ABSTRACT

NEGOTIATION OF SOFTWARE REQUIREMENTS IN AN ASYNCHRONOUS COLLABORATIVE ENVIRONMENT

by
Catherine Lowry Campbell

The effect of task structure and negotiation sequence on collaborative software requirements negotiation is investigated. This work began with an extensive literature review that focused on current research in collaborative software engineering and, in particular, on the negotiation of software requirements and the requisite collaboration for the development of such requirements. A formal detailed experiment was then conducted to evaluate the effects of negotiation sequence and task structure in an asynchronous group meeting environment. The experiment tested the impact of these structures on groups negotiating the requirements for an emergency response information system. The results reported here show that these structures can have a positive impact on solution quality but a negative impact on process satisfaction, although following a negotiation sequence and task structure can help asynchronous groups come to agreement faster. Details of the experimental procedures, statistical analysis, and discussion of the results of the experiment are also presented, as are suggestions for improving this work and a plan for future research.

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by
Catherine Lowry Campbell

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NEGOTIATION OF SOFTWARE REQUIREMENTS IN AN ASYNCHRONOUS COLLABORATIVE ENVIRONMENT

Catherine Lowry Campbell

Dr. Fadi P. Deek, Advisor — Date
Professor of Information Systems, New Jersey Institute of Technology

Dr. Bartel Van de Walle, Co-Advisor — Date
Assistant Professor, Tilburg University, The Netherlands

Dr. Stephen B. Seidman, Committee Member — Date
Dean and Professor of Computer Science and Information Systems, New Jersey Institute of Technology

Dr. Vassilka Kirova, Committee Member — Date
Adjunct Professor, Information Systems, New Jersey Institute of Technology

Dr. J. Fernando Naveda, Committee Member — Date
Professor and Department Chair, Software Engineering,
Rochester Institute of Technology

BIOGRAPHICAL SKETCH

Author: Catherine Lowry Campbell

Degree: Doctor of Philosophy

Date: January, 2005

Undergraduate and Graduate Education:

- Doctor of Philosophy in Computer and Information Science
  New Jersey Institute of Technology, Newark, New Jersey, 2005

- Masters of Science in Computer Science
  The University of Dundee, Dundee, Scotland, United Kingdom, 1994

- Bachelor of Science in Environmental Engineering Technology
  Temple University, Philadelphia, Pennsylvania, 1979

Major: Information Systems

Presentations and Publications:

Campbell, C.L., Van de Walle, B., Turoff, M., Deek, F.P., "A Research Design for Asynchronous Negotiation of Software Requirements for an Emergency Response System", Proceedings of the Tenth Americas Conference on Information Systems, New York, New York, August 2004.

Campbell, C.L., Van de Walle, B., Turoff, M., Deek, F.P., "Measuring Consensus and Conflict among Stakeholders in Emergency Response Information Requirements Negotiations", International Conference on Crisis Response and Management, Brussels, Belgium, May, 2003.

Campbell, C.L., Van de Walle, B., "Asynchronous Requirements Engineering: Enhancing Distributed Software Development", International Conference on Technology in Education, August, 2002.

Bernard of Chartres used to say that we are like dwarfs on the shoulders of giants, so that we can see more than they, and things at a greater distance, not by virtue of any sharpness of sight on our part, or any physical distinction, but because we are carried high and raised up by their giant size. (John of Salisbury *The Metalogicon* (1159) bk. 3, ch. 4, quoted in R. K. Merton *On the Shoulders of Giants* (1965) ch. 9).

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CHAPTER 1

INTRODUCTION AND BACKGROUND

Distributed software project teams are becoming increasingly common. In the past, the physical co-location of software engineers has been an important factor in software development. With companies having an increasing global presence, distributed software engineering has become a necessity that many organizations are struggling to accommodate. The cost of conducting regular face-to-face meetings with staff located in different states or countries is prohibitive and cannot be fully passed on to the customer. Also, the time factor of traveling removes the software engineer from productive work while enroute to the meeting destination, which translates into an important process loss for the development team.

Often software development is conducted around the clock. At the end of the work day, software engineers hand off parts of their projects to other team members in different time zones. Alternatively, design may be completed in one country, with coding and testing done halfway around the world. There are many factors that affect the success of distributed teams. French and Layzell (1998) have studied communication and cooperation practices on a range of distributed commercial software projects. They reported a number of justifications for the necessity of distributed software engineering projects. For example, clients may request or require a certain level of on-site support, project members may be unwilling or unable to travel or relocate, specific skilled workers may be necessary for a specific project based at different sites, travel or relocation costs of moving a large number of project members may be too high, organizations may feel

uneasy about having other organization staff members working on their premises, and office space at specific locations may be limited.

This research looks at the process of generating software requirements in a distributed environment. Specifically, it describes an empirical study on how distributed groups work together, using established negotiation techniques, to arrive at a common solution to the problem of generating software requirements. Background theory and research questions are described and supported by an extensive literature review. A theoretical framework and conceptual model for the proposed study are drawn from the literature review, and hypotheses are identified. The experimental design and methodology are given in detail; the independent and dependent variables are explained along with measurement techniques. All measurement tools and experimental artifacts are included as appendices.

1.1 Background

Requirements engineering is one of the most important phases of the software development process. Problems in this early stage of the process can result in serious problems that can cascade throughout the downstream phases of development adding cost and development time to the final product. Brooks, (1975) in his classic article "No Silver Bullet: Essence and Accidents in Software Engineering", states:

> *"The hardest single part of building a software system is deciding what to build. ...No other part of the work so cripples the resulting system if done wrong. No other part is more difficult to rectify later. Therefore, the most*

important function that the software builder performs for the client is the iterative extraction and refinement of the product requirements."

A solid definition of a software requirement is: "*Requirements definition is a careful assessment of the needs that a system is to fulfill. It must say why a system is needed, based on current or foreseen condition, which may be internal operations or an external market. It must say what system features will serve and satisfy this context. And it must say how the system is to be constructed*" (Ross and Schoman, 1977). Alan Davis (1993) defines requirements engineering as: "*all activities up to but not including the decomposition of the software into its actual architectural components*".

1.2 The Software Requirements Process

The importance of the requirements process is well understood. As Brooks (1975), observed, if you don't know what you are building it is impossible to be successful later on in the development process when the system is actually being built.

Van Lamsweerde (2000) identifies seven stages of the requirements engineering process: domain analysis, elicitation, negotiation and agreement, specification, specification analysis, documentation, and evolution. Domain analysis studies the existing system; relevant stakeholders are identified and interviewed, and general objectives are identified. In the elicitation stage, assumptions about the new system and requirements are identified. During the negotiation and agreement stage, alternatives are evaluated, and stakeholders reach agreement on the tradeoffs needed to achieve the "best" solution. These requirements are formalized and precisely defined in the specification stage. Inconsistency and incomplete requirements are targeted in the

specification analysis stage. At this time, the feasibility of the requirements is also analyzed: are the requirements too expensive to implement for the functionality obtained. During all of these stages, the software engineer documents the procedures, reasons, and assumptions. In the documentation stage, this is formalized to support traceability and understanding of the requirements process. A software development effort evolves over time, and necessary changes to the requirements, objectives, or functionality can be anticipated. These modifications occur in the evolution stage.

Other researchers organize the requirements development process in a slightly different way. For example, Sommerville (2001) lists four general requirements engineering process activities: 1) system feasibility study, 2) elicitation and analysis, 3) specification and documentation, and 4) requirement validation. Sommerville also indicates that requirements management is another important activity of the requirements process. In this activity, the inevitable changes to the requirements list are considered and adopted into the development process. Similarly, Bray (2002) identifies four subtasks of the requirements engineering process. They are elicitation, analysis, specification, human machine interface (HCI) design, and validation. The HCI design phase is included in this process as the external design is not coordinated with the specification. Bray suggests the interface with humans or other systems deserves its own analysis and phase within the requirements procedures.

Pohl (1994) identifies three main goals of the process of requirements engineering: 1) gaining a complete specification 2) offering different representation formats 3) supporting the evolution from personal viewpoints to common agreement on the final specification. His perspective consists of three areas or dimensions:

specification, representation, and agreement. The specification dimension is concerned with how the requirements are perceived and understood. They are changeable from early specification stage and are more defined later. The representation dimension applies to the various methods and languages for expressing knowledge about the system and then the requirements. The way requirements are represented early in this stage can be done fairly informally. As knowledge progresses, movement to a more formalized representation is completed. An important consideration at this stage is maintaining consistency while moving from the informal to the formal descriptions. The agreement dimension encompasses the evolution of individual views of the specification into an agreement that is acceptable to all stakeholders. Different views in this stage are a positive element, as this will bring potential problems and solutions to the fore early, resulting in a more robust final requirements specification.

Pohl (1994) identifies five factors that influence the requirements engineering process.

- Methods and methodologies: used for guiding the requirements engineering process
- Tools: these can improve the final specification by finding inconsistencies in the formal specification
- Social aspects: the dynamics within the software engineering project group
- Cognitive skills: the level of skill in the software engineering project group
- Economic constraints: if severely limited it can affect the quality of the final specification.

All of these perspectives are consistent with the stages of the requirements engineering process defined by the Software Engineering Body of Knowledge (SWEBOK), IEEE 2004. This guideline to best practices lists elicitation, analysis,

specification, and validation as the four stages of software requirements. These four stages will therefore be used as a guide in this chapter.

Communication problems in the domain of software engineering are common. Stakeholders have differing experiences and needs and sometimes have different ways of expressing these needs. Domain experts may be totally computer illiterate, and although they know what they want and need in the new system, they cannot express themselves in a clear manner to the systems analyst. Alternatively, system analysts may not be able to bring themselves to the level of the user and therefore cannot translate the sometimes simple user needs to the functionality of the proposed system. The systems analyst's job is to ask the right questions of the users to elicit requirements that are meaningful and clear. Once this step is completed, the requirements need to be expressed in a way that the multiple stakeholders can all understand. This is a difficult task. Choosing an appropriate method of representation is critical to gaining agreement of the stakeholders. Using a representation method suitable for both domain experts and analysts helps achieve a better understanding as to whether the requirements represent the system goals. This stage results in a written document called a requirements specification; this document combines the stakeholders' understanding of the underlying problem and the expertise of the software engineers. After the specification stage is completed, the requirements must be rigorously validated. In this step, the requirements are analyzed for consistency, compatibility, completeness, understandability, and clarity. It is important for the software engineer and stakeholders to understand what the requirements mean and how they will be developed into the system the users and software engineers expect. It is in this stage that problems are brought to light to ensure a quality product is developed

and that the final list of requirements are concise enough to undergo the software testing process.

1.2.1 Elicitation

Elicitation is *"concerned with where the software requirements come from and how the software engineer can collect them..."* (SWEBOK, 2004)

The elicitation process consists of several steps. The first step is to define the problem to be solved. Stakeholders are then identified to help elicit the goals the system must meet. Several elicitation techniques may be used: traditional data gathering techniques, such as questionnaires and surveys; group techniques, such as brainstorming and focus groups; prototyping; model driven techniques; cognitive techniques such as protocol analysis; or contextual techniques such as ethnographic procedures like participant observation. Identifying the most important goals of each of the stakeholders does not always result in a comprehensive set of requirements that can go forward into the specification stage (Playle, Schroeder, 1986). Aligning the various stakeholders' goals and needs requires negotiation. Some of the factors that affect this negotiation are the organizational status of the stakeholders, organizational changes implied by the implementation of a new information system, and a host of other intangible items, such as financial or contractual restraints (Nuseibeh and Easterbrook, 2000). The following paragraphs describe these elicitation techniques.

1.2.1.1 Scenarios. Scenario based elicitation techniques allow the analyst to describe transactions involving the proposed system and its environment (Potts, Takahashi, Anton, 1998, Sutcliffe, Maiden, Minocha, Manuel, 1998). Scenarios can be used to define actions taken by users when participating in their usual business transactions, such as

interacting with other users or other information systems. Scenarios can be described as use cases or scripts, which may be represented as tables or diagrams with an "actor" being a user or a computer system outside the proposed system. The scenario is the interaction, usually defined as a sequence of actions, between the "actors" and the system being designed. These are called interaction scenarios.

Hickey, Dean, and Nunamaker (1999) have used Group Support Systems (GSS) technologies to study collaborative scenario elicitation. The researchers were particularly interested in the variables of scenario quality and user productivity. They used scenarios in their case study to achieve group consensus on descriptions of business processes that eventually, through collaborative discussions, led to requirements specifications (Dean, et al., 1997).

1.2.1.2 Introspection, Interviews, Questionnaires. The most common methods of eliciting requirements are questionnaires and interviews. Goguen and Linde, (1993) suggest that requirements elicitation can be studied as a social process, bringing techniques from ethnomethodology and sociolinguistics to the science of requirements engineering. Questionnaires, brainstorming, and interviews are helpful, but conversation, interaction, and discourse analyses have the potential to provide more accuracy and precision in the elicitation process. Goguen and Linde provide brief discussions of a variety of common elicitation techniques:

- *Introspection* asks the stakeholders to visualize what it is they need from a system. There are several problems associated with this process. Yes, introspection and "imagining" what the system might look like or might provide a user is helpful, but if a user is less than familiar with the possibilities of what a software system can provide, it is difficult to imagine something that is totally foreign. This approach might be more helpful to systems analysts, who have experience and first hand knowledge about software systems and the benefits they can provide an organization. The opposite situation is equally problematic. If the users know exactly how they do

their work and the software engineers do not understand the organizational domain or work process, the engineers might rely exclusively on the users, with the result that the final system is not as functional or useable as it might be. Close work with users and analysts with the aid of prototyping are complementary activities for this method of elicitation.

- *Questionnaires* have a set of responses to pertinent questions from which the subject can choose an answer. A problem with this approach is that the questionnaire authors do not always use the full range of possible answers. Relevant questions must be chosen in advance and the questions must be worded so that they will be interpreted uniformly by all readers so that they can elicit a valid response that can be analyzed statistically.

- *Open ended interviews* are built around questions that the interviewer asks the subjects, who respond as they please. A problem could arise in interpreting the variation arising from the subjects' varying interpretations of the question. These interpretations could also be influenced by the interviewer, resulting in data that are inherently invalid.

- *Focus and Application Development Groups* are brainstorming groups that bring together people who are chosen to participate in discussing a particular subject matter, be it a marketing group to assess a new product or a business group that is asked for its opinion on the functionality or design of a new software system. This type of elicitation technique may be better for groups that understand the subject matter, but may not be optimal or even helpful if the subjects truly do not understand systems or design issues. Group members would have a difficult time making helpful comments if they have little knowledge about an issue or organizational structure. Joint Application Development (JAD) and Rapid Application Development (RAD) groups are closely related to focus groups and are helpful in the requirements engineering field. Additional drawbacks of this approach might be that subjects who are relatively junior and/or unable or uncomfortable with expressing themselves in a joint meeting with senior members or who may not have sufficient technical expertise will not come forward with their ideas.

1.2.1.3 Protocol Analysis. In this type of analysis, subjects are asked to "think aloud" while performing their tasks. Proponents of this approach believe that it will give the interviewer a realistic view of the cognitive process. Based on this input, the researcher can modify, enhance or validate the design. Some researchers believe that it is difficult for subjects to accurately articulate their cognitive processes, so that a realistic assessment of their cognitive process is not possible.

Goguen and Linde (1993) suggest that after conducting traditional requirements elicitation techniques, it would be beneficial to use a "zooming" method to investigate in detail areas that are deemed to be critical or particularly important. This "zooming" technique, which can include protocol analysis, is very detailed and therefore expensive, but would give specific information about problems that perhaps would not be addressed thoroughly using traditional methods. This is useful for requirement areas that are problematic and are difficult to define. A combination of traditional requirements elicitation techniques and ethnographic techniques can be used to get a good definition of the real requirements of a system.

1.2.1.4 Prototyping. Prototyping can be a powerful elicitation technique, especially with users that do not have experience with systems or interface design. The use of a prototype, or a preliminary model, will help subjects visualize what the system could do for them and therefore prompt more comments on the design, resulting in a more useful software system. Prototypes can be either full computer-based mock-ups of the actual interface design or they can be paper diagrams. A preview of what the system might actually look like can validate users' ideas or help them more fully understand the possibilities of the new system.

1.2.1.5 Viewpoints. Viewpoint-oriented elicitation is a technique that recognizes that each stakeholder has different views on how he or she sees the requirements for a new system. Each stakeholder has a unique and potentially important perspective on what a system should look and feel like and how it might function. This method of elicitation takes into account that while some stakeholders will have very different requirements, there will generally be significant numbers of common elements between the lists of

requirements. The occurrence of conflicts in the requirement lists means that more work must be done to determine which of the conflicting items are valid. This method is particularly valuable because it surveys the "world" of possible requirements (assuming thorough coverage by the analysts), and it provides a way for the users to actually see their contributions to the new system. It may help in stakeholder commitment to the requirements. Viewpoints can be classified two ways. Direct viewpoints are associated directly with the users where they send and receive information to the system. Indirect viewpoints do not interact directly with the system but have an "interest" in the services that are delivered (Kotonya and Sommerville, 1996, Sommerville, 1998).

1.2.1.6 Goal Based Reasoning. Although van Lamsweerde (2000) states that using goal-based reasoning is very useful for the process of requirements engineering, these goals are hard to elicit because the stakeholders have to envision the system before it is built, and it is particularly difficult for individuals not familiar with software systems and their capabilities to visualize a working system abstractly.

1.2.1.7 Ethnography. Ethnography is a technique that uses observation to assess social and organizational structure. These observations are used to understand the work processes of an organization, yielding a more realistic set of requirements. A problem with self-reporting is that many people cannot describe their working techniques, and sometimes their perceptions are inconsistent or incomplete. The additional information an outside observer can provide by observing the organizational work process for a period of time can clarify areas that are nebulous or troublesome (Sommerville, et al., 1992).

1.2.2 Analysis

SWEBOK, 2004 defines this stage as focusing on the following activities:

- *Detect and resolve conflicts between requirements*
- *Discover the bounds of the software and how it must interact with its environment*
- *Elaborate system requirements to derive software requirements*

In the analysis stage of the process, the requirements that were discerned from the elicitation procedures are looked at very closely, both individually and with respect to how they relate to each other and to the system as a whole. Conflicts are identified and resolved to ensure a smooth transition into the final software product. The most likely initial conflict in the process is between stakeholders who have differing needs for the functionality of the system. After these stakeholder conflicts have been resolved through negotiation, a final list of requirements is then derived. The software engineers then analyze these requirements, determine if there are any conflicts, and look for any incomplete or inconsistent requirements. The goal of this stage is to describe the requirements precisely so they can be verified, tested, and their cost estimated accurately.

1.2.3 Specification

The next activity in requirements engineering is specification. This stage generates a document that provides definitive information to the stakeholders as to what the software engineers will build for them. It is confirmation that their input has been integrated into the system.

> According to SWEBOK (2004),: *"software requirements specification typically refers to the production of a document, or its electronic*

equivalent, which can be systematically reviewed, evaluated, and approved."

The ability to represent different stakeholder viewpoints through specification and modeling can allow multiple stakeholders to get a better understanding of the complex creative process that is requirements engineering. The specification process entails developing a model that describes what a system does in a way that is useful to analysts and users. Modeling approaches can be used to inform the information gathering process. Clarity, consistency, and completeness are three characteristics of formal specifications or requirements models. Using formal specification models can help users and analysts to more fully understand their proposed system and remove ambiguity (Zave and Jackson, 1997).

Ghezzi, Jazayeri, and Mandrioli (2003) describe a specification as "the statement of an agreement between a producer of a service and a consumer of the service or between an implementer and a user". The specification states what a system should do and the implementation is left up to the software engineer doing the implementation. There are three types of specifications. A *requirements specification* is an agreement between the end user and the system developer. A *design specification* is an agreement between the system architect and the implementers. A *module specification* is an agreement between the programmers using the module and the programmer implementing the module. Ensuring consistency between and among these levels of agreement enhance the opportunity for clear concise specifications.

In order for the users to validate the list of chosen requirements they must be able to understand how they are expressed. Often, a graphical depiction of a concept is much

easier for users to grasp than that same information expressed in natural language. Formal models and languages can bring all parties together conceptually so that the interpretation of any given requirement is the same. Once a specification language is determined for a project, everyone involved can be assured of consistency throughout the process. If all groups are familiar with the chosen language, it will deter misinterpretation. The use of a formal specification language or modeling technique can help to ensure completeness of requirements, therefore reducing the possibility of incomplete or inconsistent specifications. There are many different ways to look at requirements specification. Some of the approaches will be discussed in the following paragraphs.

1.2.3.1 Behavioral Modeling. Behavioral modeling focuses on the functional behavior of stakeholders and systems, or at the inputs and outputs of a system. *Data flow models* illustrate how data flows throughout the system. They can be used to give the user an idea of how a system will work and what happens during system operation. *State machine* models show the transition of the system from one state to another and detail the internal and external events that cause these transitions. This type of modeling is particularly useful for real-time systems. *Data models* are used when databases form a critical part of a system. Entity-relationship diagrams are very helpful for modeling this type of system. These directed graphs show entities, their attributes and associated relationships within the database structure. Data dictionaries are used in conjunction with entity relationship diagrams to more fully describe the associations within a database system.

Use Cases

Use case diagrams are a part of the Unified Modeling Language (UML). The Unified Modeling Language (UML) is the most often used method of describing objects and object classes. Use case diagrams are a helpful tool to describe in pictures what users do and what the system does, and how these roles relate to each other (Rumbaugh, 1994, Maciaszek, 2001). Rumbaugh, 1994, discusses how use cases can form part of a user-centered approach to capturing requirements and making them accessible to users. The requirement engineer's job is to map the requirements onto the computer domain to illustrate how the system and user interact. A use case describes a series of interactions between the actor (user) and the system. Figure 1-1 shows the use case "student advising system" where the actors are the student and advisor.

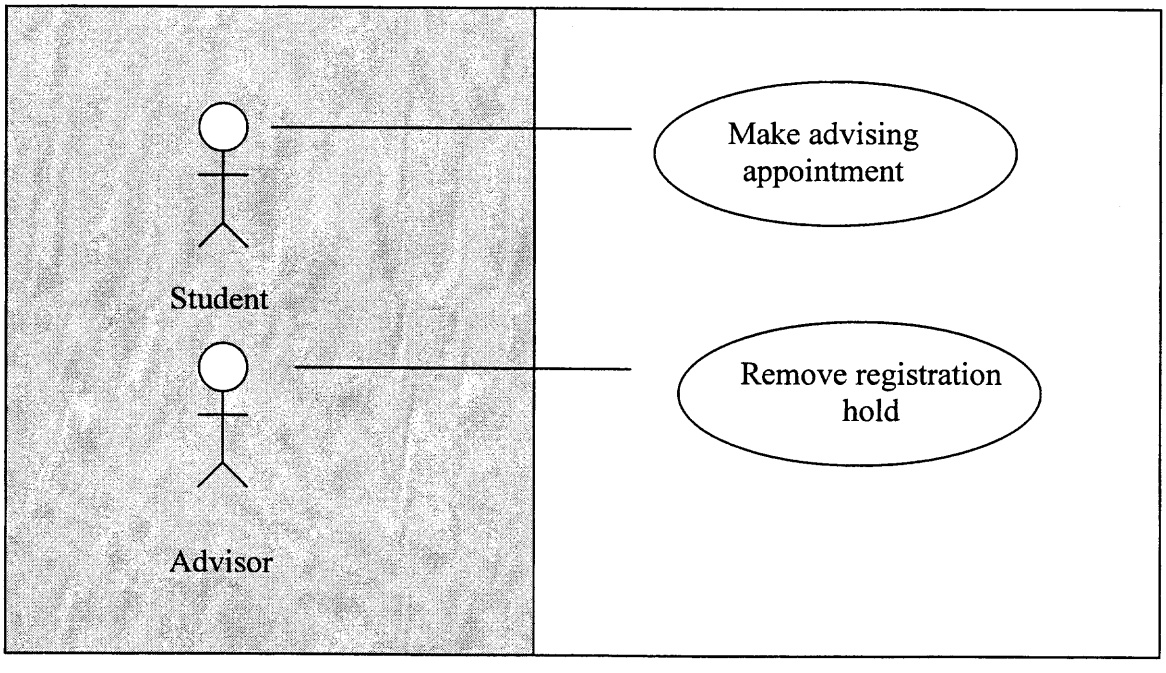


Figure 1.1 Use Case Diagram.

1.2.3.2 Representational Modeling. This type of modeling is focused on the appearance of a system. It can provide a snapshot and as such can be regarded as a static representation. The output of a system, such as the user screens, is an example of this approach. Prototypes can be viewed as dynamic representational models. Prototypes can also be expressed statically through the use of paper mockups or drawings of the two dimensional user interface.

Mehandjiev, Gaskell, and Gardler (2001) have conducted a pilot study which focused on using "live models" for strategic decision exploration. After conducting the study, the authors recognized that strategic decision exploration can be closely aligned with the process of requirements engineering. The "live multi-perspective model" is based on the premise that effective models reflect characteristics related to their roles as objects within a group learning process. They use the following characteristics to describe "live" models: ability to evolve, responsiveness, and dynamism. The "live multi-perspective model" allows the input of diverse stakeholder groups such as requirements engineers, users, managers, and technical experts. Each of these groups has a different perspective or outlook on the possible system requirements. The use of such an explicit model allows an evolving viewpoint-oriented series of representations which reflect the different perspectives of the multiple stakeholders. Although this method is not widely used, it can be very helpful with systems that have some concurrency or parallelism and where event synchronization is critical (Bray, 2002).

It is clear that the requirements design and development process should culminate in a precise requirements specification document. This document should be readable by not only the software engineering authors but also by the stakeholders for whom the

system will be built. This document details what is planned, fleshes out inconsistencies, and ensures completeness of the final list of requirements.

1.2.4 Validation

The success of the requirements engineering phase of the software lifecycle depends on the process of communicating the requirements in a fashion that is understandable to all stakeholders. The main vehicle for this is the specification document. The next step in the process is that of requirements validation. Stakeholders and software engineers review the specification and determine if it conforms to company policy and represents the system they have requested.

> According to SWEBOK, 2004, requirements validation is the stage where "*the aim is to pick up any problems before resources are committed to addressing the requirements. Requirements validation is concerned with the process of examining the requirements document to ensure that it defines the right software (that is, the software that the users expect.)*"

After the stakeholders have agreed to the requirements, they must be validated. *"The validation process is concerned with checking the requirements for omissions, conflicts, and ambiguities and for ensuring that the requirements follow quality standards."* (Sommerville and Sawyer, 2000). Alternatively, validation of requirements is the process of establishing that the requirements elicited provide an accurate account of stakeholder goals (Nuseibeh and Easterbrook, 2000). The requirements engineer must make sure that the requirements that have been chosen to go forward to implementation are indeed the ones that will provide the system the users have requested. Each requirement is reviewed and checked against the others for consistency, clarity, and

usefulness and also that the specification is consistent with the requirements definition (Pfleeger, 2001, Sommerville, 2001, Robertson and Robertson, 1999).

Validation consists not only of ensuring the system meets the users' goals, it also involves tracing back from the specification to the requirements (and vice versa) to ensure each requirement is anchored in the specification document. Pfleeger, 2001, nicely categorizes requirement validation techniques in Table 1.1:

Table 1.1 Requirements Validation Techniques

Manual Techniques	Reading Manual cross-referencing Interviews Reviews Checklists Manual models to check functions and relationships Scenarios Mathematical proofs
Automated Techniques	Automated cross-referencing Automated models to enact functions Prototypes

Source: Pfleeger, 2001

At the end of this stage of the requirements engineering process, the customer should fully understand the requirements that the software system will satisfy in other words - *what the software engineer intends to build.* The customer will have been supplied with requirements documentation on the proposed system. The software engineer should have a full understanding of the requirements specification and have great confidence that the specification is consistent, clear, and traceable.

1.3 Issues in Requirements Engineering

Five areas stand out in the literature as having consistently impeded the requirements engineering process: communication, describing requirements, social/organizational issues, traceability, and the agreement of requirements.

1.3.1 Communication

A frequent theme in requirements engineering research is that communication problems are the largest detriment to effective requirement negotiations and requirements validation (Zave, 1997, Goguen, Linde, 1993, Sommerville, et al. 1992). Al-Rawas and Easterbrook (1996) have found that there are three major types of communication barriers within the requirements engineering phase of the software development lifecycle: 1) ineffectiveness of the current communication channels; 2) restrictions on expressiveness imposed by notations; and 3) social and organizational barriers. In a two-stage empirical field study, these authors found that the communication between stakeholders and software developers most likely occurs through the "one-way communication channel" of a specification document. This type of communication produces volumes of documentation but does not produce effective communication, since the developers often speak a technical language or use formal terminology or notations. The stakeholders may not understand them well enough to make good judgments on the requirements outcomes. The authors suggest that a combination of natural language descriptions and face-to-face discussions can alleviate these problems. Software engineers each use different notations to describe a system.

Potts, Takahashi, and Anton (1996) studied 23 organizations' requirements analysis methods. They found that the primary problems in project teams are communication, agreement about requirements, and managing change. They used a hypertext model that records and exchanges pieces of information in requirements discussions. This model captures the ongoing process, not just a static description of the final requirements. It is comprised of three stages: requirements documentation – where stakeholders write down their own interpretation of the needed requirements; requirements discussion – where stakeholders challenge the proposed requirements; and requirements evolution – where stakeholders request changes on the basis of the previous discussion phase. These stages ensure that the final list of requirements includes all possible stakeholder input.

Communication between developers and users can be problematic when interpreted through the sales and marketing teams, which may agree to deliver system features that are unrealistic or that would seriously impact schedules without considering the technical aspects of the work (Hall, Beecham, Rainer, 2002).

When discussing job and system requirements with stakeholders, the analyst's communication and listening skills are critical to the success of requirements capture. Extracting the "real" requirements from the conversation or questionnaires is a challenge all analysts face. Even if the stakeholders understand systems and think they understand what they need, there may be other functions they don't know they need but would be extremely happy and appreciative to have. It is the analyst's job to extract these invisible and unsolicited requirements from his/her interaction with the stakeholder. Robertson (2002) suggests that analysts actually invent requirements for the stakeholder – that the

analyst's innovation and creativity will lead to a system that the user wanted all along, but didn't realize he/she did. This technique is useful when the stakeholder looks at the proposed system in a closed loop or box, whereas the analyst can look and think "outside the box" to create a system that is useable and functional.

The applied language model, *Requirements Engineering Metamodel*, developed by Rupp (2002), uses a method derived from neurolinguistic programming to examine semantic language and to discover unspoken meaning from it. The model looks at three common language phenomena which indicate linguistic ambiguity or omission. *Deletion* is a method that is commonly used to delete an overabundance of information. It allows us to reduce information to a manageable level. Unfortunately, this lost information may be precisely that which is needed by the system analyst. One method to uncover this lost information is to look at the verbs in a sentence and from there the analyst can define when the system conducts its processing. Generalizations are defined as universal qualifiers; these are words like "never", "always", "no", "every", and "all". An analyst will need to look at the individual context where these words are used or not used helps focus on exceptions or special cases. *Distortion* is when normalization occurs where a statement's meaning changes when a process is reformulated into an event. If the process is clearly defined within the context of the system, then normalization is acceptable. One needs to be cognizant of inputs and outputs to the process to ensure clarity. These techniques can be applied by inspecting the stakeholder statements for missing facts. This can be difficult because the software engineer lacks the stakeholder's detailed understanding of how the system should work. Another method is to inspect the written

record of requirements for ambiguities or omissions. This method can also be combined with the first method for complete coverage of the requirements record (Rupp, 2002).

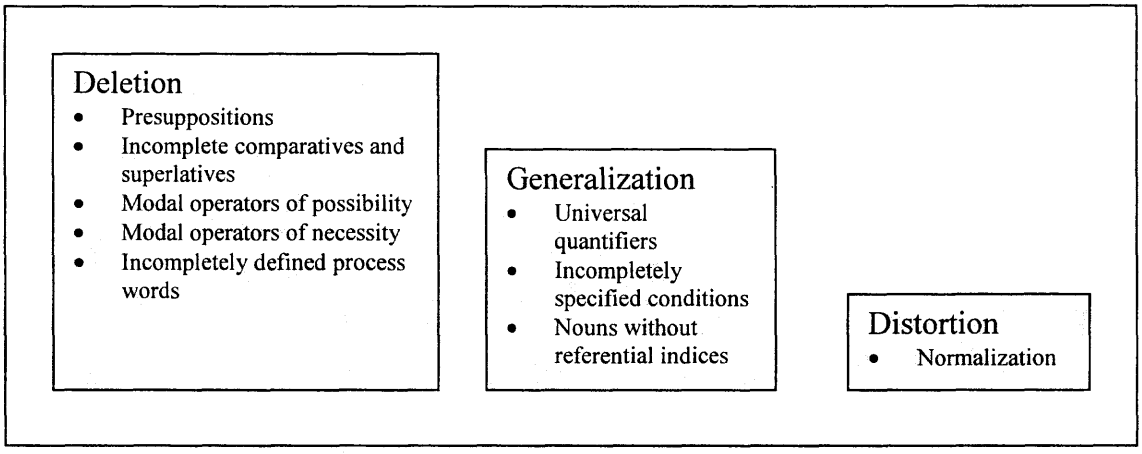


Figure 1.2 Methods of describing requirements.
Source: Rupp, 2002.

1.3.2 Describing Requirements

Expressing and documenting requirements is critical to the success of a software development project. Communication problems during the specification stage of requirements engineering can be critical, leading to an unwanted and unused system. Stakeholders have differing experiences and needs and different ways of expressing themselves. The domain experts may be totally computer illiterate and although they know what they want and need in the new system, they cannot express themselves in a clear manner to the systems analyst. Alternatively, the concept of a system may be so foreign to the stakeholders that they can't give the analyst what he/she needs to transform a manual work flow into an automated one. The systems analyst's job is to ask the right

questions of the users and to listen to the responses, resulting in a final requirements list that is meaningful and clear.

The specification of requirements is often an area of disagreement between how the software engineers envision the system and the users' interpretation of what the system should be. The stakeholders may represent the requirements differently. This leads to frustration and misinterpretation on all sides. It is imperative that an organization choose one representation style and use it consistently. It is also very important that the organization take into account the expression of requirements in a manner that the stakeholder understands. At this critical juncture, agreement upon the final requirements list is necessary and if the description of requirements is not sufficient to inform the stakeholders of the characteristics of the system, then agreement cannot be reached. The stakeholders do not see what the analysts see when they look at the description of the system. Clear distinct links between the stakeholders' requests and the final requirement specification describing that request are needed. A specification language should be simple, consistent, and concise. Following these guidelines will make the requirements easier to read and to understand (Sommerville and Sawyer, 1997).

1.3.3 Social/organizational

Social factors are an intangible source of requirement error. Some authors recommend social issues should be ignored when writing requirements, as they are technical specifications. Other opinions suggest that a robust, usable system cannot be built without incorporating the social aspects of the environment where it will be implemented.

Three major social groups participate in the requirements process: the client organization, the requirements team, and the development team. Goguen (1994) states

that groups can be divided into six separate locations that can be the source of social issues: within the client organization, within the requirements team, between the client organization and the requirements team, between the requirements team and the development teams, and within the development team Goguen classifies the issues as follows:

- Issues within the client organization – it might not always be obvious who is considered the 'client'. The users may not be the individuals interacting with the requirements team. If the users are not involved in the requirements process, they can sabotage the system when it is implemented.

- Requirements team issues – it is important to understand how work is organized, what methods and notations are used, and what beliefs team members have about organizations; this will influence how the requirements process is conducted, as these beliefs generally make their way into the fabric of the requirements.

- Issues between the client organization and the requirements team – professional and commercial relationships are important here, such as financial restraints, legal issues, ethical and personal issues. Perhaps there are client employees who are not given access to the requirements team. In addition, workers can sometimes behave differently around outsiders in their organization.

- Issues between the requirements team and the development team – lack of direct contact between these teams can lead to incomplete knowledge dissemination, such as the inability to resolve inconsistencies. The development team can be given a completed requirements document from the requirements team and have to build the system from it with no recourse to the original writers of the requirements.

- Development team issues – in a poorly organized team, there can be problems with demoralization and this could lead to teams that lose valuable members in mid production. Poor documentation could also be a problem. If the developers do not have direct contact with the clients, the quality and usability of the final product may be compromised.

Al-Rawas and Easterbrook (1996) also found that social and organizational issues are important in the requirements engineering process and can affect the quality of the final product. Who is chosen by management to represent the organization when developing new software requirements is critical to the pertinence of the resulting

requirements. Often the practitioners who will actually be using the system will not be chosen to represent the organization because they are doing valuable and productive work and cannot be spared from their job for extended periods of time. This leaves management level representatives supplying requirement inputs when they are not the end users, and truly do not understand the intricacies of the work that will be automated. The organization's own goals are put before the success of the new software system.

"Face-to-face discussions are widely used in spite of their higher cost. The lack of alternative interactive support for such informal communication forces analysts to resort to expensive and time consuming discussions and meetings." (Al-Rawas and Easterbrook, 1996). Note that informal information exchange is critical to the success of requirements negotiation.

In their empirical study of twelve software companies, Hall, Beecham, and Rainer (2002), found several organizational issues to be of importance. They feel that most requirements problems are organizational in nature, particularly in high-maturity companies. Unfortunately, organizational problems do not seem to be addressed in the planned way in which development process problems often are. While individual issues can be addressed specifically, organizational issues and memory are very deep and difficult to change. Sometimes even challenging them can result in diminished stakeholder cooperation or even contract termination.

1.3.4 Traceability

Traceability of requirements is important for several reasons; first, the ability to trace a requirement from the design phase to the implementation phase to the specific module of code can give the software engineer more flexibility in designing patches or updates to a

deployed system; second, it is easier to verify that a traceable requirement has been satisfied, and finally, traceability of requirements is required by IEEE software engineering standards.

> *"A significant factor in quality software is the ability to understand, or trace, requirements through the stages of specification, architecture, design, implementation, and test. Historical data shows that the impact of change is often missed, and small changes to a system can create significant reliability problems. Therefore, the ability to track relationships, and relate these relationships when change occurs, is key in software quality assurance processes." (Leffingwell, 2001)*

There are clear benefits to maintaining traceability throughout the software development life cycle (Bruegge and Dutioit, 1997). Cost savings can be realized through accountability of requirements. This can be achieved when a requirement is modified or deemed unnecessary. The module that implements the requirement can be isolated and removed from the system. Doing so maintains good coding practice and facilitates maintenance by reducing redundant and unnecessary code. System modification during the software's life cycle can be made much easier by the ability to trace the functionality of a requirement to a particular module of code. Adding or changing functionality is therefore much swifter and cleaner, again resulting in better and more robust code and a more efficient software system.

There are several kinds of traceability links. Jarke (1998) and Davis (1993) identify four specific kinds of traceability. They look at traceability forward from requirements, backward to requirements, forward to requirements, and backward from

requirements. Critical requirements are usually chosen for tracing: the tracing of minor requirements is deemed as not worth the expense and effort (Ramesh, Edwards, 1993, Ramesh, 1998).

Ramesh and Edwards (1993) have developed a model that represents traceability information at the level of systems design, relating requirements to all system components. They believe that a comprehensive scheme for such traceability encompasses all system components, including hardware, software, manuals, policies, and procedures. These authors suggest the need for a comprehensive model that includes semantic models supporting various stakeholders in development activities. Some of the issues they identify are listed here:

- *Bidirectional traceability*, – forward and backward traceability, forward is defined if each requirement specifically references a design component. Backward traceability is when a requirement is referenced by a design element. This type of traceability helps ensures that a design element satisfies a requirement.

- *Criticality of Requirements* – relating the requirement to the central mission of the system. Traceability is not required or necessary for routine decisions.

- *Design Rationale* – identifies the 'why' or reason behind design decisions. The tracking of the relationships between design objects increases the maintainability of a system. This helps in the understanding of the logic behind a system.

- *Project Tracking and Management* – helps ensure all requirements have been met and helps in the validation process.

- *Accountability* - allows one to communicate with the or

- *Humanware* – tracing the responsibility of a component to a human counterpart.

- *Documents/Manuals* – traces the thread between previous and future iterations of a document. References and inconsistencies can be tracked and rectified.

- *Dependencies* – interdependent components can be tracked and maintained.

- *Horizontal and Vertical Traceability* – an example of vertical traceability might be a relationship between a requirements statement and a design statement –

associations between objects of different types. Horizontal traceability would refer to associations of the same types, for example a subprocess transferring data to another subprocess.

- *Automated Support for Traceability* – for large software systems automated support is important. Trying to trace tasks manually is time consuming and often not accurate due to the many changes and iterations during development.

Ramesh (1998) distinguishes low-end and high-end traceability users. Low-end users are those that comply with traceability requirements to model dependencies among requirements and tracing requirements to components: they look at the traceability issue in terms of requirement compliance and validation. High-end users have a more proactive method of traceability, using it to improve and enrich their development and process quality procedures (Ramesh, et al., 1995).

Jarke (1998) states that "Requirements tracing is emerging as an effective bridge that aligns system evolution with changing stakeholder needs". Another important feature of traceability is that it enhances and provides input for the testing of the requirements. Traceable, consistent requirements are more easily tested further down the development process.

A relationship exists between traceability and the Software Engineering Institute's Capability Maturity Model. The understanding of how requirements form the final product and how they can be used to enhance the quality of the intervening development process by tracing plans to defined processes, relate directly to the achievement of higher CMM maturity levels. The achievement of these higher levels is significant to the status of an organization and its ability to consistently create top quality software products. Traceability of requirements is an important step toward achieving this goal.

1.3.5 Agreement

A critical phase of the requirements engineering process is the negotiation and agreement of the many and varied individual requirements into one cohesive requirements specification. Different expectations and needs from stakeholders, financial constraints, organizational issues, and schedule restrictions all play a role in the need for negotiation to reach agreement on a final set of requirements to go forward to the developers. Usually a requirements team will elicit the requirements from users and managers, document these requirements and then seek approval from the client. At this stage, it is imperative that the client and the developers understand the purpose of the system being built and that limitations on functionality are necessary as not everyone can get everything they want in the proposed system. The description of these final requirements in the form of a requirements specification is presented to the customer for final agreement before design and implementation.

The process of agreeing to requirements is one of negotiation and renegotiation between the clients, requirements team, and the developers (Boehm, Bose, Horowitz, and Lee, 1995, Boehm, Abi-Antoun, Port, and Lynch, 1998, Grünbacher, Koszegi, Halling, and Biffl, 2003, Horowitz, Lee, and Lee, 1999). In the end, the clients must sign off and agree to the final requirements to go forward to the developers and feel comfortable that the system to be built is one that is functional and useable.

Reaching agreement is not always smooth. Often there is conflict, either between the stakeholders themselves with conflicting goals, or between the stakeholders and requirements engineers (In and Roy, 2001). It is at this stage where stakeholders realize that everything they want they cannot have. Give and take is required. Compromise is

necessary and hopefully this compromise results in the best requirements being chosen and the not so important ones being left behind. Negotiation is required, which can be facilitated by the software developers or outside parties. The next chapter will present the process of negotiation and its influence on the requirements selection process.

CHAPTER 2

NEGOTIATION AND COLLABORATION

Negotiation research is based on ideas from cognitive psychology and behavioral decision research. Each participant in a negotiation is regarded as a decision maker whose behavior is a result of choices based on judgments about the negotiation situation (Bazerman and Carroll, 1987). We all conduct negotiations each day as situations arise where we need to come to some agreement with another person or persons. These situations can require simple negotiations, such as agreeing to a date and time for a meeting; others can be more complicated, such as negotiating a salary for a new job. Some situations require complex and difficult negotiations.

2.1 Negotiated Decisions

Decisions need to be negotiated when there are two or more participants. A decision is defined as arriving at a solution that ends uncertainty or dispute. *Conflict* and *interdependence* are two key aspects to negotiated decisions. When people have different objectives and goals, conflict can occur. With multiple participants, conflict can add complexity as each participant has different objectives with limited information or knowledge about the others preferences (Van de Walle, 2003. Decision makers are interdependent, where one participant reaching their objective is influenced by others agreeing to it and vise versa. These key aspects, *conflict* and *interdependence*, can lead to participants thinking that the more information they know about the other negotiators the stronger their position can be. This attitude is called *calculated behavior*. *Formulation of messages*, which is another key aspect of negotiated decisions, is related

to calculated behavior. Formulation of messages involves defining the issues and constraints surrounding the decision (Kersten, 1997).

What can be done when a situation arises where the best negotiated situation a participant will accept is not reached? Fisher and Ury describe the Best Alternative to Negotiated Agreement (BATNA). This is a proposed agreement that protects the participant from accepting something that is too unfavorable and from rejecting terms that might be in their best interest given the situation. In order to generate possible BATNAs, three steps are necessary, 1) invent a list of actions you might take if no agreement is reached, 2) improve some of the promising ideas and convert them into acceptable alternatives, and 3) tentatively select the one alternative that seems the best. This process entails setting some r*eservation levels* which are the minimal acceptable levels for all or some of the negotiated item's attributes.

Based on the eight-phase process model of negotiations proposed by Gulliver, 1979, and expanded by Kersten, 1997, the phases and activities of multiple decision makers are described below:

1. Search for arena and selection of the communication mode – participants agree on where the decision process will take place. This can be a face-to-face or virtual meeting space for synchronous or asynchronous exchange of information.

2. Agenda setting – decision makers agree to the issues and, if possible, partial problem representation and categorization.

3. Exploring the field – further problem specification and analysis where parties try to establish limits, formulate best alternatives, assess their opponents, and decide on initial negotiation strategies.

4. Narrowing the differences and search for integration – through exchange of information, the participants learn of the limitations of others, their aspirations and objectives, and knowledge about efficient solutions and their outcomes.

5. Search for agreement and improvements – identify critical issues and areas of disagreement, try to develop joint proposals to come up with a limited number of acceptable compromises. At this stage, few issues should remain to be addressed.

According to Kersten, 1997, there are several models of negotiation and group decision making. Most of these derive from game theory. *Game theory* focuses on strategic interactions while assuming perfect or near perfect knowledge of all parties. *Decision analysis* and *multiple criteria decision making* (MCDM) are other models, decision analysis is concerned with structured thinking about how a decision is made to lead to a result (Zeleny, 1982, Decision Analysis Society, web). MDCM is the "study of methods and procedures by which concerns about multiple conflicting criteria can be formally incorporated into the management planning process" (International Society on Multiple Criteria Decision Making, web). *Negotiation analysis* focuses on collaboration between parties based on predictions of one of the participants behaviors. The last model that Kersten describes is that of *cognitive theory* which is based on structural problem representations to facilitate decision making.

Cognitive limitations, cognitive biases, and socio-emotional aspects all contribute to less than optimal negotiation results. Modern negotiation situations present a variety of issues to a large number of negotiators and with many possible outcomes. The solutions are increasingly complex. As a consequence, the negotiators simply don't have enough cognitive capacity to handle all of the possibilities unaided. Such *cognitive limitation* or *bounded rationality* can result in decision makers to satisfice or choose solutions that are not optimal for all parties (March and Simon, 1958). There are several reasons why negotiators may come into a negotiation situation with *cognitive bias*, which is described as observer effects which can include human statistical and memory errors.

These effects all influence the outcome of a negotiation situation. Some common examples are:

1. Consideration of issues in isolation, in the presence of difficult multiple issues
2. Negative framing of the negotiation – negotiators look at their losses rather than gains
3. Fixed-pie, win-lose mentality – negotiators feel there is only so much to go around in a solution and what each wants conflicts directly with what the others want
4. Premature closure or finalizing of positions – negotiators settle on one solution and don't work towards other more optimal solutions
5. Preference for available, salient information or solutions – negotiators select solutions that are either familiar or very unfamiliar, not looking at other possibilities (Foroughi, 1996).

Socioemotional aspects of negotiator behavior are also relevant to negotiation and can adversely affect outcomes. Possibilities include:

1. Face-saving behavior – negotiators may ignore a suitable or optimal solution because they have stated their preferences and don't want to be seen as giving in to another negotiator
2. Ineffective communication –negotiators can become distracted by the appearance of others, their use of language, hierarchical competitiveness or subservience can hamper optimal solutions
3. Negotiator overconfidence – negotiators can see their ideas as best and think that if they hold out, the other side will capitulate and give in
4. Nonrational escalation of conflict – negotiators can up the ante for no real reason, making the negotiations increasingly hostile (Foroughi, 1996, Harinck, De Dreu, and van Vianen., 2000).

Negotiation is most effective when participants work toward integrative solutions which benefit both parties. An integrative solution satisfies each negotiator's preferences, whereas a distributive outcome would be one that is more competitive and results in only one party getting what they want. The characteristics of integrative verses

distributive negotiations are defined in Table 2.1.

Table 2.1 Integrative vs. Distributive Negotiations

Characteristic	Integrative Negotiations	Distributive Negotiations
Outcome	Win / win	Win / lose
Motivation	Joint gain	Individual gain
Interests	Congruent	Opposed
Relationship	Long-term	Short-term
Issues	Multiple issues	Single Issue

Source: http://www.lapiana.org/resources/tips/negotiations/11_1998.html , retrieved 10/29/04.

Putnam (1990) links the attitude or strategy with which participants enter a negotiation closely to the outcomes. Negotiators who are less experienced in negotiating may not go into the negotiation with a problem solving attitude, or they may not be ready to work together with their partners to achieve an integrative goal. Also, members of smaller groups encounter multiple preferences of other parties, and a group member may oppose some preferences, while at the same time sharing the preferences of other group members (Beersma and De Drue, 2002). Conflict can impede negotiators from understanding the situation and progressing to a common agreement. If agreement is achieved, the solution may not be the most beneficial to both parties or the most integrative solution. As described above, cognitive bias and presupposed judgments of the participants may lead to problems when negotiators are trying to come to an integrative agreement (Foroughi, 1996, Thompson, 1990, Walton and McKersie, 1965, Thompson, 1990). The type of task the group is working on also affects the negotiation

process. McGrath, 1984, describes a conceptual framework for categorizing tasks and discusses four general processes for this framework. The tasks are categorized into two dimensions. The first dimension looks at tasks based on the outcome: intellectual or behavioral. The second dimension focuses on the type of group behaviour: cooperative or conflicting. The processes for the framework are: Generate, Choose, Negotiate, and Execute. These categories form the *Task Circumplex* which describes relationships between the types of tasks. Each process is again divided into two, and the relationships between them are linked. Figure 2.1 shows the Task Circumplex. Quadrant 1, *Generate*, deals with problem solving activities and creative thinking. Quadrant 2, *Choose*, deals with intellective and decision making tasks. Intellective tasks are tasks that have a right answer, and decision making tasks are those where the answers are based on consensus. Quadrant 3, *Negotiate*, deals with cognitive conflicts and mixed motive tasks. Quadrant 4, *Execute*, is comprised of the performance and competitive sections where performance means striving to meet high standards and competition refers to tasks where there is competition between participants.

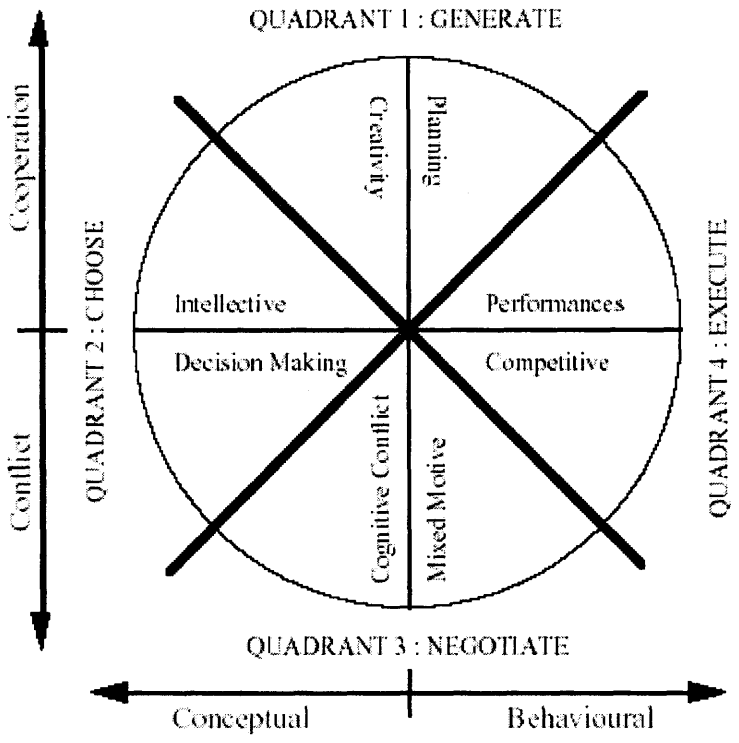


Figure 2.1 McGrath's Task Circumplex.
Source: McGrath, 1984

2.2 The Negotiation Life Cycle

The negotiation life cycle consists of several stages, starting with negotiators communicating their needs, and ending with a shared conclusion. This life cycle has some similarities to the software life cycle (Robinson, 1990). For example, the negotiation process can be regarded as consisting of a similar sequence of stages: requirements, specification, design, implementation, and maintenance. There are important differences as well as similarities between the lifecycles, in some situations the items negotiated can satisfy a range of needs of a participant, whereas with requirements, that may not be possible as each stakeholder may desire very different functionality from

the system, (Robinson and Volkov, 1998). Figure 2-2 from Robinson and Volkov (1998) illustrates the negotiation life cycle and shows how it applies in a contract negotiation. The participants in the negotiation are analyst, owner, designer, technologist, implementer, and facilitator. The owner is the main stakeholder in the negotiations. The analyst helps the owner structure and flesh out goals. The designer has an understanding of the negotiation process and plans interactions that will achieve the owner's requirements. The facilitator and technologist work together to provide an environment to nurture a successful negotiation. The contract negotiation life cycle Figure 2.2 illustrates similarities with the analysis, design, and implementation phases of the software development lifecycle

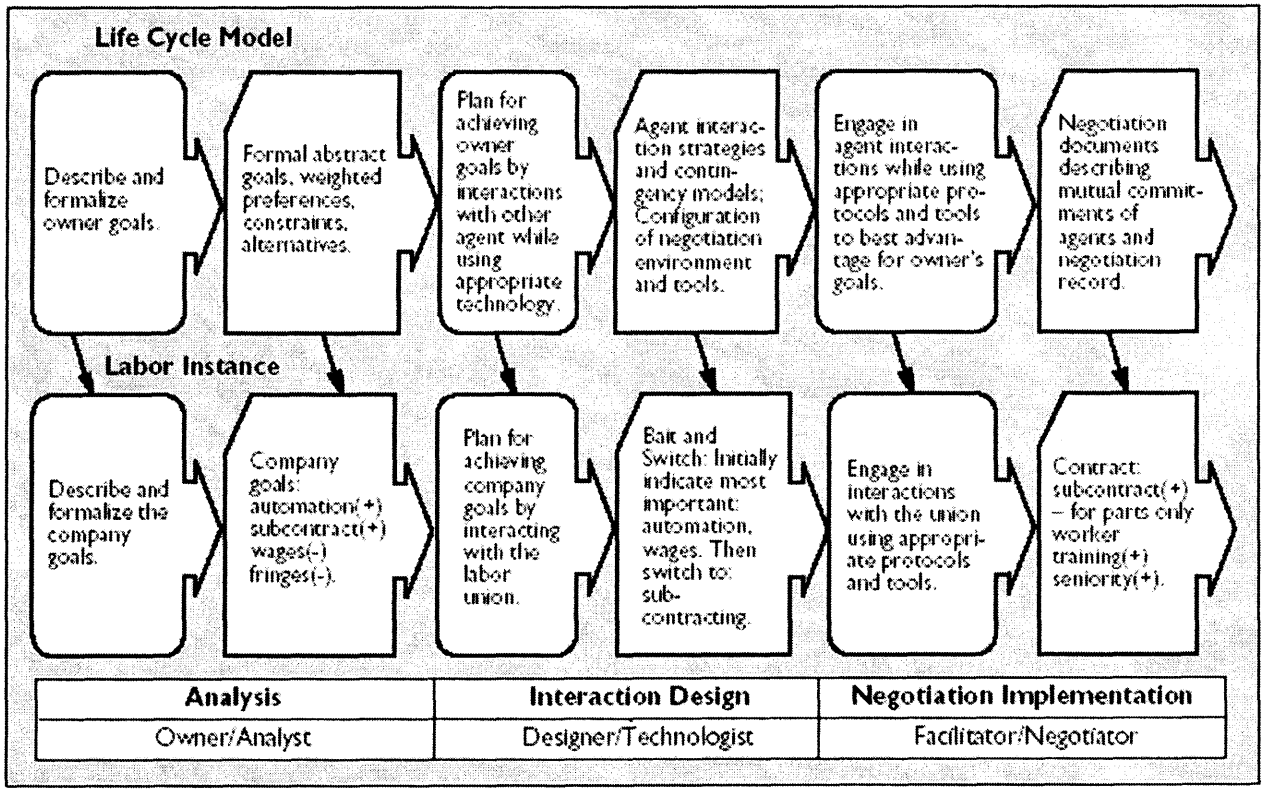


Figure 2.2 The negotiation life cycle and an application to a labor contract negotiation.
Source: Robinson and Volkov, 1998.

2.2.1 Conflict in Negotiation Situations

A negotiation situation requires two or more individuals or groups (parties to the negotiation). The parties must want different things which leads to a conflict of interest (Pruitt, Carnevale, 1993). Conflict can also arise when participants have common goals yet have different ideas on how to achieve them. The parties have voluntarily chosen to negotiate; they feel they can do better by doing so rather than by taking what the other side has to offer right away or by disagreements, which can lead to poor relations in the future. Negotiation always involves concessions by both sides. Over a period of time, parties ask for concessions and then modify their positions to see if they can reach a mutually agreeable compromise. As explained above, a fundamental aspect of negotiation is *interdependence*; each negotiating party needs the other. In order to accomplish a series of interconnected goals, each party needs to work with each other even if the individual goals are different. Negotiation conflicts can be distinguished as intrapersonal, interpersonal, intragroup, and intergroup conflicts (Lewicki, Saunders, Minton, 2001).

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. They describe four principles for effective negotiation: 1) separate the people from the problem; 2) focus on interests rather than positions; 3) generate a variety of options before settling on an agreement; and 4) insist that the agreement be based on objective criteria. These principles are to be followed during each stage of the negotiation process.

2.2.2 Computer Supported Negotiations

The use of computer technology may help overcome cognitive bias, cognitive limitations, and socio-economic problems that can occur in face-to-face negotiation situations. Computer support for negotiations has been based on experience with group support systems (GSS), which are designed to support decision makers in non-cooperative, mixed motive tasks. GSS have proven to be beneficial to information exchange (Dennis et al. 1990, Nunamaker, et al., 1991, Valacich, 1999). Dennis (1996) found that groups interacting using a GSS exchanged about 50% more information than those interacting only verbally. Decision Support Systems (DSS) are technology based solutions that are used to support complex decision making and problem solving. Negotiation Support Systems (NSS) add a Decision Support System (DSS) for each negotiator with the addition of an electronic communication channel for use between them (Lim and Benbasat, 1992). More advanced NSS feature group process structuring techniques, mediator support, and documentation of the negotiations (Foroughi, 1996, Delaney et al., 1997). Electronic Negotiation Systems (ENS) employ the internet and computing technologies to support decision makers (Kersten, 1997). Kersten (2004) states that this type of decision support tool has one or more of the following functions:

1. Supports decision and concession making
2. Suggests offers and agreements
3. Assesses and criticizes offers and counteroffers
4. Structures and organizes the process
5. Provides information and expertise
6. Facilitates and organizes communication

7. Aids agreement preparation, and
8. Provides access to negotiation knowledge, experts, mediators, or facilitators

E-negotiation systems can be passive, such as email and streamed video. Other systems provide active participation in the negotiation by assessing what is being negotiated by interacting with participants and providing offer assessment and critiques of counteroffers. This type of NSS is an example of a socio-technical electronic negotiation system.

2.2.3 Negotiation in Requirements Engineering

Stakeholders and software engineers work together to create requirements for a new software system. The software engineer or systems analyst elicits 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 requirements that will define a useable functional software information system that meets the client's need (Karlsson and Ryan, 1996). Therefore, negotiating conflicting requirements is an important part of the requirements phase of the software engineering life cycle (Grünbacher, Hofer, 2002, Egyed and Boehm, 1997). Many studies have found that clear, consistent, and traceable requirements result in more robust, maintainable software systems (Bray, 2002, Brooks, 1975). In order to provide this quality, consistency, and traceability, conflicts between users, analysts, and managers must be resolved during this important phase of software design and development (In and Roy, 2001).

Conflict in and of itself is not a negative activity at this stage of software development. Actually, conflict and its resolution at an early stage in the development process can have the result of saving both time and money further along in the life cycle (Hall, Beecham, and Rainer., 2002, Damian, 1999, Boehm, 1994). During requirements negotiation, conflicts should be resolved effectively and measures taken to ensure that no critical requirements are lost due to poor negotiation skills on the part of the user or analyst (Blackburn, Scudder, and Van Wassenhove, 2000, Conboy, 2002). Keeping a record of the requirements negotiations provides a method of traceability and allows for cross checking for consistency (Bubenko, 1995). One method is to conduct negotiation using an asynchronous bulletin board. This would automatically log each stakeholder's comments and trace the progress through the initial requirements discussions through to the final list. Providing a method of capturing the requirements negotiation process eases the pressure in each later development stage. When new requirements or modifications to existing requirements are suggested or found to be necessary, it will be possible to return to the records

Conflict in requirements is usually negotiated after elicitation and problem definition. Mackenzie, et al., (2003) suggests conflict negotiation can be facilitated using a two-stage software system and process which uses cognitive mapping and design rationale techniques to prompt stakeholders to engage in negotiations prior to the problem definition phase. The "Wisdom Process", Figure 2.3, by Mackenzie consists of two-stages starting with an asynchronous component where preliminary issues are elicited and finishes with a co-located meeting where cognitive maps are used to flesh out problems

and finalize requirements (Mackenzie, Warren, Sommerville, Westcombe, and Pidd, 2003). to determine what will be affected by the proposed changes.

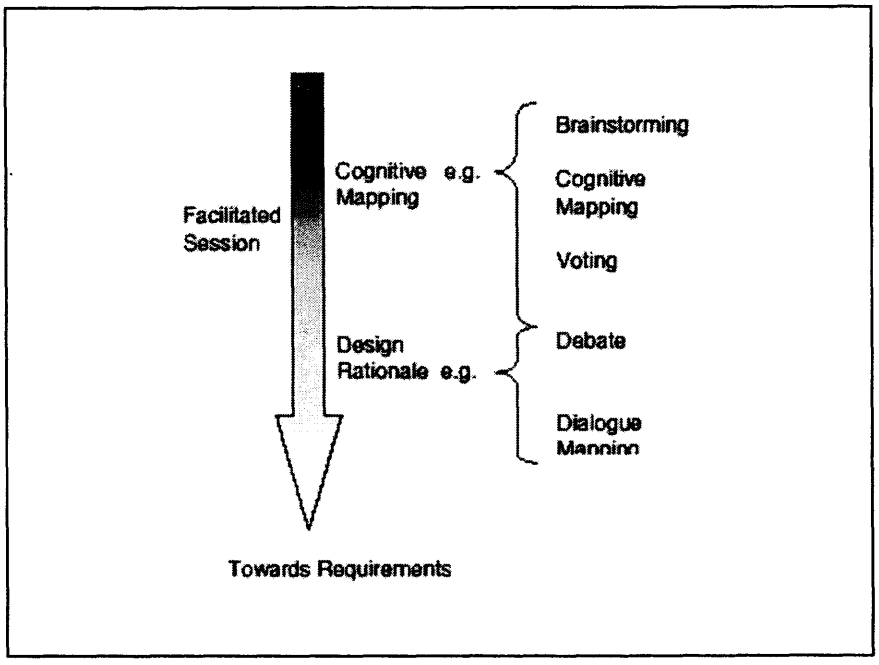


Figure 2.3 The Wisdom Process.
Source: Mackenzie, et al., 2003.

This tool provides solid steps to formulate requirements. Brainstorming, cognitive mapping, voting, debate, and dialogue mapping all move the effort towards a final set of requirements. This process facilitates problem detection and definition. The asynchronous component provides more time and cognitive processing by providing a traceable log of stakeholder negotiations. Following the trail of cognitive processing can give the stakeholder more information on why a requirement is important/critical to other stakeholders. This process can open dialog, reduce conflict, and facilitate negotiation.

One of the most commonly known and studied approaches to resolving conflict

and reaching agreement in requirements design is a model proposed by Boehm, et al., (1995). Based on Boehm's 1988 Spiral Model of software development, Figure 2.4, the extended model is called *A Theory-W Based Spiral Approach*, depicted in Figure 2.5. It focuses on stakeholder collaboration and negotiation to achieve *win-win* software requirements, where all stakeholders are winners in the negotiations. Boehm's spiral development model illustrates an iterative approach to the process of software development. This iterative process facilitates the uncovering and resolution of problems before they reach the implementation stage and therefore save time and money while at the same time enhancing software quality and reliability (Boehm, et al., 1998).

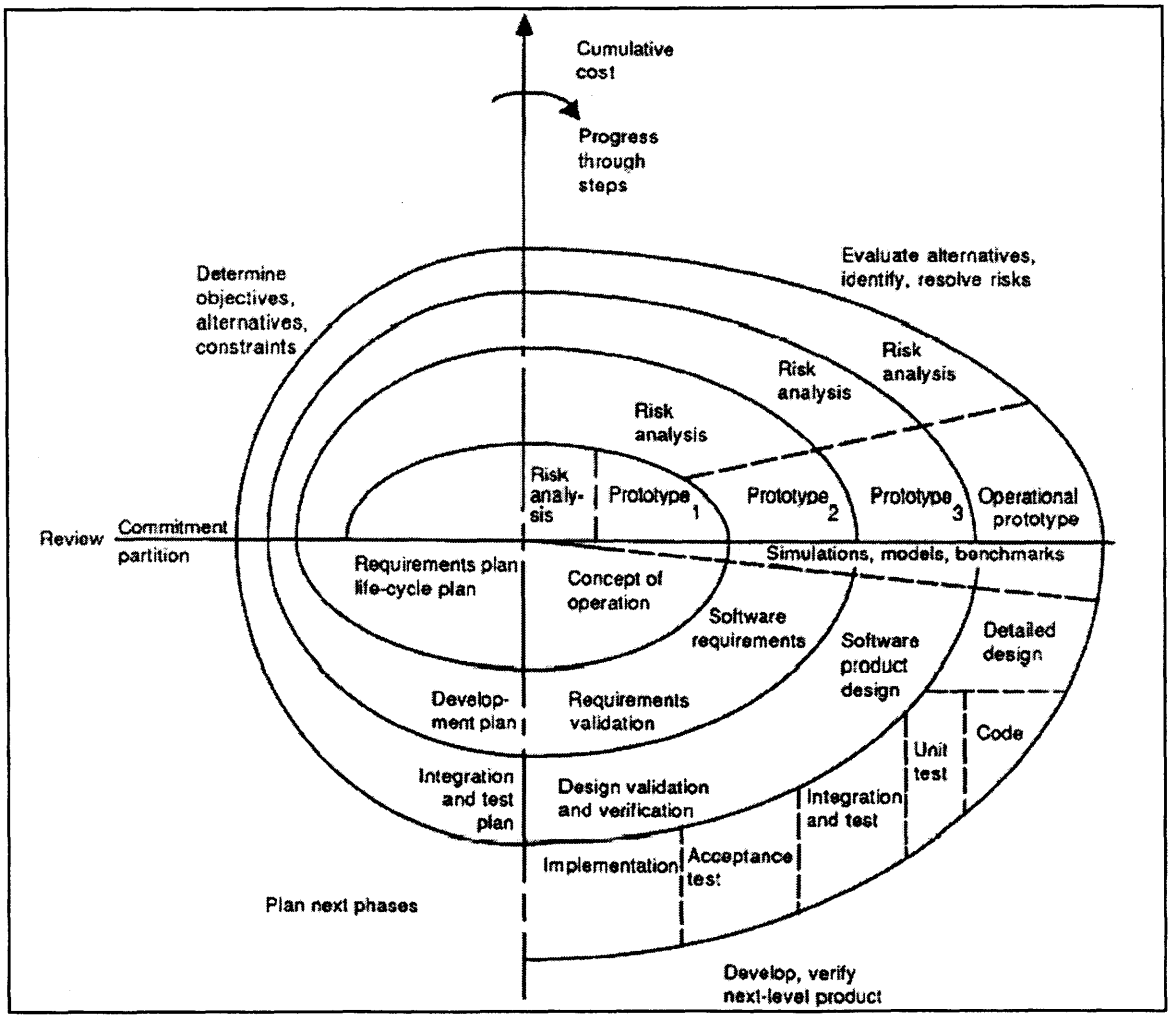


Figure 2.4 Win Win Spiral Process Model.
Source: Boehm, Bose, 1994.

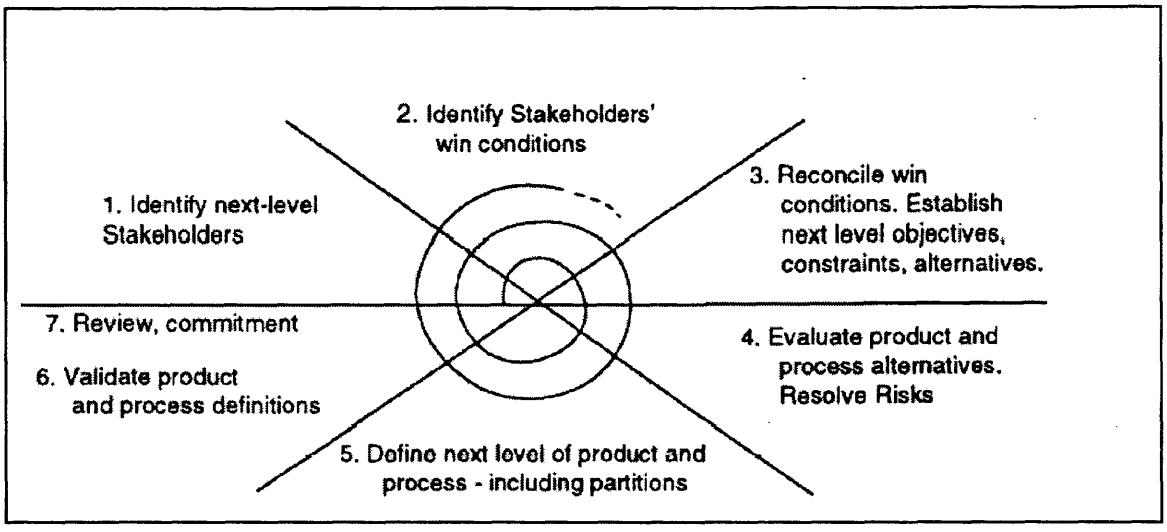


Figure 2.5 Theory W extensions to the Spiral Model.
Source: Boehm, Bose, 1994.

The extensions to the Spiral Model above provide support for stakeholder needs and tailors the model to focus on requirements negotiation and collaboration. Boehm lists three conceptual entities in the requirements engineering phase that address the concerns of multiple stakeholders. They are: the *Win condition* – ensuring that an individual's objectives are noted; *Conflict/risk/uncertainty specifications* – capturing conflicts between the win conditions of the stakeholders and the risks and uncertainties associated with them; and *Points of Agreement* – capturing the agreements of the stakeholders' objectives and also defining the system objectives.

Boehm's negotiation model facilitates good communication and collaboration throughout the requirements phase. This model incorporates four considerations: *Win Conditions* are the goals of the system as viewed by the stakeholders, *issues* are items on which the stakeholders do not agree, *options* are alternatives suggested by the stakeholders that may resolve the issues, and *agreements* are solutions agreed to by stakeholders. These conditions are not only valid for the face-to-face or co-located

stakeholders, but are also important for distributed groups. This collaborative approach has been developed for co-located stakeholders but has not been investigated for distributed users (Grünbacher,et al., 2003). Figure 2.6 depicts the WinWin Negotiation Model.

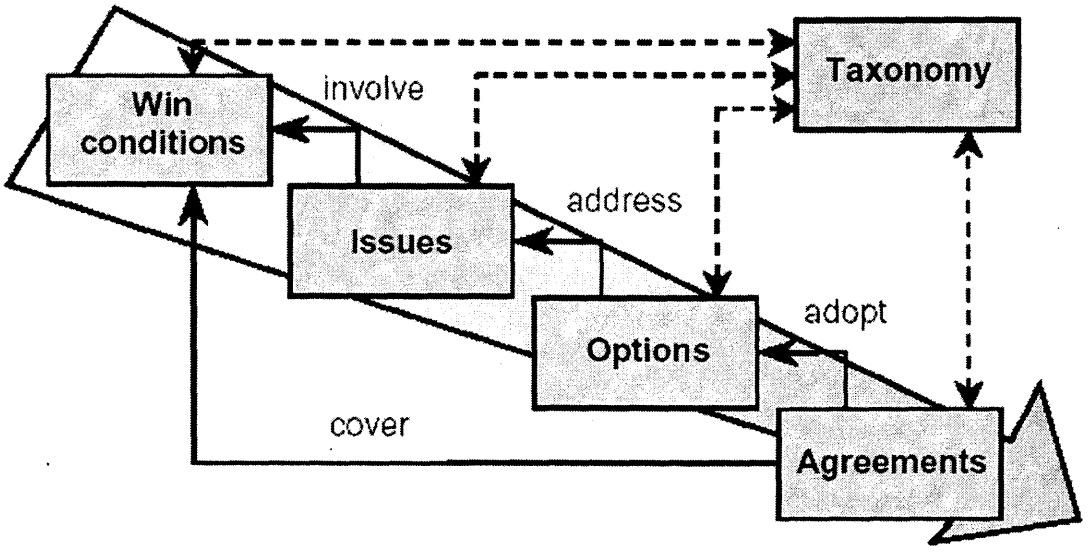


Figure 2.6 WinWin Negotiation Model.
Source: Egyed, Boehm, 1999.

Another view of requirements negotiation is to look at it as a decision-making process. Stakeholders negotiating the functionality and quality of the system to be developed have to decide which requirements to keep and which to let go. Research in this area focuses on using decision support theory and appropriate processes to provide support for the requirements engineering process. An example of how decision support may be used to support the requirements engineering process is shown in Figure 2.7, The example shows a "salmon ladder" style graphic where the requirements are elevated or downgraded in a continuous, asynchronous refinement process.

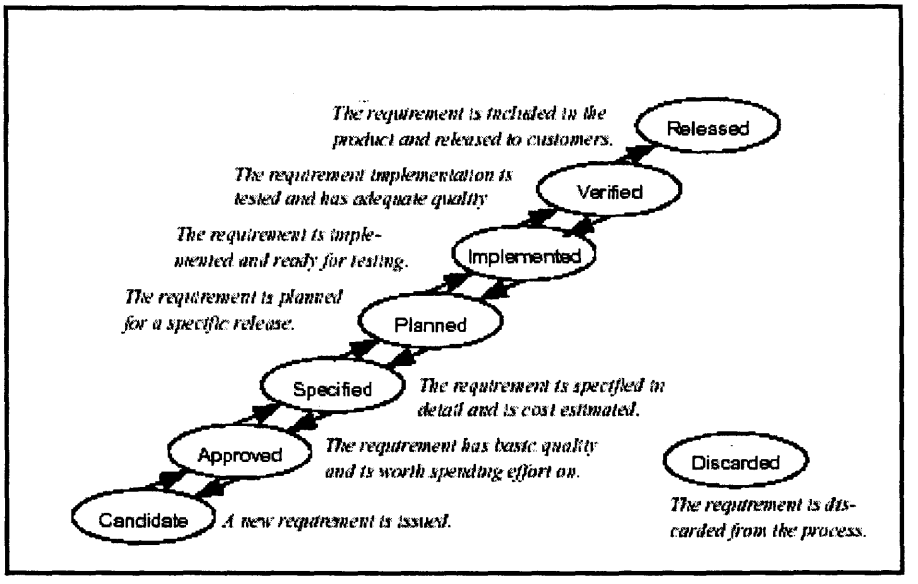


Figure 2.7 Salmon ladder example of requirements decision making process.
Source: Regnell, et al., 2001.

This type of support can potentially provide traceability and decision recording which can in turn contribute to an efficiently maintained system and provide contextual information for system patches and updates (Regnell, Paech, Aurum, Wohlin, et. al, 2001).

Capturing the negotiations by documenting the process provides critical data for requirement changes and updates. One example is that of the ARBAS language by Ramesh and Bui (1999). This language captures and analyzes software development process knowledge. The ARBAS language was developed to support network-based requirements engineering procedures. The aim of the language is to not only capture the requirement process proceedings but also to provide some analysis and reasoning of the process in the form of decision support. Using a tool to track the process and provide traceability can improve maintenance and updates by providing the software engineers

knowledge as to where software changes can be made in the least detrimental manner and provide the most cost and time savings.

2.2.4 Distributed Asynchronous Requirements Engineering

Requirements engineers and stakeholders generally meet face-to-face to determine the list of possible requirements for a proposed system. A series of meetings is necessary to ensure that all stakeholders concerns are addressed. When this face-to-face collaboration is completed, the analyst then compiles a list of requirements, makes an appropriate cost estimate and then goes 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, in a distributed mode, among all the possible system requirements to ensure the choice of a set that will satisfy the stakeholders' needs.

Technology can enhance the effectiveness of distributed negotiation by providing organizing and cognitive processing tools for the negotiators (Damian, 1999). There are several technologies that have been used to facilitate the negotiation and discussion of software requirements in a distributed mode. For example, the Distributed Collaboration and Prioritization Tool (DCPT) combines the use of a voting model and a bin model to help distributed stakeholders come to agreement on prioritizing a final list of requirements. A bin model is used for partitioning the voted items into "bins" according to a model which prioritizes concerns, for example, as "risk reduction" or "maximizing return on investment". DCPT provides a prioritization model which helps in focusing of the requirements prioritization effort and is compatible with the WinWin collaboration tools by exporting prioritized requirements into WinWin for negotiation (Park,et al.,

1999).

Another example of this type of technology has been developed by Anton, Liang, and Rodenstein (1996). These researchers have studied collaborative distributed requirements analysis using a technology called Goal Based Requirement Analysis Tool (GBRAT). This method uses WWW technologies to support *goal analysis* – exploring the information and then organizing the goals, and *goal refinement, and decomposition* – refining the goals and decomposing them into functional requirements. This tool allows users to organize their requirements, refine, and collaborate together to ultimately agree to a set of requirements suitable to all stakeholders. GBRAT allows the stakeholders to look at their lists from different stakeholder views, therefore enhancing their understanding of the interrelationships between the requirements.

Technology can and does enhance the negotiation of requirements and clearly supports the traceability of the process (Damian, 1999, Anton, et al, 1996). This is invaluable further down the development path. Inevitably changes are made to the "optimal" list of requirements and the effect of these changes can be more accurately assessed with full knowledge of where and what each requirement impacts.

The use of computer-mediated requirements negotiation tools enhances and enriches the contributions of geographically disparate stakeholders. Damian, (2002) asserts that the use of multimedia meeting systems in distributed requirements negotiation results in more effective meetings and outcomes and has conducted a study of distributed requirements negotiation performed in a laboratory setting. The experiment employs five different communication modes: face-to-face, and four mixed distributed settings. Figure 2.8 illustrates Damian's group communication settings.

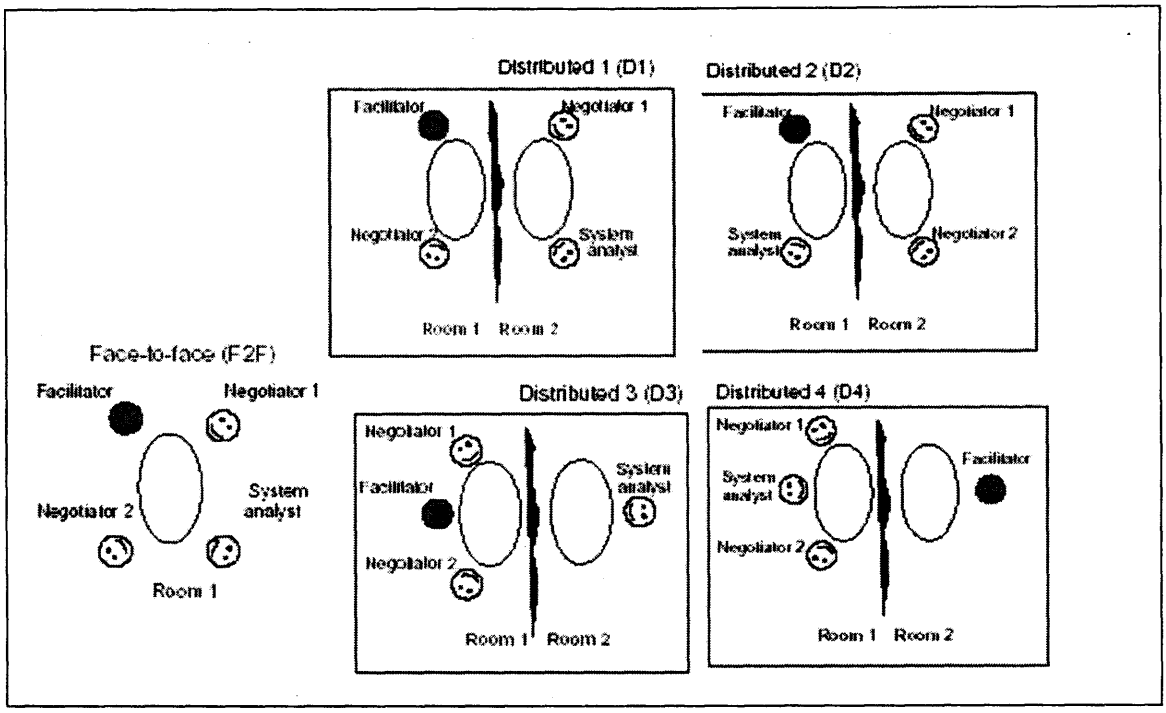


Figure 2.8 Damian's Communication Mode Settings.
Source: Damian, 2001.

This study used two software engineering stakeholder roles working collaboratively towards a solution. The roles were system stakeholder, system analyst, and included a trained facilitator as a third group member. Damian found that 1) group performance in face-to-face requirements meetings was no better than in distributed group meetings, 2) remote collaboration of the two system users benefited the negotiation, 3) the co-location of the two negotiators was helpful but not beneficial, and that 4) the use of the shared electronic workspace was particularly useful in the requirements negotiation. The use of videoconferencing in this study promoted the participation of a larger group of stakeholders.

It is not uncommon for users to remember a function, or nuance of the system or organizational work flow after the systems analyst completed the fact finding visit and

leaves the facility. Keeping the communication channels open can enhance full participation by users and more understanding by software engineers. The use of asynchronous distributed technologies can keep stakeholders involved and active long past the initial stage of requirements determination. Enabling this type of ongoing involvement can preclude the problems that may arise when the system is implemented, facilitating a smooth transition to the new software (Grünbacher, 2000).

Inadequate communication problems, knowledge management, cultural diversity, and time differences are important reasons distributed requirement engineering teams are challenged. French and Layzell (1998) have studied communication and cooperation practices on a range of distributed commercial software projects. They have found different reasons for the necessity of distributed software engineering projects. Although the participants in French and Layzell's study felt that their distributed projects were successful, they felt they would have been more successful had they not been distributed. Although they report this finding, they also provide some insight into the advantages of distributed work:

- Workers have less informal relationships with co-workers in distributed sites, which led to more formalized and better documented procedures
- Co-located members are not available to ask walk-in questions which can disrupt work flow, therefore more productive work is done
- Different sites can supply different functions to the team which is helpful in areas such as separating development and testing functions
- Rivalries between sites can increase the resulting quality of products produced by each site wanting to look good in the view of the other sites and management
- When work is distributed it forces coordination and documentation, which may result in a more stable project environment.
- When email is used to communicate, it provides a built-in log of the decision- making

process, which can be indexed and searched for later projects.

French and Layzell recommend a series of "good practices" for distributed work teams. The most important factor they found to influence distributed software development was communication. Here are some of the findings from their study:

- There is no single team structure that is universally suitable for all projects
- Communication procedures should be formalized
- Projects should have a proactive highly organized coordinator
- A single senior manager should oversee all distributed sites
- Team members should be personally interested in the project
- Projects should have a regular meeting time or teleconference between managers
- All sites should use a common set of standards and procedures

Communication is critical in distributed work teams as it is in all phases of the software development process. Working collaboratively with geographically distributed stakeholders and software engineers to design and create a new information system is problematic, particularly in the upstream parts of the software lifecycle. Communication must sometimes be conducted asynchronously for efficiency and cost savings. With organizations growing globally, looking more closely at different communication modes to inform the process of building a strong core of requirements would be a helpful scientific endeavor. Several studies have looked at the effect of different modes of communication on the requirements engineering phase (Ocker, 1995, Palmer and Aiken, 1990, Palmer, Aiken, and Fields, 1991, Damian, 2002). Technologies such as email, threaded discussions, and computer conferencing to support collaborative teamwork has not been extensively studied when compared to synchronous systems, (Benbunan-Fich,

Hitlz, and Turoff, 2002, Turoff, 1991). Combining the strengths of face-to-face communication with the convenience and efficiency of computer conferencing may provide a method for developing a process that is traceable and flexible.

Ocker, Hiltz, and Turoff (1997) provide research on four modes of communication during the development of software requirements. The authors 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 at the beginning and 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 (Ocker, Hiltz, Turoff, Fjermestad, 1995).

Distributed communication and negotiation provides the software engineer with a variety of methods to support and provide a higher quality software product. Collaboration, be it face-to-face or distributed, is a necessary part of the development process. Communication has consistently proven to be an area throughout the software development process that needs to be improved. As we grow to a more global society, and with the advancement of distributed software engineering, furthering the development of asynchronous negotiation and communication technologies will enhance and strengthen our software development process. Providing support for the distributed

negotiation of the requirements stage of software development adds a strong component to the toolset of distributed software engineering procedures.

2.3 Collaboration

Software development has always been a collaborative activity. It is essential that software engineering teams work together effectively to ensure the software product will be the best it can be, utilizing the skills and contributions of all team members. It is infrequent that a software engineer creates, designs, programs, and tests software in isolation. It is becoming common that individual developers are geographically separated during the software development process (Cook and Churcher, 2004). Although teamwork is the norm, traditionally development tools have been created for the use of individuals, not for group communication and collaboration (Spellman, Mosier, Deus, Straub, Carlson, 1997). Also, tools are often developed for use with a specific language, particular development effort, or programming environment. Several fields of computer science research overlap with the collaborative software engineering domain. Cook, Churcher, and Irwin, (2004) provide a figure, shown in Figure 2.9, that illustrates the overlap between collaborative software engineering and other research areas of computer science that directly impact it.

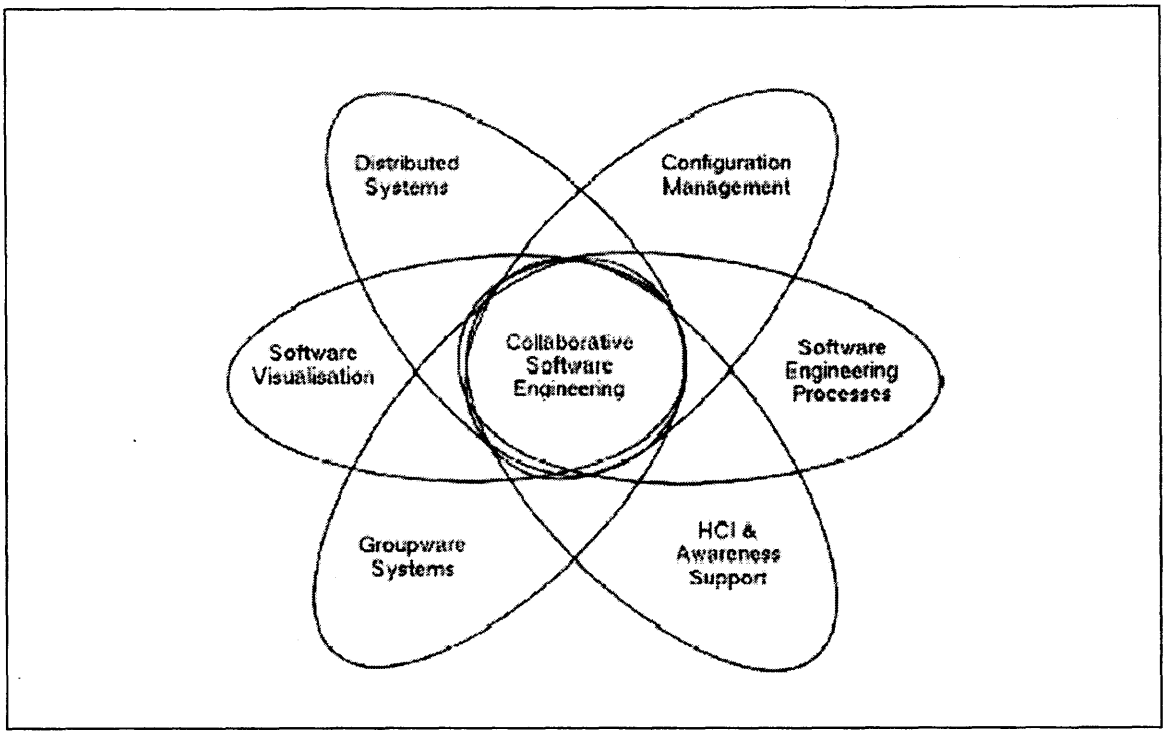


Figure 2.9 Research areas related to collaborative software engineering.
Source: Cook, Churcher, Irwin, 2004.

Groupware support, information presentation with Human Computer Interaction, software engineering processes and methodology, distributed support, and visualization of software all can be taken into consideration when studying collaborative software engineering. All of these fields contribute to an effective collaborative environment and tool set. Consideration of the interactions between and amongst these fields can provide extensible collaborative software engineering tools.

Organizations that wish to achieve distributed, collaborative processes face multiple challenges (Olson and Olson, 1999, 2000). In order to progress to an environment that is capable of collaborative success, several factors need to be considered. Maybury (2001) developed interoperable collaboration services for the US Air Force providing tools for distributed, collaborative air campaign planning where

users communicate and coordinate air tasking orders in a virtual work space. A significant time savings of 50% was realized, with users completing their tasks in half the time, as well as a 30% increase in productivity. Another benefit was a large decrease in personnel needed to complete the task. Clearly distributed collaboration provides benefits to an organization that are highly significant and in Maybury's experience, measurable.

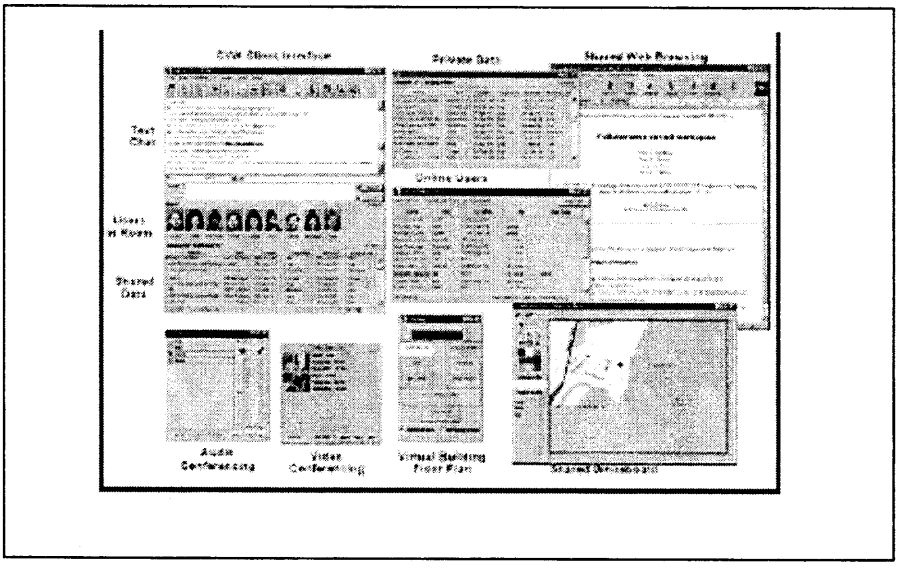


Figure 2.10 Maybury's Virtual workspace.
Source: Maybury, 2001.

Critical success factors for collaborative working environments include:

1. A shared outcome.

2. A leader for each collaborative group. Without a leader/facilitator for the group the process degenerates and a productive outcome is less likely.

3. Ensuring participants know how to use the collaborative tools and they are trained in doing so.

4. The management structure and operating procedures are clear as this promotes trust amongst the participants.

5. Face-to-face meetings to supplement asynchronous ones to support interrelationships. The initial training meeting would be a good opportunity to establish the relationships.

6. A high level supporter who encourages the collaboration and an organization that supports collaboration and knowledge sharing.

Cultivating these factors in an organization increases the chances of successful collaboration. Each is important building block towards an effective collaborative organizational structure.

2.3.1 Distributed Group Collaborative Factors

Deek and McHugh (2003) describe the positive and negative effects of distributed software development and collaboration. The positive effects can be process gain through more consistent processing by multiple stakeholders as opposed to individual processing. It also appears that distributed collaboration results in a higher quality solution to more complex problems. However, collaboration may result in process loss, due to such phenomena as group polarization. Some researchers have reported that the combination of face-to-face and asynchronous communication improves solution creativity and quality in the later stages of software development (Ocker, et. al, 1998).

Distributed teams have been found to be effective when clients had requested onsite support, or where one or more project team members had to be located at the site, separate from their teammates. Sometimes project members are unwilling or unable to travel to other sites and the opportunity to provide distributed collaboration allows expertise availability when otherwise it may be inaccessible. Other relevant considerations of distributed teams are the availability of specialized technical resources at one site or the inadequacy of the office space at a given site. Organizations may be

unwilling to have project team members co-located at their site for security or organizational issues, (Layzell, Brereton, French, 2000).

Distributed communications can be problematic. Inadequate communication problems, ineffective knowledge management, cultural diversity, and time differences are important challenges for distributed software and requirements engineering teams (Jarke and Pohl, 1994). Miscommunication, infrastructure incompatibility, cultural misunderstanding, lack of coordination, and conflicting expectations are primary problems in global software development (Herbsleb and Moitra, 2001). If distributed software teams are to be successful, it is critical to build trust and empathy between team members. Studies have shown that mutual self-disclosure and common group membership has a positive influence on negotiation processes and rapport between negotiators (Moore, Kurtzberg, and Thompson, 1999). Although these challenges are clear, the benefits of distributed collaboration are very high. As stated above, geographic distance can preclude the inclusion of critical staff in development projects. The use of technologies to facilitate such collaboration contributes to the development and implementation of higher quality software products, providing superior service to the stakeholders and a higher level of software team by the vendor.

A detailed field study of distributed collaborative design was conducted by MacGregor, Tomson, and Juster (2001). A large multinational company that produces pressure control and drilling equipment for the oil and gas industry participated in the study. The aim of the project was to study ways to avoid inconsistencies in the distributed process. These goals were to be achieved by facilitating effective integration and transfer of knowledge within and amongst the organizational units. When examining

the types of communication amongst the different organizations, it was clear that the use of asynchronous communication methods far exceeded synchronous ones (Figure 2.11). Reasons for this are the time differences and the accessibility of distributed team members. The authors categorized the activities involved in the distributed process as *Requests Out*, *Information Exchange*, *Information Out*, and *Information In*. A significant finding is that the collaborative distributed activity was continual throughout the 40 days of data collection. This indicates that asynchronous, complemented by synchronous communication techniques, are used and important in the distributed collaborative process.

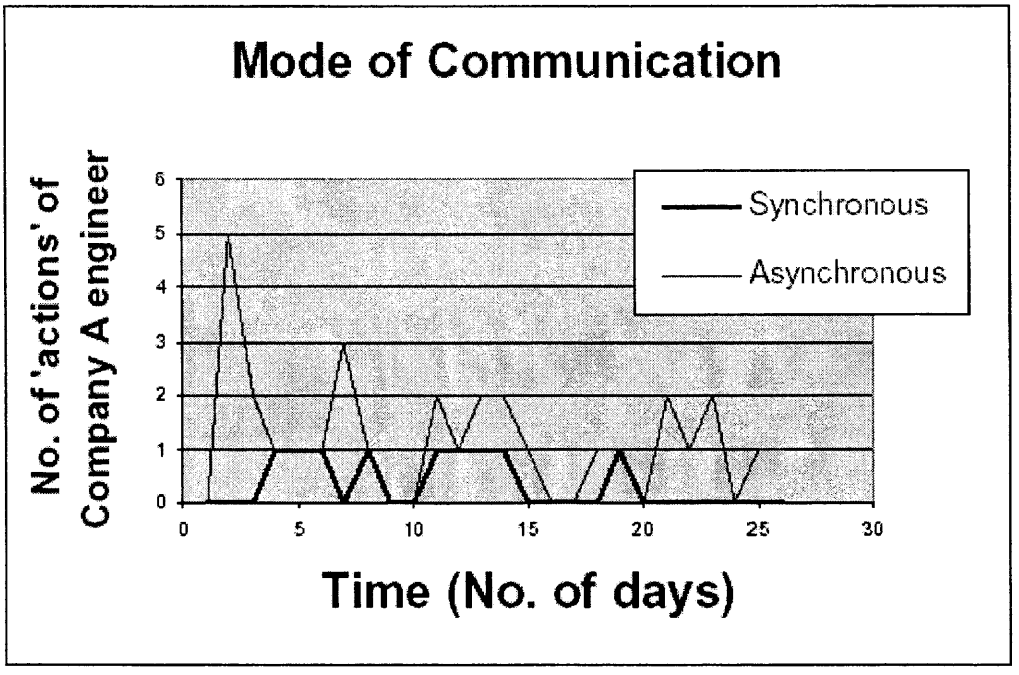


Figure 2.11 Modes of Communication used by distributed team members.
Source: MacGregor, Thomson, Juster, 2001.

Distributed collaboration is an important factor in software engineering development and design. With careful attention to the organizational support and the use of collaborative tools and concepts distributed communication can add value to an organizations knowledge base. Organizational memory can be tracked and developed for later use and dissemination. The use of asynchronous communication is a powerful tool to supplement synchronous and face-to-face collaboration.

2.3.2 Collaboration in Requirements Engineering

Software engineering is a team effort. Analysts work collaboratively with stakeholders and with each other to develop and create software systems. In order to develop a reliable, quality system the collaborative effort must be managed and facilitated by the organization. Personalities, cultural considerations, and work styles are just a few of the issues that affect the collaborative effort. Stakeholders can be expected to have different perceptions of how a proposed system might function, and members of the requirements engineering team can also be expected to have differences of opinion on the appropriate system requirements.

In defining new information systems, distributed software engineering procedures allow multiple stakeholders at different sites to contribute to requirements and be available later during the development process. This involvement and availability could greatly increase the quality and usability of the proposed system, while saving precious staff time and resources. Although distributed software engineering has been studied and implemented, the requirements elicitation, development, and definition process usually takes place in face-to-face meetings prior to distributed specification and development. Little research has been done within distributed requirements engineering (Park, Port,

Boehm, 1999). In later software development phases, distinct modules are distributed to different global locations for completion. Collaboration within and between organization units is vital for project success. Virtual organizations can be defined as those that are distributed in nature, in different geographic locations. Looking at the concept of "distributiveness" sheds light on the different viewpoints of collaborative work. The "distributiveness" of projects can be categorized as dimensions as illustrated below.

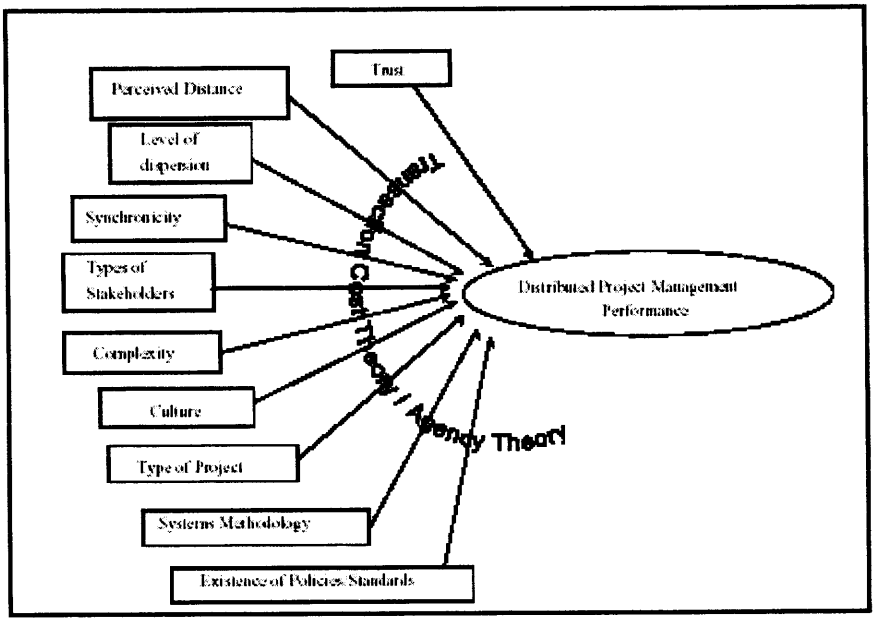


Figure 2.12 Dimensions of Distributiveness.
Source: Evaristo and Scudder, 2000.

These dimensions affect the success, management, and subsequent performance of distributed software groups. Evaristo and Scudder (2000) describe the challenges as:

- Type of project – software vs. hardware, product oriented vs. design
- Structure – a highly complex project may be easier to manage because it has to be highly defined, resulting more clarity in the design

- Perceived distance – distance affects activities that may require face-to-face meetings. The absence of this face-to-face meeting restricts the progress of work activities.

- Synchronicity – are people working on the same project concurrently or do they need frequent synchronous communication. People in the different time zones must be informed of what progress is being made overnight.

- Complexity – the level of complexity can strongly affect the progress of distributed groups. Complexity can come from the size or the nature of the project.

- Culture – different nationalities have different ways of structuring their working organizations and their interpersonal relationships. The organizational culture is also important here, affecting how work is done within the project group.

- Information systems methodology – organizations use different software development methodologies, the differences could be based on different tool sets needed by each organization. This could lead to big problems during development because although the organizations are performing similar tasks, they express their work process and products in different languages. If organizations are on the same Capability Maturity Model level, collaboration would be enhanced.

- Existence of policy and standards – if an organization has strong standards and upholds them, project integrity can be maintained. The Capability Maturity Model again can be used to help organizations adhere to uniform software or development policies.

- Level of dispersion – the team effort is affected by the distance between group members and among group members. If a group of stakeholders were highly dispersed it may affect project progress. Dispersion can be between similar groups or some groups having dispersed members where others were all collocated.

- Types of stakeholders – different stakeholders have different needs around a system and different perspectives from which they are viewing the system. Having a large number of different stakeholders increases the distributiveness of the project.

This detailed list illustrates the complexity of distributed software engineering and the many issues that arise from distributed collaborative group work.

Integrating a collaboration platform and a CASE environment provides a strong collaborative forum for distributed requirements engineering. Grünbacher (2000) has developed a system that integrates a negotiation model with views to reduce the

complexity of the model and provide a way to look at smaller sets of model elements. CASE tools can be added to the collaborative tools to provide flexible mechanisms to illustrate to a diverse set of stakeholders needs and understandings. Merging a group support system (GSS) and Rational Rose, an analysis and design tool, provides a collaborative facet to Grünbacher's system. The system merges the negotiation results from the different system views into one integrator, the EasyWinWin Integrator, and uses XML to illustrate the results. This system aims to provide access to understanding the development process through the use of collaborative work and supporting technology.

Requirements collaboration meetings are a successful method to determine the focus of a new system and to ensure full coverage of stakeholders' needs. The use of workshops where the participants interact in a focused manner can shorten the requirements determination process and can also provide a forum where hidden requirements are brought to the forefront early in the elicitation process. Concerns and conflicts are resolved on the spot and stakeholders can move forward towards agreement. Gottesdiener (2003) offers workshops for participants to involve them in the complete process. Gottesdiener provides a service to clients where she schedules successive meetings to hash out the requirements for a new system. This process can take from four days to four weeks to accomplish, depending on the complexity of the system to be developed and the cooperation and availability of the critical stakeholders.

Involving the right people will ensure success of the process. Each group member within an organization has his/her own priorities and work procedures, which sometimes conflict with those of other stakeholders. Encouraging participation from a variety of

groups will provide a wide range of system and process views. Gottesdiener includes these participants in the workshop:

- Project Sponsor – funds the project
- Product Champion – ensures needs of the user community are met
- Direct Users – people who will come in direct contact with the software
- Indirect Users – people who come in contact with the system byproducts, such as reports or files from the system
- Advisors – are not active in using the system but have organizational knowledge
- Suppliers – people who will design the software, these are developers or analysts and understand the existing system

Along with these stakeholders, a trained facilitator helps the meeting progress as found by Maybury (2001). When facilitators are effective, stakeholders work together to come up with a set of requirements that achieve everyone's top goals, when conflict arise it is addressed immediately and differences of opinions are not discouraged. Often resolving these conflicts brings a clearer understanding of the requirements in question (Foroughi, 1996). Again, it clearly can save time and money later on in the downstream phases of the software development process.

CHAPTER 3

RESEARCH MOTIVATION

As we have observed, requirements analysis rarely takes place in a distributed mode. In this early phase of the software development process, software analysts tend to travel to organizations to interview, observe, and study the current system and its users. After several sessions with direct communication, a requirements specification is written which is shared with the stakeholders. Once the requirements are agreed upon and the system specification is completed, modules can be disbursed to geographically distributed parts of the organization for implementation.

Several researchers have studied the modes of communication used in requirements engineering. Ocker, Fjermestad, Hiltz, Johnson, (1998) investigated four modes of communication used 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 studied: 1) face-to-face, 2) synchronous computer conferencing with two face-to-face meetings at the beginning and end of the work phase, 3) asynchronous computer conferencing, and 4) a combination of with face-to-face and asynchronous computer conferencing. The results of the study showed that the combination yielded the highest scores in creativity, quality, and process satisfaction. The group using the combined modes also produced better requirements definitions than the groups using other communication modes. The authors suggest that further research be undertaken to more fully explore how other combinations of computer-mediated

communication affects group quality and creativity.

Requirements engineers and stakeholders commonly meet face-to-face to determine the list of possible requirements for the proposed system. Multiple meetings are necessary to ensure that all stakeholders' concerns are addressed. The costs associated with multiple rounds of face-to-face visits and interviews can be prohibitive. Group discussion in a distributed, collaborative environment is an alternative approach to arriving at a final, prioritized list of requirements. The use of technology to assist in this decision-making process can provide 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).

Requirements negotiation frameworks typically provide strong support only for the initial iteration of requirements negotiations. Although renegotiation is needed to reach consensus on a final list of requirements, it is not strongly supported by these frameworks. A comprehensive process for negotiation support will enhance the cognitive and information processing capabilities of users (Grünbacher, Koszegi, Hallin, Biffl, 2003).

Damian, (2001) studied distributed requirements negotiation among three different software engineering stakeholder roles working collaboratively towards a solution in a context of conflicting goals. She found that the use of a shared electronic workspace was particularly useful in requirements negotiation. She also found that the use of videoconferencing promoted the participation of a larger group of stakeholders.

The use of computer-mediated requirements negotiations enhances and enriches the contributions of geographically separated stakeholders, enabling important

participants to have a contribution above and beyond participating in face-to-face requirement fact-finding meetings.

3.1 Discussion of Emergency Management Information Systems Domain

The integration of emergency response activities and information management systems has been progressing over the years, but this process has been accelerated in recent years. Much research has been done to define the needs of emergency responders. Current information systems can provide a level of support unprecedented in this field, making coordination between local organizations, state government, and federal authorities routine and seamless. Such cooperation and integration could improve emergency personnel response and bring expertise to a situation in a rapid manner, saving valuable time, equipment, money, and personnel, and preventing the development of larger and more dangerous situations. This chapter summarizes current knowledge in the area of emergency response as it relates to important stakeholders and the development of information systems for organizations involved in the response effort.

Turoff (2001) summarizes the critical concepts that must be addressed when considering the development of an emergency response system. These include assumptions: such as the following: (1) everything in a crisis situation can be an exception to the norm, (2) emergency systems are not used on regular basis, (3) people in emergencies work long days and have no tolerance or time for dealing with unrelated matters, and (4) the critical problem of the moment is the primary factor which collects the people, the authority, and the resources that are needed to be brought into play. Also, process improvement depends on knowledge of what actually happened before, during,

and after a crisis. Furthermore, establishing and supporting confidence in a decision through supplying the best possible up to date information is critical to those whose actions may risk lives and resources, and, crisis situations involve the necessity for many hundreds of individuals from different organizations to be able to exchange information freely, delegate authority, and conduct oversight, without the side effect of information overload. All of these factors and issues are critical in the planning of emergency response information systems. It is also critical to develop an information system that can be used on a daily basis during non-emergency activities, so that the personnel are familiar with the system and can transition seamlessly to emergency mode (Turoff, Chumer, Van de Walle, Yao, 2004).

Many small communities do not have the resources, personnel, or the expertise to develop a set of requirements to assist them in managing their day-to-day emergency response activities. 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. 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.

Spaite (1999) says that a statewide Emergency Management System (EMS) information system for California should include creating a data task force, revising the data collection and reporting system, using of existing EMS evaluation tools, developing linkages across EMS systems in the state, providing technical assistance, and preparing a statewide data system plan. These items are also pertinent at the local or county level. Keeping in mind the needs of the state system, a local system can be developed to integrate the local information into the state system, creating a robust database, enhancing cooperation and response effectiveness.

The collection and analysis of data prior, during, and after an incident needs to be fully addressed. Collecting and storing masses of data will not facilitate the efficient operation of an incident response. Databases that could be accessed during times of emergency include lists of generators and their owners, trucking assets for transporting emergency goods, and specialized personnel databases. Depending on the type of incident, multiple databases could be accessed. The integration of these databases would be an important feature of an emergency response information system that would be flexible and capable of handling a variety of emergency situations over a period of time.

In their Resource Document, the National Association of State Emergency Medical Services Directors suggest that an infrastructure of domestic preparedness be created which will be long term and integrate the larger EMS needs with day-to-day operations. They recommend that all players involved in dealing with domestic terrorism collaborate; this would include both public and private sector stakeholders. Appendix H details some of the types of stakeholders involved in emergency management. The state directors point out particular areas of concern: planning, coordination, infrastructure,

medical direction, workforce development, education, protective equipment, decontamination, medications, data and information system surveillance, privacy and confidentiality, trauma system, and communications.

A common thread throughout the 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 that the data is current and also, maybe equally or more importantly, that users are comfortable with the system at a time when they need to use it quickly and efficiently. Green (2001) discusses the importance of defining and understanding what information is necessary to facilitate decision making during times of emergency. His list of components for a virtual emergency operations center includes the 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. A few examples of commercially available emergency response information systems are listed in Appendix I.

Advancing the effort of investigating requirements for emergency response information systems will increase the safety of our responders and society as a whole. Providing guidance to the various organizations which are distributed throughout the country and world can be facilitated through the use of asynchronous communication technologies. As the individual members of these organizations are familiar with what they need to get the job done, development of requirements with each organizational

entity is required. Providing an overall system that can be used by multiple stakeholders is a challenge yet the resulting set of requirements would create a system that can be integrated through the different levels of critical response effort: local, state, and federal.

Emergency response information systems have become an emerging area in software development. Software to facilitate efficient coordinated response to catastrophic events is being developed in many different emergency response domains. In a real emergency, teamwork is mandatory. Numerous organizations work at full throttle to address a myriad of issues. Information needs can be similar throughout many organizations. Also, information collected by one organization might be a critical input for the next organization. Therefore, collaboration, coordination, and information sharing is fundamental to an effective response effort.

3.2 Research Questions

Virtual collaborative teams are becoming increasingly common in software engineering development. These teams have the potential to transform the software development process and increase the quality of software products by providing a stable and traceable development environment. The ability to comprise a virtual team from the best skilled members is a strong impetus to developing a strong distributed team process. Often workers that are the best for a project are not co-located, so the only option is to have team members work together in a distributed mode. Optimally, team members would have opportunities to meet, but since this is not always possible, successful teams must have a robust group process.

In this research, distributed teams have been provided with a framework that incorporates established negotiation procedures and that has been shown to be successful in face-to-face negotiations. It is reasonable to expect that if these procedures are adapted for distributed teams, they can be expected to improve the software development process and provide mutual satisfaction for team members, enabling them to move forward in a positive manner. It is also reasonable to believe that adding a task structure to the negotiation activity will enhance the group's results. The goal of this study is to investigate these issues, and therefore to ask whether negotiation theory and distributed group discussions can improve the quality and satisfaction of decision making.

In particular, this research investigates the effect of task structure and negotiation sequence on asynchronous groups. The following questions will be investigated: 1) How does providing different task or negotiation frameworks affect distributed group discussions and outcomes? 2) Does group task structure influence conflict in asynchronous group communications? 3) Are groups more satisfied with their group process and solution when a structured task and negotiation steps are provided? 4) Is there an interaction effect between task structure and negotiation sequence? 5) Does providing a negotiation sequence or task structure influence the process which asynchronous groups converge to a consensus?

CHAPTER 4

THEORETICAL BACKGROUND AND HYPOTHESES

The hypotheses were tested using a controlled experiment with a 2 X 2 factorial design. The experiment will provide a group of students with a structured or unstructured task. Student groups will be assigned to one of four categories. Groups in the first category were assigned a structured task and a specified negotiation sequence. Groups in the second category were assigned a structured task with no specified negotiation sequence. Groups in the third category were assigned an unstructured task with a specified negotiation sequence. Groups in the fourth category had neither a structured task nor a specified negotiation sequence.

Group members worked asynchronously at their own computers with no restrictions as to the time or place of interaction. The collaborative work was conducted in an asynchronous bulletin board, WebBoard. Many instructors at NJIT use this technology for student collaboration and communication. The only restriction given to the groups was that they do not communicate by phone, email, or face-to-face outside the WebBoard collaborative workspace. Each group was given a private WebBoard conference to conduct its negotiations.

4.1 Hypotheses

4.1.1 Perceived Solution Quality and Quality of Solution

The task structure provided to the participants in some of the study groups was intended to define a framework for group discussion. Structured tasks can facilitate group coordination by providing a sequence of steps that will lead to a decision. This decision

process has three phases: 1) generation of alternatives, 2) period of critical reflection, and 3) group evaluation of alternatives and consensus reaching. Task structure can assist a group to understand its task and can help to improve decisions by group members (Dufner, 1995). It can also improve group performance by encouraging information sharing and by reducing process losses due to incomplete understanding of the task to be completed (Nunamaker, Dennis, Dean, Hickey, et al., 1991). We therefore expect the quality of a group's solutions to be higher when its online discussions are more structured.

Similarly, the negotiation steps provided to the participants in some of the study groups were intended to help them reach a successful outcome. Fisher and Ury (1983) conclude that a particular sequence of negotiation steps is associated with a successful outcome. This sequence is: 1) identifying and defining the problem, 2) understanding the problem, 3) generating alternatives and solutions, and 4) evaluating alternatives and selecting the final agreed list. It is therefore hypothesized that those groups following a negotiation sequence with specific instructions will achieve a higher quality solution.

This discussion suggests the following set of research hypotheses:

H1.a. Groups following a negotiation sequence will percieve higher quality solutions as compared to groups with no specified negotiation sequence.

H1.b. Groups following a negotiation sequence will produce higher quality group reports as compared to groups with no specified negotiation sequence.

H1.c. Groups following a structured task will percieve higher quality solutions as compared to groups with an unstructured task.

H1.d. Groups following a structured task will produce higher quality group reports as compared to groups with an unstructured task.

4.1.2 Conflict

There are two basic types of conflict between negotiating parties: *conflicts of interest* which can lead to win-lose situations, and *conflicts of viewpoint* which may lead to win-win negotiations. Finding potential agreements and identifying alternative solutions are beneficial byproducts of conflict in negotiations. For both win-win and win-lose negotiations the use of a structured process can improve the results of negotiations. (Deek, McHugh, 2003). This discussion gives rise to two additional research hypotheses.

> H2.a. Groups following a negotiation sequence will exhibit less conflict in their negotiations compared to groups with no specified negotiation sequence.
>
> H2.b. Groups following a structured task will exhibit less conflict in their negotiations compared to groups with an unstructured task.

4.1.3 Process Satisfaction

Research on group decision-making also looks at how satisfied a group was with the process used in making its decisions. Some researchers have found that technology-supported groups can produce more democratic (individuals participating with equal value) or more fairly distributed decision-making processes (Watson, 1987, DeSanctis and Gallupe, 1987), which in turn leads to more satisfaction with the outcome. Some researchers have found that the more democratic the process, the "better" and more satisfying the group process and outcomes will be (Dufner, 1995, Hoffman, 1979). It is therefore natural to hypothesize that groups not following a negotiation sequence and a structured task will be less satisfied with their group process.

> H3a. Groups following a negotiation sequence will show more satisfaction with their negotiation process compared to groups with no specified negotiation sequence.

H3b. Groups following a structured task will show more satisfaction with their negotiation process compared to groups with an unstructured task.

4.1.4 Solution Satisfaction

It is also important to measure group members' feelings concerning the final group solution. Watson (1987) used a causal model to formulate a hypothesis that structure can increase the quality of decision making and improve group processes. He also theorized that structured computer-supported work could improve commitment, satisfaction, extent of input, and confidence in the solution. Watson's causal model is shown below.

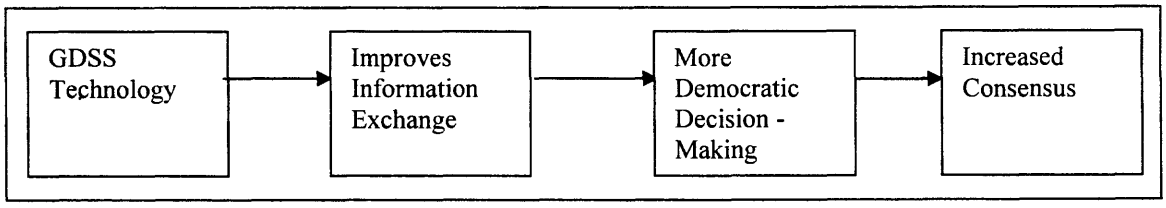


Figure 4.1 Implied Causal Model.
Source: Watson, 1987.

Watson's work suggests that there will be a positive relationship between structure of task and negotiation sequence and solution satisfaction. We therefore have the following additional hypotheses:

H4a. Groups that follow a negotiation sequence will be at least as likely to be satisfied with the group's solution as those groups not following a negotiation sequence.

H4.b. Groups following a structured task will be at least as likely to be satisfied with the group's solution as those groups with an unstructured task.

4.1.5 Negotiation Convergence

Convergence of negotiations to group consensus requires specific conditions (Stahl and Herrmann, 1999). Structured negotiation models can facilitate negotiation convergence (Herrmann, 1995). Similarly, negotiation strategies, such as sequencing, can contribute to the convergence of different perspectives (Lee, 1996; Boehm et al., 1995). These ideas suggest the following hypotheses:

> H5a. Groups in structured conditions will converge faster to a consensus and show less disagreement in this convergence process than those in unstructured conditions.
>
> H5b. Groups that follow a negotiation sequence will converge faster to a consensus and show less disagreement in this convergence process than those in non-sequential conditions.

4.2 Conceptual Model of Variables

This study has examined the effect of negotiation sequence and task structure on the outcomes of asynchronous negotiations. The conceptual model is depicted below:

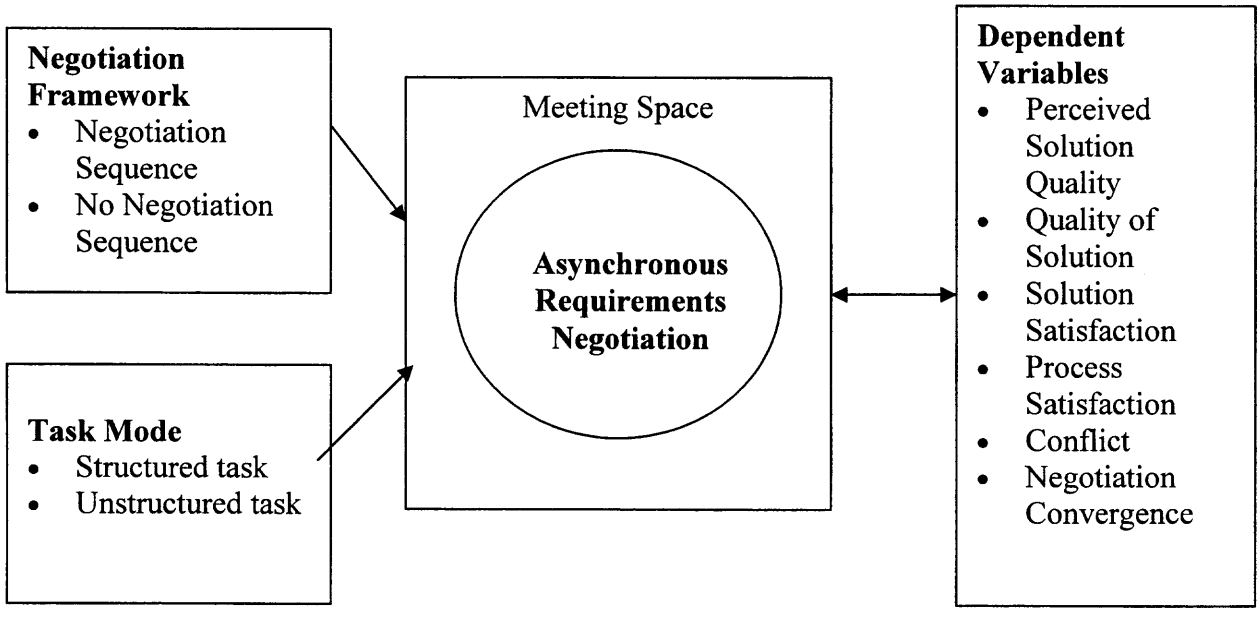


Figure 4.2 Conceptual Model.

CHAPTER 5

RESEARCH METHODOLOGY

5.0 Experimental Design

The independent variables are Structured Task and Negotiation Sequence. Both variables can be present or absent. The design is shown in the table below.

Table 5.1 Experimental Design

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**

The subjects for this study were graduate students enrolled in Systems Analysis and Design and Software Engineering courses. Students were randomly assigned to roles in groups of six. There were five stakeholder roles: 1) law enforcement, 2) fire containment, 3) public works, 4) public health, and 5) state home/civil defense unit liaison. The project manager role supplied costs and resources, chaired the meetings, and provided facilitation.

5.1 Data Collection Methodology

Subjects completed and signed a consent form and a background questionnaire prior to starting the experiment. This consent form is attached as Appendix A. Most variables were measured with an on-line post-task questionnaire provided to each subject after participating in the experiment. The post-task questionnaire is attached in Appendix B. Other variables were measured by the output from WebBoard and from subject-generated documentation (daily list of requirement priorities, final agreed list of ranked requirements, final reports). Negotiation convergence was measured by analyzing the WebBoard conferences in which the group conducted their discussions. The time it took to reach consensus and group agreement were analyzed. Group agreement was measured by the amount of activity within the group, as measured by messages posted, and the ability of the group to come to a final consensus on the list of requirements. Finally, perceived solution quality was measured by post-task questionnaire items and Quality of Solution was measured by the group's final report as assessed by two expert software engineering judges. The table below describes the measures used.

Table 5.2 Variables and Measurement Tools

Variable	**Measurement Tool**
perceived solution quality	Post-task questionnaire
solution satisfaction	Post-task Questionnaire
process satisfaction	Post-task Questionnaire
conflict	Post-task Questionnaire
negotiation convergence	Subject-generated documents and WebBoard conferences
quality of solution	Expert judge's analysis of final reports

Each dependent variable addressed in the post task questionnaire was measured with specific questions. These are detailed below with the question, variable measured, and the question number in the post-task questionnaire

Perceived Solution Quality

This variable was measured using a scale developed by Gouran, Brown, and Henry, (1978). The scale measures perceived quality of decision making and solution of the group.

1. The overall quality of the group's work was:

   Poor 1----2----3----4----5---6---7 Good

3. The content of the group's work was:

   Carefully developed 1----2----3----4----5---6---7 Carelessly developed

11. The manner in which the participants examined issues was:

    Non constructive 1----2----3----4----5---6---7 Constructive

14. The issues explored during the group's work were:

    Trivial 1----2----3----4----5---6---7 Substantial

Solution Satisfaction

This variable was measured using a scale that was developed by Green and Taber (1980). These questions measured the group' s satisfaction with their solution.

4. To what extent does the group's work reflect your inputs?

   Not at all 1----2----3----4----5---6---7 Very great extent

12. To what extent do you feel committed to the group's solutions?

    Not at all 1----2----3----4----5---6---7 Very great extent

16. How satisfied or dissatisfied were you with the quality of your group's solution?

    Very dissatisfied 1----2----3----4----5---6---7 Very satisfied

Process Satisfaction

This variable was measured using a scale that was developed by Green and Taber, 1980. These questions measured the group' s satisfaction with their decision scheme.

How would you describe your group's problem-solving process?

5. Efficient	1	2	3	4	5	6	7	Inefficient
6. Coordinated	1	2	3	4	5	6	7	Uncoordinated
7. Fair	1	2	3	4	5	6	7	Unfair
8. Understandable	1	2	3	4	5	6	7	Confusing
9. Satisfying	1	2	3	4	5	6	7	Unsatisfying

Conflict

This variable was measured with a scale from Li, 2003. These questions measured the group's conflict while conducting the asynchronous negotiations.

2. To what extent did the group experience conflict?

Not at all 1----2----3----4----5---6---7 Very much

10. Did the group members acknowledge and confront conflict openly?

Not at all 1----2----3----4----5---6---7 Very much

13. Our group's approach helped us to resolve conflicts that arose in the course of our work.

Strongly agree 1----2----3----4----5---6---7 Strongly disagree

15. Did the group handle conflict effectively?

Not at all 1----2----3----4----5---6---7 Very much

5.2 Description of Task

The task was a hypothetical situation created by the researcher. Students were instructed to negotiate requirements for an emergency response system for a fictitious county. The task was created to encourage discussion and negotiation. It is consistent with McGrath's

task Circumplex (1984) conceptualization (Figure 2.1). It can be classified according to McGraths Circumplex as a combination mixed-motive and competitive type of task.

The task focused on the ranking of the specified requirements and the stakeholders' need for each requirement. Each stakeholder's organization has different requirements for the proposed system. The stakeholders do not know the critical needs of the other organizations, as the requirements were elicited individually from each organization by the Project manager's and his/her system analysts. Because it is assumed that the organizations have been provided with state and local government funds to create this system, it is in their best interest for their representatives to work collaboratively and negotiate to find a middle ground that satisfies all stakeholders. Since the funding was insufficient to implement all requirements, the stakeholders had to negotiate to agree on a subset of suitable requirements that will go forward for implementation. Below is a master list of all the requirements that were generated by the multiple stakeholders. This master list was given to the subjects as a guide.

This description of the county and accompanying task was given to each student hard copy and also was posted as a link in WebBoard:

Task Description:

Highland County has approximately 500,000 residents, includes rural and suburban areas, and is within proximity of a large metropolitan area. The county is home to the Friendly Petroleum Processing Facility, a refinery for gasoline and other petroleum products. This facility has a large petroleum product storage depot adjacent to the processing plant. Highland County is also home to several large corporations, and has one large corporate headquarters within its boundaries.

The problem-solving task for each group is to negotiate and rank a given set of fifteen system requirements for an emergency response information system. Each group consists of representatives of the following organizations: law enforcement, fire containment, public works, public health, and a state/home civil defense liaison. There is also a project manager who is a representative of the company that will develop the software. Each team member will play the role of one of these representatives. For the purpose of this exercise, role-playing involves reading all the documentation for this experiment and as you negotiate, acting as if you were the person described in your role description.

In previous meetings with the project manager and software analysts, each of the stakeholders had agreed on a set of system requirements suitable for their organization. The final list was compiled from the group of individual organizational inputs without any interaction between the organizations. Your task is to negotiate with the other organizations' representatives to try to agree on a list that is beneficial to all organizations involved in the emergency response effort.

After careful study, the software analysts have determined that there must be some reduction in the complete list of 15 requirements due to monetary and scheduling restrictions. Due to the team's limited knowledge of the emergency response domain, they plan to ask the stakeholders to decide on the final requirements that would fulfill their needs for the functionality in the new ER system. Meeting face-to-face to negotiate these final list of requirements is out of the question, due to scheduling conflicts. Since the stakeholders are all too busy to take time out to travel and meet face-to-face, they have agreed to negotiate the final list asynchronously. During the negotiations, keep in

mind that it is only possible to implement requirements that add up to no more than 45 man-months of development time. Also, it is not possible to change the time each requirement takes to complete.

There are two requirements that have been agreed upon as necessary to the system and can be assumed will be included in the development: They are: *The system shall be secure and provide appropriate authentication* and *The system shall be redundant with automatic switchover.* These two requirements take 22 man-months to implement and are already accounted for in the budget.

Your group's task is to carry out negotiations requirements that will take no more than 45 man-months to complete. The Project Manager will act as a team facilitator, chair the meetings, help guide you through your negotiations, keep a log of activities and negotiations, and initiate activities to ensure your team completes the task on time and within budget. As you go through your negotiations, the Project manager will provide the time estimates for any requirements that are not on the list that your group may think important to add.

Your initial meeting will be conducted using WebBoard; you will be given a pre-experimental training task. Following the training exercise, you will have one week (five days) to conduct the experimental task following the instructions for your group. Once you have completed the experimental task and decided on your final list of requirements, your group will then complete a final report describing why you chose or did not choose each requirement.

Time estimates of each requirement.

This is a list of estimated time for each individual requirement. There is a years operational expense included in the total cost. The amount of funding provided by the Federal and State organizations is limited. The list of requirements you must agree on must not exceed 45 man months to implement. The amount of time for each requirement is listed below for your reference. Please note this list is not inflexible, if in your negotiations you see that you can combine two or more requirements or wish to develop a new overlooked critical requirement you may do so. This change must be sent to the Project Manager who will consult with Professor Campbell as to the feasibility and amount of time for implementation.

These two requirements are mandatory for the system and are included in the costs: *the system shall be secure and provide appropriate authentication, and the system shall be redundant with automatic switchover.*

Table 5.3 Master List of Requirements

ID	Requirement Name	Requirements Description	Man Months
R1	Command & Control	The system shall provide a physical command and control system in a centralized location that shall be integrated yet provide individual functionality to each response organization.	10.00
R2	Remote Access	The system shall provide remote access to emergency operations center databases and communications by personal computer or Personal Digital Assistant (PDA).	10.00
R3	Public Website	The system shall provide a current informational website for public access and separate pages for individual official organizations.	12.00
R4	Linked Time Log	The system shall maintain a time log of all events with information linked on the nature of the event, the reporter, status of the event, and allow for links between related events.	10.00
R5	Dispatch Service	The system shall provide a dispatch service which will include the origination and tracking of tasks. This system will be used by police, fire services, medical organizations, etc.	4.00
R6	Interagency Access	The system shall provide distributed interagency access, allowing authorized users remote access to data collected by any of the agencies during the event.	12.00
R7	GIS Database	This system shall provide access to a Graphical Information Database for digital mapping of critical infrastructures, i.e., sewer, utility, roads, river hydrology, etc.	10.00
R8	Electronic Bulletin Board	The system shall provide an ongoing asynchronous informational message board which will provide threaded discussions for authorized users.	2.00
R9	Resource Database	The system shall maintain a resource database of contact information for local and military personnel. It will also provide equipment and personnel/volunteer databases for each critical infrastructure in the county.	8.00
R10	Electronic Command Post	The system shall provide the functionality in R1 as a virtual command and control center independent of any physical location. This functionality shall be accessible to any authorized user within the communication network. *Note: if R1 AND R10 are chosen, then R10 will take only 5 additional man months in addition to the 10 in R1, otherwise R10 consumes 12 man months.	12.00 or 5.00
R11	Victim Database	The system shall provide an interactive input form and accompanying searchable database of persons involved in the incident (personal info and photo ID to be taken onsite).	4.00
R12	Laboratory Database	The system shall provide a database of laboratory measurements and tests taken from the event.	4.00
R13	Whiteboard	The system shall provide a whiteboard collaborative working area where individuals can create and view drawings. The users shall also be able to overlay markups and update/change existing drawings.	6.00
R14	Mobile Resource Tracking	The system shall provide a means of tracking mobile physical resources, i.e., ambulances, patrol vehicles, road crews, etc.	8.00
R15	Dispatch/Response Database	The dispatch event logs generated by different response organizations shall be designed and stored as one dynamically updated database, yet provide individual functionality to each response organization.	3.00

5.3 Description of Roles

Each group had six role-playing members. Each member had a specific description of his/her job and of the requirements that the organization wanted to see implemented in the new information system. These descriptions are detailed below and include specific descriptions for each stakeholder role.

5.3.1 Fire Containment

The fire containment organizations focus on identification and containment of chemical, toxic, industrial and similar hazards as well as on their primary mission of fighting fires. Examples of such organizations are local fire departments and hazardous materials specialists. These organizations will provide expertise for the containment/neutralization of the fire or hazard, track chemical/biological equipment inventories, and have access to specialized databases and equipment.

The role description given to the subjects follows:

Table 5.4 Fire Containment Organization Role Description

Fire Containment Expert

You are deputy fire chief representing the group who has developed the requirements being discussed today.

The Fire containment organizations focus on identification and containment of chemical, toxic, industrial and similar hazards as well as their primary mission of fighting fires. Examples of this type of organization would be the local fire departments and hazardous materials specialists. This organization will provide expertise for the containment/neutralization of the fire or hazard, track chemical/biological equipment inventories, and must have access to specialized databases and equipment. The fire department will provide a listing of contact information for critical personnel for each critical infrastructure, such as chemical manufacture or petroleum processing entities. The fire organization will provide on-site testing, measurement, and tracking of the hazard, onsite physical protection from hazard, and provide specialized equipment/clothing to emergency personnel. The Fire department will provide a dispatch center, with audio recordings. It will also establish a decontamination area if necessary, keep track of possible targets, and provide decontamination equipment. The fire department needs to have immediate response from the police to ensure their vehicles and equipment get to where they are needed. They also need to know when there is any indication of possible sabotage or terrorism in any event they are responding to so they can take appropriate precautions.

These are the requirements your organization wants to include in the new information system. These requirements were determined internally without interaction with the other participating organizations (public health, law enforcement, etc.). Internally your organization has identified the following requirements as its preferences. There has been no discussion of any degree between the participating organizations to determine if there is any overlap with your needs. The purpose of this negotiation task is to try to identify a set of requirements that will provide the best functionality for the proposed information system within the constraints of the current budget of 45 man months. The requirements below are not ranked in order of preference, but are categorized in a general way into critical, high priority and medium priority operations as reported by the users. Given your knowledge of information systems, you are free to apply these skills to the process of arriving at views or rankings that may be different from those provided by the users.

Table 5.5 Software Requirements for Fire Containment Experts

		Fire Containment Experts	Man Months
Critical Operations	R9	The system shall maintain a resource database of contact information for local and military personnel. It will also provide equipment and personnel/volunteer databases for each critical infrastructure in the county.	8.00
	R1	The system shall provide a physical command and control system in a centralized location that shall be integrated yet provide individual functionality to each response organization.	10.00
High Priority Operations	R2	The system shall provide remote access to emergency operations center databases and communications by personal computer or Personal Digital Assistant (PDA).	10.00
	R7	This system shall provide access to a Graphical Information Database for digital mapping of critical infrastructures, i.e., sewer, utility, roads, river hydrology, etc	10.00
	R5	The system shall provide a dispatch service to include the origination and tracking of tasks.	4.00
	R8	The system shall provide an ongoing asynchronous informational message board.	2.0
Medium Priority operations	R6	The system shall provide distributed interagency access, allowing authorized users remote access to data collected by any of the agencies during the event.	12.00
	R10	The system shall provide the functionality in R1 as a virtual command and control center independent of any physical location. This functionality shall be accessible to any authorized user within the communication network. *Note: if R1 AND R10 are chosen, then R10 will take only 5 additional man months in addition to the 10 in R1, otherwise R10 consumes 12 man months	12.00 or 5.00
	R4	The system shall maintain a time log of all events with information linked on the nature of the event, the reporter, status of the event, and allow for lateral links between related events.	10.00
		Total Man Months	78.00

5.3.2 Law Enforcement

Law enforcement organizations consist of local police and security personnel. They are responsible for security and protection of response personnel and the general public. The police will secure the incident area. The primary role of the police is to contain the situation and protect innocent personnel involved in the event. They will protect businesses from looting. The police bomb squad and SWAT units are on call to deal with terror or criminal oriented situations. The police are also responsible for ensuring the ability of emergency vehicles and personnel to get where they need to go. Finally, one of the more important functions of the police is to manage a resolution to or understanding of the event and coordinate options.

Table 5.6 Law Enforcement Organization Role Description

The role description given to the subjects follows:

Law Enforcement Organization

You are an assistant police chief in charge of emergency response preparedness in the police department.

The law enforcement organization is comprised of local police and security personnel. This organization is responsible for functions that focus on security and protection of both response personnel and the general public. The Police will establish a command post and staging area for the event. In order to ensure personal safety and accountability they may also establish a database for tracking and identification of response personnel and event victims. This database will help ensure protection/security of subjects and response personnel and also allow information dissemination in a more rapid and secure manner. The police will secure the incident area. Interviewing survivors and collecting evidence for later criminal investigations will be an ongoing activity. It is the police's role to identify any security deficiencies and to rectify them. Potential additional targets must be assessed and steps taken to protect them. The primary role of the police is to contain the situation and protect innocent personnel involved in the event. They will protect businesses from looting. Some methods to facilitate these efforts are to provide on-scene command and communication functions, report the unfolding situation and provide updates to other agencies. The police bomb squad and SWAT units are on call to deal with terror or criminal oriented situations.

The police are also responsible for ensuring the ability of emergency vehicles and personnel to get where they need to go. Finally one of the more important functions of the police is to manage a resolution to or understanding of to the event and coordinate options. Clearly the police have a strong need to be fully informed of all that is taking place and must be in a position to exert primary command and control in the emergency environment. Furthermore, the police would prefer to deal with the situation themselves rather than call in state and federal resources.

These are the requirements your organization wants to include in the new information system. These requirements were determined internally without interaction with the other participating organizations (public health, law enforcement, etc.). Internally your organization has identified the following requirements as its preferences. There has been no discussion of any degree between the participating organizations to determine if there is any overlap with your needs. The purpose of this negotiation task is to try to identify a set of requirements that will provide the best functionality for the proposed information system within the constraints of the current budget of 45 man months. The requirements below are not ranked in order of preference, but are categorized in a general way into critical, high priority and medium priority operations as reported by the users. Given your knowledge of information systems, you are free to apply these skills to the process of arriving at views or rankings that may be different from those provided by the users.

Table 5.7 Software Requirements for Law Enforcement Organization

		Law Enforcement Organization	Man Months
Critical Operations	R5	The system shall provide a dispatch service which will include the origination and tracking of tasks. This system will be used by police, fire services, medical	4.00
	R11	organizations, etc. The system shall provide an input screen and accompanying searchable database of persons involved in the incident (photo ID to be taken onsite and personal info)	4.00
High Priority Operations	R4	The system shall maintain a time log of all events with information linked on the nature of the event, the reporter, status of the event, and allow for lateral links between related events.	10.00
	R8	The system shall provide an ongoing asynchronous informational message board.	2.00
	R14	The system shall provide a means of tracking mobile physical resources, i.e., ambulances, patrol vehicles, road	8.00
	R9	crews, etc. The system shall maintain a resource database of contact information for local and military personnel. It will also provide equipment and personnel/volunteer databases for each critical infrastructure in the county.	8.00
Medium Priority operations	R1	The system shall provide a physical command and control system in a centralized location that shall be integrated yet provide individual functionality to each	10.00
	R2	response organization. The system shall provide remote access to emergency operations center databases and communications by	10.00
	R10	personal computer or Personal Digital Assistant (PDA). The system shall provide the functionality in R1 as a virtual command and control center independent of any physical location. This functionality shall be accessible to any authorized user within the communication network. *Note: if R1 AND R10 are chosen, then R10 will take only 5 additional man months in addition to the 10 in R1, otherwise R10 consumes 12 man months	12.00 or 5.00
		Total Man Months	68.00

5.3.3 Public Works

The public works department includes transportation and utilities organizations. These organizations provide the infrastructure and backbone for power, communication, water, transportation, and other essential functions. They are critical in an emergency in order to provide power, get necessary vehicles/equipment to the site, and to restore vital telephone communications to the area. Public works will coordinate the transport of emergency and other necessary equipment. They will provide emergency utilities and power functionality and restore or improve telephone/wireless communications. They will assist in containment and cleanup.

Table 5.8 Public Works Role Description

The role description given to the subjects follows:

Role of Public Works

You are a vice director of the public works department in charge of the emergency response preparedness. You represent the group that has prepared the requirements for your agency.

The Public Works department can include transportation, and utilities organizations. This organization provides the infrastructure and backbone for power, communication, water, transportation, and other essential functions. This organization is critical in an emergency in order to provide power, get necessary vehicles/equipment to the site, and to restore vital telephone communications to the area. Public works will coordinate transport of emergency and other necessary equipment. They will provide emergency utilities and power functionality and restore or improve telephone/wireless communications. They will assist in containment and cleanup. An important feature of this organizations contribution to emergency response is to coordinate and ensure ease of access (flooded roads, bridges out) to the event site and surrounding areas. They will provide potable water and provide weather updates and services as necessary. The incorporation of a Graphical Information Database (GIS) is therefore utmost in priority for this group. They feel that they cannot provide the best solutions to an emergency situation without this functionality.

. A further role of the professional engineers in the public works department is to assess the safety and usability of damaged roadways, bridges, buildings, and tunnels. Furthermore, they have the responsibility and contacts with the associated utility organizations supporting the electrical, gas, water, and communication networks. A whiteboard collaborative working area would facilitate this important dissemination of information. They need to supply the command and control functions to coordinate the work of the utilities in responding to major disaster situations. They would also be able to supply any sort of maps or layout plans of any physical facilities registered with the municipal office.

These are the requirements your organization wants to include in the new information system. These requirements were determined internally without interaction with the other participating organizations (public health, law enforcement, etc.). Internally your organization has identified the following requirements as its preferences. There has been no discussion of any degree between the participating organizations to determine if there is any overlap with your needs. The purpose of this negotiation task is to try to identify a set of requirements that will provide the best functionality for the proposed information system within the constraints of the current budget of 45 man months. The requirements below are not ranked in order of preference, but are categorized in a general way into critical, high priority and medium priority operations as reported by the users. Given your knowledge of information systems, you are free to apply these skills to the process of arriving at views or rankings that may be different from those provided by the users.

Table 5.9 Software Requirements for Public Works

		Public Works	Man Months
Critical Operations	R7	This system shall provide access to a Graphical Information Database for digital mapping of critical infrastructures, i.e., sewer, utility, roads, river hydrology, etc.	10.00
	R5	The system shall provide a dispatch service which will include the origination and tracking of tasks. This system will be used by police, fire services, medical organizations, etc.	4.00
High Priority Operations	R13	The system shall provide a whiteboard collaborative working area where individuals can create and view drawings. The users shall also be able to overlay markups and update/change existing drawings.	6.00
	R14	The system shall provide a means of tracking mobile physical resources, i.e., ambulances, patrol vehicles, road crews, etc	8.00
	R9	The system shall maintain a resource database of contact information for local and military personnel. It will also provide equipment and personnel/volunteer databases for each critical infrastructure in the county.	8.00
	R4	The system shall maintain a time log of all events with information linked on the nature of the event, the reporter, status of the event, and allow for lateral links between related events.	10.00
Medium Priority operations	R12	The system shall provide a database of laboratory measurements and tests taken from the event .	4.00
	R6	The system shall provide distributed interagency access, allowing authorized users remote access to data collected by any of the agencies during the event	12.00
	R8	The system shall provide an ongoing asynchronous informational message board which will provide threaded discussions for authorized users.	2.00
		Total Man Months	64.00

5.3.4 Public Health

Public health organizations provide health related services. These organizations coordinate the effort to provide expertise to other government organizations on strategies to control and/or prevent public health incidents. Public health organizations will provide emergency medical services to event personnel and incident victims. They will also provide expert biohazard personnel. Another important responsibility is to inform and educate the public and disseminate appropriate public health hazard information that relates to the event. Public health organizations will provide appropriate equipment, protective clothing, specialized machinery, and laboratory services to event personnel. They are responsible for controlling the response to any large communicable disease outbreak, coordinating hospital services and capacity, and tracking pharmaceutical stockpiles. They are also responsible for providing coroner/mortuary services if necessary.

Table 5.10 Public Health Role Description

Role of Public Health

You are the associate director for the county public health office in charge of emergency response preparations for that agency. You need to ensure your agency can detect a significant biological threat and direct the response to it. You can be assured that information of this type will come readily from trained medical personal from local hospitals and volunteer rescue squads.

The Public Health and accompanying medical services and biological hazards organizations, provide health related services. These organizations coordinate the effort to provide expertise to other government organizations on strategies to control and/or prevent public health incidents. Public Health will provide emergency medical services to event personnel and incident victims. They will also provide expert bio hazard personnel. An important role is to also inform and educate the public and disseminate public health hazard information as necessary depending on the type of event occurring. Public health will provide appropriate equipment, protective clothing, specialized machinery, and laboratory services to event personnel. Access to a centralized database of local facilities and personnel is an important feature this group is looking for in the proposed information system. They are responsible for controlling the response to any large communicable disease outbreak and coordinate hospital services and capacity. This organization is responsible for providing coroner/mortuary services if necessary. Public health tracks pharmaceutical stockpiles and provides protection to public and response personnel from infectious diseases.

Public health provides experts on emergency call that can collect medical samples and do preliminary on sight analysis to determine the potential severity of any bio hazard situation. They can order more detailed analysis and alert their counterparts at the state and federal level. In the case of a communicable disease they may have to assume emergency command and control of resources needed to track down and contain instances of occurrence of the disease or plague.

These are the requirements your organization wants to include in the new information system. These requirements were determined internally without interaction with the other participating organizations (public health, law enforcement, etc.). Internally your organization has identified the following requirements as its preferences. There has been no discussion of any degree between the participating organizations to determine if there is any overlap with your needs. The purpose of this negotiation task is to try to identify a set of requirements that will provide the best functionality for the proposed information system within the constraints of the current budget of 45 man months. The requirements below are not ranked in order of preference, but are categorized in a general way into critical, high priority and medium priority operations as reported by the users. Given your knowledge of information systems, you are free to apply these skills to the process of arriving at views or rankings that may be different from those provided by the users.

Table 5.11 Software Requirements for Public Health

		Public Health	Man Moths
Critical Operations	R12	The system shall provide a database of laboratory measurements and tests taken from the event.	4.00
	R5	The system shall provide a dispatch service which will include the origination and tracking of tasks. This system will be used by police, fire services, medical organizations, etc.	4.00
High Priority Operations	R9	The system shall maintain a resource database of contact information for local and military personnel. It will also provide equipment and personnel/volunteer databases for each critical infrastructure in the county.	8.00
	R7	This system shall provide access to a Graphical Information Database for digital mapping of critical infrastructures, i.e., sewer, utility, roads, river hydrology, etc.	10.00
	R3	The system shall provide a current informational website for public access and separate pages for official response organizations.	12.00
	R2	The system shall provide remote access to emergency operations center databases and communications by personal computer or Personal Digital Assistant (PDA).	10.00
Medium Priority operations	R4	The system shall maintain a time log of all events with information linked on the nature of the event, the reporter, status of the event, and allow for lateral links between related events.	10.00
	R14	The system shall provide a means of tracking mobile physical resources, i.e., ambulances, patrol vehicles, road crews, etc.	8.00
	R15	The dispatch event logs generated by different response organizations shall be designed and stored as one dynamically updated database yet provide individual functionality to the organization using it.	3.00
		Total Man Months	69.00

5.3.5 State Home /Civil Defense Liaison

In any large-scale disaster, State Home/Civil Defense liaison organization may assume an important role in the facilitation of emergency response. It will direct the securing of the event area and act as a liaison between local and federal organizations. The state liaison will provide emergency equipment/lights, generators and provide backup services to local law enforcement agencies. If called upon, it will help in the identification of triage, evacuation, decontamination, and shelter areas. The state liaison can manage interagency coordination, provide a database of out-of-county assets and their availability, and help coordinate getting those assets to the places where they are needed most. This organization could be the central vehicle for dissemination of safety and event information to the public.

Table 5.12 State Liaison Role Description

The role description given to the subjects follows:

Role of Liaison from the State Home/Civil Defense Unit

You are the governor's advisor on civil defense and emergency response, you would like to ensure the maximum coordination and cooperation among the other four representatives. You would also like to ensure that whatever system is put in place provides the state office a complete picture of what is taking place and adequate chance to alert and prepare any state resources that might be called upon.

For any large scale disaster the State Home/Civil Defense Unit organizations may step in to play an important role in the facilitation of emergency response. This organization will direct the securing of the event area and act as a liaison between local and federal organizations. The state liaison will provide emergency equipment/ lights, generators and provide backup services to local law enforcement agencies. The identification of triage, evacuation, decontamination, and shelter areas will help the local organizations if called upon to do so. This organization can make an immediate appeal to the governor for the release of state resources and the National Guard for participation in the response to the disaster. The state liaison can manage interagency coordination, provide a database of out of county assets and their availability, and help coordinate getting those assets to the place where they are needed most. This organization could be the central vehicle for dissemination of safety and event information to the public. The ability to track and store the pertinent event logs are important for the ability to help the local/county organizations and also for future study to determine what and how the event occurred.

These are the requirements your organization wants to include in the new information system. These requirements were determined internally without interaction with the other participating organizations (public health, law enforcement, etc.). Internally your organization has identified the following requirements as its preferences. There has been no discussion of any degree between the participating organizations to determine if there is any overlap with your needs. The purpose of this negotiation task is to try to identify a set of requirements that will provide the best functionality for the proposed information system within the constraints of the current budget of 45 man months. The requirements below are not ranked in order of preference, but are categorized in a general way into critical, high priority and medium priority operations as reported by the users. Given your knowledge of information systems, you are free to apply these skills to the process of arriving at views or rankings that may be different from those provided by the users.

Table 5.13 Software Requirements for State Liaison

		State Liaison	Man Moths
Critical Operations	R10	The system shall provide the functionality in R1 as a virtual command and control center independent of any physical location. This functionality shall be accessible to any authorized user within the communication network.	12.00 or 5.00
	R4	*Note: if R1 AND R10 are chosen, then R10 will take only 5 additional man months in addition to the 10 in R1, otherwise R10 consumes 12 man months. The system shall maintain a time log of all events with information linked on the nature of the event, the reporter, status of the event, and allow for links between related events.	10.00
High Priority Operations	R15	The dispatch event logs generated by different response organizations shall be designed and stored as one dynamically updated database, yet provide individual functionality to each response organization.	3.00
	R6	The system shall provide distributed interagency access, allowing authorized users remote access to data collected by any of the agencies during the event..	12.00
	R7	This system shall provide access to a Graphical Information Database for digital mapping of critical infrastructures, i.e., sewer, utility, roads, river hydrology,	10.00
	R2	etc. The system shall provide remote access to emergency operations center databases and communications by personal computer or Personal Digital Assistant (PDA).	10.00
Medium Priority operations	R3	The system shall provide a current informational website for public access and separate pages for official response organizations.	12.00
	R9	The system shall maintain a resource database of contact information for local and military personnel. It will also provide equipment and personnel/volunteer databases for each critical infrastructure in the county.	8.00
	R11	The system shall provide an input screen and accompanying searchable database of persons involved in the incident (photo ID to be taken onsite and personal info).	4.00
			81.00

5.3.6 Project Manager

The project manager leads the team of developers that collected and assessed the functional requirements for the emergency response (ER) information system from each organization. This group has elicited a list of requirements for the system but realizes that this list must be reduced if it is to be implemented within a restricted time frame and with limited funds. Due to the development team's limited knowledge of the emergency response domain, they plan to ask the stakeholders to integrate their needs and decide on the final requirements that would provide the best functionality in the new ER system. The project manager's job is to make sure that the users understand the time and financial constraints involved in the implementation of the system and make it clear that it is not possible to add any time to the allotted development schedule of 45 man-months, although future enhancements may allow upgrades to provide further functionality. The project manager is also responsible for coordinating the final group report and organizing the team effort. The role description given to the subjects follows:

5.14 Project Manager Role Description

Role of Project Manager

You are the manager of the team of developers that collected and assessed the functional requirements for the emergency response (ER) information system by working closely with the interested organizations. The requirements will be implemented within a restricted time frame and with limited funds. Due to your team's limited knowledge of the emergency response domain, you have asked the stakeholders to negotiate the requirements that would fulfill their needs for functionality in the new ER system. Your job is to make sure the users understand the time and financial constraints involved in the implementation of the system and make it clear that it is not possible to add any time to the allotted development schedule of 45 man months.

Each stakeholder representative has their own list of preferred requirements. Your software analysts worked with the users in the participating organizations and developed the requirements without interaction between organizations (public health, law enforcement, etc.). There has been no discussion of any degree between the participating organizations to determine if there is any overlap. The purpose of this negotiation task is to try to identify a set of requirements that will provide the best functionality for the proposed information system within the constraints of the current budget of 45 man months.
In your role as facilitator for your group, your responsibilities include keeping notes of the negotiations, encouraging your group to negotiate and focus on the task, remind them to fill out the online questionnaires, and coordinate the final report at the end of the study.

5.3.7 Assignment of Roles Within Groups

Group members were assigned randomly by the researcher. The project manager/coordinator was a volunteer position. The students holding these positions received 10 extra points towards their grade if they fully participated in the exercise. If a group had no volunteers, the group can nominate individuals and the experimenter will choose the group's project manager.

5.4 Description of Task Structure Experimental Conditions

5.4.1 Structured Task

A group assigned a structured task sequence was provided with the following topics (via the members' private Webboard conferences). Each of these items had brief instructions that are included here once, although they were repeated for each conference and condition.

- Important Instructions - Here are the specific directions for your group. Please read them carefully and follow the instructions provided. Thanks, clc (web link to specific instructions followed)
- Meta Discussion - Reply to this topic with an discussion of process and any suggestions of what needs a focus by the group as a whole at any time. Otherwise everyone may proceed to fill in information and viewpoints about any of the alternatives in the next fifteen topic conferences.
- R1-Command and Control - Please reply to this topic with any comments on alternatives dealing with the goals of this item, the requirements the item serves, and viewpoints on how critically important the item is and why. Feel free to reply to any replies within this topic. (This statement was repeated for each requirement topic.)
- R2 - Remote Access
- R3 - Public Website
- R4 - Linked Time Log
- R5 - Dispatch Service
- R6 - Interagency Access
- R7 - GIS Database
- R8 - Electronic Bulletin Board
- R9 - Resource Database
- R10 - Electronic Command Post
- R11 - Victim Database
- R12 - Laboratory Database
- R13 - Whiteboard

- R14 - Mobile Resource Tracking
- R15- Dispatch/Response Database
- General Discussion and Proposals - Reply to this topic for general discussion and proposals for agreement on the list of requirements. This is where your group can post current ratings of the individual items and hopefully discuss possible agreements.

5.4.2 Unstructured Task

The private Webboard of each member of a group not assigned to a structured task sequence contained the following conferences. Each of these items had brief instructions which are included below.

- Important Instructions - Here are the specific directions for your group. Please read them carefully and follow the instructions provided. Thanks, clc
  (web link to specific instructions followed)

- Meta Discussion - Reply to this topic with discussion of process and any suggestions of what needs a focus by the group as a whole at any time. Otherwise everyone may proceed to fill in information and viewpoints about any of the alternatives in the next "Requirements Discussion" conference.

- Requirements Discussion - Please reply to this topic with any comments on alternatives dealing with the goals of each item (requirement), the requirements the item serves, and viewpoints on how critically important the item is and why.
  You are also free to start a separate discussion thread on any topic your group feels necessary.

- General Discussion and Proposals - Reply to this topic for general discussion and proposals for agreement on the list of requirements. This is where your group can post current ratings of the individual items and hopefully discuss possible agreements

5.5 Description of Negotiation Sequence Experimental Conditions

5.5.1 Negotiation Sequence

The members of groups assigned to follow a specified negotiation sequence were provided with the following instructions in WebBoard (Lewicki, Saunders, and Minton, 2001, Fischer and Ury, 1983)

1. Identifying and Defining the Problem: Day 1 - Monday

   - Become familiar with your role and start discussions about the task and individual requirements.

2. Understanding the Problem: Days 1-2 –Monday and Tuesday

   - On these days you will discuss your interests and listen to the other team members concerns. Look for common ground for agreement within your interests and the group system requirements. Identify and define any problem areas.

3. Generating Alternatives and Solutions: Days 3-5 – Wednesday through Friday

   - Discuss each alternative and proposed solution. Since most conflicts are based in differing interpretations of the facts, it is important to understand the different viewpoints of everyone in this committee. You should each try to put yourselves in one another's place.

   - Your team will have several negotiating sessions. Between sessions, analyze the other stakeholders' positions to see if you can understand their needs and see if you can find ways to express your needs more clearly, find some other supporting arguments for your position, or find ways to make your options more attractive to the other team members. Your Project Manager will be organizing and facilitating these discussions and taking notes to include in the final report.

4. Evaluating Alternatives and Selecting the Final Agreed list: Days 4- 5 – Thursday and Friday (finish by midnight)

   - After discussing the alternatives, select a solution with a list of requirements that is agreeable to all stakeholders and is within the 45 man-month time restriction and post it in this conference. You should do your best to note the reasons for each item in your final list and also explain why the other items

were not chosen by your group. This information is needed in the Final Report.

5.5.2 No Negotiation Sequence

For the groups followed no negotiation sequence the subjects were provided with the following instructions in Webboard.

- From Monday through Friday your team will be negotiating the rankings of the requirements. Your team will should come up with a final list that does not exceed the 45 man-month limitation and that all stakeholders can agree to put forward for implementation. Negotiations start on Monday and should be completed by midnight on Friday.

5.6 Final Report

Each group was required to produce a final report that itemized and ranked the group's choices. Each group was provided with this template.

Table 5.15 Final Report

Group Number:_____ **Date:** _____

Section 1: Requirements Chosen for Implementation

Complete this table for each requirement your group chose to go forward for implementation (Total <= 45 man months). Describe the rationale/reasons behind the ranking of each requirement and explain why your group agreed on these particular requirements and the

Requirement Name	Group Ranking 1-15	**Describe the rationale behind the ranking of each requirement.** Why did your group agree on this order of importance? Note: You are not restricted to the small space in the cell. You can take up as much space as you need for your explanation.	Cost in MM	Cumulative Cost in MM
Command & Control				
Remote Access				
Public Website				
Linked Time Log				
Dispatch Service				
Interagency Access				
GIS Database				
Electronic Bulletin Board				
Resource Database				
Electronic Command Post				
Victim Database				
Laboratory Database				
Whiteboard				
Mobile Resource Tracking				
Dispatch/Response Database				

Section 3: General Observations and Comments

In this section you may add any additional comments or observations you or your group members may have on the process of negotiation or on the solution

5.7 Technology

Asynchronous communication methods were facilitated by the use of the WebBoard conferencing system. This system provides true asynchronous communication. The students are familiar with this system from their class work so that minimal training was necessary on the use of this system. Figure 5.1 is an example of the interface of the asynchronous system.

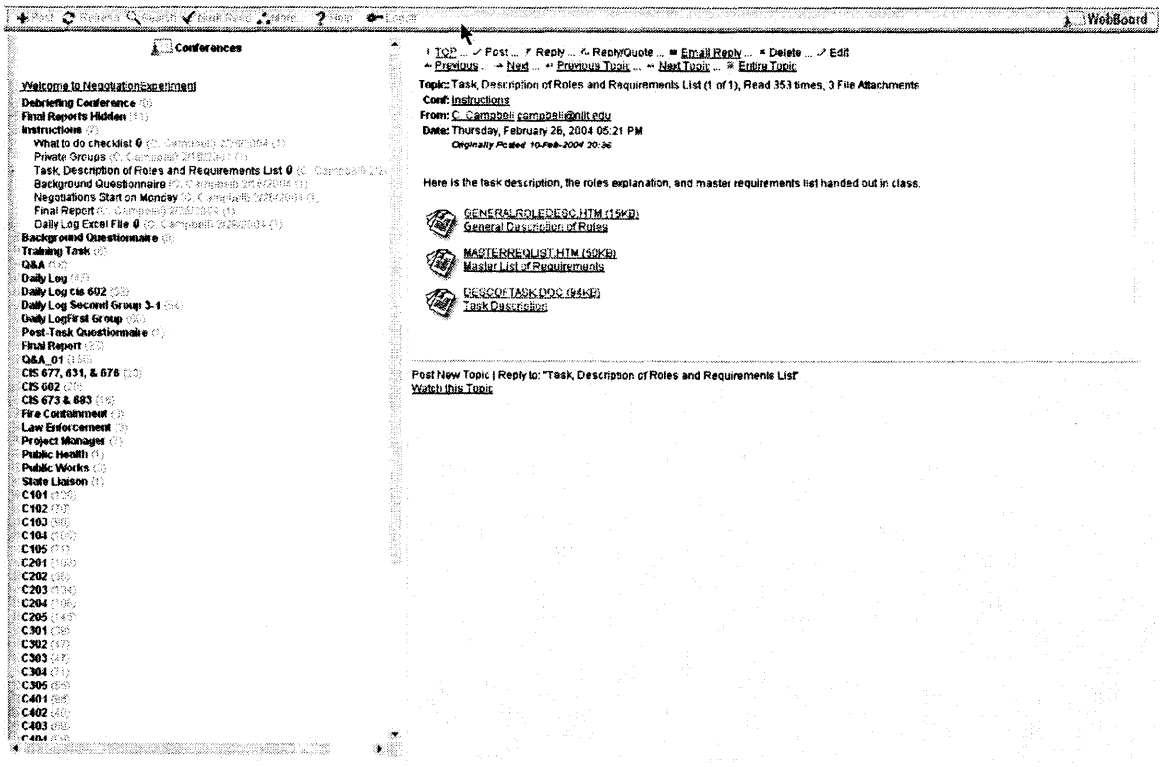


Figure 5.1 WebBoard User Interface.
Source: www.webboard.njit.edu, retrieved 11/04/04

5.8 Experimental Procedures

Over two semesters, Fall 2003 and Spring 2004, an experiment was conducted to measure the influence of structured task and negotiation sequence on solution and process quality. During the Fall semester, a pilot study was run to test the technology, group roles and interactions, task, and experimental procedures. For the pilot study 124 subjects participated with groups of four comprising 31 groups with 8 groups per condition, one condition had seven groups. From the results of the pilot study some changes were made to the final experimental design. The number of group members was increased to six and the task description was explained more thoroughly for the spring iteration. The results of the pilot study were successful and based on this experience some necessary changes were made for the formal experiment which was run with graduate students in Spring 2004. Results of the formal experiment are provided in the following chapter. As a result of the Fall semester pilot, changes were made to the roles, their descriptions, the number of stakeholders to a group, and the experimental task. The changes were made to clarify and more clearly define the experimental procedures, conditions, and task. The next few paragraphs describe the experimental procedures.

Solicitation of Subjects:

Prior to the start of the semester, instructors were contacted and a request was made to allow their students to participate in the experiment. An abstract was sent by email to the instructors upon the request. After the instructor gave permission to enter their class, discussions of the assignment and grading policies were discussed and finalized. The task was given to the students as part of their course work and they were graded individually on their participation. Initial participant training was completed in the

classroom in a one-hour face-to-face training session. During this session the students were introduced to the domain topic and the general task to be completed, given a brief background of requirements engineering (this is covered in depth by their current or previous coursework), and introduced to the project roles and what was expected of them. These training materials are included in Appendix C. The WebBoard conference also included a "Question and Answer" area where the students could post and read questions and answers about the exercise.

Consent Forms and Background Questionnaire

During the training session, the students filled out and submitted consent forms that had been approved by the NJIT Institutional Review Board. These paper forms required a signature. The consent form is attached as Appendix A. The students were then directed to an online questionnaire that was designed to collect background information on the subjects. Students were instructed to complete the form within two days of the training. The background questionnaire is attached as Appendix D. Both the background and the post-task questionnaire were web based. The data was directly sent to a database for analysis. This feature greatly enhanced the quality of the data collected.

Assignment to Groups and Roles

Prior to the initial training session the subjects were randomly assigned to groups by the researcher from class lists provided by the instructor. In class, once the groups were identified, the students were given specific instructions on how to assign roles and choose a project manager for their groups. The other group members were assigned alphabetically to roles, following the table below. If there were multiple students with the same first letter of the last name, successive letters will be used to make the choice.

Table 5.16 Assignment of Subjects to Groups

1. law enforcement	A - E
2. fire containment	F - J
3. public works	K - P
4. public health	Q - T
5. state home/civil defense liaison	U - Z

At the same time, handouts were given to the students that included the description and purpose of the experiment, general descriptions of each role, a master list of requirements (shown above), an example of the daily log file used to track negotiations, and the task description. These items are attached as Appendix C. A daily checklist was also provided to make sure they were following the procedures correctly and to provide them with a timeline for completion of each task. This checklist is attached as Appendix E.

Training Task

The students were directed to the WebBoard web conferencing system to introduce themselves to fellow group members and to participate in a short training task. This training task took three days, immediately preceding the formal experiment. During these three days, the students familiarized themselves with each other and with the conference system, and read the role descriptions and communication mode assigned to them and to the group.

Negotiation, Daily Logs, and Final Reports

After completion of the training task, the students conducted asynchronous negotiations using the WebBoard for five days. During this time, they kept track of their individual preferences by filling out a daily log which was provided by the researcher. This log is attached in Appendix F. At the end of the negotiations, the groups then had four days to

complete and comment on the final report before uploading it to the WebBoard. It was the project manager's job to ensure that this was done in a collaborative manner.

Completion of Post-Task Questionnaire

Upon completion of the negotiations, the subjects were directed to a web-based questionnaire. The subjects were encouraged to complete the questionnaire as soon as possible after they finished negotiating or by the sixth day of the experiment at the latest. The Post-Task Questionnaire is attached as Appendix B.

Debriefing and Grading of Subjects

Upon completion of the experiment and submission of all required documentation, each instructor was given a suggested grade for participation of each subject. Subjects who submitted all materials received full points. Students were provided a debriefing conference which detailed the experimental design, procedures, and a brief theoretical background for the research. The debriefing information provided to the subjects is attached as Appendix G.

5.9 Data Analysis Methods

Background data was collected on each subject including age, employment, gender, and ethnic background. This was analyzed and is detailed in the next chapter. For the questionnaire items, ANOVA was used to test the effect of the independent variables on the dependent variables. Significance levels of 0.05 or less were considered statistically significant. A Likert scale from one to seven was used to measure most variables. These scales were previously validated by other researchers. Chronbach's alpha was used to validate the individual items in the scales.

Two experienced software engineers were solicited to judge the quality of the final solution of each group report. Because of their experience, they were qualified to look at the final solutions presented to them and assess the overall quality of the reports submitted. Each expert assessed each report separately after initial training. The training session preceded the formal judging of the reports and was conducted on one day. The training session was conducted to ensure the judges understood the procedures to follow and that the judging was consistent. The guidelines that were provided for the expert judges is shown in Table 5.17. Table 5.18 details the instructions given to the judges and Table 5.19 shows the expert judge evaluation form. These guidelines and measurement tools were adapted from those used by Li, 2003. Working individually, each judge evaluated each group report.

Table 5.17 Guidelines for Expert Judges

Expert Judging Training and Grading Procedures

1. Both judges will be together for training.
2. Three groups' reports will be used for judges instruction and training. There will be one good, one average, and one poor report for reviewing.
3. The "Task Description", instructions, master requirements list, and the final report template will be distributed to the judges. The judges are given time to review the documents and ask questions.
4. The judges will read the first report and rate them. After they have finished, the responses will be written on a whiteboard. Discrepancies will be discussed until consensus is reached.
5. The same procedure will be followed for the second and third reports.
6. After each report's rating is discussed, the judging for the two reports will be compared. Judges will then have the opportunity to re-judge each group's report.
7. After the initial training session, the rest of the reports will be distributed to the judges for grading.
8.

Contents of Judges' packet:

a. Description of task, master list of requirements, and final report template
b. Evaluation Forms and instructions (one evaluation form for each report to be assessed)
c. Three example reports from the study for training
d. 30 reports from the experiment to be distributed after the training session

Table 5.18 Expert Judge Evaluation Guidelines

Expert Judging Instructions

The reports you are being asked to judge contain a list of and rationale for choosing the requirements for an emergency response information system. The rating criteria for the reports are based on the requirements the subjects have selected and the rationale behind choosing them. In the report the subjects have been asked to describe why their group chose each requirement and what benefits the stakeholders are receiving.

Judging Criteria

Part A: Evaluation of Each Requirement Chosen

For each requirement included in the final report, we are looking at the reasons why that group chose that particular requirement and rank in the list.

Criteria for inclusion:

Rationale for choice: Are the reasons this item was chosen appropriate for inclusion in the final list? Some of the considerations are: cost, benefits, and risks involved, for example, did this requirement serve a general purpose for the group as a whole, or was it critical for only one or two stakeholders?

Clarity of rationale: Is it clear why this item was chosen above others? Does the rationale explain why this particular item was more important than the others in the list?

Part B: Evaluation of Final Report

These items are for the evaluation of the final report as a whole. Use the following items to evaluate the final report.

1. Content of Report:

Rationale behind criteria chosen: This item is to determine whether or not the reasons behind each choice is clear.

Clarity of description: Is the description of each item chosen clear and understandable?

Man months: Has the group chosen a set of requirements within the required 45 man month restriction?

Clarity of choices: Has the group described in clear and understandable terms which requirements the group has chosen?

Reasons to support choices: Has the group supported the reasons for their choices of requirements?

2. Presentation format:

Clarity of Report: Is the report clear and well organized, is it complete i.e., does the report include all required sections and information?

3. Quality of Report:

Overall quality of report: As a whole, how well was the report written?

Table 5.19 Judges Instructions and Evaluation Form

Judge's Evaluation Form **Group Number:** _____

Please evaluate all sections of the final report on each of the criteria listed below. Circle the appropriate number after each question.

Section 1: In this section you are evaluating the short list of requirements chosen for implementation that add up to <= 45 man months. Evaluate the *rationale for inclusion* of each requirement in the final list.

1. **Rationale for choice of inclusion in final list:** Some of the considerations are cost, benefits, and risks involved.

Are the reasons these items were chosen appropriate for inclusion in the final list?

strongly disagree 1----2----3----4----5---6---7 strongly agree

2. **Clarity of rationale**: Is it clear why these items were chosen above others? Does the rationale explain why these particular items were more important than the others in the list? For example, do some of these requirements serve a general purpose for the group as a whole, or was it critical for only one or two stakeholders?

Is it clear why these items were chosen above others?

very unclear 1----2----3----4----5---6---7 very clear

Section 2: In this section you will be evaluating the rationale behind ranking for *all* requirements

3. **Rationale for choice in ranking all requirements:**

Is it clear why each item was given a specific ranking?

very unclear 1----2----3----4----5---6---7 very clear

Section 3: In this section you will be evaluating the content of the final report as a whole.

4. Rationale behind requirements chosen Poor 1----2----3----4----5---6---7 Superior

5. Clarity of description Poor 1----2----3----4----5---6---7 Superior

6. Clarity of choices: Poor 1----2----3----4----5---6---7 Superior

7. Reasons to support choices: Poor 1----2----3----4----5---6---7 Superior

Presentation format:

8. Clarity of report format: Poor 1----2----3----4----5---6---7 Superior

Quality of Report:

9. Overall quality of report: Poor 1----2----3----4----5---6---7 Superior

Additional comments:

CHAPTER 6

DATA ANALYSIS AND EXPERIMENTAL RESULTS

Over two semesters, Fall 2003 and Spring 2004, an experiment was conducted to measure the influence of structured task and negotiation sequence on solution and process quality, conflict, and quality of the group's solution. In the formal experiment in Spring 2004, there were 32 Groups with eight groups per condition. The Fall pilot study is described in the previous chapter. The total subject population was 192 for the Spring 2004 experiment, with drop-out the total number participating was 174. The experimental subjects were students from NJIT taking a software engineering or related course. The number of subjects and groups in each condition in the experimental study is shown in Table 6.1.

Table 6.1 Subjects and Groups by Experimental Treatment

Condition		**Task Structure**		
		With	Without	Total
Negotiation Sequence	With	8 Groups N = 43	8 Groups N = 46	16 Groups N = 89
	Without	8 Groups N = 39	8 Groups N = 46	16 Groups N = 85
Total		16 Groups N = 82	16 Groups N = 92	32 Groups N = 174

6.1 Subject Background Overview

Most subjects were graduate students. Demographics were collected with an online background questionnaire. The distribution by major was Computer Science 59%, Information Systems 21%, Ph.D. 2 %, Management 1%, Other 13 %, Undergraduate senior, 4%. The population included 51 females and 136 males. The education level of the students was 3.7 % undergraduate seniors, 39 % Information System Masters, 59% Computer Science Masters, 1% MBA, 2% PhD students, and 13% Other. Seventy three percent of subjects were male and 27% were female. The ages of the participants ranged from under 23 to over 40 with the majority in the 23-30 age range. Specifics are described in Table 6.2.

Table 6.2 Age Range of Subjects

Age Group	Frequency	Percent
<23	48	25.7
23-30	102	54.5
31-40	29	15.5
>40	8	4.3
Total	187	100.0

The majority of the subjects were experienced WebBoard users with 53% reporting that they had used WebBoard "frequently", 14% used WebBoard 3-10 times, 19% once or twice, and 14% had never used WebBoard previously. Table 6.3 details the student's WebBoard experience.

Table 6.3 WebBoard Experience

Used WebBoard	Frequency	Percent
Never	26	13.9
Once or twice	36	19.3
3-10	26	13.9
Frequently	99	52.9

Most subjects, 87%, reported that they had easy or very easy access to WebBoard from either home or work. Subjects had a range of group work experience, 71% had high to very high experience working with others in groups, while 80% like participating in group discussions. Eighty four percent indicated they were comfortable or very comfortable engaging with new people in group discussions.

From the information provided by the subjects, it is clear that most are comfortable working in groups and with new people which indicates a positive attitude towards group discussion and negotiation. Also they are experienced in using WebBoard and have easy access to it. These findings indicate the task is appropriate for the population and that the subjects have the skill to understand and undertake the task.

Subjects were randomly assigned to treatment conditions as described in Chapter 5. The Project Manager position was a volunteer position and the group voted amongst themselves to appoint that position. The groups were comprised of six participants each with a specific stakeholder role to play. The communication was totally asynchronous with no online chat, email, or face-to-face interaction. Although most groups continued with six subjects, some members were inactive or dropped out. When this occurred, the Project Manager took on that person's role and participated for them. When two were

inactive, one of the other group members was solicited to participate in two roles. The number of subjects per group in shown in Table 6.1.

6.2 Reliability and ANOVA Results

6.2.1 Scale Validation and Reliability

Most hypotheses were tested using items from the post-task questionnaire. These scale items were tested for validity in ensure the responses were reliable. The most commonly used and preferred measure of reliability is the Chronbach's Alpha calculation. This measure has a range from 0 to 1 where zero indicates complete unreliability and a one indicates perfect reliability. In order for a scale to be considered valid and reliable, a Chronbach's Alpha coefficient of 0.70 or higher is necessary (Judd, Smith, and Kidder, 1991). The reliability of each scale is reported and discussed below under the heading of each variable.

6.2.2 Inter-rater Reliability

Two expert judges, who were blind to the experimental conditions, independently evaluated the final reports. The results from both were analyzed to determine if they were trained properly and to determine the reliability and validity of the quality of solution variable. An inter-rater reliability check was performed using a bivariate Pearson's 2-tailed test. The results indicate a significant correlation of 0.997 at the 0.01 level between the two judges as shown in Table 6.4.

Table 6.4 Correlation Between Judges

Correlations

		RATER_1	RATER_2
RATER_1	Pearson Correlation	1	.997(**)
	Sig. (2-tailed)	.	.000
	N	30	29
RATER_2	Pearson Correlation	.997(**)	1
	Sig. (2-tailed)	.000	.
	N	29	29

** Correlation is significant at the 0.01 level (2-tailed).

A Paired Samples T-Test was performed to show no significant difference between the judges. The results are displayed in Table 6.5.

Table 6.5 T-Test for Judges Significant Difference

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	RATER_1 - RATER_2	-.2600575	1.05411149	.19574359	-.6610200	.1409051	-1.329	28	.195

6.2.3 Perceived Solution Quality

Perceived solution quality was measured in the post-task questionnaire by questions 1, 3, 11, and 14. The Chronbach's Alpha of the solution quality scale is 0.70 which indicates that this measure is valid as it exceeds the 0.60 value. The questions are summed and

averaged to achieve a scale measure for the variable perceived solution quality. Significance was tested using the Analysis of Variance test.

A two–way between-groups analysis of variance was conducted to explore the impact of negotiation sequence and task structure on perceived solution quality as measured by the Post-Task questionnaire. There was a statistically significant main effect for negotiation sequence ($p = .03$). There was also a statistically significant main effect for task structure ($p = .02$). The interaction effect ($p = .32$) did not reach statistical significance.

Table 6.6 Total Perceived Solution Quality Results

Tests of Between-Subjects Effects

Dependent Variable: perceived solution quality

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Corrected Model	194.412(b)	3	64.804	3.596	.015	.060	10.789	.785
Intercept	74621.560	1	74621.560	4140.974	.000	.961	4140.974	1.000
Negotiation Sequence	85.296	1	85.296	4.733	**.031**	.027	4.733	.581
TASK STRUCTURE	96.724	1	96.724	5.367	**.022**	.031	5.367	.634
NEGOTIATION SEQUENCE * TASK STRUCTURE	18.222	1	18.222	1.011	.316	.006	1.011	.170
Error	3063.450	170	18.020					
Total	78238.000	174						
Corrected Total	3257.862	173						

a Computed using alpha = .05
b R Squared = .060 (Adjusted R Squared = .043)

Table 6.7 Table of Means for Perceived Solution Quality

	Task Structure	No Task Structure	Total
Negotiation Sequence	Mean: 21.0 SD:3.76	Mean: 21.84 SD: 3.82	21.42
No Negotiation Sequence	Mean: 18.95 SD: 4.97	Mean: 21.09 SD: 4.38	20.06
Total	20.01	21.47	Grand Mean: 20.76

Task Structure: F = 5.367 p: = .022
Negotiation Sequence: F = 4.733 p: .031

Based on the results above, the mean value of groups following a negotiation sequence is significantly different that those that did not follow a negotiation sequence (p = .031) and those groups perceived they negotiated higher quality solutions. There was also a significant difference between those groups that did not follow a structured task than those that did. Those groups that did not follow a task structure had significantly higher perceptions of their quality of solution than those that did. Those groups that followed a negotiation sequence and did not follow a task structure perceived their group had higher quality solutions as measured by the post task questionnaire.

Therefore, Hypotheses H1a was supported. Hypotheses H1c was unsupported.

H1.a. Groups following a negotiation sequence will perceive their group produced higher quality solutions as compared to groups with no specified negotiation sequence.

H1.c. Groups following a structured task will perceive their group produced higher quality solutions as compared to groups with an unstructured task.

6.2.4 Conflict

Conflict was measured in the post-task questionnaire by questions 2, 10, 13, and 15. The Chronbach's Alpha of the solution quality scale is below 0.6 and therefore the scale is not

valid. Therefore, two separate questions will be used for this measure, questions 2 and 15. Significance was tested using the Analysis of Variance test.

A one–way between-groups analysis of variance was conducted to explore the impact of negotiation sequence and task structure on conflict question 2, - *To what extent did the group experience conflict?,* as measured by the Post-Task questionnaire. There was no statistical significant effect, p = .292.

Table 6.8 Conflict Measure 1 Statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.342	3	3.447	1.253	.292
Within Groups	467.566	170	2.750		
Total	477.908	173			

A one–way between-groups analysis of variance was conducted to explore the impact of negotiation sequence and task structure on conflict question 15 - *Did the group handle conflict effectively?,* as measured by the Post-Task questionnaire. There was a significant statistical effect, p = .05 for no negotiation sequence and no task structure, meaning the groups in those conditions experienced the least conflict. The effect size, calculated using eta squared, was .04, therefore the actual difference in means scores between the groups is quite small.

Table 6.9 Conflict Measure 2 Statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14.335	3	4.778	2.656	.050
Within Groups	305.854	170	1.799		
Total	320.190	173			

Therefore, Hypotheses H2a and Hypotheses H2b were unsupported.

H2.a. Groups following a negotiation sequence will exhibit less conflict in their negotiations compared to groups with no specified negotiation sequence.

H2.b. Groups following a structured task will exhibit less conflict in their negotiations compared to groups with an unstructured task.

6.2.5 Process Satisfaction

Process satisfaction was measured in the post-task questionnaire by questions 5, 6, 7, 8, and 9. The Chronbach's Alpha of the process satisfaction scale is 0.89 which indicates that this measure is valid as it exceeds the 0.60 value. The questions are summed and averaged to achieve a scale measure for this variable. Significance was tested using the Analysis of Variance test.

A two–way between-groups analysis of variance was conducted to explore the impact of negotiation sequence and task structure on process satisfaction as measured by the Post-Task questionnaire. There was no main effect for negotiation sequence ($p = .46$). There was a statistically significant main effect for task structure ($p = .00$). The interaction effect ($p = .13$) did not reach statistical significance.

Table 6.10 Results for Process Satisfaction

Dependent Variable: Total Process Satisfaction

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Corrected Model	972.486(b)	3	324.162	6.886	.000	.108	20.657	.976
Intercept	126365.555	1	126365.555	2684.158	.000	.940	2684.158	1.000
NEGOTIATION SEQUENCE	26.355	1	26.355	.560	.455	.003	.560	.115
TASK STRUCTURE	855.697	1	855.697	18.176	**.000**	.097	18.176	.989
NEGOTIATION SEQUENCE * TASK STRUCTURE	110.112	1	110.112	2.339	.128	.014	2.339	.330
Error	8003.307	170	47.078					
Total	136146.000	174						
Corrected Total	8975.793	173						

a Computed using alpha = .05
b R Squared = .108 (Adjusted R Squared = .093)

Table 6.11 Process Satisfaction Results

	Task Structure	No Task Structure	Total
Negotiation Sequence	Mean: 25.9 SD:7.20	Mean: 28.77 SD: 5.89	27.37
No Negotiation Sequence	Mean: 23.56 SD: 8.39	Mean: 29.59 SD: 5.76	26.68
Total	24.79	29.18	Grand Mean: 27.03

Task Structure: F = 18.176 p: = .000
Negotiation Sequence: F = .560 p: .455

Based on the results above, the mean value of groups following a negotiation sequence is not significantly different that those that did not follow a negotiation sequence (p = .455). There was a significant difference between those groups that did not follow a structured task than those that did. Those groups that did not follow a task

structure had significantly higher process satisfaction than those that did (p = .000), with or without the negotiation sequence. Groups that did not follow a negotiation sequence or a structured task achieved a higher process satisfaction than those that did.

Therefore, Hypotheses H3a was unsupported and Hypotheses H3b was unsupported.

> H3a. Groups following a negotiation sequence will show more satisfaction with their negotiation process compared to groups with no specified negotiation sequence.
>
> H3b. Groups following a structured task will show more satisfaction with their negotiation process compared to groups with an unstructured task.

6.2.6 Solution Satisfaction

Solution satisfaction was measured in the post-task questionnaire by questions 4, 12, and 16. The Chronbach's Alpha of the solution satisfaction scale is 0.695 which indicates that this measure is valid. The questions are summed and averaged to achieve a scale measure for this variable. Significance was tested using the Analysis of Variance test.

A two–way between-groups analysis of variance was conducted to explore the impact of negotiation sequence and task structure on solution satisfaction as measured by the Post-Task questionnaire. There was no main effect for negotiation sequence (p = .07). The main effect for task structure (p = .53) did not reach statistical significance. There was a statistically significant interaction effect (p = .02).

Table 6.12 Solution Satisfaction Results

Dependent Variable: total solution satisfaction

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Corrected Model	92.525(b)	3	30.842	3.076	.029	.051	9.227	.712
Intercept	46117.162	1	46117.162	4598.957	.000	.964	4598.957	1.000
NEGOTIATION SEQUENCE	34.417	1	34.417	3.432	.066	.020	3.432	.453
TASK STRUCTURE	3.887	1	3.887	.388	.534	.002	.388	.095
NEGOTIATION SEQUENCE * TASK STRUCTURE	57.169	1	57.169	5.701	**.018**	.032	5.701	.661
Error	1704.717	170	10.028					
Total	48086.000	174						
Corrected Total	1797.241	173						

a Computed using alpha = .05
b R Squared = .051 (Adjusted R Squared = .035)

Table 6.13 Solution Satisfaction Descriptive Statistics

	Task Structure	No Task Structure	Total
Negotiation Sequence	Mean: 25.9 SD: 7.20	Mean: 28.77 SD: 5.89	27.37
No Negotiation Sequence	Mean: 23.56 SD: 8.39	Mean: 29.59 SD: 5.76	26.68
Total	24.79	29.18	Grand Mean: 27.03

Task Structure: F = .388 p: = ..534
Negotiation Sequence: F = 3.432 p: .066

Exploring the Interaction Effect

Negotiation Sequence ANOVA

A one-way between-groups analysis of variance was conducted to explore the impact of negotiation sequence on levels of solution satisfaction as measured by the Post-Task questionnaire. Subjects were divided into two groups, those that followed a negotiation sequence and those that did not. There was a statistically significant difference at the $p<.05$ level in solution satisfaction for those groups that did NOT follow a negotiation sequence ($p = .05$). There was no significant effect for those subjects following a negotiation sequence ($p = .18$). Table 6.14 shows the results of this test. Those groups without negotiation sequence specified were statistically significantly different from those that did follow a sequence.

Table 6.14 One-way ANOVA for Negotiation Sequence

total solution satisfaction / No Negotiation Sequence

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	44.391	1	44.391	3.906	.051
Within Groups	943.186	83	11.364		
Total	987.576	84			

A one-way between-groups analysis of variance was conducted to explore the impact of task structure on solution satisfaction as measured by the Post-Task questionnaire. Subjects were divided into two groups, those that followed a structured

task and those that did not. Table 6.15 shows that those groups that followed a task structure had significantly higher solution satisfaction (p = .003) than those that did not.

Table 6.15 One-way ANOVA for Task Structure

total solution satisfaction / Task Structure

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	88.076	1	88.076	9.297	.003
Within Groups	786.277	83	9.473		
Total	874.353	84			

Based on the results above, the mean value of groups not following a negotiation sequence and with task structure is significantly different (p = .018) that those that did follow a negotiation sequence but not a task structure. Those groups that followed a task structure and no negotiation sequence had significantly higher solution satisfaction than those that didn't. Therefore, Hypotheses H4a is unsupported and H4b is supported.

H4a. Groups that follow a negotiation sequence will be at least as likely to be satisfied with the group's solution as those groups not following a negotiation sequence.

H4.b. Groups following a structured task will be at least as likely to be satisfied with the group's solution as those groups with an unstructured task.

6.2.7 Quality of Solution

Quality of Solution was measured by expert judges who reviewed the final reports created by each group of subjects. The Chronbach's Alpha of the quality of solution scale is 0.9507 which indicates that this measure is very strong as it far exceeds the 0.60 value of minimal reliability. The questions are summed and averaged to achieve a scale measure for this variable. Significance was tested using the Analysis of Variance test.

A two–way between-groups analysis of variance was conducted to explore the impact of negotiation sequence and task structure on quality of solution as measured by the final reports. There was no main effect for negotiation sequence ($p = .45$). The main effect for task structure ($p = .13$) did not reach statistical significance. There was no statistically significant interaction effect ($p = .25$).

Table 6.16 Total Quality of Solution

Dependent Variable: Total quality of solution

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Corrected Model	282.269(b)	3	94.090	1.492	.227	.077	4.476	.372
Intercept	93653.770	1	93653.770	1485.120	.000	.965	1485.120	1.000
Task Structure	152.156	1	152.156	2.413	.126	.043	2.413	.332
Negotiation Sequence	36.176	1	36.176	.574	.452	.011	.574	.115
Task Structure * Negotiation Sequence	85.910	1	85.910	1.362	.248	.025	1.362	.209
Error	3405.317	54	63.061					
Total	97772.000	58						
Corrected Total	3687.586	57						

a Computed using alpha = .05
b R Squared = .077 (Adjusted R Squared = .025)

Based on the results above, the mean value of groups following a negotiation sequence and a task structure is not significantly different from those that did not follow a negotiation sequence or a task structure. Therefore, Hypotheses H1b and H1d are not supported.

> H1.b. Groups following a negotiation sequence will produce higher quality group reports as compared to groups with no specified negotiation sequence.
>
> H1.d. Groups following a structured task will achieve higher quality group reports as compared to groups with an unstructured task.

6.2.8 Negotiation Convergence

Negotiation convergence was measured by analyzing the WebBoard conferences in which the group conducted their discussions. The time it took to reach consensus and group agreement were analyzed. Group agreement was measured by the amount of activity within the group, as measured by messages posted, and the ability of the group to come to a final consensus on the list of requirements.

Of the 32 groups that participated in the experiment, 29 came to final agreement on the list of requirements to be implemented. The negotiations took place over five days after a three day training task.

Table 6.17 shows the time that each group reached consensus on the final list of requirements. Most groups, 21, reached consensus within 6 days. Eleven groups took six days, five groups took seven days, and one group each took eight and nine days respectively. Four groups that did not have a negotiation sequence nor task structure reached agreement within five days, with the most groups reporting consensus within that time. Three groups using a negotiation sequence and no task structure also completed the task within five days.

Table 6.17 Time to Reach Consensus

	None	5 Days	6 Days	7 Days	8 Days	9 Days	Total
Negotiation Sequence & Structured Task	1	2	2	2	0	1	8
No Negotiation Sequence & Structured Task	2	1	3	2	0	0	8
Negotiation Sequence & No Structured Task	1	3	3	0	1	0	8
No Negotiation Sequence & No Structured Task	0	4	3	1	0	0	8
Totals	4	10	11	5	1	1	32

Table 6.18 shows the number and average number of messages posted by each group in WebBoard. It shows that the most messages were posted by the groups that had a negotiation sequence and structured task to follow. The second largest number of messages were posted by the group that followed a structured task for their work, while not having a negotiation sequence to follow.

Table 6.18 Number of Messages Posted per Group

Group (Condition 1)	No. of Messages	Group (Condition 2)	No. of Messages	Group (Condition 3)	No. of Messages	Group (Condition 4)	No. of Messages
101	100	201	83	301	33	401	90
102	50	202	36	302	41	402	43
103	78	203	114	303	41	403	63
104	88	204	86	304	65	404	60
105	51	205	125	305	49	405	36
106	73	206	42	306	105	406	64
107	117	207	30	307	34	407	54
108	119	208	26	308	32	408	45
Average	85		64		50		57

A two–way between-groups analysis of variance was conducted to explore the impact of negotiation sequence and task structure on negotiation convergence as measured by the number of messages generated by each group. There was a statistically significant effect for task structure ($p = .030$). The main effect for negotiation sequence ($p = .623$) did not reach statistical significance. There was no significant interaction effect ($p = .244$). Table 6.19 shows the results.

Table 6.19 Messages Posted Results

Dependent Variable: MESSAGES

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Corrected Model	5429.094(b)	3	1809.698	2.297	.099	.197	6.890	.518
Intercept	134291.531	1	134291.531	170.433	.000	.859	170.433	1.000
Negotiation Sequence	195.031	1	195.031	.248	.623	.009	.248	.077
Task Structure	4117.781	1	4117.781	5.226	**.030**	.157	5.226	.598
Negotiation Sequence* Task Structure	1116.281	1	1116.281	1.417	.244	.048	1.417	.210
Error	22062.375	28	787.942					
Total	161783.000	32						
Corrected Total	27491.469	31						

a Computed using alpha = .05
b R Squared = .197 (Adjusted R Squared = .111)

Table 6.20 Messages Posted Descriptive Statistics

Table of Means: Messages Posted to WebBoard

	Task Structure	No Task Structure	Total
Negotiation Sequence	Mean: 84.50 SD: 26.689	Mean: 50.00 SD: 24.733	67.25
No Negotiation Sequence	Mean: 67.75 SD: 39.318	Mean: 56.88 SD: 16.788	62.31
Total	76.13	53.44	Grand Mean: 64.78

Task Structure: F = 5.226 p: = .030
Negotiation Sequence: F = .248 p: .623

These results showed that the condition that followed a negotiation sequence did not converge faster to agreement in their webboard conferences (p=.623). Therefore Hypotheses H5b is not supported. There was no interaction effect. Those groups that followed a task structure and also used a negotiation sequence converged faster to

agreement based on the measure above. As a result of the statistically significant result of task structure ($p = .030$), H5a is supported.

> H5a. Groups in structured conditions will converge faster to a consensus and show less disagreements in this convergence process than those in unstructured conditions.
>
> H5b. Groups that follow a negotiation sequence will converge faster to a consensus and show less disagreements in this convergence process than those in non-sequential conditions.

6.3 Task Survey Results

In the post-task questionnaire four questions surveyed the subjects about the experimental task. The items about the task survey were measured using a seven point Lickert-type scale. The questions inquired about the difficulty of the task and other pertinent data. There were four semantic differential questions (See Appendix D)

1. How much effort was required to complete the task?
2. How easy or difficult did you find this task as an individual?
3. Did the task description provide you with enough information to easily carry out the task?
4. Did the task description make it clear what was to be accomplished?

The first question asked how much effort was needed to complete the task. Most of the subjects, 60.2%, indicated that they needed an average amount of effort with the responses ranging in the middle of the item range. Twenty one percent thought the task needed extra effort to complete. Therefore, most students found the task required effort but not anything that was very difficult. As the vast majority of students were graduate students, this was expected.

Two way ANOVA shows that those groups that did not have a task structure to guide them needed more effort to complete the task. Therefore it appears that having a structure to frame the task helped the students complete the study with less effort.

Table 6.21 Effort Required to Complete the Task
Task Survey Response: Effort Required

		Percent
little effort	1	1.4
	2	7.0
	3	10.5
	4	31.5
	5	28.7
	6	18.9
extra effort	7	2.1
	Total	100.0

Table 6.22 Effort Required ANOVA
Tests of Between-Subjects Effects
Dependent Variable: Effort Required

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Corrected Model	14.153(b)	3	4.718	3.166	.026	.064	9.499	.724
Intercept	2815.924	1	2815.924	1890.048	.000	.931	1890.048	1.000
NEGOTIATION SEQUENCE	4.270	1	4.270	2.866	.093	.020	2.866	.390
TASK STRUCTURE	9.461	1	9.461	6.350	**.013**	.044	6.350	.706
NEGOTIATION SEQUENCE * TASK STRUCTURE	.262	1	.262	.176	.675	.001	.176	.070
Error	207.092	139	1.490					
Total	3041.000	143						
Corrected Total	221.245	142						

a Computed using alpha = .05
b R Squared = .064 (Adjusted R Squared = .044)

Table 6.23 Effort Required Descriptive Statistics

Dependent Variable: Effort Required

NEGOTIATION SEQUENCE	Task Structure	Mean	Std. Deviation	N
NegotiationSequence	Task Structure	4.92	1.052	36
	No Task Structure	4.32	1.276	38
	Total	4.61	1.203	74
NoNegotiationSequence	Task Structure	4.48	1.326	33
	No Task Structure	4.06	1.218	36
	Total	4.26	1.279	69
Total	Task Structure	4.71	1.202	69
	No Task Structure	4.19	1.246	74
	Total	4.44	1.248	143

The task structure helped the subjects complete the task with less effort, but their individual assessment indicates that they found no difference in either having a negotiation sequence or task structure provided. The results of a two-way ANOVA show that there is no significance in the easiness or difficulty in the task as perceived by each individual subject.

Table 6.24 Individual Assessment Responses
Individual Assessment

		Valid Percent
Valid	1	2.1
	2	20.3
	3	23.1
	4	23.1
	5	16.1
	6	11.9
	7	3.5
	Total	100.0

Table 6.25 Individual Assessment Descriptive Statistics

Dependent Variable: Individual Assessment

NEGOTIATION SEQUENCE	task structure	Mean	Std. Deviation	N
Negotiation Sequence	Task Structure	3.89	1.450	36
	No Task Structure	3.84	1.603	38
	Total	3.86	1.520	74
No Negotiation Sequence	Task Structure	3.82	1.467	33
	No Task Structure	3.67	1.394	36
	Total	3.74	1.421	69
Total	Task Structure	3.86	1.448	69
	No Task Structure	3.76	1.497	74
	Total	3.80	1.469	143

Table 6.26 Individual Assessment ANOVA

Dependent Variable: Individual Assessment

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power(a)
Corrected Model	1.000(b)	3	.333	.152	.928	.003	.455	.077
Intercept	2063.946	1	2063.946	939.025	.000	.871	939.025	1.000
NEGOTIATION SEQUENCE	.540	1	.540	.246	.621	.002	.246	.078
TASK STRUCTURE	.351	1	.351	.159	.690	.001	.159	.068
NEGOTIATION SEQUENCE * TASK STRUCTURE	.098	1	.098	.044	.833	.000	.044	.055
Error	305.517	139	2.198					
Total	2376.000	143						
Corrected Total	306.517	142						

a Computed using alpha = .05
b R Squared = .003 (Adjusted R Squared = -.018)

Although the subjects felt they were not provided enough information to carry out the task, (60.9%, vs. 29.4% who felt they definitely had enough information), 66.5% felt that the description of the task made it clear to very clear what was to be accomplished with only 4.9% finding this unclear. These two results can be viewed as mildly contradictory but it appears that the subjects were able to complete the task with the information provided to them.

Table 6.27 Enough Information for Task Responses

		Valid Percent
Valid	1	30.1
	2	30.8
	3	9.8
	4	8.4
	5	7.7
	6	9.1
	7	4.2
	Total	100.0
Missing	System	
Total		

Table 6.28 Task Clarity Responses

		Valid Percent
Valid	1	2.1
	2	2.8
	3	5.6
	4	7.7
	5	15.4
	6	28.0
	7	38.5
	Total	100.0

Table 6.29 Summary of Hypotheses Analysis

Hypotheses	Result
H1.a. Groups following a negotiation sequence will perceive higher quality solutions as compared to groups with no specified negotiation sequence.	*Supported* $p = .031$
H1.b. Groups following a negotiation sequence will produce a higher quality group reports as compared to groups with no specified negotiation sequence.	Unsupported
H1.c. Groups following a structured task will perceive higher quality solutions as compared to groups with an unstructured task.	Unsupported
H1.d. Groups following a structured task will achieve higher quality group reports as compared to groups with an unstructured task.	Unsupported
H2.a. Groups following a negotiation sequence will exhibit less conflict in their negotiations compared to groups with no specified negotiation sequence.	Unsupported
H2.b. Groups following a structured task will exhibit less conflict in their negotiations compared to groups with an unstructured task	Unsupported
H3a. Groups following a negotiation sequence will show more satisfaction with their negotiation process compared to groups with no specified negotiation sequence.	Unsupported
H3b. Groups following a structured task will show more satisfaction with their negotiation process compared to groups with an unstructured task.	Unsupported
H4a. Groups that follow a negotiation sequence will be at least as likely to be satisfied with the group's solution as those groups not following a negotiation sequence.	Unsupported
H4.b. Groups following a structured task will be at least as likely to be satisfied with the group's solution as those groups with an unstructured task.	*Supported* $p = .003$
H5a. Groups in structured conditions will converge faster to a consensus and show less disagreements in this convergence process than those in unstructured conditions.	*Supported* $p = .030$
H5b. Groups that follow a negotiation sequence will converge faster to a consensus and show less disagreements in this convergence process than those in non-sequential conditions.	Unsupported

Summary

Of the twelve hypotheses, nine are unsupported and three are supported, two for structured task and one for negotiation sequence. Two were supported for the interaction. The results show that a structured task provides the subjects with more satisfaction with the group solution than those that did not follow such a structure. Groups perceived higher solution quality when they followed a structured task and had no negotiation sequence specified. Hypotheses H3b was reversed indicating that groups that did not follow a negotiation sequence nor structured task achieved a higher satisfaction with the process than those that did. Those groups that followed a task structure and no negotiation sequence had significantly higher solution satisfaction than those that didn't. Finally, conditions that followed a task structure converged faster to agreement in their webboard conferences.

CHAPTER 7

DISCUSSION

This chapter presents the results of the experimental hypotheses, discussion, and future work. The first section will discuss the hypotheses. The second section will investigate some of the issues encountered during experimentation. This is illustrated with content from the webboard conferences, the input of the subjects, and how they participated in the group discussions. The third section will discuss future work.

7.1 Experimental Hypotheses

7.1.1 Perceived Solution Quality

Subjects used this measure to assess their perceived overall quality of their joint solution. It also measured whether the group members felt that the work was carefully developed, whether the discussion issues were examined in a constructive way, and whether the issues explored and discussed by the group were trivial or substantial. The data analysis of the post task questionnaire shows that those subjects that followed a negotiation sequence perceived their groups had higher quality solutions than those that did not follow a negotiation sequence. As shown in the previous chapter, results of the hypotheses testing show that if subjects were provided with a guided sequence of steps to follow during their negotiation sessions they regarded their solution as better than if they did not have this guide. The negotiation sequence provided in webboard helped the groups identify and define the problem, understand the problem, generate possible alternatives and solutions, and evaluate these alternatives to come up with an agreed list of requirements for implementation. This is consistent with the contention found in

Fisher and Ury, 1983, who say that using this negotiation sequence would help the subjects organize their negotiation efforts which indeed resulted in the experimental groups having a better perception of their quality of solution.

By contrast, the groups that followed a structured task did not find it as beneficial. Since task structure can theoretically improve group processes and performance (Nunamaker, et al., 1991, Dufner, 1995), it was hypothesized that a structured task would facilitate coordination for the groups and provide a series of steps they could follow to promote a decision of higher quality. Similarly, Deek and McHugh (2003) suggest that the use of a structured process can improve the results of negotiations for both win-win and win-lose situations. The results did not support these findings. Actually, some of the students ignored the structure and made their own by creating new topics within their private conferences. The failure of a structured task to improve solution quality may have been due to the fact that the task structure was perceived as too complex by the groups, or possibly because they may not have been used to WebBoard interactions with tight structure. In the experiment, many group facilitators created their own conference topics in the WebBoard conferences, rather than using the one provided for them. It may be that the groups felt more comfortable with creating their own structures as they felt necessary as they went through their discussions. The resulting multiple self-created topic conferences may have deprived the groups of a clear path for their task, with the result that they lost some of the process knowledge and group flow.

7.1.2 Conflict

"To what extent did the group experience conflict?" and "Did the group handle conflict effectively?" were the questions asked to measure the conflict experienced within the group. The results of these questions show that the least conflict during negotiations was in the groups that used no task structure and no negotiation sequence; this was a statistically significant finding. Therefore neither conflict hypothesis was supported and it actually indicates the reverse of the experimental hypotheses for this variable. This could be explained by the fact that the lack of negotiation or task structure allowed the group members to communicate wherever and whenever they pleased. The absence of structure rules may have lessened the pressure those groups felt when participating in the negotiation. Asynchronous postings could be written at the subjects' preference rather than conforming to a predefined structure within the WebBoard conferences. The structure and negotiation sequence descriptions may have too much information and more group interaction was needed to have successful negotiations with those restricted communication structures.

7.1.3 Process Satisfaction

The process satisfaction variable measured the negotiation and problem solving process as efficient, coordinated, fair, understandable, or satisfying. Satisfaction with the negotiation and problem solving process of choosing a set of optimal requirements was found to be best when the groups did not follow either a negotiation sequence or structured task. Groups *not* following a structured task showed a significant result and felt the most satisfaction with their process, regardless of their method of negotiation mode. The absence of structure allowed the students to post freely, creating their own

process and group communication methods in the WebBoard negotiation space. Subjects may prefer this type of communication mode and therefore may have felt less restricted in their group interactions. The lack of formalized structure may have encouraged the students to be more satisfied with the process of negotiation perhaps because most of them are familiar with the WebBoard software and have used it for other purposes without such a structure in place.

7.1.4 Solution Satisfaction

The solution satisfaction variable measured an individual's satisfaction with the group's solution, their commitment to the result, and if they felt their input was reflected in the solution. There was no main effect for the solution satisfaction variable. Lack of support for this variable can be explained by the fact that some of the team members did not participate in the training exercise or were not active in the negotiations. The training task was a three day activity which provided the group a simple negotiation task with a small amount of negotiation necessary. The purpose of this short training task was to help the subjects become familiar with each other and the asynchronous negotiation process. In addition, the experimental materials were provided to the students to read over the training period. If the subjects did not familiarize themselves with the task to be negotiated, the communication rules, and the role they were to play, the subsequent negotiations would have been less satisfactory for all group members as they tried to catch up with the other group members who were more prepared. This may have frustrated all group members perhaps leading to a more disjointed discussion effort.

Although there was no main effect for either hypothesis, there was a significant interaction effect for this variable. After further analysis, there was a statistically

significant result for those groups not following a negotiation sequence and a significant effect for those that followed a task structure. Therefore, the groups that followed a task structure felt a higher level of satisfaction with their group's solutions.

7.1.5 Quality of Solution

The variable was measured using expert judging of the group final reports. This variable was unsupported with no main or interaction effects measured for negotiation sequence or task structure. It appears that using neither structure actually improved the solution quality. Some of the issues which may have led to this result were that the final report was to be coordinated by the group project manager/facilitator with input from the rest of the group members. Since some facilitators wrote the group reports with little or no group input, it is clear that some group members did not contribute. This would have led to a lower quality of report and solution as perceived by the program manager. Also, some groups had less than the optimal number of members, putting more pressure on the other group members to take on multiple roles, thus diluting the diversity of opinions about the requirements under negotiation. This may have occurred even though each subject was provided with a clear definition of each role they played and their specific requirement preferences.

7.1.6 Negotiation Convergence

The negotiation convergence variable produced a significant effect for task structure. The groups using a task structure converged faster to a solution than those that didn't follow this structure. The negotiation sequence hypothesis is unsupported. There was no interaction effect for groups following a structured task and negotiation sequence. Four

groups did not come to consensus on the final list of requirements. Also, one group had a tie for two of the requirements, and members could not decide which to choose to include in the final ranking. Of the three undecided groups, one group stated

> "As *of now, we don't have any requirements on which everyone has agreed on. We just have 2 requirements with 4 stakeholders agreeing on it and several requirements with 3 people agreeing on it."*

This group's Project Manager surveyed the conference discussions and ranked the requirements based on the negotiations. He also used his own discretion to differentiate between requirements with the same amount of votes. Although this group did not come to agreement, they had very good negotiations. The members were active and vocal in what they wanted to see in the final list. This group posted 120 messages in the board with most members participating. The Project Manager had a strong presence in this conference, with 27 postings. So even though good facilitation and discussions ensued, the group was not able to agree on a final list. This may have been caused by the restricted time allowance for negotiation. Perhaps if this group had two weeks instead of one week to negotiate they may have been more successful. By contrast, another group did not reach consensus because of lack of participation of the group members with a total of 26 messages posted for the entire discussion time frame. The group that did not reach consensus wrote:

> *"We really did very little negotiation. It took us long enough to determine the group rankings of the requirements that we did not*

discuss the importance of them or try to convince any other members to change the rankings".

This group's Project Manager posted a final ranking from the individual rankings of the members in their group using discretion to resolve any ambiguity. Using the structure provided in the webboard conferences may have helped the subjects focus on the task at hand and help provide a method for the groups to look at all the requirements available.

As the majority of the groups completed their negotiations after the date required, it appears that giving the subjects more training sessions time and/or more time to complete the negotiations would be beneficial. Ensuring the task structure and negotiation framework is clear and understandable may help improve results. For future studies, this activity could be completed with a two week time span for the stakeholders to work their way through negotiations, become more familiar with the role they played, and allow them more processing time to discuss the options thoroughly

7.2 Evaluation of Issues in the Experiment

Although there was an extensive pilot study prior to the formal experiment, several issues surfaced during the experiment. In the following section, some areas of concern and interest are discussed.

Training, Implementation and Data Collection Issues

Although extensive training materials were made available to the subjects, it was not apparent that the students read and understood it. The preliminary training was conducted face-to-face with detailed sheets handed out with the information covered and

links to further information that would only be available when the experiment commenced. Each training session was conducted with the same agenda and training materials and was consistent throughout groups. The training entailed a face-to-face session that lasted approximately one hour, handouts about the roles and requirements for the system, and included a general requirements engineering discussion. A discussion on the emergency response domain and pertinent stakeholders was also provided to familiarize the subjects with the type of information system for which they were negotiating requirements. Some comments in the WebBoard conferences made it apparent that there were some subjects that did not understand the roles they were responsible for nor the task in general. It appears that some could not understand the task they were asked to perform. For example, although all materials were explained and a detailed "to do" list was handed out in the training sessions, detailing each days tasks and all pertinent links to all the experimental information, the following comment was received from a student.

> *"Could someone guide me, step by step, and tell me what is*
>
> *required.*
>
> *I'm seeing stuff now about "private groups" and a "training task".*
>
> *I'm not sure what comes first."*

Late participation

Each group had a private conference where they were to interact with their group members. The subjects must first log into the WebBoard conference in order to be put into their private groups. Some members did not log on until the day or after the experimental study started, or later. Therefore these students did not participate in the

training task nor did they familiarize themselves with their group members and conference structures.

> *None of my team members have either introduced themselves or have done training task....I have created 2 new topics under our private discussion area. But I can't see any of my team members replying there."*
>
> And
>
> *"I am PM of Group CXXX. So far only two members from my group are participating in the process. We are missing*
>
> - *Law Enforcement*
> - *Fire Expert*
> - *Public Health*
>
> *I think they have forgotten about this. I don't have their contact information. Can you please contact them and remind about this? Thank you."*

When these group members joined the group late, they were behind and the other members had already started their interactions. This disrupted the group negotiation process and may have contributed to negative solution process and satisfaction results.

Stakeholder Investment in and Understanding of Task

One of the premises of the exercise is that local government officials work together to achieve their goals of a collaborative emergency response information system. As government representatives, the subjects were asked to negotiate conflicting

requirements. Due to the nature of the emergency response domain and its inherent complexity, achieving stakeholder buy-in by the subjects was difficult. In order to fully develop a rich negotiation environment, stakeholder investment and full understanding of the task and corresponding requirements is essential.

Complexity of Task

The experimental task may have been too complex. The subject groups were culturally diverse and the task instructions were perhaps too lengthy. In the groups where task structure was specified there were 15 topics for the requirements (one for each requirement) and this may have been too much to assimilate in the time given, even with clear instructions available to the subjects. For example, a subject made this comment in their WebBoard conference.

> *I did read those instructions, but I am still not understanding fully the purpose of the fifteen requirement discussion threads under CXXX? Do we use those threads to post the daily ranking of those specific requirements or to post any discussion about those requirements. I may be making this question more complex than it needs to be. However, I don't know how else to ask it.*

Providing a longer training period of perhaps one week and using a related emergency response type of training task may allow the subjects more time to become familiar with the domain and the task.

Lack of Active Participation

Group interaction and activity was an issue that may have affected the final solution quality and solution satisfaction variables. Some students were totally inactive or

partially active which affected the group's dynamics and morale. When producing the final report it was clear that some groups left it totally up to the project manager. This resulted in some frustration as shown in the quote below.

> *This is the project manager for group XXX. I am waiting for feedback from my group in order to complete the final report. I have posted a few messages requesting input for the final report from every stakeholder, but no one has responded so far.*
> *I will be at work until 8:00 pm this evening and hope to find some feedback when I check the webboard tonight. If by then I have not received any responses, what do you suggest I do for the final report ??*

When this lack of feedback occurred, it influenced the quality of the final report. The absence of feedback from the group members explaining their reasons for preferring some and not other requirements left the program manager guessing why the ones chosen were optimal or even if they were valid choices. Although the group facilitator was proactive in helping the group activity and the researcher took steps to encourage participation, some groups had dropouts or marginally active members. There was a wide disparity of WebBoard activity between groups. The minimum number of postings per group was 26 (and this group did not come to agreement nor submit a final report) and the maximum was 125. The groups with more postings had more active members and a proactive facilitator. These groups completed their negotiations and final report fully. Of the 32 groups, two did not come up with a final solution although one did

submit a report fully authored by the program manager compiled from the WebBoard postings.

Adherence to Experimental Conditions

One of the unknowns in the experimental study is whether the group members adhered to the asynchronous mode of communication. It was made very clear in the training and online materials that there was to be no outside communication either face-to-face, email, or phone. If the subjects did have outside contact then it would surely have impacted the results of the study. They did have opportunity to do so as they met once per week with their class. In future studies, this could be investigated by asking a few questions in the post-task questionnaire.

7.3 Future Work

7.3.1 General Discussion

The results of the experiment do not support the use of asynchronous negotiation as strongly beneficial. However, due to the nature of the subjects, time constraints, and lack of investment of the subjects, this is can be understood. One of the premises of the exercise is that there is federal or state funding for local government officials to work together to achieve their goals of a collaborative emergency response system. This external funding is a powerful motivator. The subjects in this study did not have nor understand this important feature. The next iteration of this research is planned to involve active emergency responders. Understanding the task and the role of the stakeholders will be inherent with this group. By their nature, this group of stakeholders will understand the task and the purpose of the exercise. Therefore the learning curve in

those areas will be greatly reduced, allowing the focus on the actual negotiation to take precedence and increasing the quality of both the process and result of the collaborative exercise. Using the current configuration without changes to the requirements lists will provide more insight into the intricacies of asynchronous negotiation. Along with this goal, a new questionnaire can be designed to elicit opinions from the emergency response personnel about their experiences with current systems and ask them to suggest other requirements they see valuable and may have been missed, and if the current requirements lists needs modification.

Further iterations of this research may modify the structure of the experiment to include an initial group meeting to establish trust and to initiate discussions of the experimental task. Adding other complementary modes of communication will also be considered. A face-to-face group may be added to explore how their negotiations progress as compared directly to the asynchronous groups. At this stage, there will be some modifications to focus more closely on the work of creating requirements that reflect the actual experience of the emergency response stakeholders. This extremely valuable information will be captured due to the asynchronous mode of the experiment and the reasoning behind the choices will provide valuable data for researchers and responders alike.

Looking to the future, this research provides a rich environment for exploration of emergency response software requirements. Providing guidance for enhancement of such systems and contributing to improved distributed requirements negotiation are goals in future research. Several areas for further investigation are discussed in the following sections.

7.3.2 Plans for Future Evaluation

1. Field study with Emergency Response Personnel

Conducting this experiment with active or experienced emergency responders will provide another facet to this research. These subjects can comment on the feasibility and quality of the software requirements whereas the subjects used in this first-round experiment could not and therefore the research was closely focused on asynchronous negotiation variables. Expanding the study to include analysis of the quality of the actual requirements suggest the following research directions.

During the field study, the emergency response personnel can evaluate the quality of the individual and recommended final list of requirements selected by the groups. In order to achieve this goal, the researcher will elicit opinions from the emergency response personnel about their experiences with current systems and ask them to suggest other requirements they see valuable and may have been missed. With this information, the researcher can recommend requirements that reflect the actual experience of the emergency response stakeholders. Therefore, a generic set of emergency response information system requirements can be investigated, with input from the people who actually see what works and what doesn't. This extremely valuable information and the corresponding cognitive processes will be captured due to the asynchronous mode of the experiment and the reasoning behind the choices will provide valuable data for researchers and responders alike.

2. Explore more closely the process of negotiation convergence

Negotiation convergence can be explored more deeply by analyzing the opinion of each subject by recording their individual ranked preferences each day. This data can then be analyzed to look at how the individual subjects progressed through their decision process, and how these opinions changed or did not change for the final group list of the requirements. With this analysis, we can look at what is really happening within the individual and group decision processes as they follow a negotiation sequence and a structured task.

3. Explore the relationship between the use of a facilitator and group process variables

Facilitation in meetings has been proven to be beneficial to meeting outcomes and improve group decision quality (Maier and Maier, 1957, Maier and Hoffman 1960). In the current configuration of the experimental design, the Project Manager played the role of the facilitator. This facilitator role was untrained and was an active participant in the negotiations. Providing the groups with a trained facilitator whose role is exclusively to manage relationships between the subjects, task and technology, can improve the quality of the distributed negotiation process. Having a dedicated facilitator for each group can improve the chances of integrative decision making by ensuring the group members maintain focus, ensure all stakeholders have an opportunity to contribute to discussions, and manage group creativity and conflict (Dubs, Hayne, 1992).

This dissertation investigated the effects of negotiation sequence and structured task on group outcome variables. The experiment was conducted using graduate students as research subjects. Although this was necessary to test the experimental task,

technology, training tools, and measurement methods, the next step is to conduct a field study with emergency response personnel.

The benefits of the proposed investigations are multi-faceted, providing further insight into the process of asynchronous negotiation and to investigate further the domain of emergency response information systems.

APPENDIX A

CONSENT FORM

This following is the consent form used in the experiment. Each subject filled out and signed one of these forms before participating in the experiment. This consent form was approved by NJIT's Institutional Review Board.

TITLE OF STUDY: Negotiation of Software Requirements in an Asynchronous Collaborative Environment

RESEARCH STUDY:
I,_____, have been asked to participate in a research study under the direction of Catherine Lowry Campbell. Other professional persons who work with them as study staff may assist to act for them.

PURPOSE:
The objective of the research is to illustrate that negotiation of software requirements by subjects that are not co-located will result in a high quality list of requirements for implementation. The negotiation will entail discussing the requirements for the design of an emergency response information system.

DURATION:
My participation in this study will last for two weeks.

PROCEDURES:
I have been told that, during the course of this study, the following will occur:

My team will be given a list of software requirements for a hypothetical emergency response information system. My team of five members will negotiate the software requirements provided by the investigator down to a list of 10 which will be a subset of the full list. I understand I cannot contact members of other teams and I can communicate with my fellow team members following the instructions and guidelines provided by the investigator.
The team will be required to perform specific tasks, fill out pre and post-test questionnaires, and participate in a debriefing session in the webboard conferencing system. There are specific documents and lists that I and my team will complete. My team will assign roles to its team members.

I understand that this task is part of my course requirements. My grade will be based on how thoroughly I complete the required tasks and the quality of my participation. I understand that I have the choice to ask that the results of my participation not be included in the completed research analysis. I will follow a specific task as assigned and write up the results in my group.

PARTICIPANTS:
I will be one of about 250 participants to participate in this trial.

EXCLUSIONS:
I will inform the researcher if any of the following apply to me: N/A

RISK/DISCOMFORTS:
I have been told that the study described above may involve the following risks and/or discomforts:

There are no risks or discomforts involved in the study.
There also may be risks and discomforts that are not yet known.

CONFIDENTIALITY:
Every effort will be made to maintain the confidentiality of my study records. Officials of NJIT will be allowed to inspect sections of my research records related to this study. If the findings from the study are published, I will not be identified by name. My identity will remain confidential unless disclosure is required by law.

PAYMENT FOR PARTICIPATION:
I have been told that I will receive $0.00 compensation for my participation in this study.

CONSENT
I fully recognize that there are risks that I might be exposed to by volunteering in this study which are inherent in participating in any study, I understand that I am not covered by NJIT's insurance policy for any injury or loss I might sustain in the course of participating in the study.

RIGHT TO REFUSE OR WITHDRAW:
I understand that my participation is voluntary and I may refuse to participate, or may discontinue my participation at any time with no adverse consequence. I also understand that the investigator has the right to withdraw me from the study at any time.

INDIVIDUAL TO CONTACT:
If I have any questions about my treatment or research procedures that I discuss them with the principal investigator. If I have any addition questions about my rights as a research subject, I may contact:
Richard Greene, M.D., Ph.D., Chair, IRB (973) 596-3281

SIGNATURE OF PARTICIPANT

I have read this entire form, or it has been read to me, and I understand it completely. All of my questions regarding this form or this study have been answered to my complete satisfaction. I agree to participate in this research study.

Subject Name:_____Signature:_____Date:

SIGNATURE OF READER/TRANSLATOR IF THE PARTICIPANT DOES NOT READ ENGLISH WELL

The person who has signed above, _____, does not read English well, I read English well and am fluent in (name of the language) _____, a language the subject understands well. I have translated for the subject the entire content of this form. To the best of my knowledge, the participant understands the content of this form and has had an opportunity to ask

questions regarding the consent form and the study, and these questions have been answered to the complete satisfaction of the participant (his/her parent/legal guardian).

Reader/Translator: Name:_____
Signature:_____
Date:_____

SIGNATURE OF INVESTIGATOR OR RESPONSIBLE INDIVIDUAL

To the best of my knowledge, the participant, _____, has understood the entire content of the above consent form, and comprehends the study. The participants and those of his/her parent/legal guardian have been accurately answered to his/her/their complete satisfaction.

Investigator's Name: Catherine L. Campbell

Signature:_____

Date:_____

APPENDIX B

POST TASK QUESTIONNAIRE

Data was collected over the web using automated forms. The data was sent to a Microsoft Access database and downloaded into SPSS, v 11.5 for analysis.

POST-TASK QUESTIONNAIRE

Your Name: _____ Semester: _____

Your SSN: _____ Instructor: _____

Your E-mail: _____ Course: _____

Date: _____

Please choose one number based only on your experience with your group.

1. The overall quality of the group's work was:

Poor ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Good

2. To what extent did the group experience conflict?

Not at all ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very much

3. The content of the group's work was:

Carefully developed ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Carelessly developed

4. To what extent does the group's work reflect your inputs?

Not at all ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very great extent

How would you describe your group's problem-solving process?

5. Efficient ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Inefficient

6. Coordinated ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Uncoordinated

7. Fair ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Unfair

8. Understandable ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6

○ 7 Confusing

9. Satisfying ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Unsatisfying

10. Did the group members acknowledge and confront conflict openly?

Not at all ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very much

11. The manner in which the participants examined issues was:

Non constructive ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Constructive

12. To what extent do you feel committed to the group's solutions?

Not at all ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very great extent

13. Our group's approach helped us to resolve conflicts that arose in the course of our work.

Strongly Agree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Strongly Disagree

14. The issues explored during the group's work were:

Trivial ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Substantial

15. Did the group handle conflict effectively?

Not at all ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very much

16. How satisfied or dissatisfied were you with the quality of your group's solution?

Very dissatisfied ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very satisfied

17. How much effort was required to complete this task?

Very little effort ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Extraordinary effort

18. How easy or difficult did you find this task as an individual?

Extremely easy ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Extremely difficult

19. Did the task description provide you with enough information to easily carry out the task?

Definitely ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Not at all

20. Did the task description make it clear what was to be accomplished?

Unclear ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very clear

Submit

APPENDIX C

TRAINING MATERIALS

The following documents were used for the face-to-face training. Included in this Appendix are the training task, master requirements list, the general stakeholder descriptions, and the description of the experimental task.

Training Task

Student Survey of Teaching Assistants

The department has recently decided to change the look of the student evaluation of teaching assistants form. Out of the six statements below, only three will appear on the new evaluation sheet. You are required to take a group decision on which three should be eliminated and which three will appear on the new form.

Has adequate knowledge of the course material.

Is clear and understandable.

Utilized lab time well

Is punctual for labs/tutorial.

Is efficient in handling and returning assignments.

Is approachable and helpful.

This is a list of estimated time for each individual requirement. There is a years operational expense included in the total cost. The amount of funding provided by the Federal and State organizations is limited. The list of requirements you must agree on must not exceed 45 man months to implement. The amount of time for each requirement is listed below for your reference. Please note this list is not inflexible, if in your negotiations you see that you can combine two or more requirements or wish to develop a new overlooked critical requirement you may do so. This change must be sent to the Project Manager who will consult with Professor Campbell as to the feasibility and amount of time for implementation.
These two requirements are mandatory for the system and are included in the costs: the system shall be secure and provide appropriate authentication, and the system shall be redundant with automatic switchover.

Requirements of the system are:
This is a list of estimated time for each individual requirement. There is a years operational expense included in the total cost. The amount of funding provided by the Federal and State organizations is limited. The list of requirements you must agree on must not exceed 45 man months to implement. The amount of time for each requirement is listed below for your reference. Please note this list is not inflexible, if in your negotiations you see that you can combine two or more requirements or wish to develop a new overlooked critical requirement you may do so. This change must be sent to the Project Manager who will consult with Professor Campbell as to the feasibility and amount of time for implementation.
These two requirements are mandatory for the system and are included in the costs: the system shall be secure and provide appropriate authentication, and the system shall be redundant with automatic switchover.

Requirements of the system are:

ID	Requirement Name	Requirements Description	Man Months
	Command & Control	The system shall provide a physical command and control system in a centralized location that shall be integrated yet provide individual functionality to each response organization.	10.00
	Remote Access	The system shall provide remote access to emergency operations center databases and communications by personal computer or Personal Digital Assistant (PDA).	10.00
	Public Website	The system shall provide a current informational website for public access and separate pages for individual official organizations.	12.00
	Linked Time Log	The system shall maintain a time log of all events with information linked on the nature of the event, the reporter, status of the event, and allow for links between related events.	10.00
	Dispatch Service	The system shall provide a dispatch service which will include the origination and tracking of tasks. This system will be used by police, fire services, medical organizations, etc.	4.00
	Interagency Access	The system shall provide distributed interagency access, allowing authorized users remote access to data collected by any of the agencies during the event.	12.00
	GIS Database	This system shall provide access to a Graphical Information Database for digital mapping of critical infrastructures, i.e.,	10.00

		sewer, utility, roads, river hydrology, etc.	
	Electronic Bulletin Board	The system shall provide an ongoing asynchronous informational message board which will provide threaded discussions for authorized users.	2.00
	Resource Database	The system shall maintain a resource database of contact information for local and military personnel. It will also provide equipment and personnel/volunteer databases for each critical infrastructure in the county.	8.00
	Electronic Command Post	The system shall provide the functionality in R1 as a virtual command and control center independent of any physical location. This functionality shall be accessible to any authorized user within the communication network. *Note: if R1 AND R10 are chosen, then R10 will take only 5 additional man months in addition to the 10 in R1, otherwise R10 consumes 12 man months.	12.00 or 5.00
	Victim Database	The system shall provide an interactive input form and accompanying searchable database of persons involved in the incident (personal info and photo ID to be taken onsite).	4.00
	Laboratory Database	The system shall provide a database of laboratory measurements and tests taken from the event.	4.00
	Whiteboard	The system shall provide a whiteboard collaborative working area where individuals can create and view drawings. The users shall also be able to overlay markups and update/change existing drawings.	6.00
	Mobile Resource Tracking	The system shall provide a means of tracking mobile physical resources, i.e., ambulances, patrol vehicles, road crews, etc.	8.00
	Dispatch/Response Database	The dispatch event logs generated by different response organizations shall be designed and stored as one dynamically updated database, yet provide individual functionality to each response organization.	3.00
		Total	115

A Negotiation Study

Experimental Role Descriptions

Summary of Each Organization with an Interest in the Proposed Emergency Response Information System

Fire Containment Experts

The Fire containment organizations would focus on identification and containment of chemical, toxic, industrial and similar hazards as well as their primary mission of fighting fires.. Examples of this type of organization would be the local fire departments and hazardous materials specialists. This organization will provide expertise for the containment/neutralization of the fire or hazard, track chemical/biological equipment inventories, and have access to specialized databases and equipment.

Law Enforcement Organization

The law enforcement organization is comprised of local police and security personnel. This organization is responsible for functions that focus on security and protection of both response personnel and the general public. The police will secure the incident area. The primary role of the police is to contain the situation and protect innocent personnel involved in the event. They will protect businesses from looting. The police bomb squad and SWAT units are on call to deal with terror or criminal oriented situations. The police are also responsible for ensuring the ability of emergency vehicles and personnel to get where they need to go. Finally, one of the more important functions of the police is to manage a resolution to or understanding of the event and coordinate options.

Role of Public Works

The Public Works department includes transportation and utilities organizations. These organizations provide the infrastructure and backbone for power, communication, water, transportation, and other essential functions. These organizations are critical in an emergency in order to provide power, get necessary vehicles/equipment to the site, and to restore vital telephone communications to the area. Public works will coordinate transport of emergency and other necessary equipment. They will provide emergency utilities and power functionality and restore or improve telephone/wireless communications. They will assist in containment and cleanup.

Role of Public Health

The Public Health and accompanying medical services and biological hazards organizations, provide health related services. These organizations coordinate the effort to provide expertise to other government organizations on strategies to control and/or

prevent public health incidents. Public Health will provide emergency medical services to event personnel and incident victims. They will also provide expert bio hazard personnel. An important role is to also inform and educate the public and disseminate public health hazard information as necessary depending on the type of event occurring. Public health will provide appropriate equipment, protective clothing, specialized machinery, and laboratory services to event personnel. They are responsible for controlling the response to any large communicable disease outbreak and coordinate hospital services and capacity. This organization is responsible for providing coroner/mortuary services if necessary. Public health tracks pharmaceutical stockpiles and provides protection to public and response personnel from infectious diseases.

Role of Liaison from the State Home/Civil Defense Unit

For any large scale disaster the State Home/Civil Defense Unit organizations may step in to play an important role in the facilitation of emergency response. This organization will direct the securing of the event area and act as a liaison between local and federal organizations. The state liaison will provide emergency equipment/lights, generators and provide backup services to local law enforcement agencies. If called upon, the state liaison will help in the identification of triage, evacuation, decontamination and shelter areas. The state liaison can manage interagency coordination, provide a database of out of county assets and their availability, and help coordinate getting those assets to the place where they are needed most. This organization could be the central vehicle for dissemination of safety and event information to the public.

Role of Project Manager

The Project Manager is the manager of the team of developers that collected and assessed the functional requirements for the emergency response (ER) information system from each organization. They have elicited a list of requirements for the system but realize that this list must be reduced to be implemented within a restricted time frame and with limited funds. Due to the development team's limited knowledge of the emergency response domain, they plan to ask the stakeholders to integrate their needs and decide on the final requirements that would provide the best functionality in the new ER system. The Project Manager's job is to make sure the users understand the time and financial constraints involved in the implementation of the system and make it clear that it is not possible to add any time to the allotted development schedule of 45 man months, although future enhancements may allow upgrades to provide further functionality.**The Project Manager is also responsible for coordinating the final report for their group and organizing the effort of the team. For this extra responsibility the Program Manager will receive an additional 10 points towards their grade.

Spring 2004 Asynchronous Study
NJIT College of Computing Sciences

Investigator: C. Campbell: campbell@njit.edu

12/5/2004

Webboard URL http://webboard.njit.edu:8080/~NegotiationExperiment

TO DO:

1. Read this paper first, then read the role description paper.
2. Vote on a Program Manager for your group. Assign other group roles as described below. Write them down, give a copy to Professor Campbell, and the program manager will post them in WebBoard tomorrow.
3. After class go to WebBoard and become a member of our discussion board. Our board is at the bottom of WebBoard under "Additional Boards" and is called "A Negotiation Study". The URL for obtaining a userid for our board http://webboard.njit.edu:8080/~NegotiationExperiment/new The URL for our board is: http://webboard.njit.edu:8080/~NegotiationExperiment Once you are a member of the board I can add you to your private conferences where you will be conducting all of your work.
4. Fill out the online background questionnaire in the "Background Questionnaire" conference.
5. Read the postings in WebBoard. Look for your group name in WebBoard and follow the instructions there. Introduce yourself to your group. Start your training exercise. Finish this training exercise by Sunday night. Note: I cannot add you to groups (it is a manual process) until you log into the board. Please do this as soon as possible.
6. Negotiations begin on Monday, 3/1 and you must be active in webboard TWICE every day.
7. After your negotiations have finished (3/5), fill out the online Post-Task questionnaire. This is posted in the "Post-Task Questionnaire" conference. It will only take you a few minutes. Prepare your final report from the template posted in the "Final Report" conference and submit it no later than Tuesday, March 9th.

Background Scenario and Task Description

Highland county has approximately 500,000 residents, includes rural and suburban areas, and is within proximity of a large metropolitan area. The county is home to the Friendly Petroleum Processing Facility which is a refinery for gasoline and other petroleum products. This facility has a large petroleum product storage depot adjacent to the processing plant. Highland county is also home to several large corporations, and has one large corporate headquarters within its boundaries.

The problem solving task for each group is to negotiate and rank a given set of fifteen system requirements for an emergency response information system. Each group consists of representatives of the following organizations: law enforcement, fire containment experts, public works, public health, and a state/home civil defense liaison. There is also a program manager who is a representative of the company that will develop the software. Each team member will play the role of one of these representatives. For the purpose of this exercise, role playing involves reading all the documentation for this experiment and as you negotiate, acting as if you were the person described in your role description.

In previous meetings with the Project Manager and software analysts, each of the stakeholders had agreed on a set of system requirements suitable for their own organization. The final list was compiled from the group of individual organizational inputs without any interaction between the organizations. Your task is to negotiate with the other organizations representatives to try to agree to a list that is beneficial to all organizations involved in the emergency response effort.

After careful study, the software analysts have determined that there must be some reduction in the complete list of 15 requirements due to monetary and scheduling restrictions. Due to the team's

limited knowledge of the emergency response domain, they plan to ask the stakeholders to decide on the final requirements that would fulfill their needs for the functionality in the new ER system. Meeting face-to-face to negotiate these final list of requirements is out of the question due to scheduling conflicts. The stakeholders are all too busy to take time out to travel and meet face-to-face, therefore they have agreed to negotiate the final

list asynchronously. During the negotiations keep in mind that it is only possible to implement requirements that add up to than 45 man months development time. Also, it is not possible to change the time each requirement takes to complete.

There are two requirements that have been agreed upon as necessary to the system and can be assumed will be included in the development: They are: *The system shall be secure and provide appropriate authentication* and *The system shall be redundant with automatic switchover*. These two requirements take 22 man months to implement and are already accounted for in the budget.

Your group's task is to negotiate the requirements to a list that will take 45 man months to complete. Each user has different priorities for the system based on their needs. This task will require you to negotiate with one another to identify the final requirements for the system. The Project Manager will act as a team facilitator, chair the meetings, help guide you through your negotiations, keep a log of activities and negotiations, and initiate activities to ensure your team completes the task on time and within budget. As you go through your negotiations, the Project Manager will provide the time estimates for any requirements that are not on the list that your group may think important to add.

Your initial meeting will be conducted in WebBoard where you will be given a pre-experimental training task Following the training exercise, you will have one week (five days) to conduct the experimental task carefully following the instructions for your group. Once you have completed the experimental task and decided on your final list of requirements, your group will then complete a final report describing why you chose or did not choose each requirement.

Assignment of Roles: **Groups have been assigned randomly by the researcher.**

The project manager/coordinator will be a volunteer position and will receive 10 extra points towards their grade if they participate fully in the exercise. If no one from a group volunteers, the group can nominate individuals and the experimenter will choose. The other group members will be assigned alphabetically to roles following the table below. In the instance that there are several students with the same first letter of the last name, it will be decided on the second letter, third letter, etc, with each successive name being assigned to the next role on the list.

APPENDIX D

BACKGROUND QUESTIONNAIRE

Data was collected over the web using automated forms. The information requested with the background questionnaire was demographic in nature. The data was sent to a Microsoft Access database and downloaded into SPSS, v 11.5 for analysis.

BACKGROUND QUESTIONNAIRE

First Name: Last Name:

Semester: Professor: Course #:

Email: Group #: Date:

The purpose of this questionnaire is to gather some background information. All information is confidential and names will be removed.

Please check the answer(s) which applies to you:

1. I am an:

- Undergraduate Senior
- MSIS student
- MSCS student
- MBA student
- PhD student
- Other

2. My undergraduate major is/was:

- Accounting
- Management
- Finance
- Marketing
- Information systems
- Engineering
- Other

3. My nationality is:

4. My ethnic background is:

- AfroAmerican

○ Hispanic
○ White
○ Asian or Asian American
○ Other

5. I am a: ○ Female ○ Male

6. My age is: ○ under 23 ○ 23 - 30 ○ 31 - 40 ○ over 40

7. English is my native or first language. ○ Yes ○ No

8. I have used WebBoard. ○ Never ○ Once or twice
○ Three to ten times ○ Frequently

Directions: After each statement, circle the answer that applies to you. There are no right or wrong answers. Work quickly; just record your first impression.

9. My level of experience in working in groups is:
Very low ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Very High

10. I dislike participating in group discussions.
Strongly Disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Strongly Agree

11. Engaging in group discussions with new people makes me tense and nervous.
Strongly Disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Strongly Agree

12. I have easy access to WebBoard from home or work.
Strongly Disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Strongly Agree

13. Generally, I am comfortable participating in group discussions.
Strongly Disagree ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 Strongly Agree

submit

APPENDIX E

EXPERIMENTAL CHECKLIST

This appendix shows the checklist given to each student during training and posted to WebBoard. The purpose of this document was to help the student understand the sequence of events of the experiment and also to clarify what was expected of them, due dates, and deliverables.

Negotiation Project Checklist

Spring 2004

Project Start Date:	December 5, 2004		Project Completion Date:	Tuesday, March 9, 2004	

Webboard URL: http://webboard.njit.edu:8080/~NegotiationExperiment Q&A: In Webboard.

Note: this is not to be handed in, it is for your personal use.

Start Date	Due Date	Task	Details
2/25-28	2/25-28 In Class	Complete Consent Form Role Allocation	Fill out your consent form and give it to Professor Campbell. Read the items handed out and assign the role that each team member will take.
2/25-28	2/25-28	Webboard, Forms, and background questionnaire	Establish a userid and password for our webboard conference. Introduce yourself in your groups private webboard conference. Fill out the online background questionnaire in the "Background Questionnaire" conference. Download the Daily Log from the "Daily Log" conference and rename it to your name.
2/28-29	2/28-29	Webboard Orientation and Training Task	Conduct the training exercise in your groups "Training Task" conference. Information about the task is in the WebBoard conference "Training Task". Discard task on Sunday night. Read the instructions in your groups conference and start the negotiation task (handed out in class) on Monday morning. Follow the instructions carefully.
3/1-5	3/1-5	Negotiate Requirements in Webboard	During this week of the experiment you will try to negotiate the list of 15 requirements down to a list that will take 45 man months to accomplish. All communication is to be in webboard. You need to be active twice a day this week.
3/1-6	3/6	Daily Log	Each day record your own ranking of the requirements on the Excel form provided in webboard. Post the completed list by Monday (3/8) to the webboard conference "Daily Log" – use your name as the subject of the post. Post only the completed list, do not post daily lists.
3/7	3/9	Post-Task Questionnaire	ɔmplete the online Post-Task questionnaire. This is posted in the webboard conference of that name. This must be completed by midnight Tuesday, March 9.
3/6	3/9	Final Report	With the help of the program manager, write and post the final report for the project. Instructions are in your webboard group's conference and the final report template is in the "Final Report" conference. This must be completed by midnight Tuesday, March 9d.

APPENDIX F

DAILY LOG

The daily log was part of the required documentation requested from the subjects. The subjects used this document to keep track of their individual daily requirement preferences.

Worksheet for Recording Daily Top Ten Requirements – Record your own daily rankings each day. Give each item a "grade" from 0-100 based on its importance/criticality for implementation. This is your personal choice, not necessarily the choice the group as a whole would make. The "Example Recording" below in italics is an example of a possible entry with the accompanying hypothetical grade for the chosen requirements. Your numbers will differ. Even though your group obtained a result for the report, indicate your personal ranking of all the items in day 6 of the log, as though you alone have the authority to make the final decision on this issue for the whole group. Post the completed sheet to the "Daily Log" conference in Webboard when you have completed the group negotiations - no later than Monday.

Name:								
Date:								
Group:								
Role:								
Req		*Example*	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
Number	**Requirement Name**	*recording*	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6
1	Command & Control	*90*						
2	Remote Access	*80*						
3	Public Website	*97*						
4	Linked Time Log	*91*						
5	Dispatch Service	*100*						
6	Interagency Access	*25*						
7	GIS Database	*94*						
8	Electronic Bulletin Board	*70*						
9	Resource Database	*55*						
10	Electronic Command Post	*50*						
11	Victim Database	*30*						
12	Laboratory Database	*15*						
13	Whiteboard	*85*						
14	Mobile Resource Tracking	*0*						
15	Dispatch/Response Database	*10*						

APPENDIX G

DEBRIEFING INFORMATION

This information was posted in the WebBoard conference for the subjects after the experiment concluded. Its purpose was to explain to the subjects the research objectives and goals.

An Asynchronous Negotiation Study: A Debriefing

Students, Thank you very much for participating in my experiment. Without the good will and efforts of students like you, research at NJIT (and most universities) would not be possible. Your work has enabled me to look more closely at the possibility of the requirements engineering in the distributed mode. As I told you in class, little research has been done to facilitate distributed negotiation in this early stage of requirements work. Below I have outlined my scientific study. I do not have results yet from our work together, but hope to have that in the next few weeks. The information below should give you information about my intentions, expectations, and methods in conducting this experiment. Again, thank all of you very, very much. ~Catherine Lowry Campbell

Research Motivation and Questions

Although global software engineering continues to grow and expand, the study of the most important phase remains mostly under studied (Damian 2003). Requirements analysis rarely takes place in a distributed fashion. 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.

Modes of communication within requirements engineering have been studied by several researchers. Ocker, Fjermestad, Hiltz, and Johnson, (1998) 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 at the beginning and 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 effects group quality and creativity.

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 estimates and goes back to the customer to prioritize and re-check for any possible omissions or inconsistencies. 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 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).

Organizations use a variety of asynchronous tools to facilitate their development process, email is most common, along with asynchronous messaging boards for tracking documentation and for version control. On-line meeting software is a valuable tool for large and small organizations. When employees are traveling, they can keep up to date not only by participating in teleconferences, but can update their work through such technologies which are becoming ubiquitous. The use of these technologies is inherently different than face-to-face meetings. Nuances such as body language, facial expression, and use of language are all modified or non-existent when using technology to communicate. This can be advantageous, as it brings all participants to the table with anonymity, which can create more diverse discussions and perhaps more creative solutions to a problem. Employees that are intimidated by others may participate more in an asynchronous mode.

Groups in distributed settings perform better and provide more integrative solutions of higher quality. The use of multimedia meeting systems in distributed requirements negotiation results in more effective meetings and outcomes. Damian, 2001, conducted a study of distributed requirements negotiation which was performed in a laboratory setting. The conditions of the experiment were five communication modes: one face-to-face, and four distributed settings. Damian, (2001) studied distributed requirements negotiation using three different software engineering stakeholder roles working collaboratively towards a solution although they had conflicting goals. The roles were system stakeholders or users (2), a system analyst, and a meeting facilitator.

Damian found that 1) group performance in face-to-face requirements meetings was no better than in distributed group meetings, 2) remote collaboration of the two system users benefited the negotiation, 3) the co-location of the two negotiators was helpful but not beneficial, 4) the use of a shared electronic workspace was particularly useful in the requirements negotiation. Damian concludes with a recommendation of further investigation of the effects of communication mode on negotiation and facilitation outcome during requirements prioritizing.

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. Damian found that the use of videoconferencing promoted the participation of a larger group of stakeholders.

Theoretical Framework

The research design of the planned study is a controlled experiment with a 2 X 2 factorial design. This design will be used to test the proposed hypotheses. This experiment will provide a structured task or unstructured task to a groups of students. Groups in the first condition will have structured task along with a specified negotiation sequence. Groups in the second condition will have a structured task with no specified negotiation sequence. Groups in the third condition will have an unstructured task with a specified negotiation sequence. Groups in the fourth condition will have neither a structured task nor a specified negotiation sequence. Subjects will work asynchronously at their own computers with no restrictions as to the time or place of interaction. The only restriction given to the groups is that they do not communicate out with the collaborative work

space, WebBoard. Each group is given a private WebBoard conference to conduct their negotiations. The experimental design is show below.

Experimental design

Independent variables: 2 X 2 factorial design

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: Experimental Design for each Mode

Dependent variables

- process satisfaction
- solution satisfaction
- perceived solution quality
- conflict
- negotiation convergence
- quality of solution

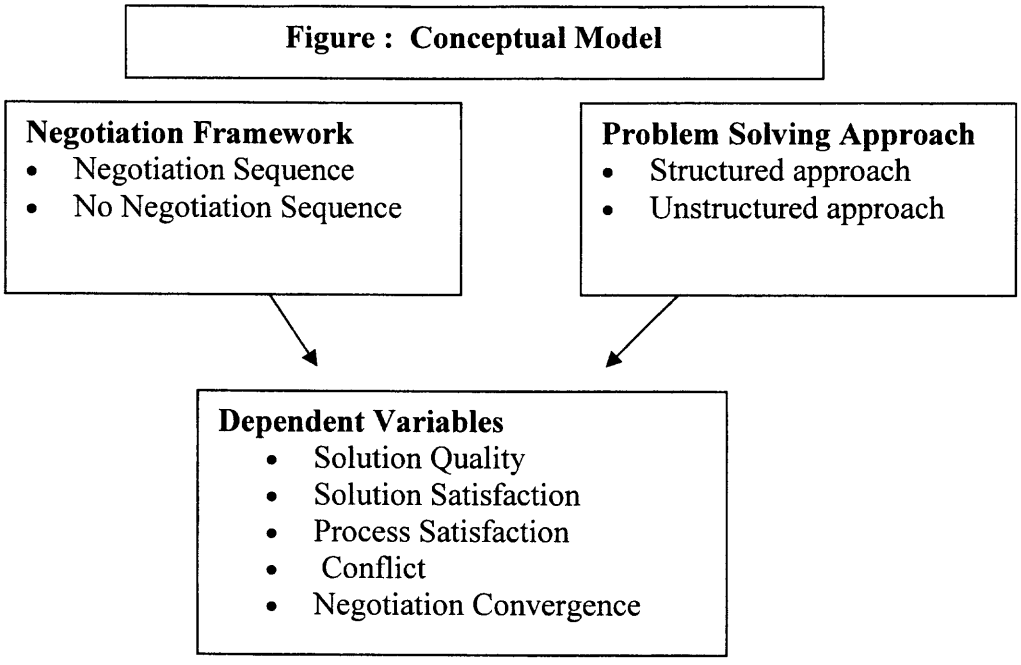
Subjects: Graduate students in Systems Analysis and Design and Software Engineering courses. Group members will randomly assigned.

Groups of six comprised of five stakeholders and one program manager:

1. law enforcement
2. fire containment experts
3. public works
4. public health
5. liaison of state home/civil defense unit

- Project Manager – to supply costs and resources and to chair the meetings and provide facilitation.

Conceptual Model



Hypotheses

Solution Quality

A series of negotiation steps and task structure defined for each group provide the participants a framework from which to conduct their discussions. Structured tasks facilitate coordination for the groups by providing a series of steps and a sequence to make a decision. The structured process consists of three phases: 1) generation of alternatives, 2) period of critical reflection, and 3) group evaluation of alternatives and consensus reaching. Task structure assists the group to better understand the task and can help improve the decisions by individuals within the group. It can also improve group performance by encouraging more information to be shared and reduce process losses due to incomplete understanding of the task to be completed (Nunamaker, et al., 1991)

Structure can increase the quality of decision making and improve group processes (Dufner, 1995). Using a structured approach to a task provides a needed framework which will assist groups in their communication process and facilitate

completion of the task more effectively. Therefore, the author expect the quality of the groups solutions to be higher when their online discussions are more structured.

Negotiations are most successful when the participants have a common willingness to find the best solution. The stakeholders in these negotiations agree to reach the shared goal of a set of common requirements for the new emergency response information system. To reach the best solution, participants must have a commitment and motivation to work together, and clear communication to achieve their goals. (Lewicki, Saunders, Minton, 2001). Objectives of a negotiation process are achieved through:

1. specification of the structure of the negotiation problem and process
2. specification of rules of feasible activities, and their sequencing and timing
3. imposition of limitations of the form and content of information exchange. (Bichler, Kersten and Strecker, 2003)

Fisher and Ury, 1983 specify certain steps for negotiators to follow in order to achieve a successful outcome. These are: 1) identifying and defining the problem, 2) understanding the problem, 3) generating alternatives and solutions, and 4) evaluating alternatives and selecting the final agreed list. Therefore, it is hypothesized that those groups following a negotiation sequence with specific instructions will achieve a higher quality solution.

H1.a. Groups following a negotiation sequence will achieve higher quality solutions as compared to groups with no specified negotiation sequence.

H1.b. Groups following a negotiation sequence will produce a higher quality group reports as compared to groups with no specified negotiation sequence.

H1.c. Groups following a structured task will achieve higher quality solutions as compared to groups with an unstructured task.

H1.d. Groups following a structured task will achieve higher quality group reports as compared to groups with an unstructured task.

Conflict

Conflict is a common byproduct of negotiation situations. There are several types of conflict that can arise. Domain level conflict refers to inconsistencies in design criteria where collaborative conflict is interpersonal between individuals belonging to a group. There are two types of conflict between negotiating parties. These are conflicts of interest which can lead to win-lose situations and conflicts of viewpoint which may lead to win-win negotiations. Finding potential agreements and identifying alternative solutions are beneficial byproducts of conflict in negotiations. For both win-win and win-lose negotiations the use of a structured process can improve the results of negotiations. (Deek, McHugh, 2003)

H2.a. Groups following a negotiation sequence will exhibit less conflict in their negotiations compared to groups with no specified negotiation sequence.

H2.b. Groups following a structured task will exhibit less conflict in their negotiations compared to groups with an unstructured task.

Process Satisfaction

Satisfaction with the group process is the method used by the group to make a decision. Some researchers have found that technology supported groups can produce more democratic decision-making processes (Watson ,1987, DeSanctis and Gallupe, 1987). Structure can be imposed upon the group with tools and sequential procedures. The more

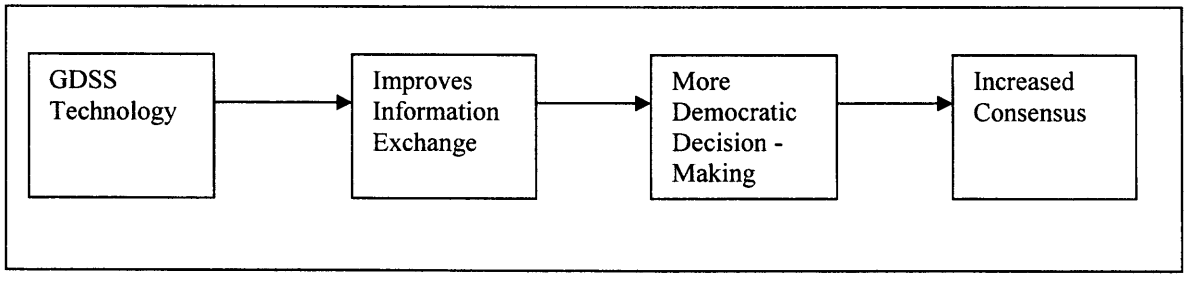
democratic the process the "better" and more satisfying the group process and outcomes (Dufner, 1995, Hoffman, 1979).

H3a. Groups following a negotiation sequence will show more satisfaction with their negotiation process compared to groups with no specified negotiation sequence.

H3b. Groups following a structured task will show more satisfaction with their negotiation process compared to groups with an unstructured task.

Solution Satisfaction

Solution satisfaction is designed to measure feelings concerning the final group solution. Watson, 1987, used a causal model to formulate his hypotheses that structure can increase the quality of decision making and improve group processes. He also theorized that structured computer supported work could improve commitment, satisfaction, extent of input, and confidence in the solution. Watson's causal model is shown below.



Implied Causal Model.
Source: Watson, 1987.

H4a. Groups that follow a negotiation sequence will be at least as likely to be satisfied with the group's solution as those groups not following a negotiation sequence.

H4.b. Groups following a structured task will be at least as likely to be satisfied with the group's solution as those groups with an unstructured task

Negotiation Convergence

Work in unstructured conditions encourages divergent thinking in ways as it does in personal perspectives. Negotiations, such as those that occur in groups, thus require the

right conditions in order to converge on consensus and achieve cooperation (Stahl and Herrmann, 1999). Structured negotiation models, in particular, can facilitate such convergence in the negotiation process (Herrmann, 1995). Similarly, negotiation strategies, such as sequencing, can contribute to the convergence of different perspectives in group negotiations (Lee, 1996; Boehm et al., 1995).

H5a. Groups in structured conditions will converge faster to a consensus and show less disagreements in this convergence process than those in unstructured conditions.

H5b. Groups that follow a negotiation sequence will converge faster to a consensus and show less disagreements in this convergence process than those in non-sequential conditions.

Data Collection Methodology

- Post-test questionnaire
- Output from WebBoard and subject generated documentation (daily list of requirement priorities, final agreed list of ranked requirements, final reports)
- Expert judges report

Variable	**Measurement Tool**
Perceived solution quality and total quality of solution	Expert judges analysis and post task questionnaire
conflict	Post Task Questionnaire
process satisfaction	Post Task Questionnaire
solution satisfaction	Post Task Questionnaire
negotiation convergence	Subject generated documents

Post task questionnaire items measuring the dependent variables:

Solution Quality

1. The overall quality of the group's work was:

Poor 1----2----3----4----5---6---7 Good

2. The issues explored during the group's work were:

   Trivial 1----2----3----4----5---6---7 Substantial

3. The content of the group's work was:

   Carefully developed 1----2----3----4----5---6---7 Carelessly developed

4. The manner in which the participants examined issues was:

   Non constructive 1----2----3----4----5---6---7 Constructive

Solution Satisfaction

1. How satisfied or dissatisfied were you with the quality of your group's solution?

   Very dissatisfied 1----2----3----4----5---6---7 Very satisfied

2. To what extent does the group's work reflect your inputs?

   Not at all 1----2----3----4----5---6---7 Very great extent

3. To what extent do you feel committed to the group's solutions?

   Not at all 1----2----3----4----5---6---7 Very great extent

Process Satisfaction

How would you describe your group's problem-solving process?

1. Efficient	1	2	3	4	5	6	7	Inefficient
2. Coordinated	1	2	3	4	5	6	7	Uncoordinated
3. Fair	1	2	3	4	5	6	7	Unfair
4. Understandable	1	2	3	4	5	6	7	Confusing
5. Satisfying	1	2	3	4	5	6	7	Unsatisfying

Conflict

1. To what extent did the group experience conflict?

   Not at all 1----2----3----4----5---6---7 Very much

2. Did the group handle conflict effectively?

Not at all 1----2----3----4----5---6---7 Very much

3. Did the group members acknowledge and confront conflict openly?

   Not at all 1----2----3----4----5---6---7 Very much

4. Our group's approach helped us to resolve conflicts that arose in the course of our work.

   Strongly agree 1----2----3----4----5---6---7 Strongly disagree

Task Evaluation

1. How much effort was required to complete this task?

   Very little effort 1----2----3----4----5---6---7 Extraordinary effort

2. How easy or difficult did you find this task as an individual?

   Extremely easy 1----2----3----4----5---6---7 Extremely difficult

3. Did the task description provide you with enough information to easily carry out the task?

   Definitely 1----2----3----4----5---6---7 Not at all

4. Did the task description make it clear what was to be accomplished?

   Unclear 1----2----3----4----5---6---7 Very clear

Task Structure

Structured Task

For the groups that were following a structured task sequence the subjects are provided with the following topics in their private conferences in WebBoard. Each of these items had brief instructions.

- Important Instructions
- Meta Discussion
- R1-Command and Control
- R2 - Remote Access
- R3 - Public Website

- R4 - Linked Time Log
- R5 - Dispatch Service
- R6 - Interagency Access
- R7 - GIS Database
- R8 - Electronic Bulletin Board
- R9 - Resource Database
- R10 - Electronic Command Post
- R11 - Victim Database
- R12 - Laboratory Database
- R13 - Whiteboard
- R14 - Mobile Resource Tracking
- R15- Dispatch/Response Database
- General Discussion and Proposals

Unstructured Task

For the groups that were not following a structured task sequence the subjects are provided with the following conferences in their private conferences in WebBoard. Each of these items had brief instructions.

- Important Instructions
- Meta Discussion
- Requirements Discussion
- General Discussion and Proposals

Negotiation Sequence

Negotiation Sequence

For the groups that were following a specified negotiation sequence the subjects were provided with the following instructions.(Lewicki, Saunders, Minton, 2001, Fischer and Ury, 1983)

5. Identifying and Defining the Problem: Day 1 - Monday

- Become familiar with your role and start discussions about the task and individual requirements.

6. Understanding the Problem: Days 1-2 –Monday and Tuesday

- On these days you will discuss your interests and listen to the other team members concerns. Look for common ground for agreement within your interests and the group system requirements. Identify and define any problem areas.

7. Generating Alternatives and Solutions: Days 3-5 – Wednesday through Friday

- Discuss each alternative and proposed solution - since most conflicts are based in differing interpretations of the facts, it is important to understand the different viewpoints of everyone in this committee. You should each try to put yourselves in one another's place.

- Your team will have several negotiating sessions. Between sessions, analyze the other stakeholders positions to see if you can understand their needs and see if you can find ways to express your needs more clearly, find some other supporting arguments for your position, or find ways to make your options more attractive to the other team members. Your Project Manager will be organizing and facilitating these discussions and taking notes to include in the final report.

8. Evaluating Alternatives and Selecting the Final Agreed list: Day 4- 5 – Thursday and Friday (finish by midnight)

- After discussing the alternatives, select a solution with a list of requirements that is agreeable to all stakeholders and is within the 45 Man Month time restriction and post it in this conference. You should do your best to note the reasons for each item in your final list and also explain why the other items were not chosen by your group. This information is needed in the Final Report.

No Negotiation Sequence

For the groups that were following no negotiation sequence the subjects are provided with the following instructions.

Discussions

- From Monday through Friday your team will be negotiating the rankings of the requirements. Your team will should come up with a final list that does not exceed the 45 Man Month limitation and that all stakeholders can agree to put forward for implementation. Negotiations start on Monday and should be completed by midnight on Friday.

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 general task to be completed, a brief background of requirements engineering (this is covered in depth by their current coursework), the stakeholder 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 throughout the activity.

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 condition.

ANOVA will be the technique 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. These scales were previously validated by other researchers. Chronbach's alpha will be used to validate the individual items in the scales.

Entropy will be used to describe the negotiation convergence of groups as they progress through the week.

For quality of groups' solution, expert judges and will be used.

Future Work

Software engineers have little guidance on the type of negotiation process to implement in a particular requirements engineering environment. The study of asynchronous human negotiation will be studied in this experiment. Future work can look at the type of requirements necessary for an electronic negotiation system. There are a variety of types of e-negotiation protocols that can be utilized with a new information system. Alternatively, another perspective is to look at what is missing for system engineers which is a thorough requirements analysis of the type of e-negotiation media that will be optimal for creating their particular information system environment. (Bichler, Kersten and Strecker, 2003)

Another focus of future negotiation research would be to look at similar research topics as presented in this study, yet facilitate the negotiation using an existing e-negotiation technology.

APPENDIX H

EMERGENCY RESPONSE STAKEHOLDER AND ORGANIZATIONAL DESCRIPTIONS

The following document shows some examples of the types of stakeholders and organizations involved in emergency response work.

Stakeholders in Emergency Response

The potential users of an emergency response information system and also those who might benefit from the implementation of an emergency response information system include, in general, local and federal government officials, emergency medical services, law enforcement, fire services, and public works officials. The specific stakeholders include state and local officials, police, fire, civil defense, public health, environmental, hospital, transportation, representatives of facilities where chemicals/hazardous materials are stored or used, community groups, public works departments, media, coroner, and federal law enforcement investigators.

Selected Stakeholder Organizational Descriptions

Law Enforcement

Law enforcement organizations are comprised of local police and security personnel. These organizations are responsible for functions that focus on security and protection of response personnel and the public. The functions of the law enforcement organizations during an event might include establishing a command post and staging area and a database for tracking and identification of response personnel and victims; ensuring protection/security of subjects and response personnel and secure incident area, interviewing survivors and collecting evidence for later criminal investigations, identifying security deficiencies; identifying potential additional targets, situation containment and protecting of innocent personnel, on scene command and communication, reporting situation updates to other agencies, liaison and coordinating with other law enforcement agencies, and managing resolution.

Fire, Chemical, Toxic, and Industrial Hazards

The Fire, Chemical, Toxic, and Industrial Hazards organizations would focus on identification and containment of like hazards. Examples of these organizations would be the local fire departments, hazardous materials specialists and the local, state, and federal environmental protection agencies. The response functions of these organizations might include providing expert advice, access to specialized databases and equipment, containment/neutralization of fire or hazard, provide on-site testing, measurement, and tracking of hazard, onsite physical protection from hazard, provide specialized equipment/clothing, establishment of a decontamination area, keeping track of possible targets, and provide decontamination equipment.

Public Works, Transportation, and Utilities

The Public Works, Transportation, and Utilities organizations provide the infrastructure and backbone for power, communication, water, transportation, and other essential functions. These organizations are critical in an emergency in order to provide power, get necessary vehicles/equipment to the site, and to restore telephone communications to the area. The functions of these organizations might include coordinating transport of emergency and other necessary equipment, providing emergency utilities/power, restoring or improving telephone/wireless access, assisting in containment and cleanup, coordinating, ensuring ease of access (flooded roads, bridges out), providing potable water, and providing weather updates and services.

Public Health, medical services and biological hazards

The Public Health, medical services and biological hazards organizations provide health related services. These organizations coordinate the effort to provide expertise to other

government organizations on strategies to control and/or prevent public health incidents. The functions of these organizations might include providing emergency medical services, expert bio hazard personnel; informing and educating the public by disseminate public health and hazard information; providing appropriate equipment, protective clothing, specialized machinery, laboratory services; and controlling any large communicable disease outbreak, providing coroner/mortuary services, coordinate hospital services and capacity, tracking pharmaceutical stockpiles, and providing protection to public and response personnel from infectious diseases.

Civil Management

The civil management organizations play an important role in the facilitation of emergency response. Civil management organizations should have a rapid response capability and support roles to other organizations. This organization would provide assistance to local and state jurisdictions. Some functions they will provide might include central vehicle for dissemination of safety and event information to the public; notification services to pertinent personnel via pagers, PDAs, web sites, cell phones; remote access to emergency operations center databases, communications, and coordination of all agencies activities within their political boundaries; tracking event information, linking geographically dispersed individuals to perform emergency operations center functions, displaying geographical graphical representation of event occurrences, and providing data for coordination of response personnel; and managing interagency coordination, tracking chemical/biological equipment inventories, providing county maps online with real-time updates, and listing of contact information for critical

personnel for each critical infrastructure, for instance, critical employees of the petroleum processing plant and other corporations.

Liaison from the State Home/Civil Defense Unit

The State Home/Civil Defense Unit organizations play an important role in the facilitation of emergency response. Responsibilities might include securing event area, liaison between local and federal organizations, protecting businesses from looting, providing emergency equipment/ lights, generators, and ensuring backup services to local law enforcement agencies; identification of triage, evacuation, decontamination and shelter areas; ability to have a shared whiteboard collaborative working area; and maintaining a database of out of county assets and their availability.

Agencies involved in Emergency Response

There are many government agencies that participate in emergency planning and response. Some of them specialize in specific areas of expertise and are necessary for particular incidents. Other agencies hold oversight roles where they would be involved in all types of emergencies. Still others would be involved in a support role, facilitating the actions, response, and record keeping necessary for any type of emergency incident. Here is a list and brief description of the roles of the government agencies that participate in emergency planning and response.

Occupational Safety and Health Administration (OSHA)

OSHA requires Material Safety Data Sheets for hazardous substances that are listed under the Emergency Planning and Community Right-to-Know Act (EPCRA). With this data, OSHA helps ensure safe and healthful workplaces in America.

http://www.osha.gov/

State Emergency Response Commission (SERC)

It is the mission of the State Emergency Response Commission (SERC) and Local Emergency Planning Committees (LEPCs) to implement EPCRA and to mitigate the effects of a release or spill of hazardous materials.

http://www.ak-prepared.com/serc/

The National Response Center (NRC)

The National Response Center (NRC) is the sole Federal point of contact for reporting oil and chemical spills via their hotline or website. NRC Duty Officers take reports of actual or potential domestic terrorism and link emergency calls with DOD for technical advice on dealing with weapons of mass destruction and with the FBI to initiate Federal response actions. The NRC also provides reports and notifications to other Federal agencies as necessary. All local plans include contact information for the local FBI Field Offices.

http://www.nrc.uscg.mil/index.htm

Department of Defense (DOD)

See entry for the NRC.

http://www.defenselink.mil/

Federal Bureau of Investigation (FBI)

See entry for the NRC. The FBI is also the overall Lead Federal Agency (LFA) for a domestic terrorist incident involving weapons of mass destruction and will lead the crisis management activities (including law enforcement activities) of the response.

http://www.fbi.gov/

The Federal Emergency Management Agency (FEMA)

The Federal Emergency Management Agency (FEMA) is the lead agency for coordination of Federal support to State and local responders during consequence management activities of the response. FEMA support is provided only after a Presidential declaration, typically after State and local agencies request their assistance. The U.S. Attorney General may transfer the overall lead Federal Agency role to FEMA.

http://www.fema.gov/

Environmental Protection Agency (EPA)

EPA supports the Federal counter-terrorism program by: (1) helping State and local responders to plan for emergencies; (2) coordinating with key Federal Partners; (3) training first responders; and (4) providing resources in the event of a terrorist incident. Several offices within the Agency are involved in these efforts: The Chemical Emergency Preparedness and Prevention Office (CEPPO), the Office of Emergency and Remedial Response (OERR), the Office of Radiation and Indoor Air (ORIA), and the National Enforcement Investigations Center (NEIC).

http://www.epa.gov/ceppo/cntr-ter.html

Department of Health and Human Services (DHHS): The Office of Emergency Preparedness

The Office of Emergency Preparedness is responsible for coordinating DHHS continuity of government, continuity of operations, and the provision of public health and medical services following emergencies and disasters that sufficiently degrade local capacity as to require national assistance. In this role, DHHS also work with other federal agencies and

the private sector to develop capabilities and capacities for responding to the health and medical needs of affected populations.

http://www.hhs.gov/asl/testify/t980602c.html

American Red Cross (ARC)

The Red Cross use public information systems to provide human services information to the community, perform crisis counseling, provide insurance information and assistance, and provide translation services.

http://www.redcross.org/

The Department of Justice's Office for State and Local Domestic Preparedness Support (OSLDPS)

The Office for Domestic Preparedness (ODP) (formerly The Office for State & Local Domestic Preparedness) is the program office within the Department of Justice (DOJ) responsible for enhancing the capacity of state and local jurisdictions to respond to, and mitigate the consequences of, incidents of domestic terrorism. They also provide equipment grants and technical assistance to eligible communities.

http://www.ojp.usdoj.gov/odp/

http://www.ojp.usdoj.gov/terrorism/funding.htm

Department of Justice (DOJ)

The Department of Justice provides funds to cities participating in the Nunn-Lugar-Domenici (NLD) Domestic Preparedness Program (DPP) for the purchase of specialized training equipment for fire, emergency medical, hazardous materials response services, and law enforcement agencies. These funds will be used to build the training capacity of

these cities, and by extension, their capability to respond to acts of terrorism involving weapons of mass destruction (http://www.ojp.usdoj.gov/odp/docs/106120.pdf)

http://www.usdoj.gov/

APPENDIX I

COMMERCIAL EMERGENCY RESPONSE SYSTEMS

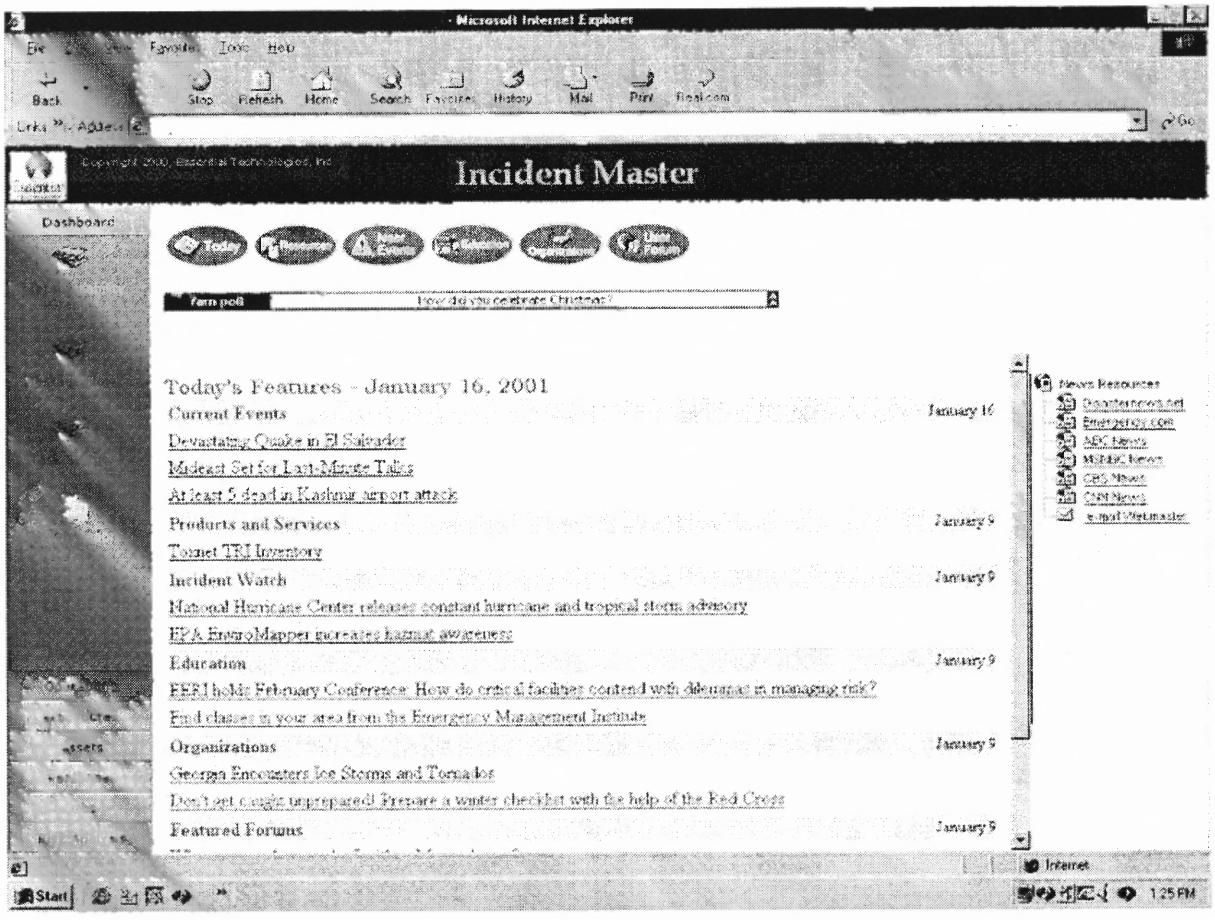
The following shows examples of commercially available emergency response systems.

Commercially Available Emergency Response Information Systems

A variety of information systems exist to facilitate emergency planning and response. They range from a rudimentary group of Excel spreadsheets to very sophisticated systems that incorporate GPS data for incident mapping. Listed below are examples of information systems that are available commercially.

Incident Master

Incident Master is designed by Essential Technologies. It is designed for management during crisis, rather than for planning purposes. It can also be used as a daily procedural tool that then shifts into crisis mode when needed. The design is appropriate for small scale incidents such as traffic accidents or larger incidents such as a hazardous waste spill. Incident Master helps the user keep a log of who did what and when. The software can then generate summary reports on what happened during the incident. For example, we could have a small county police department that uses the tool for daily information management, briefings, officer telephone number & locations, and asset/fleet management. When an incident or an event happens, Incident Master can be used to distribute manpower and materials in the appropriate fashion. A 3-day county fair would be a good example of a possible scenario. The software can print maps, assign vehicle assets, and act as an incident log for the duration of the fair. If a person is ejected from the fair by police, that person's picture can be taken and posted on the system for retrieval.

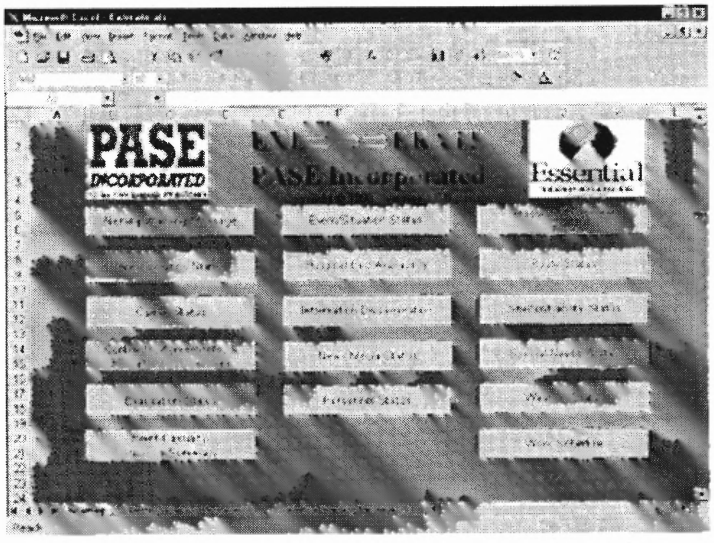


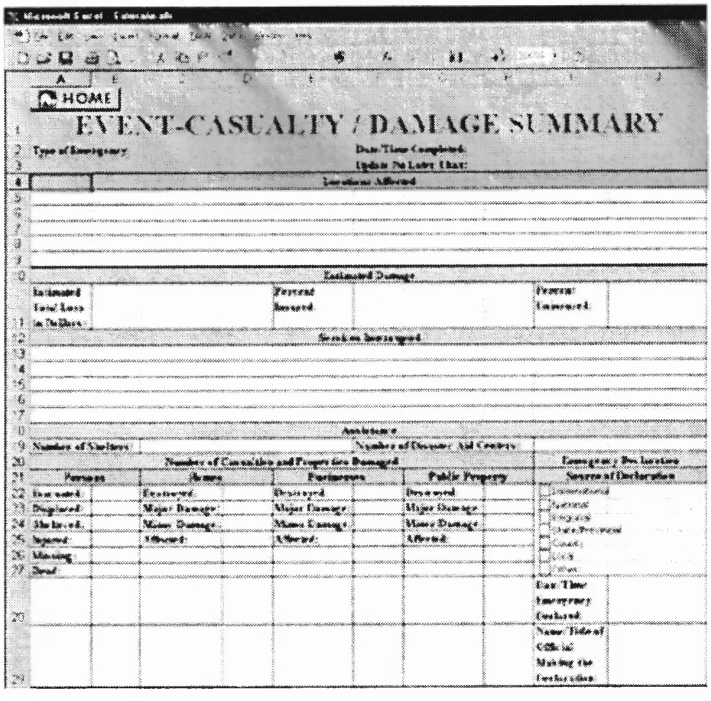
Exl-Erate

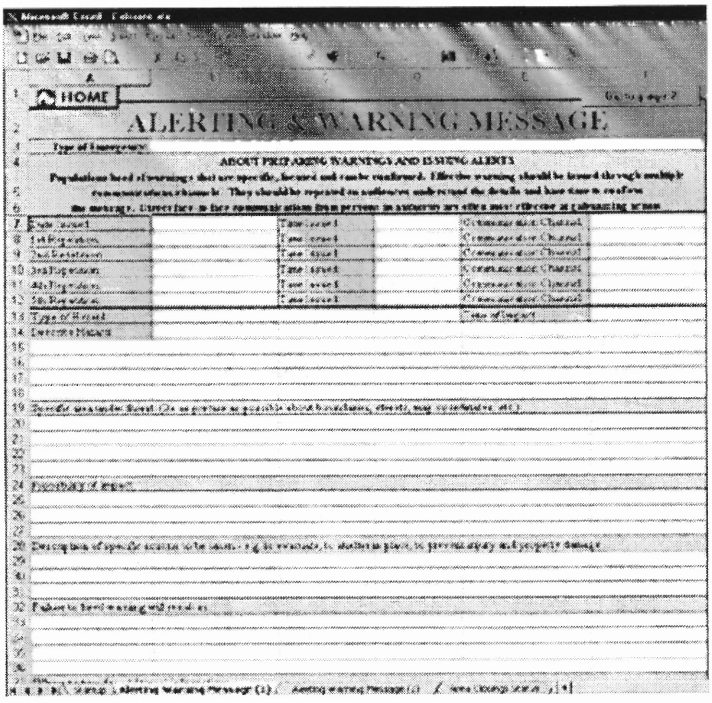
This software is one the simplest forms of an emergency response information system. Exl-Erate is essentially an organized collection of Microsoft Excel templates. It is very inexpensive. The inexpensive price would allow some local governments or other organizations access to a software package for emergency response, however rudimentary, when otherwise they may have nothing.

The system stores the relevant data about a specific town: population size, number of hospitals, number of beds in each hospital, amount of water in reserves, etc. When a disaster hits data is entered about that specific incident: for example, number of people homeless, injuries, number of homes damaged/destroyed. Exl-Erate then uses Excel

macros to calculate simple statistics: the amount of available shelter space, hospital space, the amount of food that is needed.

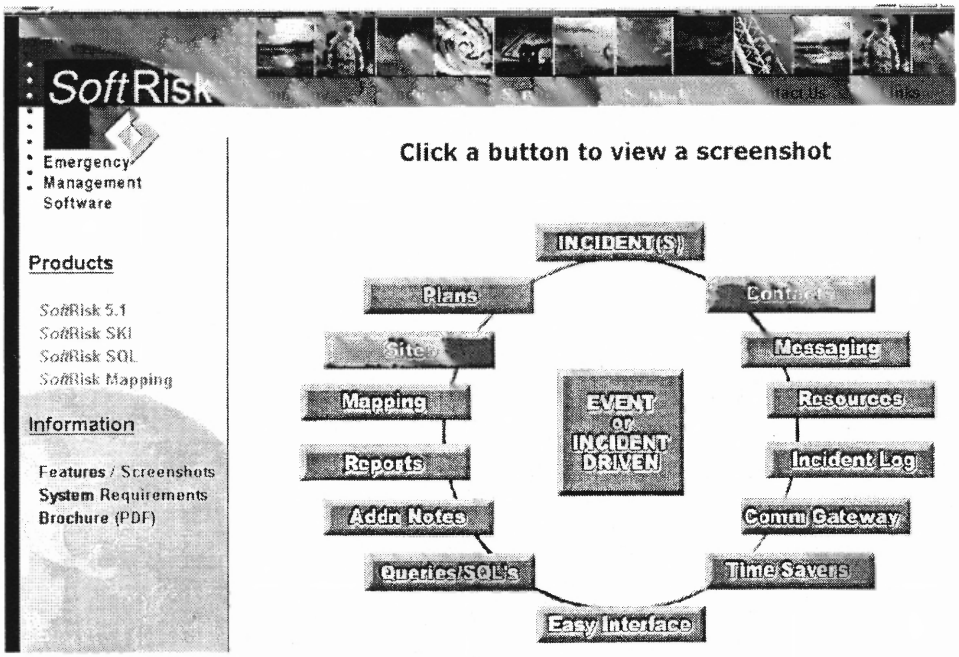






SoftRisk

SoftRisk Technologies has been developing emergency management software programs for over 10 years. SoftRisk has a built in mapping solution and also has an SQL version to handle WAN requirements and large amounts of data.



The basic design of the response system is based around the event or incident in question. Other functions allow the user to access plans for a given event, view database and spreadsheet data as visual maps, locate resources, create reports, and communicate with internal or external contacts. SoftRisk is a large database management system with advanced features like visual mapping to allow for quick view of data, update of data, and as a result may facilitate better response to situations.

SoftRisk's product line includes:

- SoftRisk 5.1 - basic system
- SoftRisk SKI- was created with help from the Copper Mountain, Colorado Ski Resort. SoftRisk SKI is the basic system with a customized add-on.
- SoftRisk SQL- is a modified version of SoftRisk created it to work with the Microsoft SQL Server® database.
- SoftRisk Mapping - This tool uses integrated mapping technology to locate shelter, routes and resources.

SoftRisk has been used or is currently being used by the following customers: Emergency Preparedness Canada , Missouri Emergency Management Agency, Royal

Canadian Mounted Police , Orange County, Florida Office of Emergency Management, City of Toronto Police , Copper Mountain Ski and Snowboard Resort, and Waterways Authority New South Wales.

EM/2000

EM/2000™ is an "open architecture" software system created by Specialized Disaster Systems International, Inc. that features flexible and user-friendly emergency planning, response and recovery capabilities. Decision makers can use EM/2000™ to quickly ascertain the magnitude of an emergency or disaster, locate and deploy resources, log incident activities, track requests and tasks, generate situation reports, and communicate critical information across local and wide-area networks and the internet. EM/2000™ has been designed to be adapted to the individual operational methods of each jurisdiction. EM/2000 resides in both in the client and the server. This allows for redundancy in the event of hardware failure or natural disaster. Through a process called replication, the client can set a scheduled update so the data on the client side and server side synchronizes. The client and servers are not directly connected so the system is portable. The system is regularly synchronized through dial-up, LAN, or directly through the server, based on a time schedule specified by the user. EM/2000 is also ODBC compliant and can be used with third-party reporting software like Lotus Notes.

EM/2000 has other backup features that will allow it to run in case of other disastrous scenarios. For example if there is a failure the EM/2000 can simply be switched to "stand-alone mode" and the client can resume normal operations with the

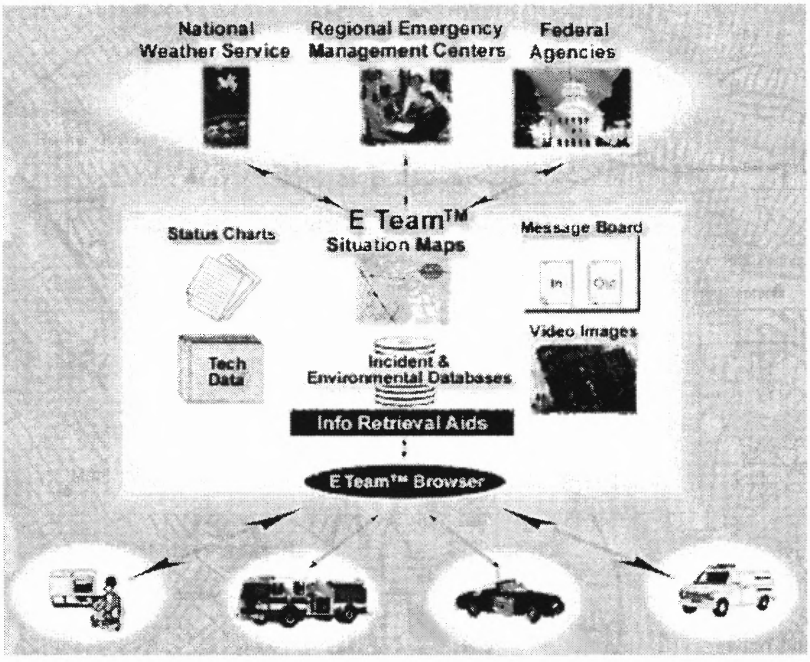
data that was previously replicated from the server. The user can still enter and query data on the client side.

Several county, state and federal government agencies are using EM/2000. These include Army National Guard, Air National Guard and the Wilmington District of the Army Corps of Engineers. The EM/2000 system played a crucial rule in the relief efforts for the Florida Wildfires in 1998, Hurricanes Dennis, Floyd and Irene in 1999 in North Carolina, the January 2000 winter storms of the East Coast, and the floods in Raleigh, NC in 1999.

E-TEAM

E-TEAM is more of a brand name of emergency management systems than an actual system. E-TEAM is an enterprise management system that helps organizations minimize the impact of disruptions to their operations via their numerous systems. According to the E-TEAM website, "E-Team™ is a "revolutionary Internet-based Incident Management Solution that enables government, public and private entities to dramatically improve their ability to prepare for, respond to, and recover from daily incidents, unplanned disasters and major events". This suite of tools enables emergency, event, and management personnel to create and immediately share the critical information that's required for accurate and timely incident summaries, response

management, resource procurement and management, as well damage assessment.



An integrated map system allows users to place event or incident icons at the exact location of the incident. Maps can be viewed to street level. E-Team is useful for collaborative, real-time Incident Management reporting, communication and decision making.

E-TEAM software is web and browser based. Some of the features of E-TEAM include: ASP or self-hosted: E-TEAM, Inc. hosts the system so the customer has direct access. There is no need to purchase, install, configure, or maintain hardware and software, the system is fully replicable, multilevel access and secure, instant messaging and interactive GIS mapping, resource and asset management, wireless PDA support for field operations, and it supports the Incident Command System.

The E-TEAM suite has three editions that cater to a wide variety of customers:

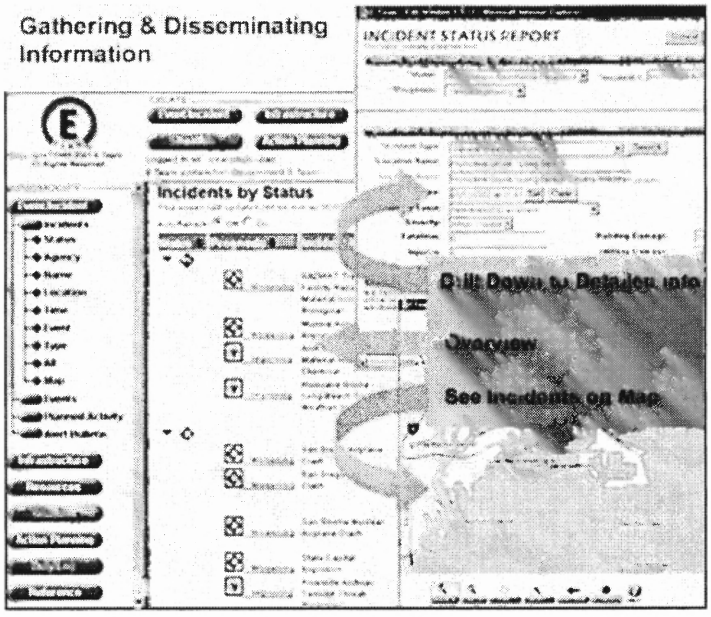
1. The *E-TEAM Government Edition* which caters to cities, counties, states and interagency.

2. *E-TEAM Enterprise Edition*, which caters to corporations, community organizations, facilities, and the general population.

3. *E-TEAM Mobile Edition* is for access with a laptop and Microsoft's Internet Explorer.

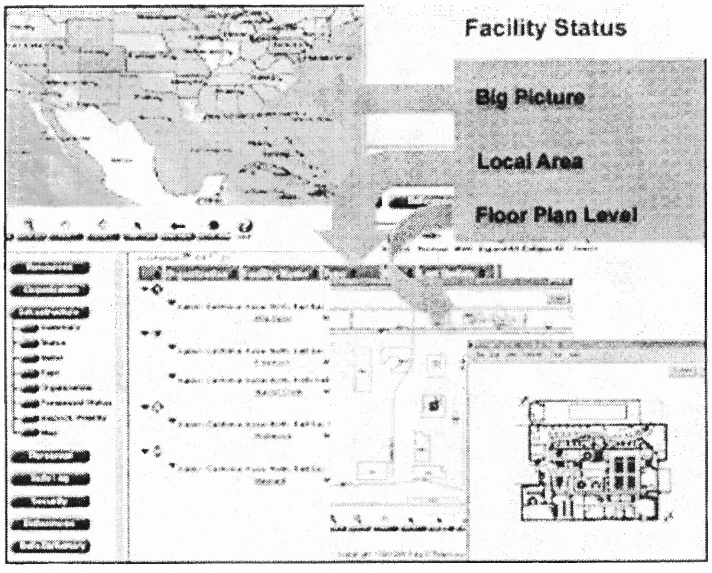
4. *E-TEAM Everyware* enables enterprise tools for jobs and incident management on PDA handhelds.

The *E-TEAM Government Edition* offers the following capabilities: The creation of different types of reports like Incident, Emergency Event, Planned Activity, Planned Event, Medical Incident, Alert Bulletin, Situation, Agency Situation, Intelligence, Corporate Situation and Public Information Reports. This Edition supports several infrastructures like hospitals, public facilities, road closures, shelters, and transit systems and utility outages. The Data Dictionary supports keywords, color-codes and check lists. The system can also create models and logs.



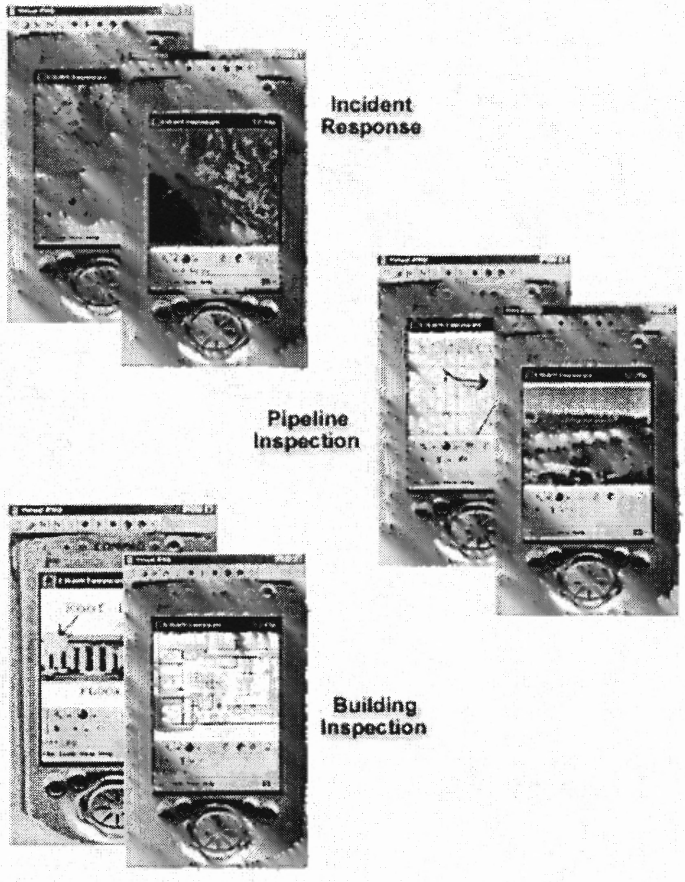
E-TEAM Government Edition

The *E-TEAM Enterprise Edition* is geared toward businesses and corporate clients. The features include the following types of reports: Emergency Events, Planned Events, Incidents, Planned Activities, Resource Request, Vendor, Infrastructure, Organization, Media, Personnel, Staff Assignments, Security and Duty Logs. This edition also allows web-enabled mapping displays of incidents, infrastructures, and resources. Latitude/longitude coordinates label these maps by address and intersection. Other features include email notification, full-text searching, and the ability to sort and categorize information.



E-TEAM Enterprise Edition

The *E-TEAM Mobile Edition* allows the user with a laptop, Internet Explorer and a wireless modem to become an "Incident Command Post" at the disaster site. This post will be linked to the organizations main system for easy coordination. The *E-TEAM Everyware Edition* integrates the following capabilities with PDA handhelds: Forms and reports such as incident reports, inspection forms, job orders, resource requests, field audits, contact reports, and floor plans. This edition also facilitates management decisions by providing updates, messaging, alerts, security, and user annotated maps and photographs, and global positioning.



E-TEAM Everyware Edition

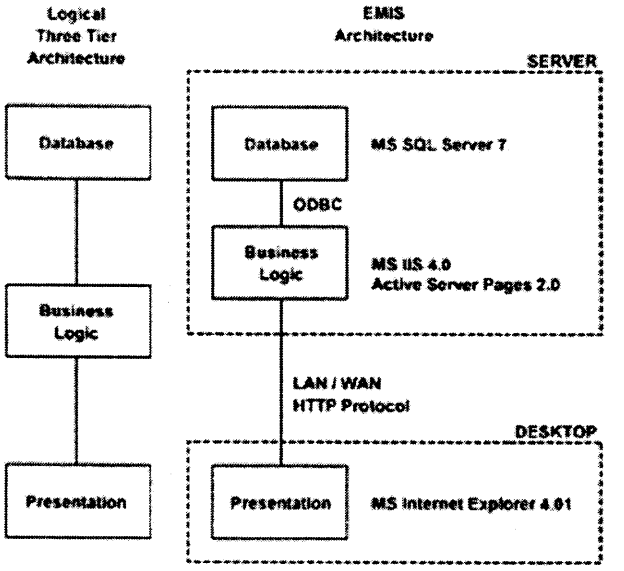
Emergency Manager

Emergency Manager is intranet based and logs, manages, and tracks emergency events and related actions and tasks as they occur. It is customizable and facilitates distributed information sharing. Emergency manager has these features:

- Roles and initial action checklists correspond to specific corporate emergency plans. In addition, all those logged on to the system can see which tasks have been completed and by whom.

- Emergency Manager permits activities and incidents to be logged as they come in, allowing all those involved to share information "real time.
- Participants can log on to the web from anywhere, 24 hours a day for remote access.
- Employees can keep in touch with their families through the Employee and Family Message Centre.
- Designed for viewing one-line summaries of the incidents recorded, the BBS can display photos as well as text.

Emergency Manager uses a logical three tier architecture according to the following diagram:



ERIS, Emergency Response Information System

This is a system that is funded by the state of Iowa and consists of GIS databases of local emergency response agency boundaries and attributes. It is distributed in a cd-rom

format that can be accessed with free GIS viewing software. This software may be developed into a web-based application in the future. The purpose of the system is to help local agencies visualize and improve their resource allocations.

infoWorx™

infoWorx is not a singular application, it is a collaborative environment made up of a number of tools. infoWorx offers you ***rental*** of your e(office + conferencing) collaboration environment. Each tool is either used for e-conferencing or to create an e-office. This in and of itself is not directly related to the emergency response domain, but it can easily be used towards those ends.

The infoWorx system is very unique in that you do not buy the software, instead you rent an e-office. A town or city pays a set amount per user month to have an e-office setup and hosted by infoWorx. A username and password is then given to all of the people that would be important to keep up to date in an emergency. Once the e-office is setup, users can login from anywhere in the world and communicate with everyone else. The system has a white board, text chat, A/V conferencing, and secure file storage that is searchable and accessible 24/7. The use of a laptop at the incident scene facilitates collaboration on emergency response alternatives.

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