supported the negotiations in distributed settings. Contrary to the belief that negotiations are not as effective when carried out over videoconferencing systems, these findings suggest new opportunities for computer-mediated requirements negotiations. Software industry practitioners need to be aware of this potential when making decisions about computer technology to facilitate requirements conflict resolutions in distributed settings, such as 'distributed JAD meetings'.

Also, in this study the requirements negotiation task was designed as a scheduled meeting of 40 minutes. As long as the resources that make computer-mediated requirements meetings possible are only available for a pre-determined amount of time (e.g. the videoconferencing room is scheduled for an hour), these results are relevant to virtual software development enterprises. They suggest that the apprehension in using videoconferencing systems for

conflict resolution tasks in requirements meetings is no longer justified if shared application channels are added, which is possible in an era of "multichannel" computer-mediated communication.

Recommendations for multimedia meeting system design. This study investigated a system that incorporated audio and video channels, and real time file sharing capabilities. Based on the evidence found we recommend that the design of meeting system to support groups negotiating requirements in virtual software enterprises include a high quality audio channel for the synchronous interaction in the distributed setting. Also, access to a visual space that consists of at least two video feeds, e.g. the image of the remote participants and real-time sharing of task objects (i.e. the list of requirements to be negotiated in this study) is also important to creating a rich communication channel that affords greater mutual understanding in the negotiation of requirements.

Issues that need to be investigated further. As with any controlled experiment, caution should be exercised in extrapolating the results from this study to all users of such multimedia meeting systems in distributed software enterprises. Although participants were randomly assigned to experimental conditions (roles and group settings), factors that could have confounded the results include personality, gender and level of acquaintance.

Also, an important methodological issue facing laboratory studies of negotiation tasks relates to the fact that the processes and outcomes of such studies can be affected by whether or not participants' personal views are consistent with the case they are asked to argue. To alleviate this problem, the task in this study provided a clear description of the experimental roles and the participants' understanding of the views associated with such roles was validated with each participant.

However, future studies are needed to address these issues in diverse study settings.

FUTURE RESEARCH

Future studies are needed to overcome the weaknesses of the current study, some discussed above. First, one limitation is that of a relatively small sample size. Thus, a possible direction for future research is to replicate the same experimental situation with a larger sample size and observe whether the same results are obtained.

Similarly, the use of students in the laboratory setting is noted as a limitation of this study. A distinction between experimental and field studies in negotiation situations has to do with human participants and their working relationships, and the motivation that the participants have (or they are told they have) to negotiate in the study. This difference is related to studies "in vitro" vs. "in vivo". As Basili notes [2], A sign of maturity in experimental

Software Engineering is the move towards field studies rather than controlled laboratory settings. Once an understanding of the phenomena is achieved in the controlled environment, attempts could be made to tackle less controlled settings. Field experiments, as field studies with one major intervention, are a natural step towards studies of settings with greater realism of software development projects. For example, condition D1 was identified as most conducive to negotiation in distributed requirements negotiations in this study and its further investigation in the field is worthwhile and important.

Finally, the present study did not investigate computer technology that incorporated explicit support for the negotiation process. Future studies are important that examine multimedia meeting systems that incorporate systems such as WinWin [4].

CONCLUSIONS

This paper reported on our ongoing research in building a body of knowledge about groupware support for distributed requirements negotiations. The lessons learned from a laboratory study that compared the group performance in face-to-face and computer-mediated requirements negotiations were presented. Issues that need further investigation were outlined and are intended to foster discussion during the workshop.

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