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A Research Design for Asynchronous Negotiation of Software Requirements for an Emergency Response Information System

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ABSTRACT

Negotiation of software requirements is a critical phase of the software development process. Multiple stakeholders and/or organizations must agree to a final set of requirements for implementation. With global distributed software development increasingly prevalent, the study of asynchronous negotiation and collaboration is valuable. Emergency response activities and accompanying information management have been maturing over the years but with recent events, the development has been accelerated. A research design for asynchronous negotiation of software requirements for an emergency response system is discussed. This paper describes a research in progress which examines the negotiation of multiple emergency response stakeholders, striving to agree to a set of common software requirements to meet their needs for their organization.

Keywords

Software requirements, negotiation support, emergency response information systems, asynchronous communication, requirements engineering

INTRODUCTION

Global software development is a growing trend. Increasingly companies are segmenting their development activities among several countries for round the clock development. This global work effort has been focused mainly on the downstream phases of software engineering after requirement elicitation and specification. The upstream phases of the software development process have traditionally been focused on face-to-face negotiations to elicit and define system software requirements. This phase is critical to the development of quality, useable software systems (Boehm, Bose, Horowitz, Lee, 1995; Bui, Cho, Sovereign, 1999; Damian, 2001). Requirements elicitation and determination is difficult at best for organizations that have common goals and needs. When multiple organizations are involved at different geographic locations, the task becomes more challenging (Bui, et. al, 1999, Damian, 2001). This research looks at the final phase of software requirements determination for an emergency response information system. Five stakeholders with the assistance of a program manager negotiate asynchronously to finalize system requirements. The stakeholders, representatives of several emergency response organizations at the local and state level, understand the importance of having a system that functions as a knowledge repository and facilitates response in a rapid, efficient manner. This realization and the cost saving implications of creating a collaborative system provides a strong impetus for the stakeholders to work together to find a set of robust requirements for the system. Because these organizations are geographically dispersed and the stakeholders time is valuable, they have agreed to negotiate virtually using an electronic bulletin board as their "meeting room". The negotiation scenario lies in agreeing to a series of requirements that will satisfy the stakeholders interests and critical needs while staying within specified monetary constraints.

RESEARCH OBJECTIVES

The goal of this research project is to investigate the effectiveness of asynchronous collaboration and negotiation on the determination of software requirements and to contribute to the knowledge base for common system requirements for emergency response information systems. In this domain, multiple diverse stakeholders must work together in crisis mode to efficiently ensure critical safety procedures. The development of an information system that can be used on a daily basis during non-emergency activities will ensure the emergency response personnel are familiar with the system and can transition to emergency mode smoothly (Turoff, Chumer, Van de Walle, Yao, 2003). Formulating a set of generic critical software requirements for an emergency response information system would provide compatibility and facilitate the distribution of common systems throughout state and local organizations, capturing organizational memory, saving money, and more importantly, perhaps saving lives.

BACKGROUND: NEGOTIATION IN REQUIREMENTS ENGINEERING

Negotiation research looks at and incorporates the concepts of cognitive psychology and behavioral decision research. Using decision making research as a basis, each participant in a negotiation is a decision maker whose behavior is a result of choices based on judgments they make about the negotiation situation (Bazerman, Carroll, 1987). Incorporating these tenets in requirements engineering, stakeholders and software engineers work together to negotiate a final set of requirements for a new software system. First, the software engineer or systems analyst elicit requirements from the stakeholders. After elicitation, there is a period of negotiation where software engineers work with the stakeholder to resolve conflicts. It is important at this stage to ensure that no critical requirements have been overlooked and that the final list contains those that will define a useable, functional system that meets the client's needs. Once the requirement negotiations have been completed the final list can go forward for validation (Boehm, et al., 1995, Damian, 2001).

DISTRIBUTED ASYNCHRONOUS REQUIREMENTS ENGINEERING

Requirements engineers and stakeholders commonly meet face to face to determine the list of possible requirements for the proposed system. Series of meetings are necessary to ensure all stakeholders concerns are addressed. When this face to face collaboration is completed, the analyst then compiles a list of requirements, their associated cost estimate and go back to the customer to prioritize and re-check for any possible omissions. Seldom is there enough time or money to implement all requirements requested by the stakeholders. There has been little research done on the process of selecting and prioritizing among all the possible valid system requirements to choose a set that will satisfy the stakeholders needs (Bui, et al., 1999). The associated costs with having another round of face to face visits and interviews can be prohibitive. Discussion in a distributed, collaborative environment is an option for resolution of the final priority list. Using technology to assist in this decision-making process provides traceability, greatly enhancing the consistency, clarity, and maintainability of the proposed software system. Distributed asynchronous requirements engineering discussions have specific challenges unlike face to face situations. Some examples are lack of immediate feedback, less rich communication in the absence of face to face cues, stakeholders remaining active so the negotiations can go forward in a timely manner, and difficulty coming to agreement (Grunbacher, Koszegi, Hallin, Biffel, 2003).

EMERGENCY RESPONSE INFORMATION SYSTEMS

Emergency response activities and accompanying information management have been maturing over the years but with recent events, the development has been accelerated. There are several issues that should be addressed with the development and implementation of an emergency response information system. Many small communities do not have the resources, personnel, nor the expertise to develop a set of requirements to assist them in managing their day to day activities as they pertain to emergency response. The development and description of a generic set of requirements that could be utilized by state and local jurisdictions would clearly enhance the effectiveness of any emergency management information system (Spaite, 1999). It would also reduce the incompatibilities between local systems so they could be networked at the state level more easily. In the event of an emergency, it is the local responders that provide the first efforts in containing the event. These critical first minutes could mean life or death in these communities. Having a set of common system requirements will be very valuable in assisting local communities who might not have the resources to do intensive research in this area in developing a useful and used emergency response information system for their community. A thread throughout the emergency response literature is the need to create a system whereby data and information can be compiled and used by the emergency response community not only during a crisis situation but also on a regular basis. This would ensure the data is current and also, maybe equally or more important, that users are comfortable with the system at a time when they need to use it quickly and efficiently.

Green (2002) and Turoff et al. (2003) discuss the importance of defining and understanding what information is necessary to facilitate decision making during times of emergency. These authors list components for a virtual emergency operations center. They include: use of emergency management software to communicate internally and externally and to manage data, remote access to emergency operations center databases and communications, access to internet sites to gather information, dissemination of information on the internet both to official response organizations and for public access, and linking dispersed individuals to perform emergency operations center functions remotely. This research effort proposes to further the study of these important features of emergency response. Collaboration amongst the multiple diverse emergency response stakeholders will increase the quality and effectiveness of the response effort.

RESEARCH MOTIVATION

Although global software engineering continues to grow and expand, the most important phase remains mostly understudied (Damian 2003). Requirements analysis rarely takes place in a distributed mode. In this early phase of the software development process software analysts travel to organizations to interview, observe, and study the current system and users. From this direct communication, which may take several iterations, a specification is written which is shared with the stakeholders. This specification documents the design of the system. Once the specification is completed, work can be disbursed to different parts of the globe for implementation.

Seldom is there enough time or money to implement all requirements requested by the stakeholders. There has been limited research on the process of selecting and prioritizing among all the possible system requirements to choose a set that will satisfy the stakeholders needs. The associated costs with having multiple rounds of face to face visits and interviews can be prohibitive. Group discussion in a distributed, collaborative environment is an option for resolution of the final priority list. Using technology to assist in this decision making process provides traceability to the process, greatly enhancing the consistency, clarity, and maintainability of the proposed software system. (Park, Port, Boehm, 1999, Anton, Liang, and Rodenstein, 1996). Re-negotiation to determine the final priority list for stakeholders is not currently supported in requirements negotiation frameworks. Typically support is quite strong for the first iteration of requirements negotiation, but re-negotiation procedures where final issues and conflicts are resolved, are not well supported. More comprehensive negotiation support is needed. A definitive process for negotiation support will enhance the cognitive and information processing capabilities of users. (Grunbacher, et al., 2003).

Modes of communication within requirements engineering have been studied by several researchers. Ocker, Fjermestad, et al., 1997, provide research on four modes of communication during the development of software requirements. They looked at the effects of different combinations of modes of communication and measured how they related to quality, solution satisfaction, and process satisfaction. The four modes of communication were 1) face to face, 2) synchronous computer conferencing with 2 face to face meetings, one at the beginning and one at the end of the work phase, 3) asynchronous computer conferencing, and 4) a combined group with face to face and asynchronous computer conferencing. The results of the study showed that the combined group had the highest scores in creativity, quality, and process satisfaction. The combined group also produced better requirements definitions than the groups using other communication modes. The authors suggest further research be undertaken to more fully explore how other combinations of computer mediated communication affects group quality and creativity.

Damian, (2001) studied distributed requirements negotiation using three different software engineering stakeholder roles with conflicting goals working collaboratively towards a solution. She found that the use of a shared electronic workspace was particularly useful in requirements negotiation. The use of computer-mediated requirements negotiations enhance and enrich the contribution of geographically separated stakeholders, enabling important participants to have a contribution above and beyond the face to face requirement fact finding meetings.

EXPERIMENTAL DESIGN

This research proposes an experiment focusing on the negotiation of requirements by stakeholders who are located in separate locations and cannot meet face to face. Two research questions are examined: what is the effect on asynchronous negotiation of 1) a structured task ; and 2) a specified negotiation sequence.

A structured task was used to frame the discussion around the problem. Conklin and Begeman, 1988, argue that a design rationale provides a structure for focusing discussion among team members. The design rationale in this experiment is provided in the form of structure of the asynchronous discussion. The structured framework for this experiment is provided by separate threaded discussion boards for each requirement and for general discussion. Providing a process or structure to negotiation support can enhance cognitive and information processing capabilities of stakeholders (Grunbacher, et al., 2003). This can improve resulting negotiation outcomes. The

structured decision sequence is broken down into three main phases: 1) generation of decision alternatives 2) period of critical reflection and individual evaluation of alternatives, and 3) group evaluation of alternatives and solution discussions. (Ocker, 1995).

The negotiation life cycle consists of several stages starting with negotiators communicating their needs and ending with a common agreed upon conclusion. According to Fisher and Ury, 1983, a successful negotiation is one that results in an agreement that satisfies the parties' interests, is fair, and improves the relationship. The experimental negotiation sequence framework is based on Fisher and Ury's steps for effective negotiations. These are: 1) identifying and defining the problem 2) understanding the problem, 3) generating alternatives and solutions, 4) evaluating alternatives and selecting the final agreed list.

In the experimental task, stakeholders will negotiate using asynchronous online threaded discussions to choose a set of software requirements that satisfy their needs. The stakeholders have monetary restrictions and each are provided with a series of preferred ranked requirements to guide them. The experiment provides a structured task with a formal negotiation sequence. The experiment will be a 2 X 2 factorial design with independent variables of negotiation sequence and task structure. The dependent variables are: conflict, process satisfaction, negotiation convergence, solution satisfaction, and solution quality.

The subjects are graduate computer science or information system students taking a class that has software engineering as part of the syllabus. The students complete this exercise for course credit. After groups of six are randomly assigned, each student is given one of six stakeholder roles to play. Each stakeholder is provided with a role description and a set of requirements that were ranked according to criticality for their role. Hypothetically, the master list of requirements was determined by the traditional methods of requirement elicitation by program analysts visiting each organization. From this master list, the participating organizations will now negotiate asynchronously to determine the requirements for a multi-user system that will serve the needs of all the participating organizations. Accordingly, the stakeholders each have a list of critical, medium, and low priority requirements they determined with the help of the software development firm. For five days, the stakeholders negotiate asynchronously to choose a set of requirements that would fit their own and the group needs yet stay within the allocated budget. This activity simulates real world requirements determination as not all needs for all users can be met for any information system. Some of the needs must be placed on a list for future enhancements or omitted altogether. Stakeholders work together and negotiate to find the best set of requirements that will provide needed functionality for all users. Providing a structure to the negotiation problem and specifying each step in the negotiation process provides a framework for the problem solving activity. The main objective of this study is to determine if the use of a problem solving framework enhances the results of asynchronous negotiation of high quality software requirements. Figure 1 represents the conceptual framework for this research project.

The two independent variables are structured task (with structured task and without structured task) and negotiation sequence (with negotiation sequence and without negotiation sequence). The design is shown in the table below.

Media	With Structured Task	Without Structured Task
Web-based Conferencing	With Negotiation Sequence	With Negotiation Sequence
Web-based Conferencing	Without Negotiation Sequence	Without Negotiation Sequence

Table 1. Experimental Design for each Mode

The subjects for this study will be graduate students in Systems Analysis and Design and Software Engineering courses. Group members will randomly assigned. Groups of six are comprised of five stakeholders and one program manager. The stakeholder members are: 1) law enforcement, 2) fire containment experts, 3) public works, 4) public health, and 5) liaison of state home/civil defense unit. Also in the group is a Project Manager to supply costs and resources, chair the meetings, and provide facilitation. Groups members will be assigned randomly by the researcher.

Conceptual model

This study is designed to measure the effect of negotiation sequence and task structure on group outcome factors when negotiating in an asynchronous mode. The variables are measured using post task questionnaires, expert judges, and analysis of subject generated documentation. Outcome factors to be measured are solution quality, solution satisfaction, process satisfaction, conflict, and negotiation convergence. The conceptual model is depicted in Figure 1.

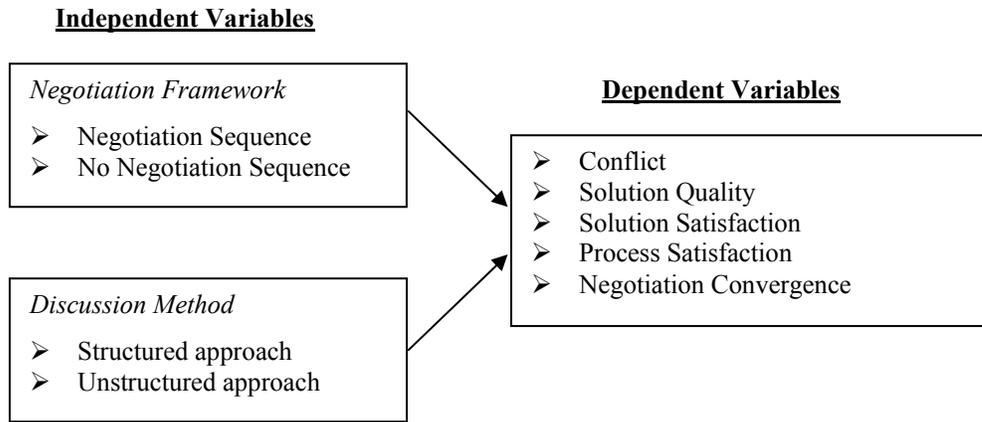


Figure 1. Conceptual Model

DATA COLLECTION METHODOLOGY

Subjects will be asked to fill out a consent form and a background questionnaire prior to starting the experiment. Most variables will be measured with a post-task questionnaire provided to each subject after participating in the experiment. Other variables will be measured by the output from webboard and subject generated documentation (daily list of requirement priorities, final agreed list of ranked requirements, final reports). Negotiation convergence will be measured by collecting a "daily log" file where each subject is requested to write his/her requirement rankings each day of the study. This log file is provided to the students as an Excel template that they can download. The completed logs are then uploaded to webboard and manually compiled for analysis by the researcher. Finally, solution quality will be measured by post task questionnaire items and by an expert judges report. The table below describes the measures to be used.

Variable	Measurement Tool
<i>solution quality</i>	Expert judges analysis, final reports, and post task questionnaire
<i>conflict</i>	Post Task Questionnaire
<i>process satisfaction</i>	Post Task Questionnaire
<i>solution satisfaction</i>	Post Task Questionnaire
<i>negotiation convergence</i>	Subject generated documents

Table 2. Variables and measurement tools

TECHNOLOGY

The asynchronous communication methods are facilitated by the use of the conferencing system WebBoard. This system provides a true asynchronous communication mode. The students are familiar with this system from their class work and therefore minimal training on the use of this system is necessary.

TRAINING

The subjects are given one face to face training session which lasts approximately one and a half hours. During this session the students are introduced to the domain topic, the specific task to be completed, a brief background of requirements engineering (this is covered in depth by their current coursework), and the roles and what is expected of them. In the webboard conference there is also a "Question and Answer" area where the students can post and read questions and answers about the exercise.

DATA ANALYSIS METHODS

Background data will be collected on each subject including age, employment, gender, and ethnic background. This will be analyzed for comparability with experimental conditions. ANOVA will be used to test the independent variables effect on the dependent variables. Significance levels of 0.05 or less will be considered statistically significant. A Lickert scale from one to seven was used to measure most variables. Chronbach's alpha will be used to validate the individual items in the scales.

DISCUSSION

This article details the research framework, experimental design, and methods for requirements negotiation in an asynchronous communication mode for an emergency response information system. As software communities continue to grow and globalize, communication becomes more complex, with time and physical location differences much more common. Using techniques of asynchronous negotiation can improve and strengthen the requirements engineering process by providing another valuable layer of input and agreement that may otherwise be dispensed with due to organizational travel and time concerns. The final negotiation and accompanying agreement in the requirements engineering cycle are critical to the success of the end product; the software.

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