Using Different Communication Media in Requirements Negotiation

Contrary to traditional wisdom, the authors found that when it comes to requirements negotiations, groups meeting face-to-face perform no better than those using video conferencing and computer support. Furthermore, their study identified a particular distributed group configuration that significantly improved performance and was more conducive to negotiation than face-to-face meetings.

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Although researchers noted the importance of effective communication among stakeholders in software development projects more than a decade ago,[1] recent empirical studies show that it continues to be a challenge for requirements engineering.[2] Two issues in particular are the topic of much research: communication between system analysts and stakeholders and the need for sound negotiation techniques in reconciling conflicting viewpoints.[3–8]

As organizations become more global and interest groups more widely distributed, these issues become even more challenging. Groupware technology has supported distributed requirements engineering and modeling multiple perspectives.[3,8,9] Nowadays, however, organizations are offered a sophisticated array of multimedia meeting systems with video, audio, and computer support for remotely specifying requirements. In addition to evaluating such systems, we must also gain a better understanding of how these communication media facilitate social processes in requirements engineering.

Steve Easterbrook[3] defines *conflict* as something arising out of differences between the goals and desires of participants in the system development process. Negotiation thus becomes an essential part of system specification: users negotiate among themselves and with analysts,[8] and trade-offs are made to resolve conflicts.[7] Researchers have developed requirements negotiation models[3,8,9]—some of which use computer-mediated technology—but their emphasis is largely on automating conflict identification and resolution. Little attention is given to the sociopsychological aspects of the group process.

Our research investigates both the group performance and interpersonal relationships in distributed requirements engineering. As the "Related Work" sidebar explains, behavioral researchers and computer scientists have been interested in the way people use different communication media for different tasks for a long time.[10–12] Most theories argue that face-to-face meetings are the richest communication medium and are best suited for tasks that require group negotiations and conflict resolution. However, the empirical evidence presents a rather complex pic-

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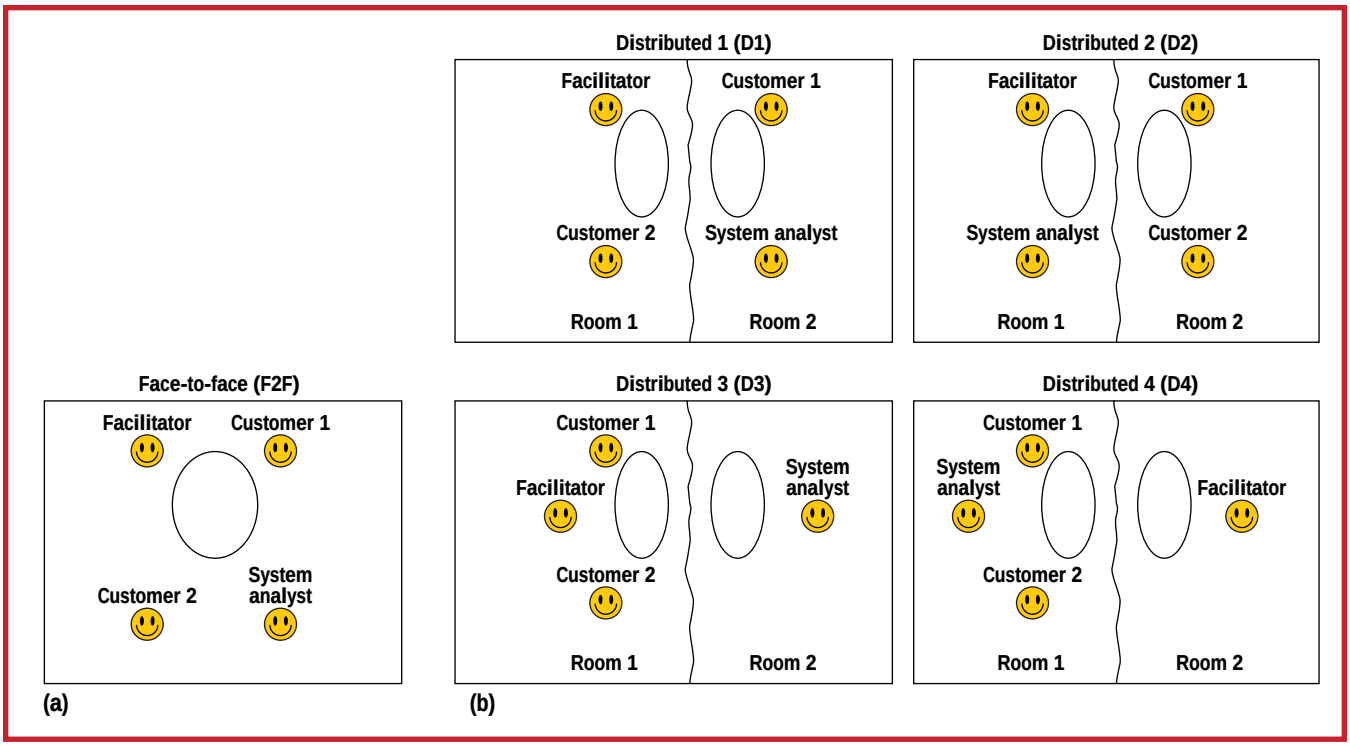

Figure 1. Five physical group configurations: (a) face-to-face and (b) four distributed communication settings.

ture and offers no definite support to such claims.[12] Much of the existing research, for example, focuses on how users perceive or choose media, rather than on a particular medium's effect on objective task performance. When researchers tested the objective performance for equivocal and cognitive conflict tasks,[13,14] groups performed better using other media—such as video phones, telephones, and computer-mediated communications—than they did face-to-face.

Among the questions in requirements engineering that need further investigation are whether group performance improves over face-to-face meetings if the stakeholders communicate using multimedia systems that integrate video, audio, and shared electronic files (hereafter referred to as computer conferencing.) Also, from a sociopsychological perspective, an interesting question is whether stakeholders with conflicting requirements better manage conflict when they are colocated or physically separated. As these unanswered questions illustrate, communication technology might be impressive, but little systematic research exists on its social and psychological significance for requirements engineering.

As a step in this direction, we report here on our laboratory experiment that compared the performance of groups negotiating requirements in face-to-face meetings with that of distributed groups using real-time computer conferencing. We investigated the effects on group performance of both the communication media and different physical configurations of customers and developers. We used a mixed-method research approach that uses quantitative group-performance measures and qualitative inquiries into the group behavior in computer-mediated meetings.

Research Design

We designed a simplified scenario that illustrates the conflict between requirements scope and resource constraints. Our scenario involves the communication between a system analyst and two customers, mediated by a facilitator. The two customers were from two different organizational units and had different perspectives on the system to be developed. The system analyst insists that it is impossible to implement the system in the given time frame, and thus the customers must agree on a subset of the original requirements. This triggered a conflict between the customers' needs.

Using this scenario, we designed our investigation with two goals. First, we wanted to investigate the communication media's effects on group performance in negotiating the requirements. As Figure 1 illustrates, we

Our ultimate goal was to identify a setting that was most conducive to requirements negotiation.

varied the communication medium from face-to-face (F2F) communication (Figure 1a) to four physical configurations that used distributed, computer–conference communications (Figure 1b). Second, we wanted to investigate the effects of group setting on group task performance within the distributed condition. We chose the group settings to vary the relative location of the stakeholders: In D1, the two customers participate from different branch offices; in D2, the customers are colocated; in D3, we isolated the system analyst; and in D4, we isolated the facilitator. Our ultimate goal was to identify a setting that was most conducive to requirements negotiation.

The Experiment

Forty-five volunteers from the University of Calgary's student population took part in our study: 16 females and 29 males, ranging in age from 19 to 44, with 91% age 30 or under. The prerequisite for participation was experience in software engineering or negotiation. All subjects gave informed consent and were paid for their participation. Three professional facilitators volunteered to mediate the meetings.

For our study, we used Microsoft's NetMeeting, which is a widely available technology and has full video, audio, and shared files facilities. Our distributed conditions were two rooms connected with a 100 Mbyte Ethernet link that transmitted images and sound. All groups, including those who met face-to-face, used a shared editor that reflected the negotiation results on electronic displays.

Task

In our scenario, the goal is to define a set of functional requirements for a banking management system, which has a fixed 21-week development time. The overall business goal was to provide efficient face-to-face service to the bank's clients. In addition to the system analyst, the stakeholders were a bank teller and a personal banking representative (PBR), each of whom had an initial requirements list as follows; only the analyst knew the estimated development time at the start of the meeting.

- The system should enable the open and deactivate account operations for banking and credit. Estimated time: *one week*.
- The system should have a screen showing the transaction history on client's banking accounts for the last three months. Estimated time: *three weeks*.
- The system should enable check ordering online. Estimated time: *two weeks*.
- The system should automatically provide credit rating from an external agency. Estimated time: *two weeks*.
- For each banking account, the system should display detailed account information, such as owners, date created, and balances. Estimated time: *three weeks*.
- The system should enable transactions, such as deposit, withdraw, transfer, and payment. Estimated time: *three weeks*.
- The system should have a screen with a profile of all accounts with information on the owners and date created. Estimated time: *four weeks*.
- The system should enable the updating of terms of credit accounts, such as granting credit and changing payment terms. Estimated time: *five weeks*.
- For each credit account, the system should display detailed information on the account, such as overdue payments, owners, date created, and balances. Estimated time: *four weeks*.
- The system should display a screen with information on client's due dates, liabilities (for all credit accounts), and assets (for all banking accounts). Estimated time: *three weeks*.
- The system should have a screen showing the history of transactions in any client's accounts. Estimated time: *two weeks*.
- The system should display the list of all the client's accounts. Estimated time: *two weeks*.

The initial requirements were elicited at a previous meeting and are in no particular order of importance. The system analyst has since determined that it's infeasible to implement all 12 requirements, given the fixed development time. We also informed the system analyst that the implementation of the third and fourth requirements together only takes three weeks.

In our study, we first gave the teller and PBR a description of their job operations (see Table 1). The customers represent business units that perform different operations on client accounts; the teller provides services to

Table 1

Two Customers' Job Descriptions According to Priority

	Teller representative	Personal banking representative
Critical operations	Browse client's list of accounts.	Open and inactivate accounts.
	Access client's banking accounts profile (owner, date created, and balance).	Update terms of credit accounts.
	Access client's credit accounts profile (owner, date created, and balance).	Browse client's list of credit accounts.
	Pay bills and deposit, transfer, and withdraw funds.	Obtain transaction history on client's credit accounts.
High-priority operations	Obtain transactions history on client's banking accounts.	Access client's credit accounts profile (owner, date created, and balance).
	Obtain list of due dates on client's credit accounts.	Obtain overdue payments on client's credit accounts.
	Order new checks.	Obtain credit rating from an external agency.
Medium priority operations	Obtain history of transactions on client's credit accounts.	Access client's banking accounts profile (owner, date created, and balance).
No authority or responsibility to perform	Open and inactivate accounts.	Pay bills and make transfers and deposits.
	Update terms of credit accounts.	Order new checks.

the bank's walk-in clients involving banking accounts (checking and savings); and the PBR provides more personal services, by appointment, involving credit accounts, such as loans, mortgages, and credit cards.

We gave the system analysts only the implementation time for each of the 12 requirements, then told them to suggest to the customers that implementation be limited to only the first eight requirements. The group was then asked to consider these requirements, and if they were not suitable to both customers, to consider another requirements set.

Each requirement refers to one or more operations in Table 1, and each operation can be completely fulfilled by implementing one or more requirements. We aimed for a realistic task that were highly equivocal, in which customers had detailed domain knowledge of only the operations their own business unit performed; they discovered the complex interrelationships between operations and requirements only through discussion. Given this, exchanging information was the only way to understand the relative importance of requirements and explore alternatives to reach an agreement. Finally, any requirements subset the customers chose had to be discussed with the system analyst to ensure that it was feasible within the time constraints.

During the pilot sessions, a bank officer validated the task, confirming its validity. We then refined it with three experienced software engineers to ensure a sufficient level of conflict. Prior to participating, we gave subjects an overview of the task and a one-page set of instructions on their role. In the briefing period, we introduced them to their partners and gave them a warm-up task designed to familiarize them with each other and the communication medium. The actual software requirements meeting lasted 40 minutes. Each facilitator mediated a series of five group interactions, one in each setting in Figure 1. Each group participated in only one negotiation session. Following each 40-minute session, the participants completed a questionnaire.

Variables and measures

Our independent variables were the communication media (from F2F to distributed communication) and the group setting (from D1 to D4); our dependent variables were group performance and personal perception.

The key dependent variable was *group performance*, measured by the objective negotiation outcome. To analyze group performance (the resolution of conflicting perspectives) we used general concepts from negotiation literature.[8,15] Negotiation behavior can be *distributive* or *integrative*. Distributive behavior reflects a "your loss is my gain" attitude (and in this case, would produce a system representing only one customer's goals), and integrative behavior consists of incorporating opposing proposals,

Table 2

Negotiation Outcomes and Their Frequency

Objective negotiation outcome	Optimal 68 a / b	Suboptimal 65 a / b	Suboptimal 62	Suboptimal 60	No agreement 0
Frequency	2 3	3 2	1	2	2
Total	5	5	1	2	2

Table 3

Negotiation Outcomes for Each Facilitator and Experimental Condition

Facilitator	Face-to-face	D1	D2	D3	D4
1	68a[1]	68b	62	65c	68b
	(42:42)	(42:42)	(38:44)	(38:44)	(42:42)
2	0	68b	65c	65d	60
	(38:34)	(42:42)	(38:44)	(44:38)	(34:34)
3	65c	68a	65d	60	0
	(38:44)	(42:42)	(44:38)	(34:34)	(40:44)

[1]*a, b, c, and d represent different combinations of requirements.*

communicating goals and constraints, and examining extreme alternatives and multiple issues.[8,15] The latter supports our goal: to incorporate both customer perspectives to support the overall business goal. However, integrative agreements are only possible when the situation has integrative potential—that is, some of the available alternatives offer higher mutual benefit than others. We designed our task to allow for integrative behavior.

The two customers were interested in different system functionality and could negotiate several alternatives during the meeting. An alternative represents any proposed and accepted change in the list of requirements during negotiation. We associated the final alternative with three measures: the objective outcome (group-related measure) and two subjective outcomes (one for each of the two customers).

We define the subjective negotiation outcome as a measure of the final alternative, selected from each individual customer's perspective, to illustrate the extent to which it incorporates requirements important for each customer. We define the objective negotiation outcome as a measure of the final alternative from the bank's perspective, to illustrate the extent to which the customers' needs are equally considered and thus most beneficial to the overall business goal. To calculate both the objective and subjective outcomes, we used a scoring system based on numerical weights measuring the relative importance of each requirement.[16]

Aspects of interpersonal relationships—such as how individuals perceive other group members—are critical in conflict situations[17] and represent another testing ground for media-effects theories. Our second dependent variable, *personal perception*, is an interpersonal variable that we analyzed on an individual basis. Using a five-point scale, the participants rated each other (excluding the facilitator) on the following qualities: polite, rational, predictable, confident, trustworthy, dominant, sociable, emotional, cooperative, argumentative, active, formal, and competitive. We developed this measure primarily from existing work on interpersonal evaluation.[17] A one indicated a positive evaluation, and a five indicated a negative evaluation.

Data collection

We recorded the use of the electronic shared editor for groups in all experimental conditions. We then analyzed and scored the final requirements list, as we described earlier. In addition to the personal ratings, the post-session questionnaire included open-ended questions on how videoconferencing helped or hindered the negotiation process. Finally, we video recorded all sessions for future group behavior analyses.

Results

Table 2 shows the negotiation outcomes and their frequency; Table 3 shows the outcomes for each facilitator. Also, although we focus here on objective negotiation outcomes, we provide the subjective negotiation outcomes in brackets (teller: PBR) to illustrate their variability across groups and conditions. Each score has particular significance as follows:

- 68 points: Two different combinations of requirements produced an optimal objective outcome and equal subjective outcomes for both customers (Table 3, F2F/Facilitator 1). They did not account for all operations important to both cus-

tomers. Thus, the subjective measures are lower than their maximum value but are equal to each other.

- *65 points*: Two different combinations of requirements produced a suboptimal objective outcome and a maximum subjective outcome for one customer—that is, the final agreement favored either the PBR's requirements (Table 3, D2/ Facilitator 2) or the teller's requirements (Table 3, D2/ Facilitator 3). In this case, we reduce the objective measure to a score that takes into consideration the difference between the subjective measures.
- *62 points*: The final agreement did not account for a critical requirement for the bank; this results in a suboptimal objective outcome and equal subjective outcomes (Table 3, D2/ Facilitator 1).
- *60 points*: The final agreement did not account for a different critical bank requirement; it resulted in suboptimal objective outcome and equal subjective outcomes (Table 3, D3/ Facilitator 3).
- *0 points*: We awarded no points if the group was unable to reach an agreement within the allocated time (Table 3, F2F/ Facilitator 2). The subjective outcomes are reported to illustrate the customers' positions at the end of the session.

Given the small sample size in each experimental condition, we used nonparametric tests to analyze the results: the Mann–Whitney test for analyzing group performance results and the sign test for related samples for analyzing personal perception results.[18]

Group performance

In analyzing the effects of communication media on group performance, we used the F2F condition as a control group and compared it with each of the four distributed conditions (D1 to D4). The Mann–Whitney test indicated that none of these comparisons demonstrated statistically significant differences:

F2F:D1 $U = 1.5$, $p > .10$
F2F:D2 $U = 4$, $p > .10$
F2F:D3 $U = 4$, $p > .10$
F2F:D4 $U = 4$, $p > .10$

We observed group outcomes within the distributed condition to analyze how group settings affected group performance. Because D1 groups had the highest scores, we analyzed them in relation to the rest of the distributed conditions: D2, D3, and D4. The Mann-Whitney test showed a statistically significant comparison ($U = 1.5$, alpha = .05).

Personal perception

In analyzing the results on personal perception, we considered the person ratings in the three distributed conditions that had a rated participant at a distance (D1, D2, and D3). Each individual interacted both with local and remote partners at the same time. A sign test for two related samples on personal 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.

Discussion

According to media-effects theories, face-to-face communication is the richest medium.[11] All other media (including computer conferencing) are thought to restrict communication and thus are less rich. Furthermore, most theories claim that group performance on negotiation tasks decreases when such leaner media are used because of a mismatch between the task needs and the medium's information richness. In our study, we sought to test these assumptions in the context of requirements negotiations. The results of the statistical analysis comparing face-to-face with each distributed setting (D1 to D4) do not support traditional claims that groups using the richest communication medium perform better than those using leaner media. However, a qualitative assessment of the differences between face-to-face and distributed conditions reveals some interesting trends.

- Among the distributed conditions, groups in D1 perform most differently from those in face-to-face groups: All groups in D1 reached agreements that were equal to or better than those in face-to-face groups. This is the opposite of what media-effects theories would predict.
- Among the distributed conditions, groups in D4 perform most like those in face-to-face groups. Not only are these

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Related Work

Sara Kiesler and her colleagues investigated sociopsychological aspects of computer-mediated communication;[1] Ederyn Williams and his colleagues,[2] Richard Daft and Robert Lengel,[3] and Joseph McGrath and his colleagues[4] developed media-effects theories. Whereas social-presence theory[2] predicts the media that individuals will use for certain types of interaction, media-richness theory[3] draws on organizational information-processing premises. Media richness defines the medium's richness as its information-carrying capacity, in terms of feedback, channel, source, and language. Its fundamental claim is that the task performance improves when a medium with the appropriate richness is selected. However, these conceptual contributions do not deal directly with work groups or with how technology affects them. McGrath's work[4] builds on these theories and addresses this issue, with the premise that group interaction and performance is greatly affected by both the choice of technology and the type and complexity of the assigned task.

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the only two conditions in which no agreement was reached, but they also present the widest variety of negotiation outcomes (including one optimal and one suboptimal agreement).

We also sought to investigate whether various physical group configurations of the customers, the analyst, and the facilitator would provide new insights into distributed group performance. Our results indicate that D1 groups performed better than other distributed groups and reached the best negotiated outcomes. For example, D1 groups reached three optimal agreements and no suboptimal agreements; D2, D3, and D4 groups combined reached only one optimal agreement and eight suboptimal ones. These results suggest that D1, where the customers were remote, achieved the best negotiation outcomes.

Within the distributed conditions, we noted other interesting trends.

- D1 was the only group setting in which the customers, who held conflicting views, were physically separated. Our results indicate that the electronic mediation of customer discussion is conducive to negotiation behaviors that produce the most favorable agreements, both in relation to the overall business goal (optimal objective outcome) and according to both customers' perspectives (equal subjective outcomes).
- A closer look at the suboptimal agreements reached by groups in D2 and D3 reveals a predominance of 65-point scores (four) versus only one in all the other conditions (F2F, D1, and D4). In both D2 and D3, the customers are colocated and separated from the system analyst. Also, a 65-point score represents an agreement that favors one customer's needs to the detriment of the other's (suboptimal objective outcome and one subjective outcome maximized). From a sociopsychological perspective, this might indicate that, when resolving conflicts, the customers persuaded each other too readily, reaching agreements that favored one perspective over the other. On the other hand, because good interpersonal relationships and close physical proximity play a role in the negotiation—friends negotiate differently than strangers[17]—it might be that trust between the two customers affected their subjective appreciation of the situation. In any case, the outcome was detrimental to the overall business goal.

The results on personal perception can also shed light on trends we observed in distributed group outcomes. Participants viewed the remote partner as less emotional than the local partner. This indicates that the electronic mediation might have helped the group emphasize task-related matters over interpersonal aspects of the interaction. When we consider this in light of D1 group outcomes, it might indicate that such a change in group behavior can enhance performance: the lowered ability to perceive emotional cues might encourage more objective exploration of alternatives, which in turn produces a greater consideration of the overall business goal and, consequently, optimal agreements.

Our quantitative data was complemented with rich qualitative data gathered from the open-ended questions. We asked partici-

pants to comment on the aspects of both face-to-face and distributed communication that helped or hindered them in achieving their objectives in the negotiation. Although several participants noted the positive aspects of close physical proximity—such as the ability to be more sensitive to people's reactions—participants also mentioned that an increased ability to influence and pressure the partner was detrimental to task performance. Anecdotal comments indicate that a reduced ability to perceive emotional cues helped customers "think better and understand their needs" and helped system analysts "attain a level of impartiality in the negotiation of requirements."

Our investigation is related to studies using an objective measure to evaluate media effects,[13,14] as well as to studies that found that electronic mediation created a more task-oriented environment.[19] This work, like our own, challenges the claims of current media-effects theories.

The most important finding of our study was that the highest group performance occurred when customers were separated from each other and colocated with the facilitator or system analyst. These groups reached agreements that supported the overall business goals, rather than a particular customer's perspective, which suggests a more rational approach to conflict.

However, as with any laboratory experiment, we are cautious about extrapolating the results from this study to all users of such communication media in software enterprises. Our small sample size makes any generalization of results problematic. Our study was essentially an exploration 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—such as personality characteristics and acquaintance levels—which might have confounded our results.

Our future research will include comparing further group performances in F2F and D1 conditions to confirm our initial results. We've also made arrangements with a major industry partner to carry out a similar but less controlled field investigation to see whether there is sufficient continuity between laboratory and field setting.

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