An extended abstract of this paper is published in the Proceedings of the Fourth International Conference on Requirements Engineering (ICRE), June 2000.
A short version of this paper appears in the May issue of IEEE Software, as one of the best papers selected at ICRE2000

Group performance and distributed requirements negotiations

Daniela E. Herlea Damian[1], Armin Eberlein[2], Mildred L.G. Shaw[1] and Brian R. Gaines[1]
University of Calgary, 2500 Univ. Dr. NW, AB T2N 1N4, Canada

[1]{danah, mildred, gaines} @cpsc.ucalgary.ca
Department of Computer Science

[2]eberlein @enel.ucalgary.ca
Department of Electrical Engineering

Abstract

In recent years, distributed development has become more and more common practice. As a result, investigations into the efficacy of distributed meeting systems in supporting group work in requirements engineering are needed. This paper reports on the results of a laboratory experiment in which video-conferencing and computer support were used in requirements negotiation. The study used a requirements negotiation task and compared the performance of local groups to those in four distributed configurations of the design team. Contrary to the belief that face-to-face contact increases performance, our findings suggest that groups in face-to-face meetings performed no better than the electronically mediated groups. Moreover, we identified a particular distributed group configuration that significantly improved performance across all distributed conditions and was qualitatively more conducive to requirements negotiation than face-to-face meetings. The results suggest that the electronic mediation reduced the transmission of socio-emotional cues in the interaction, thus enabling groups to have a more rational approach to conflict resolution in requirements engineering.

Keywords: requirements negotiation, group performance, video-conferencing, empirical investigation

1 INTRODUCTION

Although the critical aspect of effective communication among the stakeholders of a software development project has been noted more than a decade ago [6], more recent empirical studies show that it continues to be a challenge for requirements engineering (RE) [1,13]. In particular, the communication among system analysts and a wide range of stakeholders, as well as the need to reconcile conflicting viewpoints through negotiation have been recognized as major problems of RE [11,14,15,21,31].

As organizations become more global, requirements often come from distributed groups, and facilitating their communication at a distance becomes a new challenge [17]. Groupware technology has provided some support for distributed RE in general [16] and for the modeling of multiple perspectives in particular [4,11,31]. Nowadays however, the organizations are offered a sophisticated array of communication media, integrating different combinations of media such as video, audio and computer support for specifying requirements at a distance. The RE community would therefore benefit from more experimentation [32] and evaluation of these communication media, as well as from a better understanding of their roles in facilitating social processes in requirements engineering.

Although theories of media effects argue that face-to-face meetings are the richest communication medium for complex human processes (such as negotiation) as they allow the transmission of a full range of social cues [7,34], some empirical studies indicate that these processes are actually improved when individuals are physically separated and communicate through less rich communication media [19,36].

Questions in requirements engineering that need further investigation are whether the group performance improves when the design team communicates through a less rich communication medium that integrates video, audio and shared electronic files (henceforth referred to as computer conferencing). From a socio-psychological perspective, do stakeholders with different (conflicting) requirements/perspectives manage conflict differently when physically separated or co-located? These unanswered questions illustrate that, although the technology may be impressive, little systematic research exists on its social and psychological significance in requirements engineering.

We seek to investigate the efficacy of computer-conferencing in supporting group work in RE, in comparison to face-to-face meetings. In this paper, we report on results of a laboratory experiment of the effects of (1) communication media and (2) different physical configurations of customers and developers, on group performance in requirements engineering. We employed a mixed-method research approach that makes use of both quantitative measures of group performance as well as qualitative inquiries into the groups' behavior in computer-conferenced meetings.

The following section presents relevant research in (1) multiple perspectives in distributed requirements engineering and (2) media effects on group task performance in negotiation situations. We then describe our exploratory investigation: the research method and its design. The results are presented, interpreted and discussed. Finally, future directions in distributed requirements engineering research are discussed.

2 RELATED RESEARCH

2.1 Requirements engineering

Delivering systems that meet all stakeholders' requirements is easier said than done in a software development world in which resource constraints are everyday realities. This becomes an even bigger challenge when the customers do not have a single "voice" [27], which results in the need to analyze and negotiate conflicting requirements elicited from different stakeholders. This has led to extensive research in the identification, representation, analysis, management and integration of the different viewpoints of the stakeholders [11,14,21]. A comparison of existing approaches (see [9] for an extensive review) shows that about half of these approaches have some support for the management of conflicts and inconsistencies, while only very few approaches support viewpoint integration. Dealing with multiple viewpoints, however, requires the consideration of social issues of the group process [9], and none of these approaches addresses these issues in the negotiation between conflicting stakeholders' goals.

In this research we used Easterbrook's [11] definition of conflict, in which conflict arises because of differences between the goals and desires of participants in the system development process. Negotiation becomes an essential part of system specification: users negotiate amongst themselves and with analysts [31] and trade-offs are needed for a resolution of conflicts [27]. Field studies show that conflict between different user groups is a significant threat to the success of a software project [36]. Often stakeholders are from competing organizational units of the same company. The reward structure of a company makes negotiation more difficult since individuals are being rewarded and promoted on the basis of their performance [26]. When specifying requirements for a system, this may result in users acting in their own best interest to do whatever it takes to improve the performance of their particular business unit, even if it is harmful for other units or the overall company. Although such situations provide opportunities for integrative agreements in which parties can maximize joint gains without competing for resources in a direct win-lose fashion, the design team often settles instead for suboptimal compromises rather than searching for mutually beneficial agreements. Some models of requirements negotiation have been developed [4,11,31], but the emphasis is largely placed on the automation of conflict identification and resolution with little attention to the socio-psychological aspects of the group process.

Although the use of computer-mediated technology for distributed software engineering is becoming not only a necessity but a reality, there are not many empirical studies of such systems being applied during distributed requirements engineering. Empirical studies include analyses of how topics change and how the participants' understanding evolved during email-based requirements elicitation [22]. Boehm and Egyed also report on empirical investigations into the effects of the WinWin system [3] on requirements negotiation behavior.

We believe that our work builds and extends upon existing research in distributed requirements engineering, contributing to a multi-disciplinary facet of it [27] by empirically investigating the effects of communication media on group performance in requirements negotiation.

2.2 Media effects on group task performance

Beginning with the classic studies by Chapanis [5], behavioral researchers and computer scientists have gone a long way in investigating how people use different communication media for different tasks [7,23]. Media richness theory (MRT)[7] has been the most prominent theory of media choice over the last twenty-five years. It draws on organizational information processing premises and defines the medium's richness as its information-carrying capacity, in terms of feedback, channel, source and language. Five communication media (face-to-face, telephone, letters, written documents and numeric documents) have been fit on a continuum, with face-to-face being the 'richest' and numerical documents the 'leanest'. MRT argues that organizations process information to reduce uncertainty (lack of information) and equivocality (ambiguity, multiple and conflicting interpretations). Its fundamental claim is that the task performance improves when a medium with the appropriate richness is selected: equivocality reduction requires rich media, while uncertainty reduction occurs best in lean media. Over the years, extensions to MRT adapted this continuum to include newer communication forms such as computer-mediated and video-based media (e.g. [20,30]); face-to-face however, remained the "richest" communication medium.

Overall, however, empirical tests have not provided strong and convincing support for MRT. Recent empirical studies indicate the poverty of MRT to account for the media choice between newer media such as electronic mail and voice mail in organizations [12]. One critique of media capacity theories is that much of the empirical research that supports its predictions has focused on media perception or media choice, not on the effects of media on objective task performance. Although McGrath's Time, Interaction and Performance (TIP) theory [23] considers this issue, it still includes a mapping between task performance requirements and media richness in a manner consistent with that of MRT.

Empirically however, when the objective performance for equivocal and cognitive conflict tasks has been tested [19,35], little or no support has been found for the claims of MRT or McGrath's TIP. While the theory indicated that "tasks requiring groups to negotiate and resolve conflicts of views or conflicts of interests may require the transmission of maximally rich information" ([24] pg. 92), in practice the objective performance for the face-to-face condition was lower than in other media used (e.g. video phone, telephone and computer-mediated communication) [19,35].

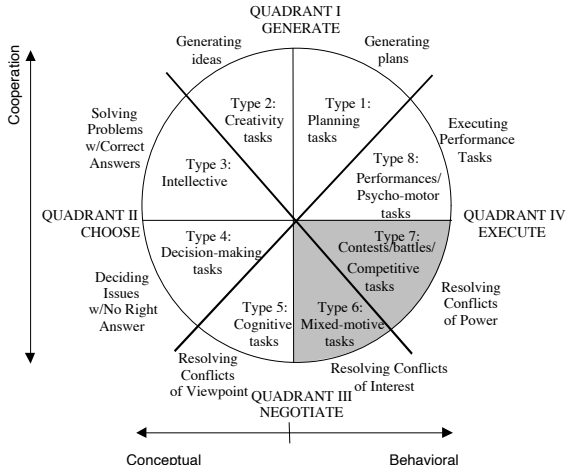
In the area of group decision making in particular, reduced socio-emotional communication can in fact enhance group work [36]. Complementing the findings on task performance, research into the socio-psychological aspects of telecommunications and computer-mediated communication (CMC) [18,34,36] provide some insights into these controversial empirical findings. It was found that computer-mediated decisions are less influenced by social norms and pressures than face-to-face group decisions [25], and group decision support systems appear to achieve useful group-level outcomes by dampening interpersonal communication. Interpersonal relationships (i.e. perception of one's partner) are seen as critical in conflictual situations [34] and represent another testing ground for theories of media effects. Laboratory studies of negotiation tasks found that participants rated their partners differently across several communication media such as face-to-face, video and audio systems [34,38].

The greater task orientation of CMC (for a review see [36]) is seen as a potential boon for the medium, where "computer conferencing ... promotes rationality by providing essential discipline (task orientation, coordination, equality of participation, etc.), by filtering out affective components of communication and emphasizing the content, minimizing social influences (influence of status, interpersonal 'noise', and so on)" ([10] p. 381).

In face-to-face RE, we expect that socio-emotional concerns such as conflict or relationship management among the design team members would take time and effort away from task resolution. The question is then, would a less rich media (such as computer-mediated) act as a mechanism to reduce the need to expend effort in managing interpersonal relationships and therefore enhance the group performance during requirements negotiation.

2.3 Present investigation

In order to address this question we designed a simplified scenario that illustrates the conflict between requirements scope and resource constraints. It involves the communication between a system analyst and two representative customers, socially mediated by a facilitator. The two customers are from two different organizational units and have different perspectives of the system to be developed. The system analyst represents that it is not possible to implement the system in the given time frame. Therefore the customers need to agree on a subset of the original requirements to accommodate the time constraints. This triggers the need to resolve conflicts between the needs of the two customers. This task is consistent with McGrath's [23] equivocality and task circumplex conceptualization (figure 1) and can be classified as a combination of types 6&7.



In order to evaluate the efficacy of computer-conferencing systems for requirements negotiation and their effects on interpersonal relationships we compared the face-to-face with distributed, computer-conferenced meetings, using the scenario described above. Because there are no definite results in the literature, it makes it difficult to formulate hypotheses. Therefore we designed an exploratory investigation with the following goals:

1) to investigate the effects of communication media on group performance in requirements negotiation. We vary the communication medium from face-to-face communication (figure 2a) to distributed, computer-conferenced communication (figure 2b).

Within the distributed condition, we defined four "group settings" distinguished by different physical configurations (figure 2b, D-1 to D-4). These were chosen to vary the relative location of the two customers, the system analyst and the facilitator. Our purpose in including the facilitator is to examine potential changes in

the facilitator's behavior in distributed conditions compared to face-to-face meetings. Future work will report on media effects on the facilitation style in such group settings. Therefore, our second goal was:

2) to investigate the effects of group setting on group task performance within the distributed condition.

We were interested in identifying a particular group setting that is conducive to requirements negotiation and maximizes the group performance.

In describing and analyzing the quality of group performance (resolution of conflicting perspectives) we used general concepts from negotiation literature [29]. Negotiation behavior can be distributive or integrative. While distributive behavior reflects the situation "your loss is my gain" (here: only one customer perspective is supported by the system), integrative behavior consists of incorporation of opposing proposals, communication of goals and constraints, as well as searching through extreme alternatives and multiple issues [29,31] (here: the incorporation of both customer perspectives to support the overall business goal). In exploring the potential for an integrative behavior, numerical weights are used to account for the relative importance of each issue in discussion.

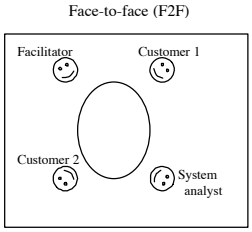


Figure 2a. Face-to-face communication

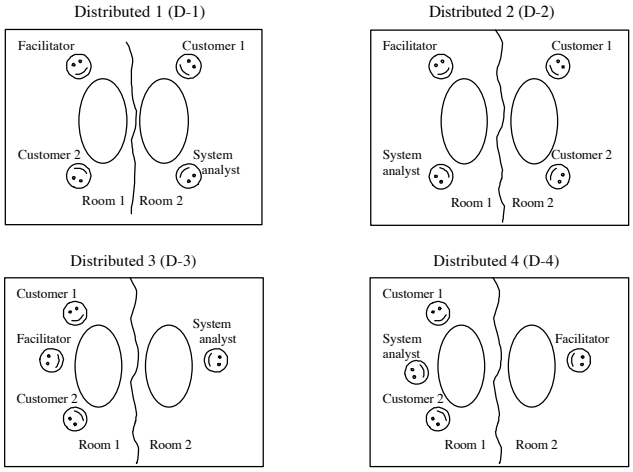


Figure 2b. Four physical group configurations within the distributed communication setting

3. METHOD

3.1 Subjects

Forty-five volunteers from the student population of the University of Calgary took part in this study, 16 females and 29 males. The participants ranged in age from 19 to 44. The prerequisite for their participation was experience in software engineering and/or negotiation. They gave informed consent and were paid for their participation. Three professional facilitators volunteered to mediate these meetings.

3.2 Materials and Design

3.2.1 Equipment

In designing any experiment of this nature a large number of decisions have to be made concerning the equipment used. As the goal of this study was to investigate the effects of multimedia meeting systems currently used by the software industry in remote collaborations, this study used widely available meeting technology (Microsoft's NetMeeting system with full video/audio and shared files facilities).

Figure 3 depicts the equipment configuration in the distributed conditions. The two rooms were connected such that the images and sounds from one room were transmitted with high quality to the other via audio/video conferencing facilities (an 100Mb Ethernet link was used). Further, the task was electronically mediated through a shared editor to reflect the results of the negotiation and displayed on both electronic displays. Therefore, all groups (including F2F, figure 2) used the shared editor in completing the task.

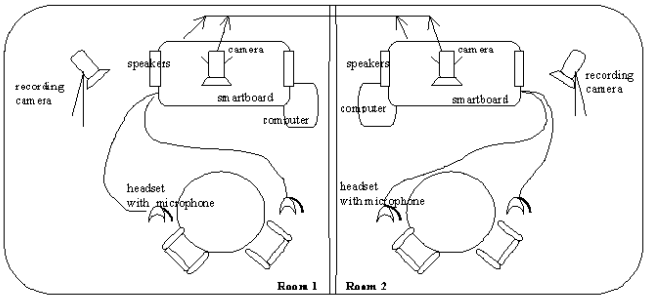


Figure 3. Equipment used in the distributed condition

3.2.2 Task

The scenario proceeds as follows. Two customer representatives and one system analyst are involved in defining a set of functional requirements for a banking management system. The overall business goal in using the system is to provide efficient face-to-face service to the bank's clients. The system development time is non-negotiable and fixed at 21 weeks. The customers, a Teller and a Personal Banking Representative (PBR), are given an initial list of requirements (all 12 requirements in figure 5) elicited at a previous meeting in no particular order of importance. An analysis of the requirements by the system analyst has shown that the implementation of all 12 requirements is not feasible given the fixed development time.

The Teller and PBR are each presented with a description of their own job responsibilities at the bank summarized in figure 4. As can be observed, the customers represent business units that perform different operations on the clients' accounts: the Teller provides services to the bank's clients on a "walk-in" basis, with respect to banking (chequing/savings) accounts; while the PBR provides services on an "appointment", more personal basis, being concerned with credit (loan/mortgage/credit card) accounts.

The system analyst is given only the information on the number of weeks (in brackets, figure 5) required for the implementation of each of the 12 initial requirements. The system analyst suggests that the implementation be limited to only the first 8 requirements (see dotted line in figure 5). The group is then asked to consider the requirements selected by the analyst: if these eight requirements are not agreed upon as being helpful in aiding both customers do their jobs efficiently, they are asked to agree on another set of requirements.

Each requirement in figure 5 refers to one or more operations in figure 4, and each operation can be completely fulfilled by the implementation of one or more requirements. For instance, operation TC2 (which is the same as LM1) can be fulfilled by the implementation of either requirement R5 or both requirements R7 and R10. On the other hand, requirement R11 refers to both operations LC4 (which is the same as TM1) and TH1.

We aimed for a real-life task that is highly equivocal, in which each customer has detailed domain knowledge of only the operations performed by his/her own business unit. The only common piece of knowledge the participants had was the initial list of 12 requirements, and only through discussion did they discover the complex interrelationships between operations and requirements. There was the need to exchange information to understand the relative importance of requirements (e.g., R5 is regarded as very important by Teller while not important at all by PBR), and to explore alternatives in order to reach a mutual agreement.

The system analyst was the only one with the ability to estimate the development time for each requirement. Any subset of requirements chosen by the customers had to be discussed with the system analyst in order to determine the feasibility of implementation, given the time constraint.

During the pilot sessions (reported in [8]), the task was validated with a bank officer to confirm the validity of the task and was refined with three experienced software engineers to ensure a sufficient level of conflict.

	Customers	
	Teller Representative	**Personal Banking Representative**
Critical operations	TC1. Browse client's list of accounts TC2. Access client's banking accounts profile (owner, date created, balance) TC3. Access client's credit accounts profile (owner, date created, balance) TC4. Pay bills, deposit/ transfer/withdraw funds	LC1. Open/inactivate accounts LC2. Update terms of credit accounts LC3. Browse client's list of credit accounts LC4. Obtain history of transactions on client's credit accounts
High priority operations	TH1. Obtain history of transactions on client's banking accounts TH2. Obtain list of due dates on client's credit accounts TH3. Order new cheques	LH1. Access client's credit accounts profiles (owner, date created, balance) LH2. Obtain payments overdue on client's credit accounts LH3. Obtain credit rating from an external agency
Medium priority operations	TM1. Obtain history of transactions on client's credit accounts	LM1. Access client's banking accounts profile (owner, date created, balance)
No authority/ responsibility to perform	TN1. Open/inactivate accounts TN2. Update terms of credit accounts	LN1. Pay bills, transfers, deposits. LN2. Order new cheques

Figure 4. Job descriptions of the teller and PBR sorted according to priority.

(1) R1. The system shall enable the open/deactivate accounts (**banking**/**credit**) operations.
(3) R2. The system shall display a screen showing history of transactions on **banking** accounts for the last 3 months.
(2) R3. The system shall enable the ordering of cheques on line
(2) R4. The system shall automatically provide **credit** rating from an external agency.
(3) R5. For each **banking** account, the system shall display detailed information on the account: owner(s), date created and balances.
(3) R6. The system shall enable transactions such as: deposit/withdraw/transfer/payment
(4) R7. The system shall display a screen with a profile of *all* accounts with information on owner(s) and date created.
(4) R8. The system shall enable the updating of terms of **credit** accounts (e.g. grant credit, change payment terms).

---

(4) R9. For each **credit** account, the system shall display detailed information on the account: payments overdue, owner(s), date created, and balances.
(3) R10. The system shall display a screen with information on client's due dates, liabilities (for all **credit** accounts) and assets (for all **banking** accounts).
(2) R11. The system shall display a screen showing history of transactions on *all* accounts a client holds, for the last month.
(2) R12. The system shall display the list of *all* accounts a client holds.

(the system analyst was informed that the implementation of R3&R4 together require only 3 weeks)

Figure 5. The list of 12 initial requirements

3.2.3 Procedure

Participants were informed of the nature of the task prior to the study. A one-page set of instructions on the role was distributed and the need to become familiar with the role was explained. During the briefing period the understanding of the role was validated with each participant. They were introduced to their partners and completed a warm-up task designed to familiarize the participants both with each other and with the medium. Then they started the software requirements session, which was presented as a scheduled meeting of 40 minutes. Each facilitator mediated a series of five group interactions, one in each setting in figure 2a/b. Each group participated in only one negotiation session. The sessions were ended after 40 minutes and the final list of requirements was recorded. The participants then completed a post-session questionnaire.

3.2.4 Variables and measures

The independent variables in our exploratory investigation were the *communication media* (varied from face-to-face -- figure 2a, to distributed communication -- figure 2b) and the *group setting* (varied from D-1 to D-4, figure 2b).

Dependent variables were: (a) *group performance* and (b) *person perception*.

(a) The key variable was group performance, measured by the objective negotiation outcome.

Each final agreement was associated with three measures: the *objective outcome*, which is a group-related measure, and one *subjective outcome* for each of the two customers.

We define the *subjective negotiation outcome* as a measure of the final agreement from each individual customer's perspective, to illustrate the extent to which the final agreement incorporates requirements important for each customer.

We define the *objective negotiation outcome* as a measure of the final agreement from the bank's perspective, to illustrate the extent to which the needs of both customers are considered equally in a way that is most beneficial to the overall business goal.

We define a scoring system to measure both *objective* and *subjective negotiation outcomes*. We use the following notations for weights given to operations and scores received by requirements:

- $w_{T\{PBR\}}(O)$ = weight of the operation O from the Teller's {PBR's} perspective
- $score_{T\{PBR, B\}}(R)$ = score of requirement (or list of requirements) from the teller's{PBR's or bank's respectively} perspective

To calculate the *subjective outcome*, weights of 8, 4 and 2 points are given to operations of critical, high and medium priority respectively (figure 4). For example, operations TC2 and LM1 are identical for both customers but are weighted differently: $w_T(TC2) = 8$ while $w_{PBR}(LM1) = 2$.

Each requirement receives a score that is the sum of the weights of the operations it helps to achieve. For example, $score_{PBR}(R11) = w_{PBR}(LC4) = 8$, while $score_T(R11) = w_T(TH1) + w_T(TM1) = 4+2=6$;

The overall subjective outcome is determined by the sum of scores of the requirements that are part of the final agreement. For example, if R represents the final agreement with R = {R1, R4, R5, R6, R8, R9, R11 and R12}, then $score_T(R) = 38$ while $score_{PBR}(R) = 44$ (the final agreement considered more items that were important for PBR than for T).

To calculate the *objective outcome*, weights of 8, 4 and 2 points are given to operations of critical, high and medium priority respectively to either customer. If both customers require an operation of different relative importance, the higher weight is considered. For example, TC2==LM1, $w_B(TC2) = \max\{w_T(TC2), w_{PBR}(LM1)\} = \max\{8,2\} = 8$ (if an operation is critical for one customer then it is also critical for the bank).

Again, each requirement receives a score that is the sum of the weights of the operations it helps to achieve. For example, $score_B(R5) = w_T(TC2) = 8$; $score_B(R11) = w_T(TH1) + \max\{w_T(TM1), w_{PBR}(LC4)\} = 4+8 = 12$.

The overall objective outcome is determined by the sum of scores of the requirements that are part of the final specification. For example, $score_B(R) = 65$. To remember, the subjective outcomes were unequal in this case, $score_T(R) = 38$, $score_{PBR}(R) = 44$.

The scoring system accounts for both cooperative and competitive negotiation behavior.

Cooperative behavior in this case results in both customers defending their positions equally strong and the agreement illustrates the implementation of requirements that consider the operations of both customers equally. This does not allow the performance of all operations important for both customers, i.e. the subjective measures are lower than their maximum value, but are equal to each other. This situation is characterized either by an exploratory search through alternatives and selection of an optimum subset of requirements, or by an expedient resolution by abandoning goals early and missing the implementation of critical requirements.

Competitive behavior in this case results in one customer being stronger on his/her own position, and the agreement illustrates the implementation of requirements that favor the operations of one customer over the other (i.e. the subjective measures of the two customers are unequal). The objective measure in this case is reduced to a score that takes into consideration the difference between the subjective measures.

(b) The second dependent variable was *person perception*, an interpersonal-related variable that received individual-level analysis. The participants rated their partners (except the facilitator) on 13 five-point scales: 'polite', 'rational', 'predictable', 'confident', 'trustworthy', 'dominant', 'sociable', 'emotional', 'cooperative', 'argumentative', 'active', 'formal' and 'competitive'. The instrument was developed primarily from the work of Short, Williams and Christie [24] and Williams [38] on interpersonal evaluation. A score of 1 indicated a positive evaluation of the person, while a score of 5 indicated a negative evaluation.

3.2.5 Collection of data

The usage of the electronic shared editor has been recorded for groups in all experimental conditions. The final list of requirements that the group agreed on was analyzed and scored as described above. The post-session questionnaire was used in collecting both quantitative data on person ratings (using rating scales) and qualitative data on the aspects of videoconferencing that helped/hindered the negotiation process (using open-ended questions). The sessions were video recorded for future analyses of group behavior.

4 RESULTS

Due to the small sample size in each experimental condition, we used non-parametric tests to analyze the results. These tests included the Mann-Whitney test for the analysis of results on the group performance variable, and the sign test for related samples for the analysis of results on the person perception variable [33].

4.1 Group performance

The group performance variable was measured by the objective negotiation outcome. Thirteen out of fifteen groups reached an agreement. The outcomes were scored with values ranging from 60 to 68 points and the groups with no agreement were scored 0 points. The obtained scores and their frequency is shown in Table 1; Table 2 illustrates the distribution of both objective and subjective outcome scores across all five experimental conditions

Objective negotiation outcome:	I Optimal **68**		II Sub-optimal **65**		III Sub-optimal **62**	IV Sub-optimal **60**	V No agreement **0**
	(a)	(b)	(a)	(b)			
Frequency:	2	3	3	2	1	2	2
Totals:	**5**		**5**		**1**	**2**	**2**

Table 1. Negotiation outcomes and their frequency

(F2F, D-1, ..., D-4). While the objective negotiation outcomes are the focus of this paper, the subjective negotiation outcomes are provided in brackets (teller: PBR), to illustrate their variability across groups and conditions. The significance of these scores is explained below.

I. 68 points: two different combinations of requirements resulted in an optimal objective outcome (Table 1, 68(a) and (b)) and in equal subjective outcomes for both customers (Table 2, F2F/Facil-1).

II. 65 points: two different combinations of requirements resulted in a suboptimal objective outcome, and a maximum subjective outcome for only one customer, i.e. the final agreement favors either the PBR's requirements (Table 1, 65(a); Table 2, D-2/Facil-2) or the teller's requirements (Table 1, 65(b); Table 2, D-2/Facil-3).

III. 62 points: the final agreement did not include the specification of a particular critical requirement for the bank; it resulted in a suboptimal objective outcome and equal subjective outcomes (Table 2, D-2/Facil-1).

IV. 60 points: the final agreement did not include the specification of a critical requirement for the bank (different requirement than in III.); it resulted in suboptimal objective outcome and equal subjective outcomes (Table 2, D-3/Facil-3).

V. 0 points were given if the group could not come to any agreement within the allocated time (Table 2, F2F/Facil-2).

Table 2. Negotiation outcomes for each facilitator and experimental condition

	F2F (all co-located)	**D-1** (customers separated)	**D-2** (customers co-located, sys. analyst and facilitator at a distance)	**D-3** (customers and facilitator co-located, sys. analyst at a distance)	**D-4** (customers and sys. analyst co-located and facilitator at a distance)
Facilitator 1	68 (a) (42 : 42)	68 (b) (42 : 42)	62 (36 : 36)	65 (a) (38 : 44)	68 (b) (42 : 42)
Facilitator 2	0	68 (b) (42 : 42)	65 (a) (38 : 44)	65 (b) (44 : 38)	60 (34 : 34)
Facilitator 3	65 (a) (38 : 44)	68 (a) (42 : 42)	65 (b) (44 : 38)	60 (34 : 34)	0

4.1.1 Face-to-face vs. Distributed condition

In analyzing the effects of communication media (Face-to-face vs. Distributed communication) on group performance, the face-to-face condition was used as a control group and compared to each of the four distributed conditions (D-1 to D4). The non-parametric Mann-Whitney test indicates that none of these comparisons demonstrated statistically significant difference (F2F:D-1 U=1.5, p>.10; F2F:D-2 U=4, p>.10; F2F:D-3 U=4, p>.10; F2F:D-4 U=4, p>.10).

4.1.2 Within the distributed condition

We observed the group outcomes within the distributed condition in order to analyze the effects of group settings on group performance. There was an indication that the groups in condition D-1 had the highest scores and thus an analysis to compare D-1 to a combination of all other distributed conditions (D-2, D-3 and D-4) was performed. A Mann-Whitney test indicates that this comparison reached statistical significance (U=1.5, alpha =.05).

4.2 Interpersonal relationships

In analyzing the results on person perception, the person ratings of participants in the three distributed conditions (D-1&D-2&D-3) were considered. These individuals interacted both with *local* (physically co-located) and *remote* partners (encountered through videoconferencing) at the same time. A sign test for two related samples on the person perception indicates that *local* partners are rated differently than *remote* partners on some attributes. *Local* individuals were regarded as more emotional (p=.008), argumentative (p=.033) and competitive (p=.029) than those encountered remotely through computer conferencing.

5 DISCUSSION

5.1 Interpretation of results

As Table 1 shows, there was a fair distribution of the different outcomes among the five conditions, which indicates that the task was non-trivial. A thorough discussion of the analysis of the outcomes follows.

According to media richness theory (MRT), the face-to-face communication is the richest medium since it supports synchronous communication and allows the full transmission of visual, auditory and non-verbal cues [7]. All other media (including computer-conferencing as used in this experiment) are thought to restrict aspects of these communication modes, thus are less rich. Furthermore, the group performance on equivocal and complex tasks, when leaner media is used, would decrease due to a mismatch between the task needs and the medium's information richness. In this study we investigated the groups' performance on a requirements negotiation task when computer-conferencing was used in distributed settings. Contrary to most studies that support MRT, we used an objective measure of performance.

First we were interested whether groups in face-to-face meetings would perform better than groups communicating from separate physical locations through computer-conferencing. The results of the statistical analysis comparing F2F (figure 2a) with each Distributed setting (D-1 to D-4, figure 2b) indicate that we did not find support for the claim that groups in the richest communication medium would perform better than those using less rich communication media. This indicates that MRT may not be powerful enough to account for equivocal and complex phenomena in requirements negotiation.

However, a qualitative assessment of the differences between F2F and distributed conditions reveals some interesting trends:

1. Among the distributed conditions, groups in D-1 appear to perform most differently than those in F2F: all groups in D-1 reached agreements of higher or equal quality with those in F2F. This is the opposite of what MRT would predict.
2. Among the distributed conditions, groups in D4 appear to perform most similarly to those in F2F: not only are these the only two conditions in which "no agreement" has been recorded, but they present the widest variety of negotiation outcomes (also including one optimal and one suboptimal agreement). On the one hand, this similarity may be explained by the way the study was designed: they are the only two conditions in which all stakeholders (the two customers and system analyst) are physically co-located, with D-4 involving electronic mediation between the group and the facilitator. On the other hand, the variability in the group outcomes indicate the complexity, richness and unpredictability of close physical proximity in face-to-face interactions.

Second, we wanted to investigate whether various physical group configurations would provide new insights into the groups' performance in the distributed condition. The results indicate that groups in D-1 (figure 2b) performed better than those in other distributed conditions. Also, when optimal vs. suboptimal agreements are considered, groups in D-1 reached three agreements that are optimal and none suboptimal, while groups in conditions D-2, D-3 and D-4 combined reached only one optimal but eight suboptimal agreements. These results answer our question whether there is such a group setting that maximizes the group performance within the distributed groups: D-1, where the customers were remote achieved the best negotiation outcomes. Also, interesting trends could be noted within the distributed conditions:

1. D-1 was the only group setting in which the customers with two conflicting views are physically separated (figure 2b). The results indicate here that the electronic mediation of the customers' discussion is conducive to a negotiation behavior that results in agreements most favorable to the overall business goal (optimal objective outcome), while equally incorporating the perspectives of both customers (equal subjective outcomes).
2. Then, a close look at the suboptimal agreements reached by groups in D-2 and D-3 reveals the predominance of scores of 65 points (four) vs. one score of 65 in all the other conditions (F2F, D-1 and D-4). Of note is that D-2 and D-3 are the only two conditions in which the two customers are co-located and the system analyst is at distance (figure 2b); and that a score of 65 represents an agreement that favors one customer's needs in the negotiation, to the detriment of the other's (suboptimal objective outcome, one subjective outcome maximized). From a socio-psychological perspective, this indicates that when resolving conflicts, the two customers may have had the ability to overlook the system analyst, to persuade each other too readily and come to an agreement that favors one perspective over the other, to the detriment of the overall business goal.

The results on person perception may aid in understanding the trends of group outcomes in the distributed conditions. We found that the remote partner was seen as less emotional than the local partner. This indicates that the electronic mediation might have helped the group place greater emphasis on the task-related matters rather than interpersonal aspects of the interaction. When this is considered in light of group outcomes in D-1, in which the two customers were separated, it may indicate a change in group's behavior that enhanced its performance: the lowered ability to perceive emotional cues may have been beneficial to a more objective exploration of alternatives which resulted in improved consideration of the overall business goal and consequently optimal agreements.

A post-hoc explanation that provides deeper insights into these results is offered by considering the theory of Argyle and Dean [2]. They proposed an intimacy equilibrium model, in which 'intimacy' is a function of proximity, eye contact, smiling, topic of conversation and other factors. They hypothesize that immediacy has a □-shaped relation to liking, so that either too high or too low intimacy is avoided. This suggests that with tasks of very high intimacy – perhaps personal or conflictual ones – a less rich medium (e.g. computer-conferencing) would lead to more positive evaluations. Then it is only necessary to consider the requirements negotiation situation, in which the two customers had to decide on the relative importance of particular requirements that were often critical for one customer but not important at all for the other customer. We found a predominance of suboptimal outcomes in distributed conditions where the two customers were co-located. The fact that close proximity led to more negative evaluations (local partner was perceived as more argumentative and competitive) suggests, in the light of the 'intimacy' equilibrium model, that the two customers changed their behavior accordingly: the groups had a more competitive negotiation behavior that resulted in a greater subjective outcome for one customer (at the expense of the other) but which exacted a toll on the objective outcome.

The quantitative data was complemented with qualitative rich data from the open-ended questions. The participants were also asked to comment on aspects of both face-to-face and distributed communication that helped/hindered them in achieving their objectives in the negotiation. Their comments (figure 6 and 7, frequency of comment or similar, in brackets) emphasize the preference for the remote partner in the interaction.

(a) "better able to judge people's reaction and be more sensitive to that" (11 times)
(b) "it may have been more difficult to sway my banking colleague if we weren't in the same room because he wouldn't have felt as pressured" (5 times)

Figure 6. Perceived advantages and disadvantages of face-to-face contact

One can observe that while participants stressed the positive aspects of the face-to-face communication (figure 6, (a)), the close physical proximity was also characterized by an increased ability to influence and pressure the partner in negotiation situations (figure 6, (b)).

[Customers]
(a) "less emotional or personal, stayed focused on task" (11 times)
(b) "helped me achieve my objectives because I believe it allowed me to think better and better understand my needs" (4 times)

[System analyst]
(c) "in the distributed setup, with a video link between myself and other participants, I felt a motivation to get along in order to get around whatever hurdle, subconscious or not, was imposed by being connected by an electronic link. Judgements of the other participants as people, good or bad, but particularly bad, get left behind – you overcome prejudices to overcome the link"
(d) "less emotional, I found it easier to maintain a level of detachment in the remote room" (4 times)
(e) "focused better on objective, don't get caught in personal conversations" (7 times)

Figure 7. Perceived advantages of distributed communication

The comments in figure 7 illustrate both the customers' and system analysts' preference for physical separation. They indicate that a reduced ability to perceive emotional cues enabled the customers to have a more rational approach to conflict and developers to attain a level of impartiality in the negotiation (figure 7). Comment (c) in particular adds to the evidence that reduced affective cues leads to a decrease in importance of "irrelevant" personal

considerations and enhance the chances to be more task oriented and objective in the meeting.

In summary, our investigation relates to studies that used an objective measure and not perceptions of media in evaluating media effects [19,35], and to studies that found electronic mediation to create a more task-oriented environment [10,36]. Our results align most with the results of these studies, in challenging the claims of MRT.

The results of our study have very important practical applications as more and more multidisciplinary teams of software developers and customers are not co-located. Commonly the design team is gathering requirements from customers scattered across different physical locations. Our findings have two main implications: (1) the use of computer-conferencing to enable group settings in which customers with conflicting perspectives are remote would be a first step in developing systems that satisfy the customers' needs better and (2) the system analysts' preference for remote communication with the customers (observed in the anecdotal comments) suggests a possible way to improve their work and performance. It is for these situations that the investment in computer-conferencing systems pays off.

6 LIMITATIONS

As with any laboratory experiment, caution should be exercised in extrapolating the results from this study to all users of such communication media in software enterprises. The small sample size used in this study makes any generalization of results difficult. However, our study had an exploratory nature, with the intent to investigate the use of computer-conferencing systems in several meaningful group configurations in requirements engineering. Although only three groups performed in each experimental condition, we believe that the random assignment of participants to conditions and facilitators minimized the effect of uncontrolled variables that might have confounded the results (i.e. personality characteristics and level of acquaintance). This study still makes a contribution to our better understanding of groups' performance and behavior in computer-conferenced requirements meetings.

7 CONCLUSIONS AND FUTURE WORK

Group interaction and performance is greatly affected by the type and complexity of the tasks that the group is performing [23]. When groupware is used to mediate group interaction, group tasks differ in the degree of "media richness" required for their accomplishment. In this study we investigated the effects of computer-conferencing (a less rich communication medium than face-to-face) on group performance in requirements conflictual tasks (tasks of type 6&7 in figure 1). Probably the most important finding of the present study was that the performance of groups in D-1 (i.e. where customers are remote, but co-located with either the facilitator or system analyst, figure 2b) was higher than the performance of groups in the other conditions. The fact that the groups in D-1 reached agreements which supported the overall business goal rather than favoring only one customer perspective in the negotiation suggests that they adopted a more rational approach to conflict. These results indicate that electronic mediation in a particular group setting enabled groups to transform a task which is classified as behavioral/conflict on McGrath's tasks circumplex into a conceptual/cooperation.

Due to the exploratory character of our investigation however, these results are based on the use of a small number of groups in all conditions; we believe our results indicate possible effects of media use in requirements negotiation. Future work that focuses on comparing the F2F and D-1 conditions is necessary in order to confirm our results.

Arrangements have been made with a major industry partner to carry out a similar but less controlled investigation in the field, to see whether there is sufficient continuity between laboratory and field setting to which we wish to generalize for a particular effect to be found in both arenas.

Acknowledgements

Financial assistance for this work has been made available by the Industrial Research Chair in Software Engineering. Thanks are due to the facilitators and students that participated in the experiment. Many thanks also to Michele Jacobsen and Kim Burgraff for their useful comments on an earlier draft of this paper.

REFERENCES

1 Al-Rawas, A. and Easterbrook, S. (1996). Communication problems in requirements engineering: a field study, Proceedings of the First Westminster Conference on Professional Awareness in Software Engineering, London

2 Argyle, M. and Dean, J. Eye contact, distance and affiliation, Sociometry, 28, 1965, 289-304.

3 Boehm, B. and Egyed, A. (1998): WinWin requirements negotiation: A multi-project analysis. Report 97-508, Center Software Engineering, Univ. South California

4 Boehm, B. and Egyed, A. (1998): Software Requirements Negotiation: Some Lessons Learned, International Conference on Software Engineering, Kyoto, Japan, 503-507

5 Chapanis, A. (1975): Interactive human communication, Scientific American, 232(2), 36-42

6 Curtis, B., Krasner, H and Iscoe, N. (1988). A field study of the software design process for large systems**,** Comm.. Of the ACM, 31(11)

7 Daft, R.L. and Lengel, R.K. (1984). Information richness: a new approach to managerial information processing and organizational design, Research in Organizational Behavior, 6, 191-234

8 Damian, E.H., Eberlein, A., Shaw, M.L.G. and Gaines, B.R. (1999). Studies in distributed requirements engineering. To appear in Proceedings of Workshop on Knowledge Acquisition, Banff, Alberta, Canada

9 Darke, P. and Shanks, G. (1996). Stakeholder viewpoints in requirements definition: a framework for understanding viewpoint development approaches, in Requirements Engineering Journal, Springer-Verlag, 1, 88-105

10 Dubrovski, V.J. (1985). Real time computer conferencing versus electronic mail, Proceedings of the Human Factors Society, 29, 380-384

11 Easterbrook, S. (1994): Resolving requirements conflicts with computer-supported negotiation, in Jirotka, M. and Goguen, J. (Eds.), Requirements Engineering: Social and Technical Issues, Academic Press, 41-65

12 El-Shinnawy, M. and Markus, M. L. (1997). The poverty of media richness theory: explaining people's choice of electronic mail vs. voice mail, International Journal of Human-Computer Studies 46, 443-467

13 Emam, K.E. and Madhavji, N.H. (1995). A field study of requirements engineering practices in information systems development, in [28], 68-80.

14 Finkelstein, A., Kramer, J., Nuseibeh, B., Finkelstein, L. and Goedicke, M. (1992). Viewpoints: a framework for integrating multiple perspectives in system development**,** International Journal of Software Engineering and Knowledge Engineering, 2(1), 31-58

15 Goguen, J.A. (1994): Requirements Engineering as the reconciliation of social and technical issues, in Jirotka, M. and Goguen, J. (Eds.), Requirements Engineering: Social and Technical Issues, Academic Press, 165-200

16 Hrones, J.A., Jedrey, B.C. and Zaaf, D. (1993). Defining global requirements with distributed QFD, Digital Technical Journal, 5(4), 36-46

17 The Fourth International Conference on Requirements Engineering 1998, Colorado Springs, Colorado, USA

18 Kiesler, S., Siegel, J. And McGuire, T. W. (1984). Social psychological aspects of computer-mediated communication, American Psychologist, 39(10), 1123-1134

19 Kinney, S. and Dennis, A. (1994). Reevaluating media richness: cues, feedback, and task, Proceedings of the Twenty-seventh Annual Hawaii International Conference on System Sciences, Hawaii, 21-30

20 Kydd, C.T. and Ferry, D.L. (1991). Computer supported cooperative work tools an media richness: an integration of the literature, Proceedings of the Twenty-fourth Annual Hawaii International Conference on Systems Sciences, Volume III, IEEE Society Press, Los Alamitos, CA, 324-332

21 Kotonya, G. and Sommerville, I. (1996). Requirements engineering with viewpoints, BCS/IEE Software Engineering Journal, 11(1), 5-18

22 Matsuura, F., Takada, S. and Nakakoji, K. (1998). A study of communication during requirement elicitation processes, Proceedings of International Conference on Software Engineering, 63-66

23 McGrath, J.E. (1991). Time, interaction, and performance (TIP): a theory of groups, Small Group Research, 22(2), 147-174

24 McGrath, J.E. and Hollingshead, A.B. (1993). Putting the "group" back in group support systems: some theoretical issues about dynamic processes in groups with technological enhancements, Group Support Systems: New Perspectives, L.M. Jessup and J.S. Valacich (eds), New York: Macmilllan, 78-96

25 McGuire, T.W., Kiesler, S. and Siegel, J. (1987). Group and computer-mediated discussion effects in risk decision-making, Journal of Personality and Social Psychology, 52, 917-930

26 Norman, D. (1998). The Invisible computer: Why Good Products Can Fail, The Personal Computer Is So Complex, And Information Appliances Are The Solution, MIT Press

27 Nuseibeh, B. (1996). Conflicting requirements: when the customer is not always right, Requirements Engineering Journal, Springer-Verlag, 1, 70-71

28 Proceedings of 2nd International Symposium on Requirements Engineering, York, England

29 Pruitt, D. (1981). Negotiation Behavior, Academic Press

30 Rice, R.E. (1992). Task analyzability, use of new media, and effectiveness: a multi-site exploration of media richness, Organization Science, 3, 475-500

31 Robinson W. N. (1990). Negotiation behavior during requirement specification, Proceedings of the 12th International Conference on Software Engineering, IEEE Computer Society Press, Nice, France, 268-276

32 Ryan, K. (1995). Let's have more experimentation in requirements engineering, Panel in [28], p. 66

33 Siegel, S. (1956). Nonparametric Statistics for the behavioral sciences, McGraw-Hill

34 Short, J., Williams, E. and Christie, B. (1976). The Social Psychology of Telecommunications. Wiley

35 Valacich, J.S., Mennecke, B.E., Wachter, R.M. and Wheeler, B.C. (1994). Extensions to media richenss theory: a test of the task-media fit hypothesis, Proceedings of the Twenty-seventh Annual Hawaii International Conference on System Sciences, 11-20

36 Walther, J.B. (1996). Computer-mediated communication: impersonal, interpersonal, and hyperpersonal interaction, Communication research, 23(1), 3-43

37 Warne, L. (1998). Organizational politics and information systems development - a model of conflict, Proceedings of the 31st Annual Hawaii International Conference on Systems Sciences IV, IEEE Computer Society Press, Los Alamitos, CA

38 Williams, E. (1975). Medium or message: communications medium as a determinant of interpersonal evaluation, Sociometry 38, 119-130