# Synchronous Communication Media in the Software Requirements Negotiation Process

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**Abstract.** This paper presents an empirical study in the requirements negotiation process. In particular, the study compares traditional face-to-face meeting and distributed communication by using two rich synchronous communication media (i.e., an enhanced chat, and a three-dimensional virtual environment). We have observed that there is a difference in the time taken to negotiate software requirements in favor of face-to-face meeting. As the only assessment of the time could not be meaningful, we have also analyzed the quality of the structured description of the negotiated software requirements. We observed that the quality of the structured descriptions is not influenced by the used communication media.

**Keywords:** Requirements engineering, distributed virtual environment, synchronous communication media, and distributed software development.

## 1 Introduction

Requirements analysis is a time consuming and difficult process involving many psychological and technical skills [7, 13]. One of the most challenging and critical activity in the requirement engineering process is perhaps the requirements elicitation. The requirement elicitation is mainly focused on the development of a common understanding of the software requirements and generally needs an intense collaborative process (i.e., the negotiation) involving stakeholders.

Currently, many software companies are moving their business to distributed virtual organization models, thus creating new software engineering challenges (e.g., time zones, distance, or diversity of culture and communication). In the global software development new methods and practices are required to overcome these challenges. In such a context, the need for collaboration creates additional challenges to effectively negotiate software requirements [4, 5, 6].

The large number of available lean and rich media could generate confusion in the management of software companies in case same-place interaction is problematic. In this scenario empirical investigations could be conducted to acquire a general knowledge about which method, technique, or tool is useful for whom to conduct which task in which environment [1, 14].

One of the most often investigated issues in the requirements negotiation regards whether group performance improves over face-to-face meetings if stakeholders

communicate using communication media [5]. As a step in this direction, this paper reports on a preliminary empirical investigation to compare three synchronous communication media in the software requirements negotiation. Indeed, this study attempts to compare the effectiveness of a traditional face-to-face meeting, an enhanced chat [8], and a distributed three-dimensional virtual environment implemented within Second Life [15]. One of the main goals here is to verify whether the time to negotiate software requirements is influenced by the used communication media. Furthermore, as the only assessment of the time could not be meaningful, we have also investigated the quality of the structured description of the negotiated software requirements.

The remainder of this paper is organized as follows. Section 2 discusses related work, while Section 3 highlights the considered communication media. Section 4 and Section 5 present the design and the results of the empirical investigation, respectively. Final remarks and future direction conclude the paper.

## 2   Related Work

In the last two decades research effort has been devoted to define and/or assess tools for computer supported collaborative work in general and for supporting distributed meetings in particular [4, 9, 11]. As our contribution concerns the comparison between distributed and traditional face-to-face meetings in the requirements negotiation, in this section we present some tools/environments implementing distributed meetings. This section is not intended to exhaustively present all the available tools/environments. Note that research studies related to the investigation of communication media in the requirements negotiation is discussed as well.

### 2.1   Distributed Meeting

Nijholt *et al.* [12] proposed a virtual environment implementing the meeting room metaphor. In this environment, the authors restricted themselves to simulate a real-time meeting and embodied participants. Differently, De Lucia et *al.* [9] proposed a tool named SLMeeting to enhance the synchronous communication among users within Second Life. This tool proposes a distributed virtual environment to support the management of collaborative activities organized as conferences or Job meetings.

Instant messaging tools have been also used in collaboration scenarios [10, 11]. For example, in [11] the authors reported the RVM (Rear View Mirror) tool. This tool supports presence awareness, instant messaging, and group chat within geographically distributed workgroups. The results of the experience concerning the use of RVM have been presented and discussed as well. In [10] Drew (Dialogical Reasoning Educational Web tool) has been proposed. It provides a set of tools to support collaboration among students through previously defined pedagogical sequences.

### 2.2   Communication Media in Requirements Negotiation

Damian et *al.* in [4] propose an empirical study to compare five physical group configurations: one face-to-face and four distinct distributed communication settings. In case of distributed settings different relative locations of the stakeholders were considered. Differently from us, the stakeholders' communication was based on

computer-conference communication. This study revealed that the highest group performance occurred when customers were separated from each other and collocated with the facilitator or system analyst.

An interesting empirical study aimed at investigating the effect of using mixed media (i.e., rich and lean) in distributed requirements negotiations has been proposed in [6]. The students used an asynchronous text-based tool and a synchronous videoconferencing based communication tool. The study reveals that the requirements negotiation was more effective when an asynchronous structured discussion was conducted before a synchronous negotiation meeting. Furthermore, they observed that asynchronous discussions were useful in resolving issues related to uncertainty.

Boehm and Egyedin [2] presented some lesson learned in the software requirements negotiation. They captured and analyzed requirements negotiation behavior for groups of undergraduate students, who were asked to develop library multimedia archive systems, using an instrumented version of the WinWin groupware system. Indeed, 15 different projects were conducted by about 90 students. Several real world problems were evidenced in this study (e.g., fuzzy requirements, conflicts with resources and personnel, Domain Expertise, and so on).

## 3 Investigated Communication Media

There is a common understanding on the fact that the infrastructure to negotiate software requirements in synchronous way is expensive to set up and maintain [4]. The coordination across organizational boundaries could be problematic as well. However, the media selected in this study (i.e., enhanced/structured chat and virtual environment) are simple to set up and maintain, thus making them appealing and potentially easy to use in the negotiation.

### 3.1 Face-to-Face

The face-to-face interaction used in the study is composed of two steps. In the first step the students organized in teams were asked to conduct the negotiation making the possible conflicts explicit. To facilitate the identification of the right decision the students for each conflict had to explicit: the relevant alternatives, the argumentations, and the underlying rationales. The right decision had to denote a decision rationally made evaluating the alternatives and selecting the best one according with the client expectations. In the second step a facilitator was asked to formalize the software requirement according to the template proposed in [3].

### 3.2 Enhanced Chat and CoFFEE

As enhanced synchronous tool to remotely negotiate software requirements we used the CoFFEE system [8]. This system has an extensible architecture designed to mediate the interaction of face-to-face group discussions in the classroom. Although, it is mainly aimed at improving collaborative learning in the context of computer support collaborative workgroup, the system offers good tools to support the synchronous collaborative activities during discussions. Discussions are organized in a session, which is divided in steps. The activities that can be accomplished within each step are defined combining one or more CoFFEE tools. In the experiment, we used two

meaningful and well known tools: the chat and the threaded discussion. The chat tool enables the discussion in a group by using the so called synchronous conferencing and offering an interface based on the internet relay chat system.

The threaded discussion tool enhances the chat tool enabling the users to structure a discussion flow in threads. Notice that the threaded tool can be configured so that it is possible to instance multiple threaded chats with different topic called categories. A user can submit a contribution after he has selected the appropriate category and the other users can provide multiline contributes attached to the previous users' contributions. Furthermore, the threaded tool can be configured in order to tag the user contribution type (e.g., suggest, agreement, or revision).

In our study we have created a session composed of two steps. Each step is composed of a threaded chat and a chat tool. The threaded chat provides a discussion point for each entry within the structured description of the negotiated software requirement. In the first step the students had to interview the client to get clarification on the negotiated software requirement, while in the second step a facilitator was in charge of formalizing the negotiated requirement according to template proposed in [3].

### 3.3   Virtual Environment and Second Life

Virtual reality worlds have become increasingly popular in the recent years. Second Life is one of the most popular three-dimensional virtual worlds. It is based on a community where each member assumes an identity and takes up residency. Each member can create a customizable avatar, which can be moved in the virtual world using the mouse and/or the keyboard.

To perform the experiment within Second Life we leased some land and set up a virtual building where the meetings have been conducted. We tried to offer a successful approach of self-organizing systems inside the virtual world designing an open-space meetings room. Successively, within the building we arranged the groups of students around four tables. The student within a group could communicate using a chat and/or the voice. A slideshow was also provided to each group in order to present the template to be used in the modeling of the negotiated software requirement [3].

To take notes during the negotiation the students used a virtual object called note-card. The note-card is a simple text documents that every avatar can create and share with other avatars. In our experiment a note-card can only be shared with the students of the same group. This object was also used to reach an agreement on the structured description of the modeled requirement. In fact, a facilitator was in charge of specifying the software requirement when the negotiation was concluded. Once this software requirement specification was completed, the facilitator had to share it with the other developers, who could suggest or propose corrections to improve it.

## 4   Experimental Setting

This section presents the context of the empirical study experiment and its design.

### 4.1   Definition and Context

The context of the experiment was constituted of Bachelor students in Computer Science at the University of Basilicata. The total number of involved subjects was

forty-eight voluntary students. Thirty two subjects have been attending a Software Engineering course and acted as developers, while the remaining twelve subjects have been attending an Operating System course and acted as clients. The developers had knowledge on methods and techniques widely employed in the requirements engineering. Conversely, the clients were familiar with neither software engineering nor requirements engineering, so they were only able to provide details on the problem domain and on their needs.

The subjects were randomly grouped in twelve software development teams. The teams were composed of three developers and one client. The experiment has been performed in a controlled setting within a laboratory at the University of Basilicata.

The experiment has been organized in two days. The first day was a training session where details on the traditional face-to-face meeting, CoFFEE, and Second Life were presented. Subjects have also used them on tasks not directly related with the experimentation (e.g., Open Source advantages and disadvantages). In the second day the subjects performed two tasks in two subsequent laboratory sessions. The tasks regarded the negotiation of two functional requirements of a software system on which they were familiar with, namely an E-Commerce Platform (ECP).

To perform the tasks we considered the following methods:

- FF (Face-to-Face meeting). It involves the communication between three developers and a client. The stakeholders are in the same place.
- SC (Structured Chat with CoFFEE). The communication is distributed and the subjects remotely interview the client to get clarification on the requirement.
- VFF (Virtual Face-to-Face with Second Life). The communication is distributed and is implemented within a virtual environment.

When the negotiation is concluded each facilitator (one of the developers) formalizes the discussed requirements using a structured description, which had to be compliant with the template proposed in [3].

Notice that the rationale for asking each team to define structured description of the negotiated requirements relies on the fact that the negotiation process should affect this description. It is also true that developers' ability could condition the overall quality of that description. However, all the developers had comparable background and experience on requirements engineering.

## 4.2   Research Questions

The first goal of the experiment was to verify whether the communication media influences the time required to negotiate a software requirement. To this end, the following research question has been formulated:

**Q1.** Does the use of one of the considered media (i.e., FF, SC, or VFF) affect the time to negotiate a software requirement?

To assess the overall quality of the negotiated software requirements, the authors together with an external reviewer inspected the produced structured descriptions (without being aware of the used communication media).

To assess the negotiation quality we have considered the total number of defects within the structured description resulting from the inspection meeting. Therefore, the following research question has been formulated:

**Q2.** Does the use of one of the considered media affect the number of defects within the structured description of the negotiated software requirements?

### 4.3 Experiment Design

The design of the experiment is summarized in Table 1. In particular, this table shows the groups' identification, the number of teams for each group, the experimented media, the performed task (i.e., T1 or T2), and in which laboratory session (i.e., LAB1 or LAB2) a task has been performed. The subjects (i.e., developers and clients) were randomly assigned to a software team. Successively, the twelve teams composed of three developers and one client were randomly assigned to the groups S1, S2, and S3.

Within the two laboratory sessions the subjects were asked to perform the following tasks:

**T1.** Negotiate the software requirement *"create a new client within ECP"* and construct its structured description.
**T2.** Negotiate the software requirement *"remove a product from the catalog within ECP"* and construct its structured description.

**Table 1.** Experiment design

| Group | Number of Teams | SC | EFF | FF |
|-------|-----------------|----|-----|----|
| S1 | 4 | | | T1, LAB1 |
| S2 | 4 | T1, LAB1 | | T2, LAB2 |
| S3 | 4 | | T1, LAB1 | T2, LAB2 |

**Table 2.** Descriptive Statistics of LAB1

| Group | Method | Time | | | Defect | | |
|-------|--------|------|------|-----------|--------|------|-----------|
| | | Med. | Mean | Std. Dev. | Med. | Mean | Std. Dev. |
| S1 | FF | 65 | 63.75 | 7.5 | 2 | 2.25 | 1.26 |
| S2 | SC | 81 | 80.25 | 3.77 | 1.5 | 2.00 | 1.41 |
| S3 | VFF | 79 | 75.50 | 13.07 | 1.00 | 1.25 | 1.26 |

**Table 3.** Descriptive Statistics of LAB2

| Group | Method | Time | | | Defect | | |
|-------|--------|------|------|-----------|--------|------|-----------|
| | | Med. | Mean | Std. Dev. | Med. | Mean | Std. Dev. |
| S2 | FF | 63 | 62.5 | 6.6 | 2.5 | 2.5 | 0.57 |
| S3 | FF | 63.5 | 63.00 | 9.05 | 3 | 2.75 | 2.21 |

## 5 Results

Some descriptive statistics are shown in Table 2. In particular, this table shows the median, the mean, and the standard deviation (grouped by FF, SC, and VFF) of the

negotiation time and identified defects of the teams within LAB1. These statistics show that less time is needed to negotiate software requirements when using traditional face-to-face meeting. Accordingly, we can affirmatively answer Q1. To further confirm the research question Q1, we performed a further analysis (see Table 3). This analysis revealed that on average the teams within S2 spent less time to accomplish T2 in LAB2 using FF (62.5 minutes) as compared with the time to perform T1 in LAB1 using VFF (80 minutes). Similarly the teams within S3 spent less time to accomplish the task in LAB2 (63 minutes) with respect to LAB1 (75.5 minutes).

Regarding the research question Q2, we can observe that the communication media slight influence the overall quality of the structured descriptions. In fact, the average number of defects is nearly the same for all the considered media. However, the average number of defects is larger in case the method FF is used (group S1). Furthermore, a slight difference was observed in terms of defects when the teams used a virtual meeting (i.e., VFF or SC) first and then FF, thus suggesting that the considered media does not affect the number of defects within the structured description of the negotiated software requirements (research question Q2). In fact, the teams of the groups S2 and S3 obtained worse performance within LAB2 in terms of defects within the description of the use cases. In particular, the average number of defects within LAB1 for the teams of the group S2 was 2, while in LAB2 was 2.5. Similarly, for the teams within S3 the average number of defects was 1.25 in LAB1 and 2.75 in LAB2.

## 6   Conclusion

According to media-effects theories, face-to-face communication is the richest medium as compared to all the other communication media (including computer conferencing). Moreover, most theories assert that the negotiation performance decreases when less reach media are used because of a mismatch between the negotiation needs and the medium's information richness. In this study we investigated these assumptions in the context of requirements negotiations. Similarly to the empirical investigation presented in [4], our study do not support traditional claims that groups using the richest communication medium generally perform better than those using leaner media. Indeed, we observed that subjects using face-to-face meeting are able to negotiate software requirements in less time. Differently, no difference was observed in terms of the number of defects in the use case structured descriptions.

In the future we plan to conduct a further analysis on the gathered data using statistical tests. For example, we will investigate whether the order of laboratory sessions and the subjects' background influence the achieved results. The effect of the conflicts aroused in the requirement negotiation according with the used communication media will be considered as well. This further investigation could provide some directions from a socio-psychological perspective. In particular, a question that could be addressed is whether stakeholders with conflicting requirements better manage conflicts in case they are physically separated. Future work will be also devoted to conduct empirical studies in different contexts, thus confirming or contradicting the achieved results.

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