12-12-2012 12:00 AM

Charateristics and Impact of Interpersonal Conflicts on Requirements Risks

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A thesis submitted in partial fulfillment of the requirements for the degree in Master of Science

CHARACTERISTICS AND IMPACT OF INTERPERSONAL CONFLICTS ON REQUIREMENTS RISKS

(Spine title: Impact of Interpersonal Conflicts on Requirements Risks)

(Thesis format: Monograph)

by

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Graduate Program in Computer Science

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science

The School of Graduate and Postdoctoral Studies
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London, Ontario, Canada

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CHARACTERISTICS AND IMPACT OF INTERPERSONAL CONFLICTS ON REQUIREMENTS RISKS

is accepted in partial fulfillment of the
requirements for the degree of
Master of Science

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Date

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Chair of the Thesis Examination Board

Abstract

Interpersonal conflicts in software projects have an impact on project's success, product's quality, team's performance, etc. However, in Requirements Engineering (RE), there is dearth of research on this topic; previous research has focused largely on conflicts among requirements. We conducted a case study of an industrial project to determine the *characteristics* (e.g., type, severity, conflict management styles, etc.) and *impact* of *interpersonal conflicts* rooted in *RE (RE-Conflicts)*, on project risks associated with requirements (e..g., inadequately identified requirements, incorrect requirements, etc). The findings show that the conflicts over administrative procedures (47%) had the highest frequency count. The highest number of RE-Conflict incidences took place in the elicitation activity (46%). A significant impact of RE-Conflicts on requirements risks was also observed (e.g., '*continually changing requirements'* was affected by 80% RE-Conflicts). This knowledge can aid in initiating risk management in RE and in developing tools, mitigation strategies and mid-range theories on RE-Conflicts.

Keywords: Software Engineering, Requirements Engineering, Empirical Study, Interpersonal Conflicts, Characteristics of Conflicts, Case Study, Nominal Group Technique, Project Risks, Requirements

Acknowledgments

First and foremost, I would like to thank Dr. Nazim Madhavji for his constant guidance, supervision, dedication and encouragement during this time for which I am truly indebted.

I am grateful to Mr. Puneet Arora, for participating in this study; I highly appreciate the energy and effort that was expended on his part. I would also like to thank all the members in my research team. A special thanks goes to Khalid Sherdil and Rashed Nekvi who have suggested many valuable ideas for conducting the research.

Last, but not the least, I would like to thank my grandparents, parents Mr. Varinder Walia and Mrs. Amarjit Kaur, brother Varjeet Walia and my friends Mrs. Gunwant Kaur and Savneet Arora for their ongoing patience , support, love and trust that acted as a driving force for the completion of the work.

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Glossary: List of Abbreviations

AORE	Aspect Oriented Requirements Engineering
DSD	Distributed Software Development
GORE	Goal Oriented Requirements Engineering
GQM	Goal Question Metric
NFR	Non Functional Requirements
NGT	Nominal Group Technique
PM	Project Manager
RA(s)	Requirement Analyst(s)
RE	Requirements Engineering
SE	Software Engineering
SLR	Systematic Literature Review
SRS	Software Requirements Specification

Glossary: List of Terms

Agile Software Development	It is a conceptual framework that follows iterative and incremental approach to software development. The requirements and solutions evolve through high collaborative process between self-organizing teams (Beck, 2003).
Aspect Oriented Requirements Engineering (AORE)	It is the process of identification of crosscutting properties of the system being developed at the requirements level. Crosscutting properties are those which either affect or rely on other system components or requirements (Grundy, 1999).
Case Study	It is empirical method involving information gathering from entities (e.g. a person, group, event, etc.) and having lack of experiment control (Yin, 2009).
Compliance requirements	Compliance requirements are those which are compliant with the related regulations (Maxwell et al., 2011).
Descriptive statistics	Descriptive statistics are used on a sample to estimate characteristics, or traits of a population, i.e., describing the main features of a collection of data (Nick, 2007).
Delphi Study	The Delphi method is a proven, popular tool in information systems research for identifying and prioritizing issues by considering opinions of all the participants who are isolated from each other. An anonymous summary of results of all the participants in the panel are shared to encourage them to revise their earlier answers in light of the replies of other participants (Ven & Delbecq, 1974).
Empirical Studies	It is a method of gaining knowledge or results from either direct/ indirect observations or experimentations, using qualitative and/or quantitative analysis methods (Shull, F., Singer, J., & Sjoberg, D. I. K., 2008).
Enterprise Resource Planning (ERP)	ERP systems automate business functions of an organization by providing an integrated software application that considers the internal and external management information across an entire organization. For example, it embraces finance/ accounting, manufacturing, sales and service, etc. business functions of the organization to facilitate the flow of information between all business functions inside the boundaries of the organization and manage the connections to outside stakeholders (Dredden & Bergdolt, 2007).
Goal Oriented Requirements Engineering (GORE)	It is the process of identification of requirements that capture the goal and objectives, a system under consideration should achieve at different levels of abstraction (Yamamoto, S., Kaiya, H., Cox, K. & Bleistein, S., 2006).
Interpersonal Conflict	An interpersonal conflict defined as a situation in which people are involved in a disagreement over some issues; perceive threat to their

	needs, interests, or concerns (Thomas, 1976).
Mid-Range Theories	Mid-range theories aim to discover and discuss relationships between abstract concepts and are closely linked to observations (Carroll, 2000).
Nominal Group Technique (NGT)	Nominal Group Technique (NGT) is an established, qualitative research tool that aids in developing a prioritized list of responses to a specific question by taking into account the opinions of all the participants (Harvey & Holmes, 2012).
Requirements Engineering (RE)	Requirements Engineering is a process of system and software development that covers all of the activities involved in discovering, documenting and maintaining a set of requirements for a computer-based system (Kotonya & Sommerville, 1998).
RE-Activities	The activities performed during the Requirements Engineering (RE) process. They include elicitation, negotiation, prioritization, analysis, validation and specification of requirements (Kotonya & Sommerville, 1998).
RE-Conflict	A conflict rooted in Requirements Engineering.
Risk	Risk is an uncertain event or condition that might have positive or negative impact on objectives of a project (PMBOK, 2012 edition).
Risks Dimensions	The researchers have categorized software risks into six dimensions, namely, user (U), requirement (R), project complexity (Comp), planning and control (P&C), team (T), and organizational environment (Org) (see Table 16, Appendix C).
Systematic Literature Review (SLR)	It is a systematic, rigorous literature reviewing technique that aims to gather all existing evidence relevant to the research questions. It follows a methodological approach by explicitly defining full protocol (e.g., research questions, search process, inclusion/exclusion criteria, etc.) to guide the process (Kitchenham et al., 2007).
Software Engineering (SE)	"Software engineering refers to the disciplined application of engineering, scientific, and mathematical principles and methods to the economical production of quality software" (Humphrey, 1988).
Software Requirements Specification (SRS)	The requirements of the system under development are recorded in this document (SWEBOK, 2004 edition).
Thematic Coding Scheme	This technique involves scanning the data and categorizing segments of interest.

Definitions

(i) A *conflict* is defined as a situation in which people involved in a disagreement over some issues; perceive threat to their needs, interests, or concerns (Thomas, 1976). These include the following example situations:

a) Disagreement among stakeholders over technical issues
b) Disagreement among stakeholders over schedules
c) Disagreement among stakeholders over project priorities

(ii) *Risk is* defined as an uncertain event or condition that might have a positive or negative impact on the objectives of a project (PMBOK, 2012 edition).
In the context of this thesis, risk is defined as an uncertain event or condition that could positively or negatively affect the system requirements. Examples of these include:

a) Elicitation of incorrect requirements
b) Elicitation of non-testable requirements
c) Frequent changes in the elicited requirements

Chapter 1

1 Introduction

In significant software development projects, conflicts, if not inevitable, are known to occur. Though the *interpersonal conflicts* have been extensively explored in several fields such as general managerial projects (e.g.,Kerzner,1992;Posner,1986), Software Engineering (SE) projects (e.g., Karn & Cowling, 2008; Liang, T. P., Jigan, J., Klein, G.S. & Liu, J.Y.C., 2010), etc., yet they have not been well researched in the current context of Requirements Engineering (RE) field. Our study investigates the characteristics and impact of interpersonal conflicts, rooted in RE (henceforth, termed as RE-Conflicts[1]), on the project risks (specifically those associated with requirements). Since the interpersonal conflicts impact several aspects of a project (Barki & Hartwick., 2001; Gobeli, D.H., Koenig, H.F., & Bechinger, I., 1998; Karn, 2008; Karn & Cowling, 2008; Liang, T. P., Jigan, J., Klein, G.S. & Liu, J.Y.C. , 2010; Sawyer, 2001; Sherif, K., Zmud, R.W., & Browne, G.J., 2006; Robey, D., Farrow, D., L., & Franz, C., R., 1989; Robey, D., Smith, L.A., & Vijayasarathy, L.R., 1993; Robey & Farrow, 1982), therefore, exploring the interpersonal conflicts in RE has its implications both in the software development practice and research.

In Section 1.1, we discuss the motivation for our study. Section 1.2 gives an overview of the related work on conflicts in RE and Section 1.3 describes the originality of the research. The generalized research question is given in Section 1.4. The significance of the study has been described in Section 1.5. The key results of the study have been discussed in Section 1.6. Finally, the chapter concludes by describing the organization of the thesis in Section 1.7.

1.1 Motivation

The literature has shown that unresolved interpersonal conflicts have a strong, negative effect on the software product success and customer satisfaction (Gobeli et al., 1998;

[1] In this thesis, we have termed the interpersonal conflicts rooted in Requirements Engineering as *RE-Conflicts*

Robey et al., 1993). Further, conflict management has been stated as one of the eight most critical project success factors by Gemunden and Lechler (1997). Also, a manager is known to spend on an average 18-26% of their time dealing with the conflicts (Thomas & Schmidt, 1976). Kerzner (1992) claims that conflict "may be the single most important characteristic of the project environment." Hence, conflicts are clearly an important topic for a project's outcome, yet in the field of RE not much is known about interpersonal conflicts and their impact on project parameters.

In group interactions, requirements definition is a prime area for substantial conflicts (Elam & Walz, 1988). Also, a "close" relationship between conflicts and risks in downstream software development has been mentioned by Sage (2003); yet no scientific studies appear to exist on the "conflict-risk" relationship in *RE*. This is important to investigate because as much as 24% of the overall project risks which are "high level risks", are rooted in the early phases of software development (Amber, S., Shawoo, N., & Begum, S., 2012).

1.2 Background Overview

In the conflicts area, the research in RE has largely focused on RE tools and frameworks to identify and resolve conflicts among requirements. Studies have been conducted on both conflicts in general requirements (Hartwell, 1991; Kim, M., Park, S., Sugumaran, V. & Yang, H., 2007) as well as conflicts in specific requirements such as Non Functional Requirements (NFR) (Boehm & In, 1996; Egyed & Grubacher, 2004; In H., Boehm, B., Rodgers, T., & Deutsch, M., 2001;Liu, 2010; Poort & De With, 2004; Sadana & Liu, 2007), compliance[2] requirements (Maxwell, J.C., Anton, A.I., & Swire, P., 2011), requirements in Aspect Oriented Requirements Engineering[3] (AORE) (Sardinha, A., Chitchyan, R., Weston, N., Greenwood, P. & Rashid, A.,2009) and requirements in Goal

[2] Compliance requirements are those which are compliant with the related regulations (Maxwell et al., 2011).

[3] Aspect Oriented Requirements Engineering (AORE) is the process of identification of crosscutting properties at the requirements level. Crosscutting properties are those which either affect or rely on other system components or requirements (Grundy, 1999).

Oriented Requirements Engineering[4] (GORE) (Lamsweerde, A.V., Darimont, R., & Letier, E. ,1998).

A web-based model that supports resolving inter-personal conflicts among group members to produce a correct formal software specification document was presented by Sullabi, M.A., Abugharsa, M.B. and Taher, A.M. (2012). Elam and Walz (1988) showed that conflict is a consistent but fairly small percentage of the group interaction, and that the issues are not resolved in a top-down manner which causes them to resurface at later meetings. Damian and Zowghi (2003) studied how culture, conflict and distance interplay in globally distributed requirements. Khan, H.H., Malik, N., Usman, M., and Ikram, N. (2011) had reported a positive impact on the conflict resolution due to the change of sequence of communication medium in Distributed Software Development (DSD) settings. Beyond these works, there have been no studies, to our knowledge, on inter-personal conflicts in RE.

1.3 Originality of Research

While studies show that there is significant impact of interpersonal conflicts on project success (Gobeli et al.,1998; Robey et al., 1993), product's quality (Liang et al., 2010), team's performance (Karn & Cowling, 2008), etc., there is scarcity of research in RE, on the interpersonal conflicts. As discussed in Section 1.2, the research in RE has largely focused on RE tools and frameworks to identify and resolve conflicts among requirements. Our work, on exploring the *characteristics and impact of interpersonal conflicts, rooted in RE,* is thus quite complementary to these other works. To the best of our knowledge, no scientific studies have been conducted on these aspects of interpersonal conflicts in RE. An example of interpersonal conflict, rooted in RE, is disagreement between clients and developers over the selection or prioritization of requirements for the next release.

[4] Goal Oriented Requirements Engineering (GORE) is the process of identification of requirements that capture the goal and objectives, a system under consideration should achieve at different levels of abstraction (Yamamoto, S., Kaiya, H., Cox, K. & Bleistein, S., 2006).

1.4 Generalized Research Question

A software project has several aspects such as costs (Boehm & Papaccio, 1988), quality (Berenbach, 2006), RE-Success factors (El Elam & Madhavji, 1995), risks (Arnuphaptrairong, 2011), etc. The RE-Conflicts might have an impact on these aspects of a software project. However, this thesis investigates specifically the impact of RE-conflicts on the project risks associated with requirements such as inadequately identified requirements, non-traceable requirements, incorrect requirements, etc.

In the quest to explore RE-Conflicts, the key generalized research question posed in this study is:

"What are the characteristics and impact of interpersonal conflicts, rooted in requirements engineering, on the project risks associated with requirements?"

We conducted an exploratory case study on a software project of a small-sized software development company to investigate the research question.

1.5 Significance of Research

Determining the types of risks associated with requirements (e.g., inadequate requirements, incorrect requirements, non-testable requirements, etc.) affected by the RE-Conflicts (e.g., conflicts over administrative procedures, schedules, priorities, etc.) can aid practitioners to initiate the risk management process in the RE phase itself which is usually considered from the design phase (Amber et al., 2012). Amber et al. (2012) have also supported the initiation of risk management in RE by reporting the fact that 24% of the overall project risks which are "high level risks" occur in the early phases of software development. In addition, both lack of conflicts management (Gobeli et al., 1998; Sherif et al.,2006) as well as risks management (e.g., Cerpa & Verner, 2009; Svensson & Aurum, 2006) have been independently stated as major factors leading to project failures. Therefore, initiating risk management process in RE by managing the RE-Conflicts might also contribute in lowering the project failures.

The project risks associated with requirements such as inadequate requirements, incomplete requirements, inconsistent requirements, etc. have critical impact on software's quality (Bell & Thayer, 1976). Boehm (1981) estimated that late corrections done to requirements errors could cost up to 200 times more than the corrections performed during RE. Hence, to improve the quality of software and to lower the costs of project development, practitioners can utilize the findings of the study to create strategies for the mitigation and avoidance of RE-Conflicts affecting project risks associated with requirements.

To the best of our knowledge, there are no scientific studies conducted on the RE-Conflicts. Hence, this study can aid in developing emerging mid-range theories[5] on the RE-conflicts. Similarly this study can also encourage researchers for conducting further confirmatory and complementary studies on RE-Conflicts. It can also motivate researchers to develop new RE technologies such as RE-Conflict sensitive tools. Our study can also provide a ground work for conducting further research to explore the impact of RE-Conflicts on other project parameters such as costs (Boehm & Papaccio, 1988), quality (Berenbach, 2006), RE-Success factors (El Elam & Madhavji, 1995), etc.

1.6 Key Results

The case study has explored the characteristics (e.g., type, severity, conflict management style, etc.) of RE-Conflicts and their impact on requirements risks. The findings have shown that conflicts over administrative procedures (47%) had the highest frequency count and conflicts over schedules (8%) had the lowest frequency count (see Figure 7, § 4.1.1). The highest numbers of RE-Conflicts were encountered in the elicitation (46%) and negotiation (31%) activities respectively (see Figure 8, § 4.1.2). 70% of the RE-Conflicts in the case study were between users and analysts (see Figure 9, § 4.1.3). 77 % of these RE-Conflict incidences were unresolved and 80% of those unresolved RE-Conflicts were between users and analysts (see Figure 11, § 4.1.5). Most of the RE-Conflicts (46%) were associated with high severity levels, i.e., 5 and 6 in the ordinal

[5]Mid-range theories aim to discover and discuss relationships between abstract concepts and are closely linked to observations (Carroll 2000).

scale ranging from 1 to 6 (see Figure 10, § 4.1.4). The 'forcing' (39%) conflict management style was observed to be the most widely adopted management strategy for resolving conflicts in the case study whereas 'collaborating' conflict management strategy was never used to resolve RE-Conflicts (see Figure 12, § 4.1.6).

A significant impact of RE-Conflicts on requirements risks was also reported by the findings of the case study. The following requirements risks were affected the most by the RE-Conflicts: *'misunderstanding of requirements'* (80%), '*continually changing requirements'* (80%), *'late changes to requirements'* (80%) and *'development of wrong software functions'* (60%) (see Figure 13, § 4.2).

1.7 Thesis Organization

Chapter 2 discusses the research work related to the conflicts in SE and RE and presents the analysis of the research gap. In Chapter 3, we have described the core parts of the case study, which describes the research goals, includes a discussion on the Goal Question Metric (GQM) method (Basili, V. R., Caldiera, G., & Rombach, H., 1994) which was followed to structure the study. In this chapter, we will also discuss the context of the study (project under case study), the research procedures followed, the participants of the study and the threats and risks to the study. Chapter 4 discusses the results of the study and their interpretations. The implications of the study have been described in chapter 5. Finally, chapter 6 concludes the thesis by discussing the limitations of the study and our ongoing future work.

Chapter 2

2 Related Work

Interpersonal conflicts are an important characteristic of project environment (e.g., Harris & Looney, 1999; Karn, 2008). They have been well researched in various fields such as project management, social sciences, psychology, etc. However, since the focus of our study is on RE, which is an integral part of SE field, therefore, in this chapter we have examined and demonstrated the work on conflicts in SE and RE.

In order to find the research gap in the area of interpersonal conflicts in the field of SE with focus on the field of RE, we performed a Systematic Literature Review (SLR)[6] (Kitchenham, B., Brereton, O.P., Budgen, D., Turner, M., Bailey, J., & Linkman, S., 2007). The design, process and the outcomes of the SLR were validated by relevant experts. In addition, several brainstorming sessions were conducted with various software researchers and industry personnel to gain insights into the present demands of the industry and research on this topic. The following example questions were investigated using this technique:

- *What is the importance of exploring interpersonal conflicts?*
- *What research topics have been addressed on interpersonal conflicts in SE and RE?*
- *What are the future works suggested by researchers on the interpersonal conflicts in SE and RE?*
- *What research topics have not yet been addressed by the previous works on conflicts in SE and RE?*

Several search strings (keywords) were used including the following example strings:

- *Conflicts (or Interpersonal Conflicts) AND Software Engineering*
- *Conflicts (or Interpersonal Conflicts) AND Software Projects*

[6] Systematic Literature Review (SLR): It is a systematic, rigorous literature reviewing technique that aims to gather all existing evidences relevant to the research questions. It follows a methodological approach by explicitly defining full protocol (e.g., research questions, search process, inclusion/exclusion criteria, etc.) to guide the process (Kitchenham et al., 2007).

- *Conflicts (or Interpersonal Conflicts) AND Information Technology Projects*
- *Conflicts (or Interpersonal Conflicts) AND Requirements Engineering*
- *Conflicts (or Interpersonal Conflicts) AND Requirements*

These strings were used in the search engines of some of the most important scientific publications such as IEEE Digital Library, ACM Digital Library, Wiley InterScience, Springer, Kluwer, Synthesis Digital Library of Engineering and Computer Science Literature and others. An important source of grey literature, i.e., Google Scholar was also taken into account. In SE, only studies regarding *interpersonal conflicts* were considered as the inclusion criteria because the focus of our study was on interpersonal conflicts in particular. Hence studies on the conflicts regarding specific phases of software development life cycle (e.g., architecture, testing, maintenance, etc.) were not selected for the review. Also, since our study focused on RE, research on conflicts in requirements were also examined along with the research on interpersonal conflicts.

The goal of our study and the associated research questions, which are discussed in detail in Section 3.1 were derived by analyzing the research gaps obtained (see § 2.3) by performing this SLR. Section 2.1 and Section 2.2 describe the work related to our study on conflicts in SE and RE fields respectively. We conclude in section 2.3 by giving the analysis of the research gap based on our literature review.

2.1 Conflicts in Software Engineering (SE)

On performing SLR, we found that the previous work on conflicts in SE has focused on the following three key dimensions: *(i) the impact of interpersonal conflicts, (ii) the management of interpersonal conflicts and (iii), the factors affecting interpersonal conflicts.* Sections 2.1.1 to 2.1.3 describe the work done on these dimensions of conflicts in SE. In Appendix A (Table 14) we have provided the summary of research conducted on interpersonal conflicts in SE in a chronological order.

2.1.1 Impact of Interpersonal Conflicts

In SE, the researchers have studied the impact of interpersonal conflicts on various aspects such as software quality, team performance, project success, etc. As early as 1998, a strong, negative effect of unresolved conflicts was found on the overall software product success and customer satisfaction based on a survey comprising of 117 software professionals and managers (Gobeli et al., 1998). Karn and Cowling 2008 observed three teams consisting of Master of Science students during the feasibility, requirements analysis, and design phases of SE projects to find the impact of interpersonal conflicts on the performance of teams. The analysis showed that the team that experienced moderate levels of task conflicts in comparison with other teams performed the highest. The authors also concluded that conflicts in SE teams per se are not intrinsically good or bad and their nature depends on factors such as effectiveness of conflict management strategies adopted and frequency of occurrence of conflicts.

Three forms of conflicts have been identified in general team-process research: task conflicts (Dreu & Weingart, 2003), relationship conflicts (Amason, 1996) and process conflicts (Jehn, 1995). Researchers in SE have found that these forms of conflicts have different consequences. For example, Karn (2008), based on the analysis of the ethnographic study of seven SE teams, reported that task conflicts were beneficial when they were based on either core project or technical issues. Process conflicts were found to be slightly more destructive whereas the relationship conflicts were found to be overwhelmingly destructive. Analogously, (Liang et al., 2010) reported that relationship conflicts have negative impact on the quality of software whereas the task-conflicts aid in improving software quality by increasing learning opportunities.

2.1.2 Management of Interpersonal Conflicts

There is an abundance of research work done in SE on the management of interpersonal conflicts. Sherif et al. (2006) studied the management of conflicts in software reuse. The authors found that companies implementing appropriately devised managerial

interventions for managing conflicts are the ones that experience greater success as compared to others who do not implement them. Similar results were reported by Sawyer (2001) , showing nearly one-half of the variance between the most successful software development teams and the least successful software development teams based on how effectively the conflicts were managed. However, Barki & Hartwick (2001) found that conflict management could not substantially ameliorate the negative effects on the information system development outcomes.

In a seminal paper in management projects, Blake and Mouton (1964) presented five general techniques for resolving conflicts: avoiding (withdrawing), accommodating (smoothing), compromising, forcing and problem solving (confronting). Several researchers have explored these conflict management strategies in the SE context. Gobeli et al. (1998) , from the survey of 117 software professionals and managers, discovered that smoothing, withdrawing, and forcing conflict management strategies have dysfunctional effects whereas the compromising conflict management strategy has beneficial impact on the project success. The 'compromising strategy' was found to be the most frequently adopted conflict management strategy by Laurindo & Moraes (2006). The findings of Dechurch, L.A., Hamilton, K.L., and Haas, C. (2007) showed that adoption of the 'forcing' conflict management strategy has the highest negative impact on relationships whereas using the 'collaborating' management strategy has the least effect on the interpersonal relationships.

2.1.3 Factors affecting Interpersonal Conflicts

Factors affecting interpersonal conflicts have also been explored in the SE field. A series of studies were conducted in 1982, 1989 and 1993, to investigate the relationship among conflict, influence, user participation and conflict resolution (Robey & Farrow 1982; Robey et al.1989; Robey, D., Smith, L.A., & Vijayasarathy, L.R., 1993). Studies conducted in 1982 and 1989 showed that the user participation results in influence which in turn positively affects both conflicts and conflict resolution. In 1993, on further exploring these relationships, it was found that a strong negative relationship exists between conflict resolution and project success and a modest positive relationship exists

between user participation and project success. Lewis and Smith (2008) investigated the impact of dominance of problem solving style on the group conflict. From the case-study comprising of 38 students enrolled in two fifteen week SE courses, they found that a negative relationship exists between the dominance of problem solving style and group conflicts.

2.2 Conflicts in Requirements Engineering (RE)

Researchers have covered two dimensions of conflicts in RE: *(i) conflicts in requirements and (ii) interpersonal conflicts*. By carrying out SLR, it was found that the work on conflicts in RE has been mostly focused on the conflicts in requirements whereas the interpersonal conflicts in RE have not been well researched. Section 2.2.1 describes the work done in RE on the conflicts in requirements and Section 2.2.2 gives the work done on the interpersonal conflicts in RE. In Appendix A (Table 15) we have provided the summary of the work done on conflicts in RE in a chronological order.

2.2.1 Conflicts in Requirements

In the area of RE, previous research on conflicts has been focused largely on identifying and resolving conflicts in general requirements (Hartwell, 1991; Kim, M., Park, S., Sugumaran, V., & Yanag, H., 2007) as well as conflicts in specific requirements such as conflicts among NFR (Boehm & In, 1996; Egyed & Grubacher, 2004; In et al., 2001;Liu, 2010; Poort & De With, 2004; Sadana & Liu, 2007), compliance requirements (Maxwell et al. 2011), requirements in AORE (Sardinha et al., 2009) and requirements in GORE (Lamsweerde et al., 1998). An early research for identifying quality requirements conflicts was carried by Boehm (1996). The author presented an exploratory knowledge-based tool for identifying potential conflicts among quality requirements, named 'Quality Attribute Risk and Conflict Consultant (QARCC)'. In 2001, the effectiveness of the tool was tested, and it was found that the tool surfaced a larger number of quality requirements conflicts and options than performed manually by the stakeholders (In et al., 2001).

Egyed & Grubacher (2004) presented an automated and tool-supported approach for the identification of requirements conflicts. Poort & De With (2004) presented a framework for resolving requirements conflicts, termed as Non- Functional Decomposition (NFD). Similarly, Sadana and Liu (2007) also presented a framework for the analysis of conflicts among NFR based on the integrated analysis of functional requirements and NFR. Recently, Liu (2010) also proposed a conflict analysis method for NFR. He proposed a domain independent NFR ontology, 7 kinds of metadata for modeling NFR and 7 conflict detection rules for NFR.

Kim et al. (2007) had presented an approach for the systematic identification and management of conflicts. Various techniques for the evaluation of conflicts among requirements, analysis methods for the resolution of conflicts and the impact of technology trends on conflicts have been discussed by Hartwell (1991). Conflicts among compliance requirements have been recently studied by Maxwell et al. (2011). Based on the results of a case study, the authors identified five sets of conflicting compliance requirements and recommended strategies for resolving these conflicts. Sardinha et al. (2009) presented an automated tool, EA-Analyzer for the identification of conflicts in AORE. A formal framework for clarifying various types of inconsistency that might arise in GORE and various formal techniques and heuristics for conflict detection has been proposed by Lamsweerde et al. (1998).

2.2.2 Interpersonal conflicts

Interpersonal conflicts have not been very well researched in RE. To our knowledge, none of the studies have explored the characteristics (e.g., severity of conflicts, RE-Activities in which they were encountered, etc.) and impact of interpersonal conflicts in RE on various project parameters such as risks, costs, quality, etc.

Early in this year, a study was conducted on how conflicts among the group members may be managed in order to produce a correct software formal specification (Sullabi et al., 2012). A web-based model of Computer Supported Cooperative Work (CSCW) that supports collaborating on preparing a correct formal software specification document was

presented. The requirements instability was reported to lead to potential interpersonal conflicts by Liu, J. Y., Chen, C. C., Chen, H., and Sheu, T. S. (2011) based on a survey of top 1600 companies in Taiwan. Another study on the interpersonal conflicts within a software design team which took place during the requirements definition phase of an actual software development project was carried out by Elam and Walz (1988). The analysis showed that conflict is a consistent but fairly small percentage of the group interaction, and that the issues are not resolved in a top-down manner which causes them to resurface at later meetings.

A few studies have also been conducted in RE on the interpersonal conflicts in DSD environment, particularly the off-shore model. Damian and Zowghi (2003) studied how culture, conflict and distance interplay in globally distributed requirement negotiations and presented a model of impact on RE activities due to various challenges such as cultural diversity, time and distance differences, etc. Khan et al. (2011) had reported a positive impact on the conflict resolution due to the change of sequence of communication medium in DSD settings.

2.3 Research Gap Analysis

As discussed in Section 2.1.1, conflicts in SE teams impact the software quality (Liang et al., 2010) and the performance of teams (Karn & Cowling, 2008). The unresolved conflicts were found to have a strong negative effect on the overall software product success (Gobeli et al., 1998 ;Robey et al., 1993) and customer satisfaction (Gobeli et al., 1998). Therefore, as discussed in Section 2.1.2, many researchers have emphasized the need for effective conflict management (Barki & Hartwick, 2001; Gobeli et al., 1998; Laurindo & Moraes, 2006; Robey et al., 1989; Robey & Farrow, 1982; Sawyer, 2001; Sherif et al., 2006). For example, the results of the study conducted by Sawyer (2001) showed that there was nearly one-half of the variance between the most successful and least successful software development teams based on how the conflicts were effectively managed.

Thus, clearly, conflicts are an important topic for a project's outcomes. Yet in the field of RE, to our knowledge, there is no scientific study on the characteristics and impact of interpersonal conflicts on project parameters such as risks (e.g., inadequate effort-estimation, inadequately identified requirements, failure to manage end user expectations, etc.), costs (e.g., documentation costs, development costs, rework costs, etc.), RE-Success factors (e.g., the clarity of the business process in the architecture, the extent of user consensus on the recommended solution, the completeness of coverage of the cost/benefits analysis, etc.) (El Emam & Madhavji, 1995), etc. Table 1 enumerates the research gap in RE by giving those aspects of interpersonal conflicts that have been explored in SE but have not yet been investigated in RE. The research questions which are discussed in the next chapter (§ 3.1) have also been specified in the Table 1 to demonstrate their link with the research gap.

Table 1: The research gap on interpersonal conflicts in RE and the research questions addressing the research gap

Research gap: Aspects of interpersonal conflicts explored in SE but not yet investigated in RE (§ 2.1, § 2.2.2)	**Questions in this study addressing the research gap (§ 3.1)**
Characteristics of interpersonal conflicts (e.g., types of interpersonal conflicts, conflict management strategies, severity, etc.)	• Types of RE-Conflicts (**Q 1.1**) • RE-Activities in which RE-Conflicts are encountered (**Q 1.2**) • Stakeholders involved in RE-Conflicts (**Q 1.3**) • Severity of RE-Conflicts (**Q 1.4**) • Degree of resolution of RE-Conflicts (**Q 1.5**) • Management styles adopted for RE-Conflicts (**Q 1.6**)
Impact of interpersonal conflicts (e.g., impact on software quality, team performance, project success, etc.)	• Impact of RE-Conflicts on project risks associated with requirements (**Q 2.1**)

As discussed in Section 2.2.1, largely, the focus of the research on the conflicts in the RE field has been on the conflicts in requirements such as conflicts among NFR (Boehm & In, 1996; Egyed & Grubacher, 2004; In et al., 2001;Liu, 2010; Poort & De With, 2004;

Sadana & Liu, 2007), compliance requirements (Maxwell et al., 2011), requirements in AORE (Sardinha et al., 2009), and others.

Little consideration has been given to the interpersonal conflicts in RE. In Section 2.2.2, we discussed the studies that have been conducted so far on the interpersonal conflicts in RE. It was found that there have been no studies conducted on the characteristics and impact of RE-Conflicts on project parameters.

Also, as mentioned above, the impact of RE-Conflicts on other project parameters such as costs, product quality, RE-Success factors, resource consumption, product release, etc. has not yet been explored in RE. Thus, these are the research gaps in RE on the interpersonal conflicts. However, the scope of this thesis is to determine the characteristics of conflicts rooted in RE and their impact on project risks due to the resource and time constraints.

As discussed earlier in Section 1.1, Sage (2003) had mentioned a "close" relationship between conflicts and risks in downstream software development, yet no scientific studies appear to exist on the "conflict-risk" relationship in RE. This is important to investigate because Amber et al. (2012) have reported that 24% of the overall project risks are "high level risks" and they are rooted in the early phases of software development. Investigating this relationship might help in contributing towards the project success as both lack of conflict management (Gobeli et al. 1998; Robey et al., 1993; Sherif et al., 2006) as well as risks management (e.g., Cerpa & Verner, 2009; Svensson & Aurum, 2006) have been independently stated as major factors leading to project failures. Thus, by having knowledge about the RE-conflicts' generating risks, risk-management may be initiated in the RE phase by managing those RE-conflicts.

Project risks have several dimensions such as requirements, teams, users and others (e.g., Addision, 2003; Schmidt R., Lyytinen K., Keil M. & Cule, P., 2001). For example, risks associated with the 'user' dimension include failure to gain user involvement (Addison, 2003), failure to manage end-user expectations (Schmidt et al., 2001), user's resistance to

change (Wallace & Keil, 2004), etc. Table 16 in Appendix C gives the risks associated with various dimensions.

For this thesis, the "requirements" dimension of risk has been chosen since this study focuses on RE. Examples of the risks associated with the 'requirements' dimension include misunderstanding of requirements (Schmidt et al., 2001), development of wrong user interface (Boehm, 1991), inadequately identified requirements (Wallace & Keil, 2004), etc. Table 6 in Section 3.1 gives the risks associated with the requirements dimension.

Arnuphaptrairong (2011) compiled seven major project risks of which the following two fall under the RE dimension: (i) changes to requirements and (ii) misunderstanding of requirements. It was observed by Bell and Thayer (1976) that the project risks associated with requirements such as inadequate requirements, incomplete requirements, inconsistent requirements, etc. have critical impact on software's quality. Thus, clearly, it is important to investigate the impact of RE-Conflicts on requirements risks.

The costs of performing late corrections to requirements errors have been estimated to be up to 200 times more than the corrections performed during RE (Boehm, 1981). Hence, the practitioners can utilize the findings of the study to create strategies for the mitigation and avoidance of RE-Conflicts affecting project risks associated with requirements to improve the quality of software and to lower the project costs.

Chapter 3

3 The Case Study

The literature survey of project conflicts (e.g., Karn & Cowling, 2008; Liang et al., 2010) has shown that deeper understanding of conflicts in a field can be gained by characterizing them and investigating their impact. We have taken a similar approach in the study involving characterizing and investigating the impact of interpersonal conflicts in RE. This chapter describes the core parts of the case study which includes the research goals, questions and metrics (§ 3.1), the context of the project under case study (§ 3.2), the participants in the case study (§ 3.3), the research procedures followed (§ 3.4) and the threats to the study (§ 3.5).

3.1 Goal, Questions and Metrics

Recall from Section 1.4 that the generalized question for this study was the following:

"What are the characteristics and impact of interpersonal conflicts, rooted in requirements engineering, on the project risks associated with requirements?"

We have followed the Goal Question Metric (GQM) paradigm (Basili et al., 1994), a well-known SE research approach used in a top-down manner to formulate the overall goal, research questions required to achieve the goal and the metrics associated with the questions to gather appropriate data. The overall goal for the research, which is a more formalized representation of the generalized question stated above, is formulated as:

Research Goal

Purpose	To determine
Issue(s)	the (i) characteristics and (ii) impact on project risks (particularly those associated with requirements) of
Object	RE- Conflicts
Viewpoint	from the viewpoint of stakeholders (project manager and requirement analysts)
Context	in the context of software development projects with the focus on RE

The goal stated above has two dimensions: (i) *characteristics* and (ii) *impact* of RE-Conflicts on the risks associated with requirements. This goal led to the formulation of following specific research questions:

- **Q 1.1:** What are the different types of RE-Conflicts?
- **Q 1.2:** What are the different types of RE-Activities in which RE-Conflicts are encountered?
- **Q 1.3:** What are the different types of stakeholder groups involved in RE-Conflicts?
- **Q 1.4:** What is the severity levels of RE-conflicts?
- **Q 1.5:** What is the degree of resolution of RE-Conflicts?
- **Q 1.6:** What are the different types of management styles adopted for resolving RE-Conflicts?
- **Q 2.1:** What types of project risks associated with requirements are affected by RE-conflicts?

The questions stated above were formulated by mapping different question formats mentioned in Yin (2009) and the possible substances of interest from these two dimensions. This was done to ensure that research questions comply with the goal of our study. Table 2 shows the possible substances of interest and their corresponding form of questions. We have also given the IDs of research questions and their associated metrics in Table 2 to demonstrate that the research questions satisfy the goal. The instrument IDs used to investigate specific questions have also been given in Table 2.

It is important to mention that the metrics selected to satisfy the questions were limited to the scope of the study. For example, the impact of RE-Conflicts on other project parameters such as costs (e.g., documentation costs, development costs, rework costs, etc.), product quality, RE-Success factors (e.g., the clarity of the business process in the architecture, the extent of user consensus on the recommended solution, the completeness of coverage of the cost/benefits analysis, etc.) (El Emam & Madhavji, 1995), etc. has not been investigated in the current work and we intend to examine it in our future works.

Table 2: Possible substances of interest to satisfy the goal and their corresponding research questions, metrics and instruments used

Parts of goal	Question format	Substance of interest	Research questions ID	Metrics ID	Instrum-ents ID
Characteristics of RE-Conflicts	What	Types of RE-Conflicts (e.g., conflicts over priorities, administrative procedures, costs, etc.)	Q 1.1	M 1.1	SQ1, SQ 2
	Where	In RE-Activities (e.g., elicitation, prioritization, negotiation, etc.)	Q 1.2	M 1.2	NQ
	Who	Among stakeholders (e.g., inter-user conflicts, between analysts and users, inter analyst conflicts)	Q 1.3	M 1.3	SQ1, SQ 2
	How much	Degree of severity of RE-Conflicts (e.g., dealt smoothly, caused complete disruption to the work of the team, lengthy period of constructive debate, etc.)	Q 1.4	M 1.4	NQ
	How much	Degree of resolution of RE-Conflicts	Q 1.5	M 1.5	NQ
	How	Conflict management strategy adopted to resolve RE-Conflicts (e.g., avoiding, confronting, accommodating, etc.)	Q 1.6	M 1.6	NQ
Impact of RE-Conflicts	What	Project risks associated with requirements affected (e.g., inadequately identified requirements, development of wrong user interface, non-traceable requirements, etc.)	Q 2.1	M 2.1	SQ1, SQ2, SRS

To determine the *characteristics* of RE-Conflicts, the specific questions examined were:

Question, Q 1.1: *What are the different types of RE-Conflicts?*

In Table 3, we have given the types of interpersonal conflicts that were obtained from the literature of general projects (e.g., Thamhain & Wilemon, 1975; Posner, 1986) as well as software projects in specific (Hartwell, 1991; Laurindo & Moraes, 2006). The interview data from the participants was used to identify the types of interpersonal conflicts encountered in RE based on the types of conflicts given in Table 3. The associated metric ($M_{i,j}$) for this question is given below.

Metric, M 1.1: *Frequency count of different types (e.g. conflicts over priorities, technical issues, costs, etc.) of RE-Conflicts.*

Table 3 : Types of interpersonal conflicts

S. No.	Types of conflicts
1	Conflicts over project priorities
2	Conflicts over administrative procedures
3	Conflicts over technical subjects
4	Conflicts over costs
5	Conflicts over schedules
6	Personality conflicts
7	Conflicts over responsibilities
8	Conflicts over human resources
9	Conflicts over equipments and facilities

Question, Q 1.2: *What are the different types of RE-Activities in which RE-Conflicts are encountered?*

Table 10 in Section 3.4.2 gives the list of RE-Activities extracted from literature review. Answers to this question were obtained by using the Nominal Group Technique (NGT)[7]. The metric for this question is:

Metric, M 1.2: *Frequency Count of different types of RE-Activities (e.g., elicitation, prioritization, negotiation, etc.) in which RE-conflicts are encountered.*

Question, Q 1.3: *What are the different types of stakeholder groups involved in RE-Conflicts?*

Due to the focus of our study on RE, the participants of our case study were the Requirement Analysts (RAs) and the Project Manager (PM) of the project under case study. We termed these stakeholders as ‘analysts’. The clients of the project have been

[7] Nominal Group Technique (NGT) is an established, qualitative research tool that aids in developing a prioritized list of responses to a specific question by taking into account the opinions of all the participants (Harvey & Holmes 2012)

termed as ‘users’. Based on this terminology, we created three categories of stakeholder groups in which RE-Conflicts could take place:

(i) Conflicts in the user’s team *(User-User)*

(ii) Inter-analysts conflicts *(Analyst-Analyst)*

(iii) Conflicts between users and analysts *(User-Analyst)*

The data from interviews was used to investigate this question. The metric associated with this question is:

Metric, M 1.3: *Frequency count of occurrence of RE-Conflicts among specific group of stakeholders (users-users, analysts-analysts, users-analysts).*

Question, Q 1.4: *What is the severity levels of RE-conflicts?*

Gobeli et al. (1998) found that the higher conflict intensities substantially decrease the satisfaction of project team members. Therefore, we determined the severity level of RE-conflicts in the project under case study through NGT, by using an ordinal scale of conflict severities (Table 4) given in (Karn, 2008). M1.4 gives the metric for this question.

Metric, M 1.4: *Frequency count of severity levels associated with RE-Conflicts.*

Table 4: Ordinal scale for severity levels of conflicts (Karn, 2008)

‘1’ represents the lowest severity level and ‘6’ represents the highest severity level of a conflict

Ordinal ID	Description
1	Premise uncritically accepted with no interaction between team members
2	Dealt with smoothly and harmoniously after brief discussion
3	Lengthy period of constructive debate discussing the virtues of an issue
4	Caused slight disruption by forcing people off relevant issues
5	Lengthy period of destructive debates resulting in wasting a lot of time to get back on track
6	Caused complete disruption to the work of the team

Question, Q 1.5: *What is the degree of resolution of RE-Conflicts?*

As reported by Gobeli et al. (1988), the unresolved conflicts have a strong negative effect on the project success. Hence, it was important to determine the frequency of resolved and unresolved conflicts in the project under case study. This was achieved by using NGT. The metric for this question is:

Metric, M 1.5: *Percentage of RE-Conflicts resolved in the project under case study. Degree of resolution= (Number of RE-Conflict resolved/ Total RE-Conflicts)* 100*

Question, Q 1.6: *What are the different types of management styles adopted for resolving RE-Conflicts?*

There is an abundance of research conducted in SE that demonstrates the significance of conflict management (Barki & Hartwick, 2001; Gobeli et al., 1998; Laurindo & Moraes, 2006; Sawyer, 2001; Sherif et al., 2006; Robey et al., 1989; Robey & Farrow, 1982). However, this aspect of conflict was not yet explored in RE. Therefore, we investigated the different types of management styles adopted for resolving RE-Conflicts in the project under case study by using NGT. Table 5 (adapted from Verma, 1998) gives the list of conflict management strategies that were first given by Blake and Mouton in 1964. This table was provided to the participants during NGT. The metric for this question is given as follows:

Metric, M 1.6: *Frequency count of different types of conflict management styles adopted for resolving RE-Conflicts.*

To determine the *impact* of RE-Conflicts, the specific question investigated was:

Question, Q 2.1*: What types of project risks associated with requirements are affected by RE-conflicts?*

In Table 6, we have given a list of risks associated with requirements that were obtained from the literature on project risks (e.g., Pare, G.C., Sicotte, C., Jaana, M., & Girouard, D., 2008; Wallace & Keil, 2004). A combined analysis of the interview data and the Software Requirements Specification (SRS) document was used to identify the risks affected due to the RE-Conflicts. The associated metric ($M_{i,j}$) for this question is given below:

Metric, M 2.1*: Frequency of risks associated with requirements (e.g., inadequately identified requirements, development of wrong user interface, etc.) affected by a specific type of RE-Conflict.*

Table 5: Conflict management styles (Verma, 1998)

No.	Style	Description	Effect
1	Withdrawing/ avoiding	Retreats from an actual or potential conflict situation	Does not solve the problem
2	Smoothing/accommodating	Emphasizes areas of agreement rather than areas of difference	Provides only short-term solution
3	Compromising	Searches for and bargains for solutions that bring some degree of satisfaction to all parties	Provides definitive resolution
4	Forcing	Pushes one's viewpoint at the expense of others; offers only win-lose situations	Hard feelings may come back in other forms
5	Collaborating	Incorporates multiple viewpoints and insights from different perspectives; leads to consensus and commitment	Provides long-term resolution
6	Confronting/problem solving	Treats conflict as a problem to be solved by examining alternatives; requires give-and-take attitude and open dialogue	Provides ultimate resolution

Table 6: Types of risks associated with requirements

No.	Types of Risks
1	Continually changing requirements
2	Requirements not adequately identified
3	Redundant requirements
4	Late changes to requirements
5	Non-testable requirements
6	Non-traceable requirements
7	Unrealistic requirements
8	Development of wrong software functions
9	Unnecessary requirements
10	Misunderstanding of requirements
11	Requirements non-conforming to business goals
12	Development of wrong user interface
13	Incorrect requirements
14	Unclear requirements

3.2 Study Context: Packaging and Printing Project

To explore the characteristics and impact of RE-Conflicts, we conducted a case study of an industrial software project. Section 3.2.1 describes the structure of the organization and the members of the clients and development teams of the project. The core features and components of the project are discussed in Section 3.2.2. The prototypical development process and the requirements process followed for the development of project are described in Sections 3.2.3 and 3.2.4 respectively.

3.2.1 Organizational Structure and Team members

A case study of the software project involving automation of a Packaging and Printing project (henceforth termed as *P&P project*) was conducted. We collaborated with a small-sized software development organization in India which developed the P&P project. The clients of the P&P project dealt with "Packaging and Printing Services". The organizational structure and the team members of the developers and clients are discussed below.

The Development Team

The participating organization is a small software development organization, having 26 employees. It was established in 2003. The project durations of the organization usually range from nine months to three years and the budget ranges equivalent to approximately from US$ 300,000 to US$ 60,00,000 .Typically, the Agile[8] software development model (Beck, 2003) is followed by the organization. Usually four to eight people are assigned for the development of a project depending on various factors such as complexity, budget, deadlines, etc.

The development of the P&P project started in February, 2009 with a budget of equivalent to approximately US$ 400,000. The initial deadline for the completion of the project given by the clients was July, 2009. However, the development of the project continued until four months after the initial deadline had passed. *"At the end of November, 2009, we decided to abandon the project due to the presence of excess unresolved conflicts"*, emphasized the PM.

The developing team of the P&P project consisted of seven members having varying roles (e.g., PM, RA, coder, etc.) and experiences. Table 7 gives the roles and experiences of the development team members.

Table 7: Development team members of project under case study: Role and Experience

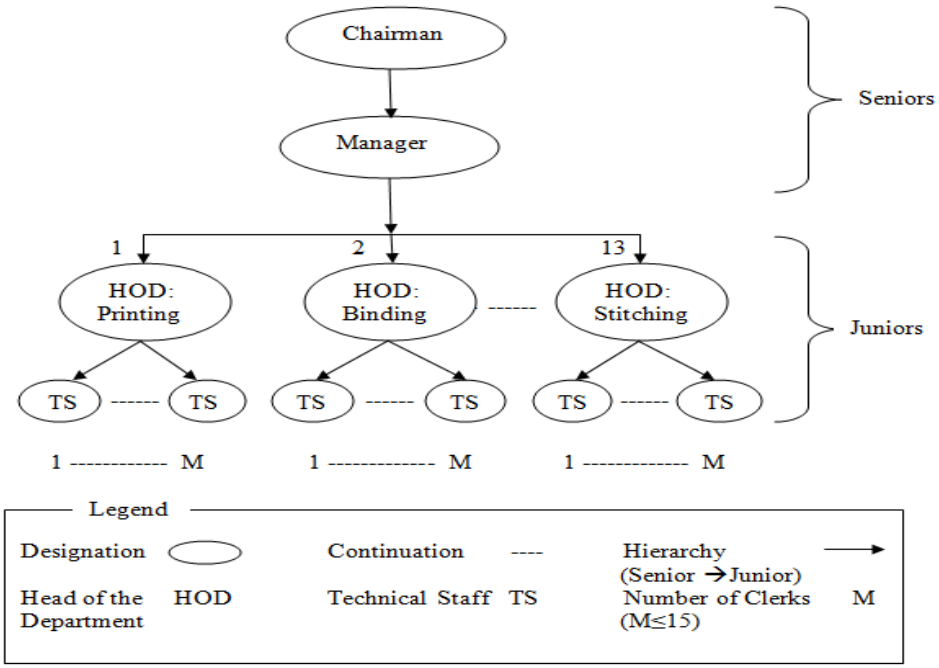
No.	Role in project	Experience in years
1	Project Manager, Quality Assurance Engineer	15
2	Requirement Analyst, Software Architect	12
3	Requirement Analyst	8
4	Requirement Analyst, Programmer	3
5	Requirement Analyst, Programmer	2
6	Programmer	7
7	Tester	2

[8] Agile Software Development: It is a conceptual framework that follows iterative and incremental approach to software development. The requirements and solutions evolve through high collaborative process between self-organizing teams (Beck, 2003).

The Client's Team

The clients of the project under case study dealt in packaging and printing services. They offered commercial packaging and printing services in gift boxes, danglers, paper bags, posters, magazines, catalogues, etc. An extensive range of specialized options were provided such as spot lamination, thermal lamination or any type of coating. The goal of the project was to automate the business process of packaging and printing system by developing an Enterprise Resource Planning (ERP)[9] (Dredden & Bergdolt, 2007) system.

The client's organization had a two level hierarchy, (i) senior employees and (ii) junior employees. Figure 1 shows the hierarchy of client's organization which comprises of the chairman and the manager as senior employees and all other employees as junior employees. There were thirteen departments, one for each task (e.g., printing, binding, creasing, stitching, etc.). Each department had a Departmental Head (HOD).



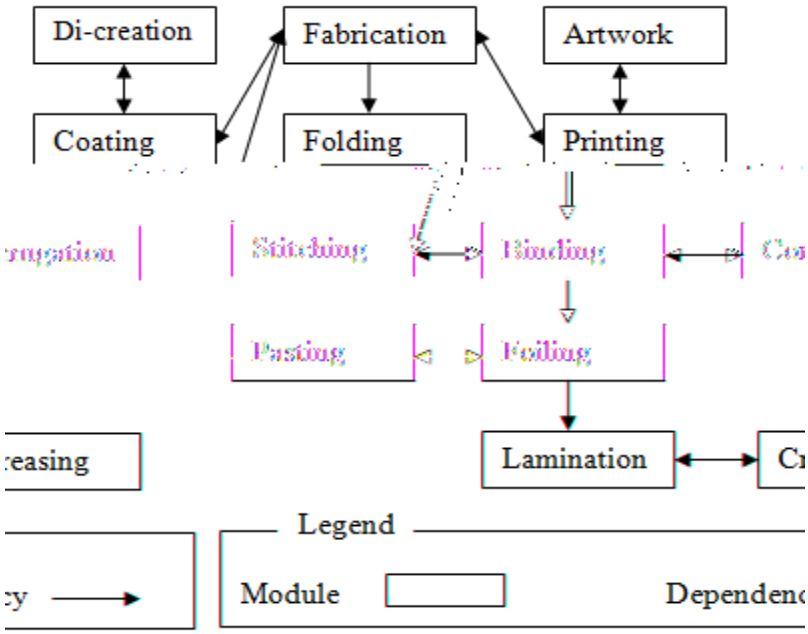
The client's organization had a 2 level hierarchy: (i) seniors (chairman and manager) (ii) juniors (head of the departments and technical staff). There were 13 departments (e.g., printing, binding, stitching, etc.).

Figure 1: Hierarchy of the participating organization in the case study

[9] Enterprise resource planning (ERP): ERP systems automate business functions of organizations to facilitate the flow of information between all business functions inside the boundaries of the organization and manage the connections to outside stakeholders by providing an integrated software application that considers the internal and external management information across an entire organization (Dredden & Bergdolt, 2007).

3.2.2 Features and Components

The development team was assigned the task of automating the designing, costing and sales processes of the organization. There were *13 business functions* to be automated in total such as binding, coating, printing, creasing, etc. Some of the processes were performed in parallel and some in a specific sequence to achieve the final packaging. Figure 2 depicts a high level architecture of the P&P project demonstrating the key dependencies between the 13 business functions. The client's business was organized in such a way that all the 13 business functions, further consisted of 4 modules each: types, properties, transactions, and costs. Hence, in total, there were *52 modules* to be automated.



The dependencies among the 13 business functions (e.g., pasting, lamination, foiling, etc.) of the P&P project are shown. Each business function further consisted of 4 modules (types, properties, transactions, and costs), which have not been shown.

Figure 2: High Level Architecture of the project under case study

3.2.3 Prototypical Development Process

Agile software development model (Beck, 2003) was followed by the development team. Figure 3 shows the development process followed which was started by creating an initial plan and then executing the requirements, analysis and design, implementation, testing

and evaluation phases iteratively until the final product was ready for the deployment. The prototype release period of the P&P project was 2 weeks. i.e., after every 2 weeks, a prototype was released to the clients for evaluation. Based on the feedback from clients, the SRS was updated and corresponding modifications were done to the next version of the prototype. The development team followed evolutionary prototyping (Hekmatpour, 1987) due to the continually changing environment of the client's organization. For example, some processes such as outsourcing of jobs, calculating costs of materials, etc. varied depending on external factors such as climate, market competition, etc. The clients were also expanding their business which led to the introduction of new requirements.

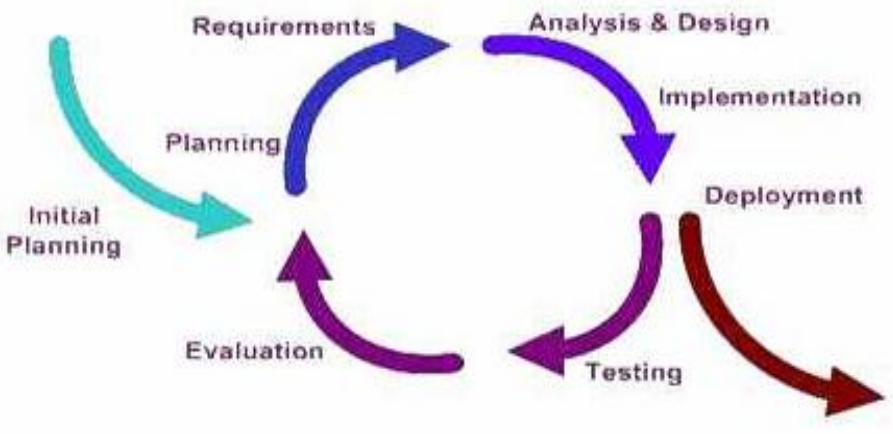


Figure 3: Agile prototypical development process followed for the development of the project under case study (Miyachi, 2011)

3.2.4 Requirements Engineering Process

The core set of features in the P&P project came from the senior members of the staff. The requirements were elicited from the junior members during the feedback session after the demonstration of prototype to them. However, the requirements elicited from the junior members had to be approved from the senior members before implementing them in the next versions of prototypes.

The requirements negotiation process for any issue such as high costs of a given requirement, infeasible sequence of implementation of requirements given by clients, allocation of requirements, etc. had to be conducted only with the senior members. Information on meta-data, such as name of the RA eliciting the requirements, the date of

elicitation of requirements, importance of elicited requirements to the clients, etc., was logged in the SRS.

3.3 Participants

Considering the focus of the study on RE, only the RAs and the PM, from the development team of the P&P project were interviewed. They were interviewed extensively over a span of approximately 10 months. Additionally, the participants also aided in analyzing the SRS and validating the emergent findings from the study. Further details of the PM and RAs are given in the table 8.

Table 8: Summary of the case study participants

ID	Participant's Role	Experience in the field	Experience in the Ecologic Corporation	Number of prior ERP projects developed	Business functions assigned for requirements elicitation (Total=13)
1	RA	2	2	0	Pasting
2	RA	3	4	0	Fabrication, Foiling, Creasing
3	RA	8	8	1	Folding, Di-creation, Binding, Stitching
4	RA	12	9	4	Lamination, Corrugation, Printing, Coating, Artwork
5	PM	15	9	6	Not Applicable

3.4 Research Procedures

A knowledge seeking interpretive case study (Klein & Myers, 1999) was conducted to understand the characteristics and impact of conflicts originating during RE on the project risks associated with requirements through the participant's interpretation of their context. The unit of analysis (Yin, 2009) of the single case embedded study (Yin, 2009) was a project which was not successfully completed (cancelled).

The following sections discuss the research procedures followed for conducting the case study. Section 3.4.1 describes the design of the study. Section 3.4.2 and Section 3.4.3 discuss the design of the instruments used in the case study and data collection procedures. Section 3.4.4 concludes this section by describing the procedures followed for analyzing the research data.

3.4.1 Study Design

This section describes the design of the study, i.e., the phases of the research, methodologies used to conduct the research, the outcomes of each phase of the research and the validations performed in the study. The research was conducted in two phases. Phase1 had four outcomes and phase 2 had three outcomes. Mixed research methodologies such as SLR, interviews, NGT, and analysis of a project artifact (SRS) were used in the study. The research methodologies adopted and their outcomes were validated by several relevant experts (Table 9).

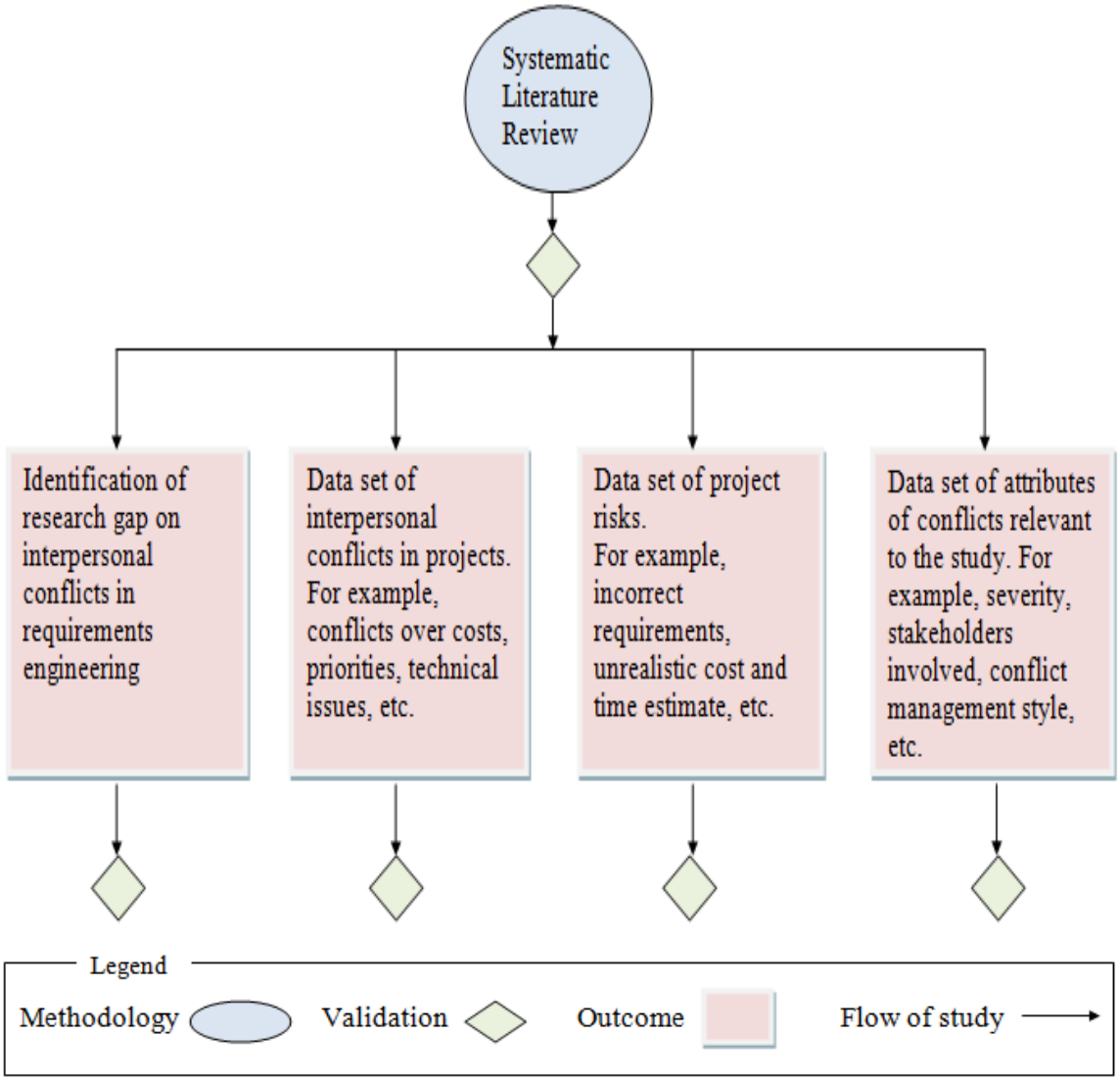
Phase 1

SLR was used as a research methodology for this phase. Firstly, the research gap regarding the interpersonal conflicts in RE was identified. As explained in Section 2.3, on performing SLR, it was found that the *characteristics* and *impact* of interpersonal conflicts in RE were not yet explored. Therefore, the subsequent stages of this phase focused on gathering the following data required to investigate the identified research gap:

- Types of interpersonal conflicts in projects
- Attributes of conflicts relevant to the research goal
- Types of project risks.

A data set of interpersonal conflicts in projects was prepared to aid in the identification of types of RE-Conflicts. To explore the characteristics of the RE-Conflicts, a data set of attributes of conflicts relevant to the study were identified. For example, severity of conflict, conflict management style, degree of resolution, etc. To investigate the impact of RE-Conflicts on the project risks, a data set of project risks (e.g., incorrect requirements,

unrealistic cost and time estimates, etc.) was created. Figure 4 shows the phase 1 of the study design.



Systematic Literature Review (SLR) was used to produce the 4 outcomes of phase 1 of the study. The methodology and the outcomes were validated by the experts.

Figure 4: Phase 1 of the study design

Phase 2

This phase focused on designing the instruments for data collection, gathering the research data, and analyzing the data to examine the research questions of the study. The two outcomes of the phase 1 i.e., data set of types of interpersonal conflicts and data set

of attributes of conflicts were used for designing the instruments (interview and NGT based questionnaires). Another outcome of the phase 1 (data set of project risks) was used for the combined analysis of the SRS and the interview data in the phase 2, to identify the types of risks affected due to RE-Conflicts. The study design of the phase 2 is depicted in Figure 5.

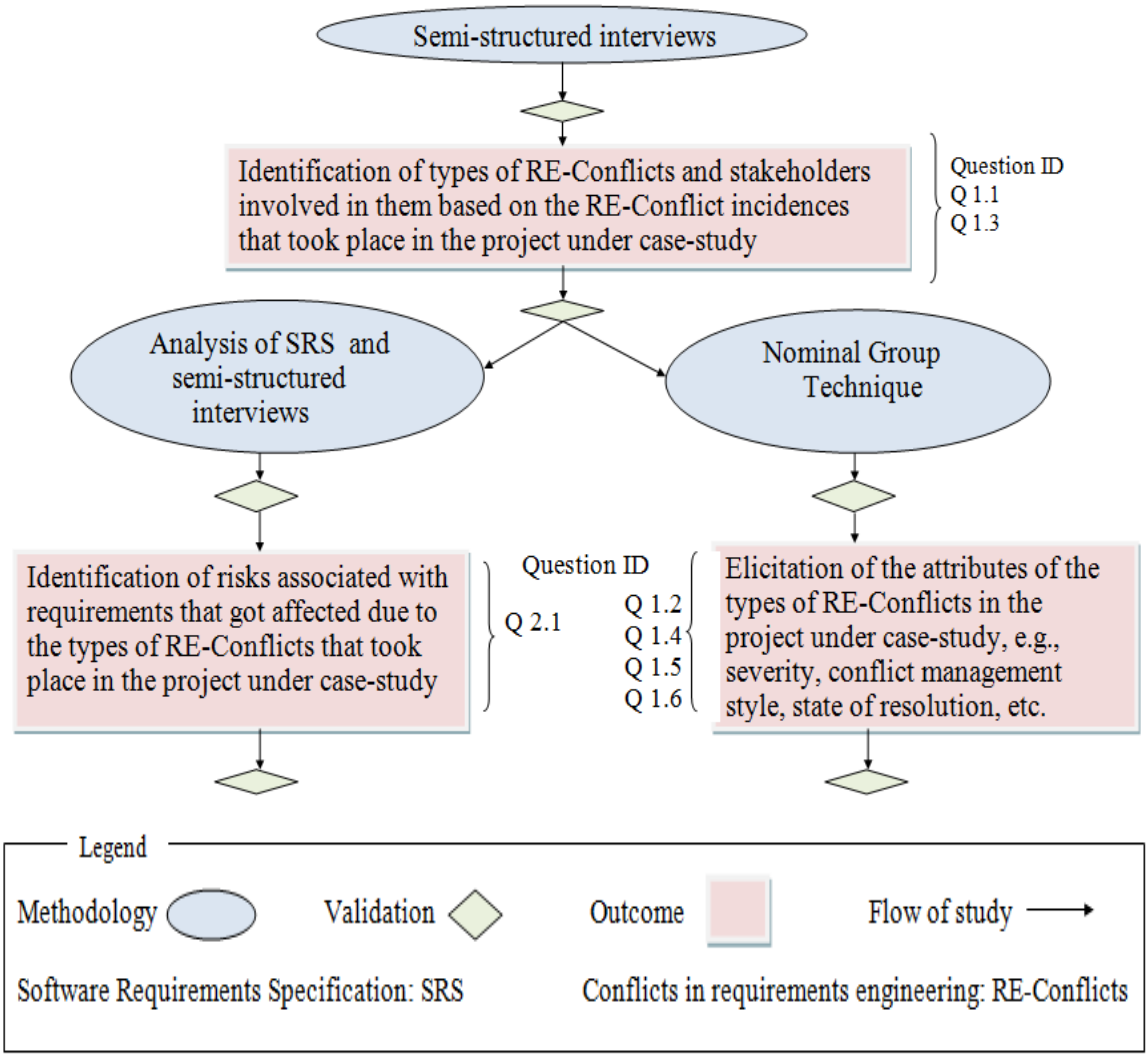
Phase 2 of the study involved conducting preliminary discussions and filling of closed questionnaires (see Appendix B) by the participants in order to gain background information of the organization and participants. To examine the types of RE-Conflicts and the stakeholders involved in them (see Q 1.1 and Q1.3, § 3.1), semi-structured interviews were conducted (see Appendix B). Their analysis led to the identification of 13 RE-Conflict incidences (see table 17, Appendix C) that took place in the P&P project along with the stakeholders groups (users-users, analysts-analysts and users-analysts) involved in them. To identify the risks associated with requirements affected due to the RE-Conflicts (see Q 2.1, § 3.1), a combined analysis of the interview data and SRS was performed.

The P&P project was not an on-going project; therefore, to capture the attributes of the RE-Conflicts (see Q 1.2, Q 1.4, Q 1.5 and Q 1.6, § 3.1), we could not use observational techniques such as ethnographic study. Since we wanted the opinions of all the RAs and the PM on the attributes of the 13 RE-Conflicts, therefore, we had the option of selecting either the NGT[10] (Harvey & Holmes, 2012) or Delphi[11] method (Ven & Delbecq, 1974). Both of them have proved to be more effective than the conventional interacting groups to obtain the views of experts on a given topic and bring about group consensus (Harvey & Holmes, 2012, Ven & Delbecq, 1974). We chose NGT over Delphi because NGT is

[10] Nominal Group Technique (NGT) is an established, qualitative research tool that aids in developing a prioritized list of responses to a specific question by taking into account the opinions of all the participants when the participants are in close proximity. The answers of the participants are not anonymous and the inconsistent answers are brainstormed in a group (Harvey & Holmes, 2012).

[11] The Delphi method is a proven, popular tool in information systems research for identifying and prioritizing issues by considering opinions of all the participants who are isolated from each other. An anonymous summary of results of all the participants in the panel are shared to encourage them to revise their earlier answers in light of the replies of other participants (Ven & Delbecq, 1974).

used when there is small group of participants having close proximity (Harvey & Holmes, 2012) as contrary to Delphi where the participants are isolated (Ven & Delbecq, 1974). NGT involves brainstorming on the inconsistent answers given by the participants to the predefined structured questions. Thus the validation of the answers of all the participants was taken into account by using NGT.



Semi-structured interview, NGT and analysis of SRS were used to produce the three outcomes of phase 2 of the study to address the research questions of the study (see Q1.1 to Q1.6 and Q 2.1 in § 3.1). The methodologies and the outcomes were validated by the experts.

Figure 5: Phase 2 of the study design

Validation processes in the study

All the research methodologies used in the study (SLR, interviews, analysis of project document and NGT) were validated by various experts at each stage. For example, while conducting the SLR, the experts validated the research questions, search process, inclusion and exclusion criteria and the results. In case of semi-structured interviews, the questionnaires (see SQ1 and SQ2 in Appendix B) were validated to ensure that they were in accordance with the scope of the study. Before conducting NGT, the design of the NGT was validated by the experts. The NGT questionnaires given in Appendix B were also validated by the relevant experts. The thematic coding scheme (Thomas & Harden 2008) followed for analyzing the interview data and the SRS was also validated by an expert in statistics. Similarly the outcomes of each stage were also validated by the experts.

A total of eight experts, with a median job experience of 15 years and minimum academic qualification of a post graduate degree, were used in the validation process. Summary of the experts who participated in the case study is given in Table 9.

Table 9: Summary of the experts involved in the validation process

The design of the research methodologies and procedures (NGT, SLR, TCS and interviews), results, and their interpretations were validated by the relevant experts.

No.	Years of Experience	Area of Expertise
1	30	Software Engineering ,Requirements Engineering, Software Architecture, Empirical Studies
2	15	Software Engineering, Requirements Engineering, Software Architecture, Empirical Studies, Software Industry
3	9	Requirements Engineering, Software Industry
4	30	Statistics
5	12	Statistics
6	18	Software Industry
7	15	Software Industry
8	14	Software Industry

3.4.2 Instrument Design

Several instruments were designed to collect data for the investigation of the research goal. They included semi-structured interview questionnaires, closed questionnaires, and NGT questionnaires. The specific questions for which these instruments were used are shown in Table 2 (§ 3.1). All these questionnaires are given in the Appendix B.

Closed questionnaires

To determine the background of the participating organization and members, two closed questionnaires, CQ 1 and CQ 2 were designed (see Appendix B). The first questionnaire, CQ 1 was filled by all the members of the development team of the P&P project to gain insights into their background (e.g., role in the project, experience, etc.). Table 7 and Table 8 gives the information gathered about the development members of the P&P project and the case study participants respectively, which was gathered using CQ 1 questionnaire. The second questionnaire, CQ 2 was designed to gather information about the participating organization (e.g., number of employees, software development process followed, etc.). Therefore, it was filled only by the owner of the organization. Section 3.2.1 gives the information gathered using the second questionnaire.

Semi-structured interview questionnaires

To investigate the research goal, we had to gather data on the RE-Conflict incidences that took place in the P&P project. Two semi-structured interview questionnaires, SQ1 and SQ2 were designed for collecting the data about the RE-Conflict incidences. These questionnaires (see Appendix B) were validated by the experts to ensure that they covered the metrics discussed in Section 3.1 and were limited to the area of RE in accordance to the study. These questionnaires were used for investigating research questions Q 1.1, Q 1.3 and Q 2.1 , discussed in Section 3.1 (also see Table 2, § 3.1).

NGT questionnaires

In addition, we had to gather data regarding the characteristics of these RE-Conflict incidences such as people involved, intensity, conflict management style adopted, etc.

Therefore, we created a data set of attributes of conflicts relevant to the study (Table 10) by performing SLR on the conflicts and conflict models. This data set of conflict attributes was used to design the questionnaires for the NGT study. The NGT questionnaire, NQ (see Appendix B) was used for investigating research questions Q 1.2, Q 1.4, Q1.5 and Q 1.6 discussed in Section 3.1 (also see Table 2, § 3.1).

Table 10: Attributes of RE-Conflicts relevant to the study

Conflict Attribute	Information	Reference
Content of the conflict	• What is the conflict about?	(Elam & Walz, 1988)
People involved in the conflict	• Who is in conflict? • With whom?	(Elam & Walz, 1988)
Severity of conflict	• Premise uncritically accepted with no interaction between team members • Dealt with smoothly and harmoniously after brief discussion. • Lengthy period of constructive debate discussing the virtues of an issue. • Caused slight disruption by forcing people off relevant issues. • Lengthy period of destructive debate, meeting disrupted a lot of time wasted getting back on track • Caused complete disruption to the work of the team	(Karn, 2008)
RE-Activity in which conflict was encountered	• Elicitation • Negotiation • Specification • Prioritization • Analysis • Validation	(Kotonya & Sommerville, 1998)
State of resolution of conflict	• Resolved • Unresolved	(Karan & Cowling, 2008)
Conflict management strategy adopted	• Withdrawing/ Avoiding • Smoothing /accommodating • Compromising • Forcing Collaborating • Confronting/problem solving	(Verma, 1998)

3.4.3 Data Collection

During the collection of data from the case study, the researcher was in direct involvement with the participants; hence, the data collection technique was of category first degree[12].

To gather data for the types of RE-Conflicts (Metric M1.1, § 3.1), stakeholders involved in RE-Conflicts (M 1.3, § 3.1) and the types of risks associated with requirements affected by the RE-Conflicts (Metric M2.1, § 3.1), we interviewed the PM and RAs of the P&P project (see Figure 5, § 3.4.1).

The interviews were conducted over a span of approximately 10 months. The duration and frequency of interviews varied depending on the demand of the study. For example, to gather data on the RE-Conflict incidences, only RAs were interviewed and the PM was interviewed at the later stage to validate the RE-Conflict incidences identified by analyzing the interview data. The interview duration also varied depending on the number of business functions for which the RA had elicited requirements. For example, in Table 8, Section 3.3, RA with ID 1 had elicited requirements for only one business function whereas the RA with ID 4 had elicited requirements for five business functions. Consequently, the duration of interview for RA 4 was more than that of RA 1. All the interviews were transcribed to provide a written account. There were a total of 40 hours of recorded interview data, leading to 97 transcribed pages.

The data for the characteristics (Metric M 1.2, M 1.4, M 1.5 and M 1.6, § 3.1) of RE-Conflicts such as severity, conflict management strategy, degree of resolution, etc. was gathered using NGT. We followed the procedures for conducting a NGT (see Figure 6), given in (Potter M., Gordon S., & Hamer P., 2004).

[12]When the researcher is in direct contact with the project members during data collection, then it comes under the category of first degree data collection (Lethbridge, 2005).

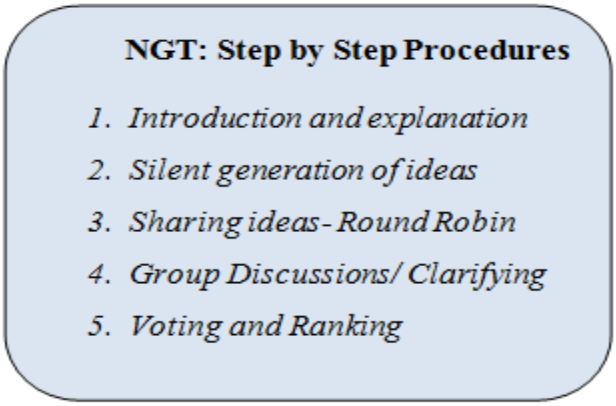


Figure 6: The Nominal Group Technique procedures (Potter et al. 2004)

In the first stage, briefing was given to the participants (all the RAs and PM) about the NGT process. In the second stage, the participants provided individual answers (without discussing with other participants) regarding the content (severity, conflict management style, RE-Activity, degree of resolution and stakeholders involved) of the RE-Conflicts they encountered in the project. The NGT questionnaire given in Appendix B was used in the second stage. In the next stages, the results were shared with all the participants and the inconsistent answers were discussed in a group. The final answers regarding the content of the RE-Conflicts were based on the voting and ranking of the answers provided by all the participants.

3.4.4 Data Analysis

As discussed in Section 3.4.3, the primary sources of data collection for the study were interviews, analysis of the SRS and NGT study. Consequently, the case study involved the analysis of interviews, data from NGT, and the SRS containing 289 requirements of the 52 modules of the P&P project; specifically analyzing the change history of requirements. All the results of the analysis have been validated by various experts as discussed in Section 3.4.1 (see Figure 4 and Figure 5).

Analysis of interview data

The interviews conducted with the four RAs of the P&P project were analyzed to determine the conflict incidences that took place during RE. The thematic coding scheme

(Thomas & Harden, 2008), a qualitative data analysis procedure, was used for retrieving the conflict incidences from the interview data. This technique involves scanning the data and categorizing text segments of interest into meaningful themes. The themes were selected based on the research questions being investigated. The three themes used in the coding process were: *issue involved in a conflict* (Q 1.1), *origin of conflicts (Q 1.3), and requirements risks affected by a conflict (Q 2.1).*The coding process was carried out by two independent researchers. The results of the two researchers were compared and inconsistencies in the coding were brainstormed by these researchers. A total of 13 RE-Conflict incidences were identified from the analysis of the interview data (please see table 17, Appendix C).

The identified incidences were validated by relevant experts (see Table 9) to ensure that a correct coding procedure was being followed. Also, the PM confirmed that the identified 13 RE-Conflict incidences took place in the P&P project.

Combined analysis of interviews and SRS

After determining the RE-Conflict incidences based on the analysis of the interviews, we analyzed the SRS to determine the risks associated with requirements that were affected due to these incidences. This was achieved by tracking the change history of requirements from the SRS and mapping these changes to the 13 RE-Conflict incidences. The interview data also contained the information about the RE-Conflict incidences that led to updates in the SRS. Interested readers can refer to Box 1 that gives an example of this data analysis procedure.

Box 1: Example Data Analysis procedure for identifying risks affected by the RE-Conflicts

Here we have described the data analysis procedure by giving an example of a RE-Conflict Incidence (see table 15 for all the RE-Conflict incidences in the case study) whose ID is REC 7, and a segment from the transcription of an interview with a RA that contains information of the modules affected due to a specific RE-Conflict incidence, REC 7. Below, we have

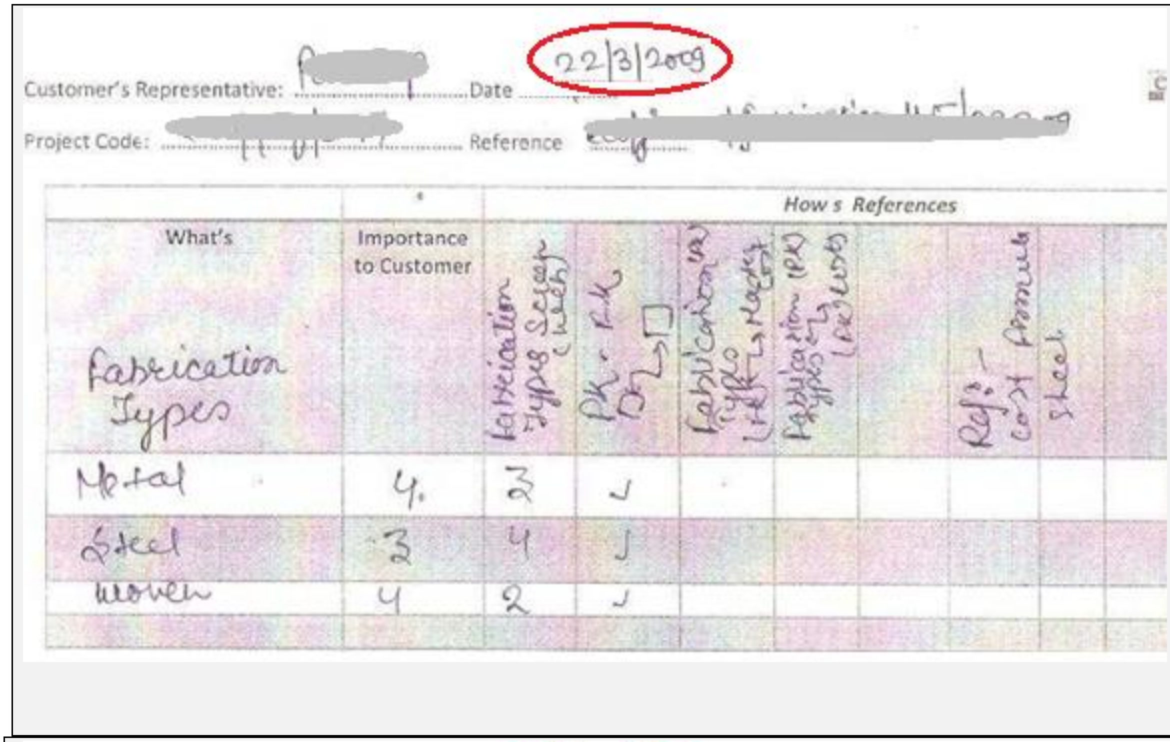
given an actual snapshot of the SRS document showing the change history of requirement related to the module mentioned in the interview. Finally we discuss the risks associated with requirements that got affected due to RE-Conflict, REC 7, based on the analysis of interview data and the SRS. Hence mappings between the interviews and the change history of requirements in the SRS have led to the identification of risks affected due to the RE-Conflicts.

RE-Conflict Incidence, ID: REC 7: There were disagreements between chairman and analysts over costs regarding the budget of the project. The clients business was expanding and the clients wanted developers to implement new requirements within the budget that was initially fixed. However, analysts disagreed to implement new requirements within the same budget as it was not feasible.

Segment from transcription of an interview: "*The clients expanded their business in May. This led to the introduction of new types of fabrication types and foiling types. Therefore, I had to again elicit requirements for the new introduced types of fabrication and foiling types in May……. I negotiated with the chairman about the new foiling type requirements and asked him to increase the budget if he wanted to implement the requirements but the manager asked the developing team to accommodate those requirements within the same budget. This conflict remained unresolved till the end……..*"

Such information from the interviews was mapped with the change history of requirements in the SRS. For example, the actual snapshot taken from the SRS of the P&P project depicting the change history of the requirements of the *fabrication type's* module is shown below.

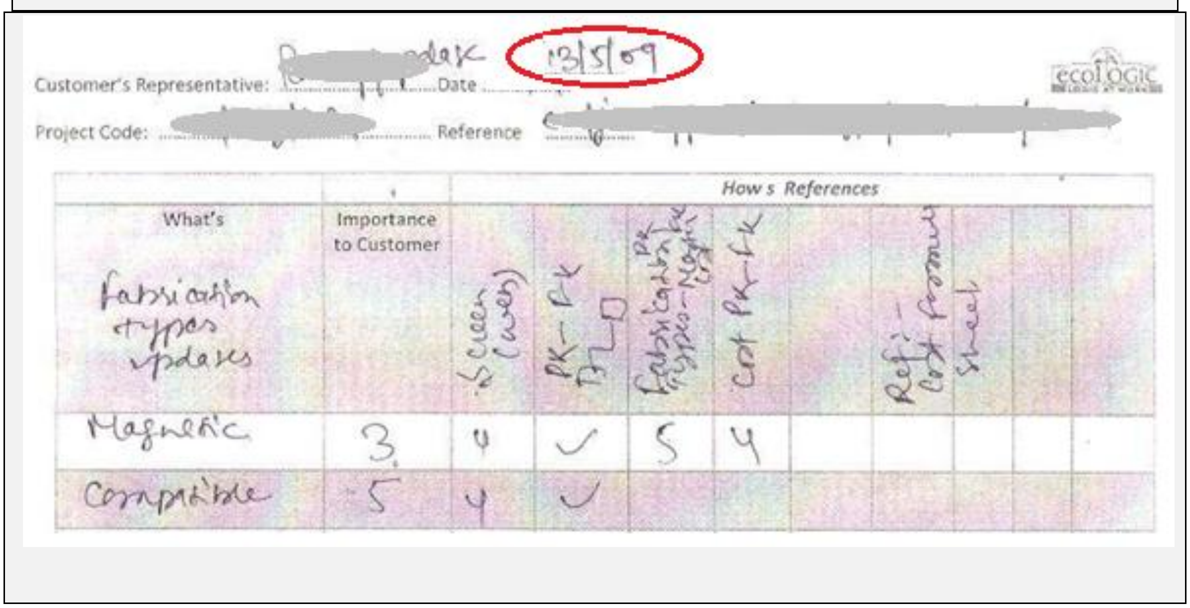
Risks affected due to RE-Conflict, ID: REC 7: (i) Late changes in requirements and (ii) Continually changing requirements.



Customer's Representative: [redacted] Date 22/3/2009

Project Code: [redacted] Reference [redacted]

What's	Importance to Customer	Fabrication types Screen (weeks)	PK - FK D□	Fabrication (W) types [illegible]	Fabrication (PK) types [illegible]		Ref: - cost formula Steel		
Fabrication Types									
Metal	4.	3	✓						
Steel	3	4	✓						
woven	4	2	✓						



Customer's Representative: [redacted] Date 13/5/09

Project Code: [redacted] Reference [redacted]

What's	Importance to Customer	Screen (weeks)	PK - FK D□	Fabrication types - [illegible]	Cost PK - FK		Ref: - Cost formula Steel		
Fabrication types updates									
Magnetic	3	4	✓	5	4				
Compatible	5	4	✓						

<u>*Analysis of data collected using NGT*</u>

As mentioned in section 3.4.2, the data on the *characteristics* (e.g., severity, conflict management style, RE-Activity, etc.) of RE-Conflicts was gathered using a NGT protocol (see Figure 5, § 3.4.1 and Figure 6, § 3.4.3) .All the answers produced in the first stage of the NGT were analyzed by sharing the results with all the participants and brainstorming the answers which were not consistent.

3.5 Threats to Validity

This section discusses different types of validity and explains how they were addressed in the study. These validities were success criteria for the study. Section 3.5.1 to Section 3.5.5 discusses the internal validity, external validity, qualitative validity, construct validity and conclusion validity respectively.

3.5.1 Internal Validity

Internal validity is of concern to the studies that try to establish causal relationships (Runeson & Host, 2009). It ensures that a researcher's experiment design had followed the principle of cause and effect. Since in our study, an exploratory case-study was conducted, therefore, the internal validity was not applicable.

3.5.2 External Validity

External validity refers to the extent to which results or findings from a study can be "generalized to and across populations of persons, settings, and time" (Creswell, 2009). Three types of validities that apply to the external validity are *population*, *ecologic* and *temporal validities*.

Population Validity

This validity refers to how well the sample used can be extrapolated to a population as a whole. In our study, this threat exists since we conducted study of only single project (see § 3.2) in which agile software development process was followed. Hence, it is possible that the overall RA's proficiency could differ depending on the type of software development process followed (e.g., waterfall model, spiral model, incremental development, etc.), leading to potentially different results. Examples of other possible factors that might lead to varying results are different complexities of projects (e.g., number of requirements, lines of code, etc.), domains of projects (e.g. banking, health care, etc.), application types of projects (e.g., database software, multimedia software, etc.), etc.

Ecologic Validity

Ecologic validity ensures that the methods, materials and the settings of the study approximate the real-world that is being examined, as opposed to a laboratory environment. Since we did a case study of an actual SE project (see § 3.2), therefore there is no threat to the ecologic validity in our study.

Temporal Validity

Temporal validity refers to the ability to generalize results of a study over time. Since our study is the first of its kind, therefore, it is difficult to discern whether this validity will hold over time. Only time will tell.

3.5.3 Qualitative Validity

It is important to consider a validation technique called *triangulation* (Berg, 2007) for an empirical research where qualitative data is involved. Triangulation aids in the establishment of accuracy of a study's findings by analyzing the research questions, methodologies, data, etc. from multiple perspectives. All types of triangulation; data, methodological, investigator and ecologic have been addressed in our study.

Data Triangulation

Data triangulation refers to using different sources of data/ information to increase the validity of the results of the study. Validity of the results is established if there is consistency in the data/ information provided across various data sources used in the study. To achieve the data triangulation, we collected data from all the RAs and the PM (table 8, § 3.3). In addition, the SRS was analyzed to verify if data reporting was being done accurately (see Box 1, § 3.4.4). The interview data collected from the participants was matched with the data obtained from the SRS and both were found to be consistent with each other; hence, proving the validity of the information gathered. Also, while using NGT (see figure 6, § 3.4.3), five participants (four RAs and the PM of the P&P project) were involved.

Methodological Triangulation

It includes using multiple qualitative and/or quantitative methods to conduct the study. The consistency of conclusions from each method reflects strong validity of the study. Various qualitative methods such as semi-structured interviews, document analysis, and NGT were used in the study (see figure 5, § 3.4.1). Similar conclusions regarding RE-conflict incidences and the risks affected by them were found from the subsequent analysis of interviews and SRS (see Q1.1, § 4.1.1. and Q 2.1, § 4.2). The results of questions Q 1.2, Q 1.4, Q 1.5 and Q 1.6 were obtained by using NGT (see figure 5, § 3.4.1) which also used combination of several methods, e.g., filling of questionnaires (see Appendix B) by the participants , group discussions on inconsistent results, etc. Thus, consistency of conclusions achieved by using various methodologies shows that our study achieved methodological triangulation.

Investigator triangulation

Investigator triangulation refers to involving several different investigators/ researchers during the course of the study (e.g., data collection, data analysis, research question validation, etc.). As discussed in section 3.4.1, we used multiple researchers (see table 9 for their field of expertise and experience) at each stage of the study to actually perform and/or to validate the various processes of the study. For example, the experts validated the research gap, research questions, questionnaires for interviews, NGT design, results of the case study, etc. Figure 4 and 5 in section 3.4.1 shows the stages where validations were performed by the experts during the course of the study.

Ecologic/ Environmental Triangulation

Ecologic triangulation involves using different locations, settings and other key factors related to the environment in which the study takes place. For example, this can be achieved by replicating a study in other contexts such as different industries. We were unable to attain this triangulation because due to the time considerations, we were able to conduct case study of only one project (see § 3.2). However, our study has provided a necessary groundwork for further studies of this kind.

3.5.4 Construct Validity

Construct validity refers to the extent to which the constructs to be measured were actually measured. In this study, the constructs were the conflicts in RE. These were measured by using the conflict template (table 10) that was created to ensure that all the conflict attributes relevant to the goal of the study were covered. To validate the measurement instruments (e.g., NGT questionnaires, interview questionnaires and closed questionnaires) with respect to the theoretical constructs, numerous peer-review sessions were held and they were also validated from experts in RE, SE and empirical studies (table 9, § 3.4.1). This was done to ensure that they were in accordance with the scope of the study.

3.5.5 Conclusion Validity

Conclusion validity refers to the degree to which conclusions we reached based on the findings of the study are reasonable or not (Johnson and Christensan, 2008). The two accepted principles that were applied to the study were ensuring reliability of data measurements and adequate implementation of study processes. For reliability of data measurements, we utilized data-collection instruments (see § 3.4.2) that were validated by several experts. To ensure adequate implementation of study processes, meetings were held with the participants to explain the tools and study processes to them. In chapter 4, we have demonstrated that all our conclusions are rooted in the results, thereby maintaining the conclusion validity. Hence we can claim that all the conclusions drawn are traceable through data analysis all the way to the research questions.

Chapter 4

4 Results and Interpretations

This chapter discusses the results of the case study and their interpretations. All the results presented were validated by relevant experts as shown in Figure 5 (§ 3.5.1) and Table 9 (§ 3.4). Section 4.1 gives the results and interpretations of the research questions addressing the *characteristics* of RE-Conflicts (Q 1.1 to Q 1.6, § 3.1). Section 4.2 discusses the results and interpretations of the research question addressing the *impact* of RE-Conflicts (Q 2.1, § 3.1) on the project risks associated with requirements. Interested readers can refer to Box 2 to Box 7 that give an example scenario from the case study for each result.

All the interpretations of the results have been reached by comparing them with the existing relevant studies along with the discussions with our industry associates and experts. The adjustments to the interpretations were made accordingly. However, it is important to mention that the interpretations made based on the results are limited to the study and should not be generalized widely before conducting further confirmatory studies. Finally, Section 4.3 concludes the chapter by giving the summary of the findings.

4.1 Characteristics of RE-Conflicts

This section gives the following questions addressed regarding the *characteristics* of RE-Conflicts, the results of the case study related to these questions and the interpretations of the findings.

- Types of RE-Conflicts (**Q 1.1, § 4.1.1**)
- RE-Activities in which RE-Conflicts are encountered (**Q 1.2, § 4.1.2**)
- Stakeholders involved in RE-Conflicts (**Q 1.3, § 4.1.3**)
- Severity of RE-Conflicts (**Q 1.4, § 4.1.4**)
- Degree of resolution of RE-Conflicts (**Q 1.5, § 4.1.5**)
- Management styles adopted for RE-Conflicts (**Q 1.6, § 4.1.6**)

4.1.1 Types of RE-Conflicts

Q1.1 *What are the different types of RE-Conflicts?*

Results

To investigate this question, all the RAs of the P&P project were interviewed to collect information regarding the conflict incidences they experienced during RE. A total 13 RE-Conflict incidences were identified from the analysis of the interviews using thematic coding (Thomas & Harden, 2008) (see § 3.4.4). Please see Table 17, Appendix C for the content of the 13 RE-Conflict incidences in the case study. These incidences were validated by the PM of the P&P project and by various experts in RE, SE, empirical studies and statistics (see Figure 5 and Table 9 in § 3.4.1).

We had prepared a data set of types of project conflicts (Table 3, § 3.1) by carrying out SLR of conflicts (see Figure 4, § 3.4.1). By mapping these 13 RE-Conflict incidences (Table 17, Appendix C) to the data set of types of project conflicts (Table 3, § 3.1), we found five types of RE-Conflicts. Table 11 gives the identified types of RE-Conflicts along with their description. We have used descriptive statistics[13] to characterize the 13 RE-Conflict incidences encountered, i.e., to identify to which type of RE-Conflict, a specific RE-Conflict incidence belonged. For example, we found that the RE-Conflict incidence, REC 7 given below was of type 'conflicts over costs' based on the description of 'conflicts over costs' given in Table 11.

REC 7: There were disagreements between clients and developers regarding budget. The clients business was expanding and the clients wanted developers to implement new requirements within the budget that was fixed initially.

[13] Descriptive statistics are used on a sample to estimate characteristics, or traits of a population, i.e., describing the main features of a collection of data (Nick, 2007).

Table 11: Types of RE-Conflicts identified in the case study and their description

Types of RE-Conflict	Description
Conflicts over priorities	This refers to disagreements among stakeholders over prioritizations/ sequencing regarding requirements, modules, tasks, etc.
Conflicts over administrative procedures	This refers to disagreements among stakeholders over administrative issues such as setting the project deadlines, allocation of resources, etc.
Conflicts over schedules	This refers to disagreements among stakeholders over the schedule such as setting the schedules for meetings
Conflicts over technical subjects	This refers to disagreements among stakeholders over technical subjects such as adoption of a programming language for development, selecting a software development model, etc.
Conflicts over costs	This refers to disagreements among stakeholders over the costs and budgets of the project

Figure 7 gives the frequency of different types of RE-conflicts encountered in the case-study. Six out of 13 (47%) RE-Conflict incidences were found over administrative procedures. These RE-Conflicts incidences over administrative issues, took place among different groups of stakeholders (users-users, users-analysts, analysts-analysts). Four of them were between users and analysts. Conflicts over schedules were the least occurring type of RE-Conflict in the case study. There was only one incidence of the conflict over schedules from the 13 RE-Conflict incidences in the case study. This incidence was between users and analysts. The difference between number of conflict incidences over costs (15%), priorities (15%), technical subjects (15%) and schedules (8%) was not found to be significant.

Interpretations

Laurindo and Moraes (2006) had conducted a survey to find the average frequency of sources of conflicts in SE. Their results had shown that conflicts over priorities were the most frequently occurring conflicts followed by the conflicts over costs and administrative procedures. On comparing the results of our study in RE with this study in

SE, we found that the conflicts over administrative procedures were more frequent in RE than in SE and conflicts over priorities were found less frequent in RE than in SE.

The discussions of the above comparison with our industry associates and the experts in RE and SE fields led to the interpretation that a plausible reason behind the occurrence of more conflicts over administrative procedures in RE in our case study might be that the clients and developers in our case study had not worked together and hence were not aware of the administrative procedures of each other. This would have led to the disagreements over some administrative procedures. The plausible reason behind the occurrence of more conflicts over priorities in SE than in RE would be that during the RE process, the conflicts over prioritizations usually involve disagreements only over requirements such as regarding its sequencing of implementation or significance whereas in SE, conflicts over prioritizations include other issues also besides requirements such as disagreements over the sequencing of other project activities (e.g., designing, coding, testing, etc.).

Box 2: Example of question, Q 1.1

Type of RE-Conflict: Conflict over administrative procedure

REC 1: There were disagreements between chairman and analysts over administrative procedures regarding allocation of resources such as people for the requirements elicitation process. Analysts wanted that during the elicitation sessions, chairman, manager and departmental head whose department's requirements were being elicited should be present together so that the elicited requirements were of mutual consent. Also, by following this process, the analysts wanted to gather everyone's perspectives. But the chairman of the client's team disagreed over this process. He wanted that only he or at the most manager should be present in the RE process. The reason for doing so was that the chairman wanted his technical staff to focus on the tasks of the organization. He wanted the analysts to consult managers or department representatives only when required and that too with special appointment and permission.

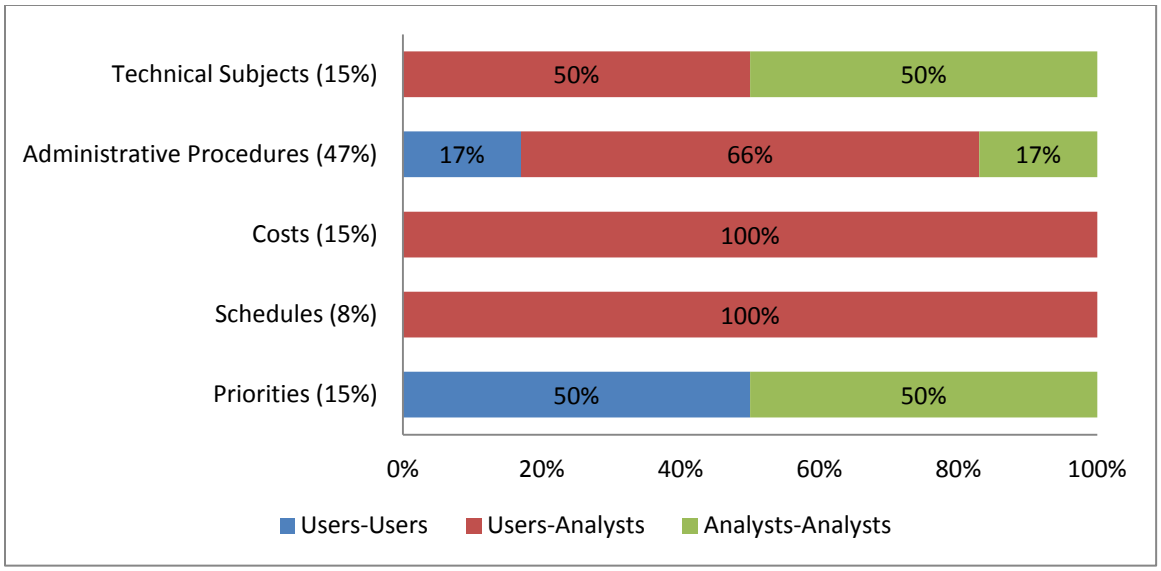


Figure 7: Percentage distribution of types of RE-Conflicts in the case study

4.1.2 RE-Activities in which RE-Conflicts are encountered

Q 1.2 *What are the different types of RE-Activities in which RE-Conflicts are encountered?*

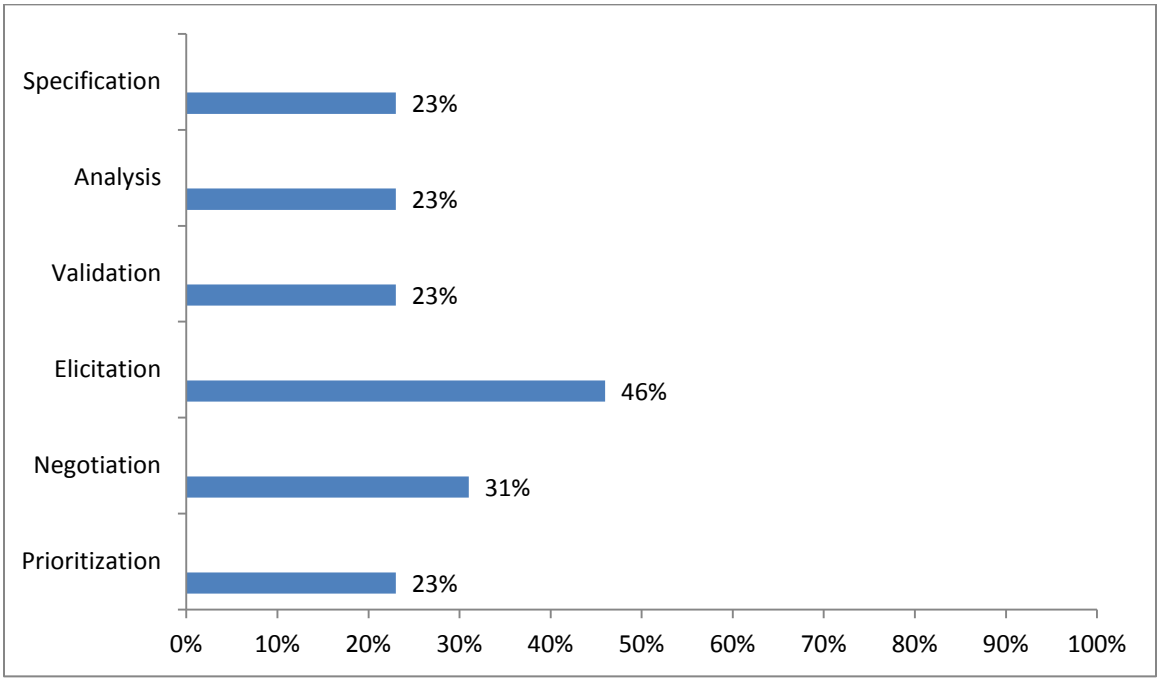
Results

To investigate this research question, information regarding the RE-Activities (e.g., elicitation, prioritization, specification, etc.) in which the 13 RE-Conflict incidences (identified in question, Q 1.1) took place was gathered. Information was gathered from all the RAs and the PM using NGT (Figure 6, § 3.4.1). The analysis showed that the highest proportions of RE-Conflicts took place in the elicitation (46%) and negotiation (31%) RE-Activities. From the analysis of case study, we found that a specific conflict could occur in more than one activities of RE. The percentage distribution of the RE-Activities in which RE-Conflicts were encountered is shown in Figure 8.

Box 3: Example of question, Q 1.2

RE-Activities in which RE-Conflicts was encountered: Prioritization

REC 10: There were disagreements between users and analysts over prioritizations regarding which requirements should be implemented first in the next release of prototypes. The analysts had different criteria for the prioritization of requirements than the clients. The analysts wanted the requirements having less functionality, require less efforts and less dependent on other requirements to be implemented first whereas the users wanted the requirements associated with the functionality that they wanted more to be automated, to be implemented first.



A specific RE-Conflict incidence was observed to occur in one or more than one RE-Activities. This can be seen in the figure as the given percentages do not sum to 100.

Figure 8: Percentage distribution of the RE-Activities in which RE-Conflicts were encountered in the case-study

Interpretations

The highest frequency of RE-Conflicts was found in the elicitation (46%) and negotiation (31%) activities (see Figure 8). The requirements elicitation process involves

understanding the problem, business of clients, application domains, needs and constraints of the system stakeholders (Kotonya & Sommerville, 1998). The purpose of negotiation process is to reach stakeholders agreement on what the real requirements are for a designated phase or release of a software product; given the reality of technology constraints, schedules and costs (Kotonya & Sommerville, 1998). Thus clearly, both of these RE-Activities involve high amount of interaction between users and analysts. Since 70% (research findings, Q 1.3, § 4.1.3) of the RE-Conflicts in the case study took place between users and analysts, therefore the results indicating the highest frequency of RE-Conflicts in the elicitation (46%) and negotiation (31%) RE-Activities seem in harmony with the latter results (research findings, Q 1.3, § 4.1.3).

Our industry associates reported that RE-Conflict incidences were generally not resolved in the RE-Activity in which they originated and consequently they used to get transferred to the next RE-Activities. Therefore, this reason can be held accountable for the occurrence of same RE-Conflict incidence in more than one RE-Activity as shown in Figure 8.

4.1.3 Stakeholders involved in RE-Conflicts

Q 1.3 *What are the different types of stakeholder groups involved in RE-conflicts?*

Results

The SRS contained 289 requirements. The names of the stakeholder from whom the requirements were elicited and the RA who had elicited the requirements were logged in the SRS. Considering the focus of the study on specifically RE, the participants of our case study were RAs and the PM of the P&P project whom we collectively termed as ‘analysts’. We termed the clients of the P&P project as ‘users’. Based on this terminology, three categories of stakeholder groups involved in RE-Conflicts were created: (i) conflicts in the user’s team (Users-Users), (ii) inter-analysts conflicts (Analysts-Analysts) and, (iii) conflicts between users and analysts (Users-Analysts). The analysis of the data from interviews was used to examine this question (§ 3.4.4).

It was found that the highest proportion of RE-conflicts occurred between users and analysts. 9 out of 13 RE-Conflicts which accounts to 70% were users-analysts conflicts. 89% of the users-analysts RE-Conflicts were unresolved. Figure 9 depicts the percentage distribution of RE-Conflicts among specific group of stakeholders in the case-study which has been further divided into resolved and unresolved conflicts.

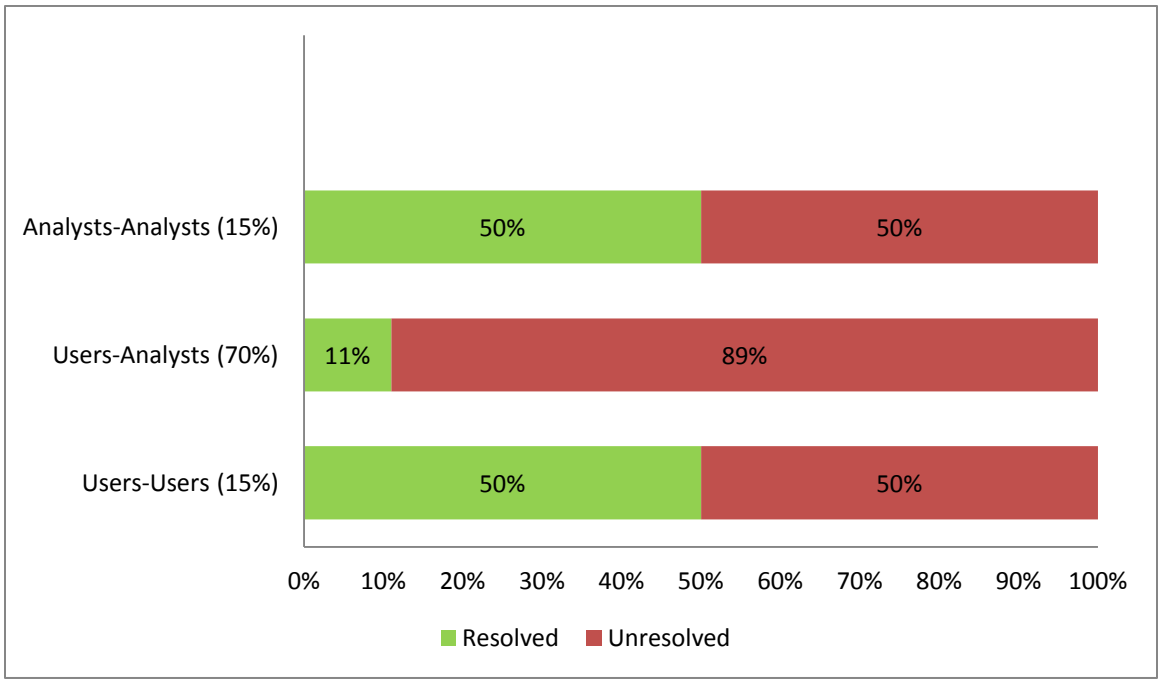


Figure 9: Percentage distribution of RE-Conflicts among specific group of stakeholders in the case-study

Interpretations

The results of the case study show that 70% of the RE-Conflicts were between users and analysts and 89% of those conflicts were not resolved (Figure 9). During the interview, the project manager of the developing team had emphasized that, with the passage of time, large amount of conflicts arose between the users and RAs which had become difficult to resolve. This caused him to take the decision to abandon the project. Thus the results of the case study clearly support the statement of the project manager.

The plausible reason for the occurrence of less conflicts in the *users-users* and *analysts-analysts* stakeholder groups can be that these groups involved members from the same organization who had the prior experience of working together. On contrary, the *users-*

analysts stakeholder group did not have the prior experience of working together which might have led to the occurrence of large number of conflicts between them.

Box 4: Example of question, Q 1.3

Type of stakeholder groups involved in RE-conflicts: Users and analysts

REC 2: There were disagreements between the chairman and analysts over administrative procedures regarding the allocation of resource such as cost formula sheet. This sheet contained the formulas for calculating costs of all the business functions of the client's organization. Analysts wanted to keep a copy of the cost sheet for referring it during requirements analysis process. The chairman disagreed to give it for security purposes.

4.1.4 Severity of RE-Conflicts

Q 1.4 *What is the severity levels of RE-conflicts?*

Results

For gathering the information about the severity levels of RE-Conflicts incidences, the ordinal scale for measuring the severity of conflicts (Table 4, § 3.1) developed by Karn (2008) was used. The scale ranged from 1 to 6, with 1 representing the lowest severity and 6 representing the highest severity. The severity levels for all the 13 RE-Conflict incidences were captured using NGT (Figure 6, § 3.4.3).

The findings of the case study show that 46% of the RE-Conflict incidences were having 6 (38%) and 5 (8%) severity levels (Figure 10). In other words, we can say that around half (46%) of the RE-Conflict incidences were associated with high severity levels. On the other hand, three out of 13 RE-Conflict incidences were found to have severity level 2. None of the 13 RE-Conflicts identified in the case study had severity level 1. The percentage distribution of severities of RE-Conflicts in the case-study has been shown in Figure 10.

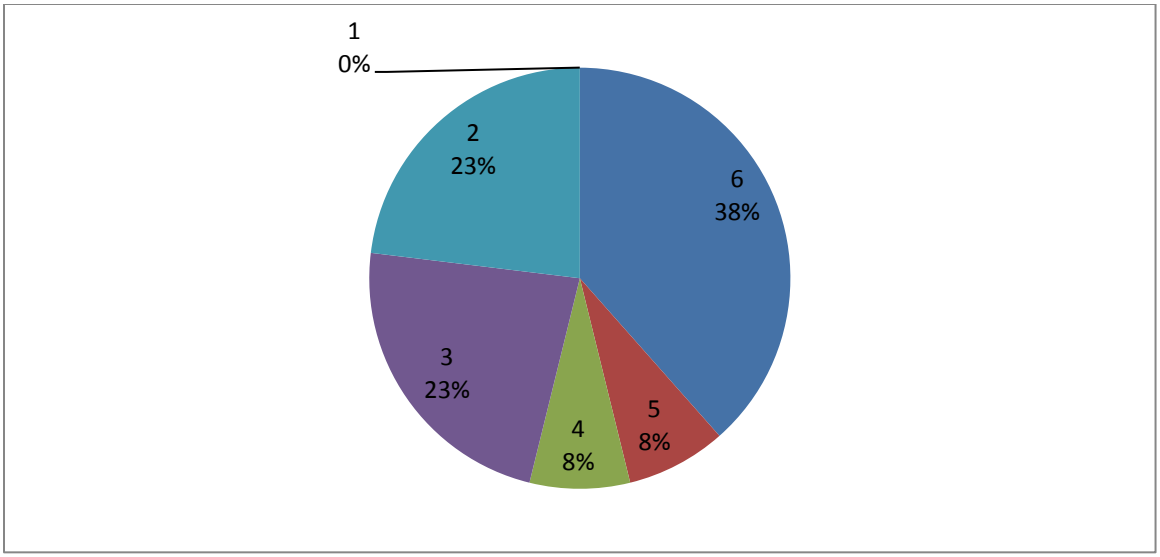


Figure 10: Percentage distribution of severities of RE-Conflicts in the case-study

Box 5: Example of question, Q 1.4

Severity of RE-conflict: 6

REC 7: The budget for the project was decided during the first month of the project. The business of the clients expanded in the fourth month. This resulted in the introduction of new features and consequently new requirements. The analysts asked the users to increase the budget in order to implement the new upcoming requirements. However, the users disagreed to increase the budget and asked the analysts to implement the new requirements within the same budget. This conflict caused complete disruption to the project.

Interpretations

Gobeli et al. (1998) had reported that higher conflict intensities substantially decrease the satisfaction of project team members. The authors also found that the combined effect of conflict intensity and conflict management style is also significant on the project success. Therefore, based on the findings of Gobeli et al. (1998), we can intuitively conclude that since 46 % of the 13 RE-Conflict incidences were having severity 6 and 5 (Figure 10), therefore, this might have led to the low satisfaction of the development team members. Consequently, the PM would have taken the decision to abandon the project. This is also supported by the following example segments from the interviews with the PM:

"*The conflict over the cost sheet was the worst. It led to the wrong implementation of all the modules having cost functionality*."

"At the end of November, we decided to abandon the project due to the presence of excess unresolved conflicts".

4.1.5 Degree of resolution of RE-Conflicts

Q 1.5 *What is the degree of resolution of RE-Conflicts?*

Results

In the case study, for each RE-Conflict incidence, its degree of resolution (resolved/unresolved) was captured from all the 4 RAs and the PM using NGT.

10 out of 13 RE-Conflicts were found unresolved (Figure 11). They account to 77% of the total RE-Conflict incidences that took place during the project. 8 from the 10 unresolved RE-Conflicts were between users and analysts, accounting to 80% of the total unresolved RE-Conflicts. Unresolved RE-Conflicts between *users-users* and *analysts-analysts* stakeholder groups were 10% each of the total unresolved conflicts. Figure 11 shows the percentage distribution of the resolved and unresolved RE-Conflicts in the case-study along with the percentage distribution of the unresolved RE-Conflicts among stakeholders.

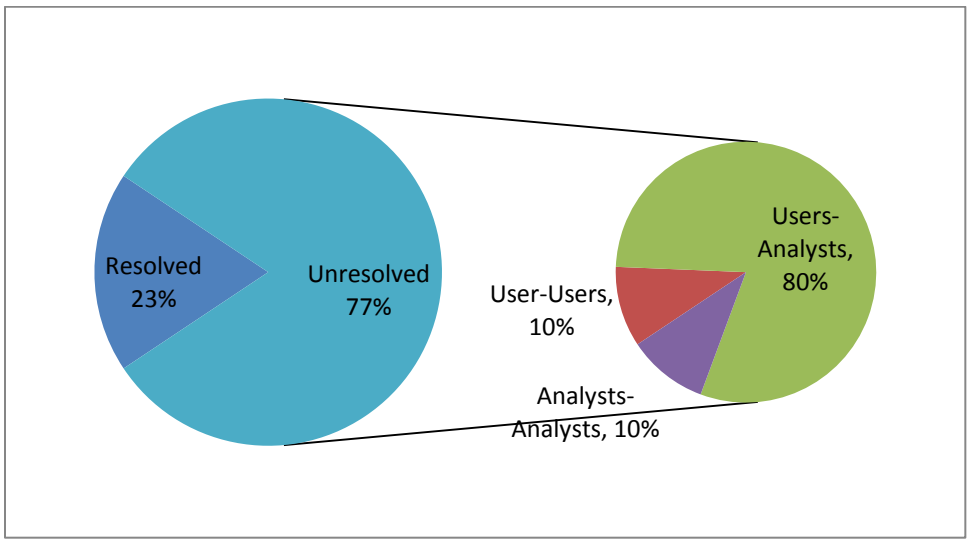


Figure 11: Percentage distribution of resolved and unresolved RE-Conflicts in the case-study

Box 6: Example of question, Q 1.5

Degree of resolution of RE-Conflicts: Resolved

REC 9: Disagreements over prioritizations of requirements used to occur between the manager and departmental heads due to their different perspectives. For managers, the requirements that intended to decrease the costs of business functions were significant whereas for the departmental heads, the requirements that intended to ease their tasks were significant. These types of conflicts were usually dealt smoothly and resolved harmoniously after brief discussion, thus having severity level of 2.

Interpretations

Gobeli et al. (1998) found that unresolved conflicts have a strong, negative effect on overall software product success and customer satisfaction. In our case study, 77% of the RE-Conflicts were left unresolved (Figure 11). Clearly, this is a significant percentage. Therefore, based on the findings of Gobeli et al. (1998), the high number of unresolved conflicts in our case study can be possibly held accountable for the failure of the project under case study. Same interpretation was given by the experts and our industry associates.

4.1.6 Management styles adopted for RE-Conflicts

Q 1.6 *What are the different types of conflict management styles adopted for resolving RE-Conflicts?*

Results

During the case study, the information regarding which management style was adopted for resolving the 13 RE-Conflicts incidences (Table 17, Appendix C), was gathered from all the RAs and the PM using NGT (Figure 6, § 3.4.3). They were asked to select the type of management strategy that they had adopted from the list of conflict management strategies that had been provided to them (Table 5, see § 3.1).

The results of the study showed that the forcing (39%) and accommodating (30%) strategies were the widest adopted conflict management strategies in the project (Figure

12). The collaborating conflict management strategy was never adopted throughout the RE. Figure 12 gives the percentage distribution of the management styles adopted for resolving RE-Conflicts in the case-study.

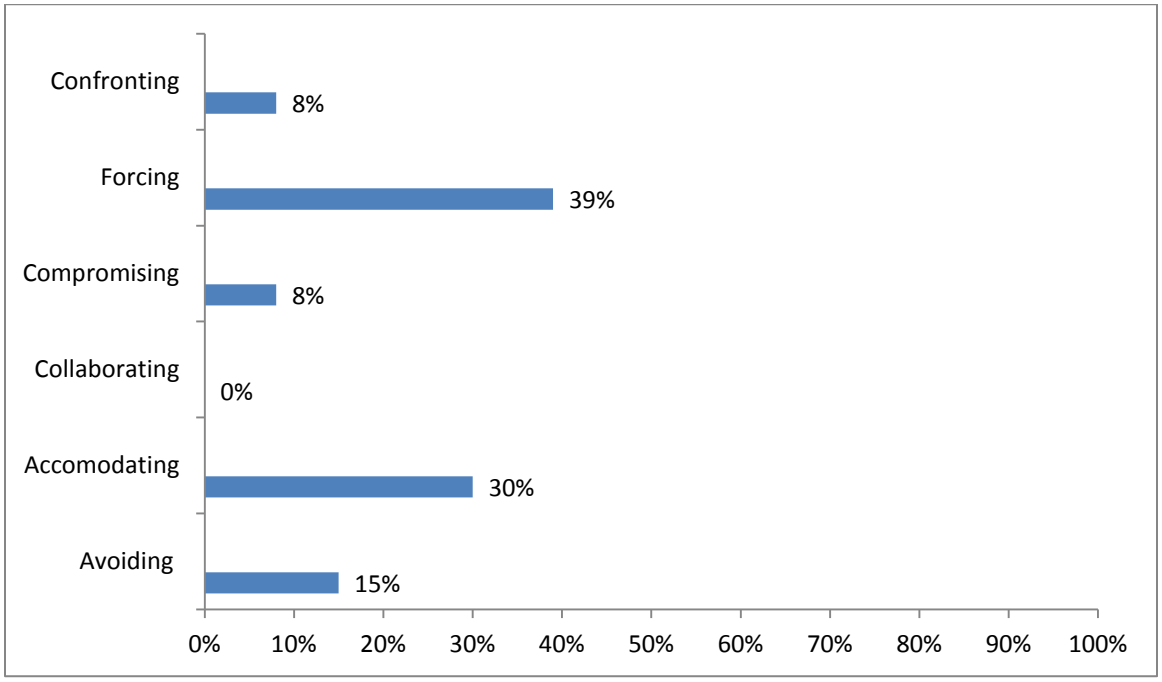


Figure 12: Percentage distribution of the management styles adopted for resolving RE-Conflicts in the case-study

Box 7: Example of question, Q 1.6

Conflict management styles adopted for resolving RE-Conflicts: Confronting

REC 4: The client's team and the developing team were located in different cities. Therefore, the analysts requested the users to allocate an office space to them as they were finding it difficult to elicit the requirements without observing the actual tasks on site. However, the users disagreed to this administrative request as they said that they do not possess sufficient resources. After two months, the users realized the importance of RE taking place on-site as the initial prototypes developed, did not contain the requirements they expected. Therefore, the users resolved this conflict using the "problem solving" conflict management style and allocated an office to the RAs in their organization.

Interpretations

In (Gobeli et al., 1998), the authors had explored the effects of conflict management strategies on a project's success. The authors found that smoothing, withdrawing, and forcing conflict management strategies have dysfunctional effects whereas the compromising conflict management strategy has beneficial impact on the project success. The findings of Dechurch et al., (2007) reported that using the 'forcing' conflict management strategy produces the highest negative impact on relationships whereas using the 'collaborating' strategy has the least effect on the interpersonal relationships.

Our case study results show that forcing (39%) conflict management strategy was adopted most widely whereas the collaborating (0%) conflict management strategy was never adopted (Figure 12). Thus, by considering our case study results and the findings of DeChurch et al. (2007) and Gobeli et al. (1998), we can interpret that due to the highest adoption of forcing as conflict management strategy, the relationships between the clients and development team would have got negatively affected which could have led to the failure of the project.

The discussions with the industry associates also led to the similar interpretation of the results. They reported that mostly the clients used to push their decisions on the developing team. Due to this, several issues used to remain unresolved and they appeared again at the later stages, causing lower satisfaction of the developing team and affecting the project's outcome as well.

4.2 Impact of RE-Conflicts on requirements risks

This section discusses the results of the question Q 2.1 (§ 3.1) that address the *impact* of RE-Conflicts on the project risks associated with requirements (e.g., inadequate requirements, non-traceable requirements, incorrect requirements, etc.). The question addressed regarding the impact of RE-Conflicts, the findings of the case study related to the question and the interpretations based on the findings are given. The question investigated was the following:

Q 2.1 *What types of project risks associated with requirements are affected by RE-conflicts?*

Results

In order to investigate the types of risks associated with requirements affected by RE-Conflicts, firstly, we prepared a list of risks associated with requirements (Table 6, §3.1) by performing literature survey. Then we examined all the RE-Conflict incidences to investigate which risks from that list were affected by them based on the interview results and analyzing the change history of requirements from the SRS (Box 1, § 3.4.4). For example, RE-Conflicts over priorities led to following three risks: (i) unrealistic requirements (ii) late changes to requirements and (iii), incorrect requirements. Table 12 gives the types of risks affected by a specific RE-Conflict.

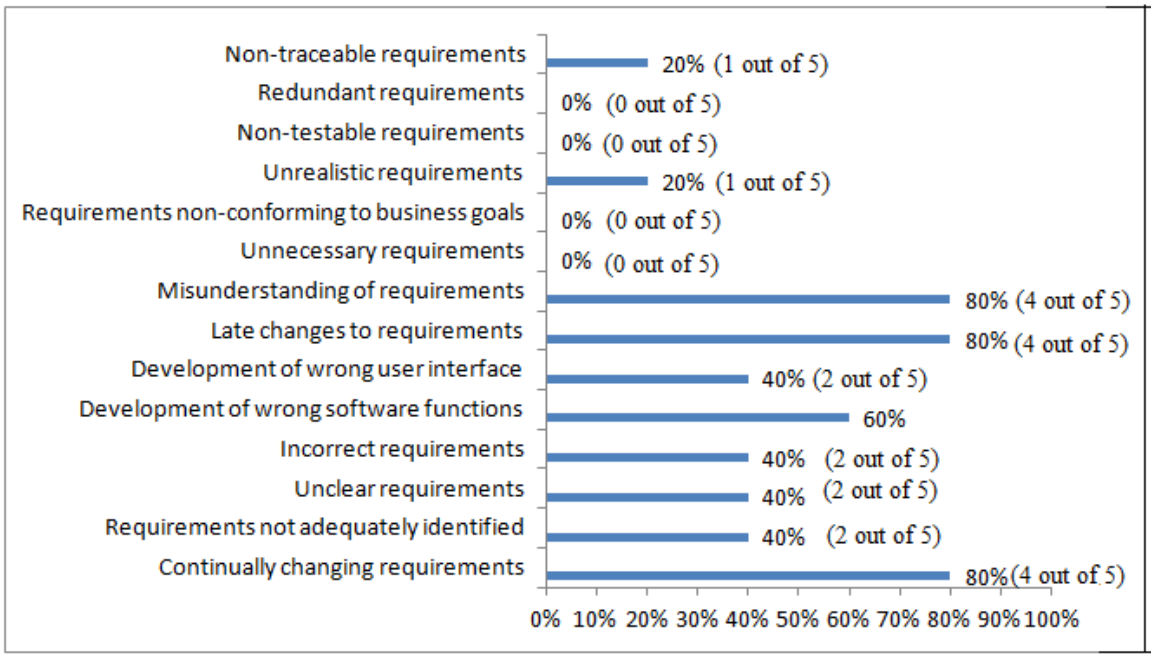
From Table 12, we can observe that the conflicts over administrative procedures affected the highest number of requirements risks (57%) whereas the conflict over technical subjects (21%) and priorities (29 %) affected the least number of requirements risks.

The findings of the case study reported that the requirements risks, *continually changing requirements, misunderstanding of requirements and late changes to requirements* (each 80%), were affected the most by the RE-Conflicts. Conversely, some risks such as *redundant requirements, non-testable requirements, requirements non-conforming to business standards* and *unnecessary requirements* were not at all affected by the RE-Conflicts. Figure 13 shows the percentage distribution of the risks associated with requirements affected by a specific type of RE-Conflict.

Table 12: Types of risks associated with requirements affected by a specific RE-Conflict

Note: "X" represents that a specific type of RE-Conflict (given in the column of the table) affected the requirements risk given in the corresponding row.

Conflict Type **Risk Number & Name**	Conflicts over Priorities	Conflicts over Administ-rative procedures	Conflicts over Technical subjects	Conflicts over schedules	Conflicts over costs	Total (1 to 5)
1. Late changes to requirements	X	X		X	X	**4**
2. Incorrect requirements	X	X				**2**
3. Continually changing requirements		X	X	X	X	**4**
4. Inadequate Requirements		X		X		**2**
5. Development of wrong software functions		X	X		X	**3**
6. Unclear requirements		X		X		**2**
7. Development of wrong interface		X			X	**2**
8. Unrealistic requirements	X					**1**
9. Non-traceable requirements			X			**1**
10. Unnecessary Requirements						**0**
11. Redundant Requirements						**0**
12. Non-testable Requirements						**0**
13. Requirements non-conforming to business						**0**
14. Misunderstanding of Requirements	X	X		X	X	**4**
Total (14)	**4 (29%)**	**8 (57%)**	**3 (21%)**	**5 (36%)**	**5 (36%)**	**25**



Five types of RE-Conflicts were identified in the case study. This figure shows that a specific requirement risk was affected by how many RE-Conflicts

Figure 13: Percentage distribution of the RE-Conflicts affecting a specific requirement risk.

Interpretations

It is a known fact that risk management aids in reducing failure of projects (e.g., Svensson &Aurum, 2006; Cerpa and Verner, 2009). Recently, a list of seven major software risks (see Table 13) was given in (Arnuphaptrairong, 2011) based on a literature survey of project risks. Two risks associated with the *requirements* dimension came in that list: (i) *changes to requirements* and (ii) *misunderstanding of requirements*.

The results (see Figure 13) of our study have shown that the same risks, i.e., *continually changing requirements* and *misunderstanding of requirements* were the risks that were most affected by the RE-Conflicts (80%).This shows the importance of studying the RE-Conflicts, considering their significant impact on the top risks of software. To the best of our knowledge, none of the studies have been conducted to investigate the impact of RE-Conflicts on the risks associated with requirements. Hence, these findings are novel.

Table 13: Seven major software project risks (Arnuphaptrairong 2011)

No.	Software Risks	Dimension[14]
1	Misunderstanding of requirements	Requirement
2	Lack of top management commitment and support	Organizational environment
3	Lack of adequate user involvement	User
4	Failure to gain user involvement	User
5	Failure to manage end user expectation	User
6	Changes to requirements	Requirement
7	Lack of an effective project management methodology	Planning and Control

4.3 Summary of the findings

Our findings give insight into various *characteristics* of conflicts rooted in RE (e.g., types of RE-Conflicts, RE-Activities in which RE-Conflicts are encountered, stakeholders involved in RE-Conflicts, etc.), and their *impact* on the risks associated with requirements. 5 types of RE-Conflicts were identified in the study (Figure 7, § 4.1.1):

- Conflicts over technical subjects (15%)
- Conflicts over administrative procedures (46%)
- Conflicts over costs (15%)
- Conflicts over schedules (8%)
- Conflicts over priorities (15%)

The results showed that the highest proportions of RE-Conflicts took place in the elicitation (46%) and negotiation (31%) RE-Activities (Figure 8, § 4.1.2). The results of the case study also reported a significant impact of RE-Conflicts on the risks associated with requirements. The types of risks that were most affected by the RE-Conflicts were (Table 12, Figure 13, § 4.2):

[14] The researchers have categorized software risks into 6 dimensions, namely, user (U), requirement (R), project complexity (Comp), planning and control
(P&C), team (T), and organizational environment (Org). Please see Table 16 in Appendix C to see the risks associated with all the six dimensions.

- Continually changing requirements (80%)
- Misunderstanding of requirements (80%)
- Late changes to requirements (80%)
- Development of wrong software functions (60%)

The following types of RE-Conflicts were found to have the highest affect on the risks:

- Conflicts over administrative procedures (57%)
- Conflicts over schedules (36%)
- Conflicts over costs (36%)

77% of the RE-conflicts in the project under case study were unresolved (see Figure 11, § 4.1.5) and approximately half of them had high severity levels (5 and 6 in the ordinal scale ranging from 1 to 6, with 6 being the highest severity level). The highest number of RE-Conflicts took place between users and analysts (70%).

So far, there was no scientific study available on the above issues. Therefore, our findings can be considered as an important step towards building knowledge on the characteristics and impact of RE-Conflicts.

Chapter 5

5 Implications

This chapter describes the implications of the results of our study. Sections 5.1, 5.2 and 5.3 discuss the implications on industry, tools and empirical research respectively.

5.1 Implications on Requirements Engineering Practice

The findings of this study have demonstrated a significant impact of RE-Conflicts on the risks associated with requirements. For example, the risks, *misunderstanding of requirements, late changes to requirements* and *continually changing requirements*, were affected by four out of five types of identified RE-Conflicts in the case study (see Table 12 and Figure 13, § 4.2). Usually, risk management is considered from the design phase of a software development life cycle (Amber et al., 2012).The practitioners can utilize the results of this study for initiating risk management in RE by managing the RE-Conflicts affecting the risks. They can also create strategies for the mitigation and avoidance of RE-Conflicts relevant to the context of their projects.

5.2 Implications on Requirements Engineering tools

The findings of this study have reported that the conflicts rooted in RE have a significant impact on the project risks associated with requirements (see Table 12 and Figure 13, § 4.2). For example the requirement risk, '*continually changing requirements'* was affected by 80% RE-Conflicts. However, as far as we know, no tools or frameworks are available for the management of RE-Conflicts which could also consequently aid in the management of risks. Thus, the findings of the study can motivate the researchers to develop new RE technologies such as RE-Conflict sensitive tools.

5.3 Implications on empirical research

In Section 5.3.1, we have discussed the hypotheses (H1, H2 and H3) that have emerged from the analysis and findings of the case study. Section 5.3.2 gives the hypotheses (H4 and H5) that have emerged from the existing literature related to the interpersonal conflicts. We have provided the rationale behind the formulation of each hypothesis.

These hypotheses can be explored through further empirical investigations. There can be various research methods that could be followed based on factors such as context of the study, resources and time availability, etc. However, we have given an example research procedure that could be followed to investigate each hypothesis. It is important to mention that the research procedures stated in this section for investigating hypotheses are just guidelines and can be modified as per the requirement.

5.3.1 Emerging hypotheses based on the analysis and findings of the case study

The hypotheses, H1, H2 and H3 that emerged from the findings of this study are discussed below.

H1: The degree of resolution of RE-Conflicts depends on the types of conflict management strategies adopted for their resolution.

Rationale for H1: Gobeli et al. (1998) had reported that unresolved conflicts have strong negative effect on project's success. The authors had also reported that the 'accommodating', 'withdrawing', and 'forcing' conflict management strategies have dysfunctional effects on project success whereas the 'compromising' conflict management strategy has beneficial impact on the project success. The findings of our case study (Figure 12,§ 4.1.6), show that 'forcing'(39%), 'accommodating' (30%) and 'avoiding' (15%) were the highest used management strategies, which according to the findings of Gobeli et al. (1998) are detrimental for the success of a project. The findings of this study also reported the presence of 77% unresolved conflicts in the project under case study (Figure 11, § 4.1.5). Therefore, it would be interesting to explore whether the adoption of a specific type of conflict management strategy has an impact on the degree of resolution of conflicts. Based on the findings of Gobeli et al. (1998) and the results of our study, the hypothesis, H1 was formulated. One of the possible option for investigating this hypothesis is, carrying out multiple case studies of software projects and observing the types of conflict management strategies adopted and the degree of resolution of RE-Conflicts in them and comparing their results.

H 2: Some types of project risks associated with requirements are never affected by any type of RE-Conflict

Rationale for H2: The findings of our study show that the following requirements risks were not affected by any RE-Conflict: *'redundant requirements'*, *'non-testable requirements'*, *'requirements non-conforming to business goals'* and *'unnecessary requirements'*(Table 12 and Figure 13, § 4.2). Therefore, this finding needs further investigation to determine whether there exist some types of requirements risks which are never affected by any type of RE-Conflict. This led to the emergence of above stated hypothesis, H2.It can be investigated by conducting case studies on the impact of RE-Conflicts on requirements risks in different projects having varying domains (e.g., banking, medical, etc.), sizes, software development processes (e.g., waterfall, spiral, etc.), etc.

H3: RE-conflicts have negative impact on the risks associated with the following dimensions: (i) users, (ii) team, (iii) organizational environment, (iv) complexity, and (v) planning and control.

Rationale for H3: Risks have several dimensions such as users, team, complexity etc. as discussed in Section 2.3 (also see, Table 16 in Appendix C). The findings of this study (Table 12 and Figure 13, § 4.2) have shown that RE-conflicts have negative impact on the risks associated with the 'requirements' dimension .The types of risks that were most affected by the RE-Conflicts were: continually changing requirements (80%), misunderstanding of requirements (80%), late changes to requirements (80%) and development of wrong software functions (60%). This finding has motivated us to state the above hypothesis, to test the impact of RE-conflicts on other risk dimensions (e.g., users, team, complexity, etc.) as well, given in Table 16, Appendix C. The research procedures used in this study can act as guidelines for investigating the impact of RE-Conflicts on other risks dimensions (e.g., users, team, complexity, etc.).

5.3.2 Emerging hypotheses based on the background literature

The hypotheses, H4 and H5 discussed in this section are outside the GQM paradigm of this study and are based on the literature survey conducted on interpersonal conflicts. Further domain analysis would be required for to validate these hypotheses and they can be modified accordingly.

H4: RE-conflicts have negative impact on project's costs (e.g., documentation costs, development costs, rework costs, etc.), project's quality, project's success, team's performance, customer satisfaction and RE-success factors (e.g., the clarity of the business process in the architecture, the extent of user consensus on the recommended solution, the completeness of coverage of the cost/benefits analysis, etc.)(El Emam & Madhavji, 1995).

Rationale for H4: In the SE field, it has been found that interpersonal conflicts impact various project parameters such as quality of a product (Liang et al. 2010), project's success (Gobeli et al., 1998; Robey et al., 1993), team's performance (Karn & Cowling 2008), etc. However, the research gap analysis discussed in Section 2.3 (also see Table 1, § 2.3), has shown that there is lack of research regarding the impact of RE-Conflicts on such project parameters. Since the findings of this study report that the RE-conflicts have negative impact on the requirements risks, therefore, the above hypothesis, H4 has emerged. Separate studies can be conducted to investigate the impact of RE-Conflicts on different project parameters such as cost, quality, success, etc. The research procedures used in this study might be used as guidelines.

H5: RE-conflicts are dichotomous in nature i.e., some are beneficial for a project; whereas some others are detrimental.

Rationale for H5: Karn (2008) investigated whether certain forms of conflict in SE teams can be either constructive or destructive. The results of his study showed that task conflicts were found beneficial when they were based on the core project or technical

issues. Process conflicts were found to be slightly more destructive whereas the relationship conflicts were overwhelmingly destructive. The findings of Karn (2008) have motivated us to state the above hypothesis, H5 which intends to determine whether RE-Conflicts are also dichotomous in nature. Our study has identified 5 types of RE-Conflicts. To investigate this hypothesis, these RE-Conflicts will have to be categorized into the process, tasks, and relationship conflicts.

This study can thus aid in creating, from concrete findings, emerging mid-range theories (Carroll, 2000) on the interpersonal conflicts in RE and hypotheses for further research. The resultant theories and hypotheses on the impact of RE-conflicts could be a significant contribution to the research baseline in RE.

Chapter 6

6 Limitations, Future Work and Conclusions

Section 6.1 of this chapter discusses the limitations of the study and intended future works. Finally we conclude the thesis in Section 6.2.

6.1 Limitations and Future Work

Based on our analysis of interpersonal conflicts literature (§ 2.3), it was found that an insignificant amount of research has been carried out on the interpersonal conflicts rooted in RE. To the best of our knowledge, this study was a first of its kind study on the characteristics of RE-Conflicts and their impact on the project risks associated with requirements. While these findings contribute new scientific knowledge in RE, it is important to note that the case study was exploratory in nature. Therefore, despite our validations of the study through industrial associates and several relevant experts (Table 9, § 3.4.1), a caution is advised while making project decisions solely based on the findings of this foundation study. Thus, we encourage other researchers to conduct confirmatory and complementary studies in other domains and context to help in building a grounded theory on the RE-Conflicts.

In this empirical study, the impact of RE-Conflicts on the risks associated with requirements was investigated based on the 13 RE-Conflicts identified in the project under case study. The investigation based on the small amount of RE-Conflict incidences could be considered as a limitation to the study. However, the presence of small amount of RE-Conflicts can be justified from the findings of Elam and Walz (1988) who reported that, “conflict is a consistent but fairly small percentage of the group interactions”. Our ongoing future work is also intended to overcome this limitation. We are conducting case studies of three other projects having different domains (call monitoring software, online shopping software, ERP for a pharmaceutical company) to determine the characteristics and impact of RE-Conflicts. The comparisons of the results of these studies can aid in determining an average percentage of occurrence of RE-Conflicts in a project.

Another limitation of the study can be identification of only five types of RE-Conflicts in the case study. By carrying out empirical studies with projects in other domains (e.g., banking, insurance, etc.), and organizations following different software development methodologies (e.g., waterfall model, spiral model, incremental development model, etc.), we can expect identification of more types of RE-Conflicts. To overcome, this limitation, we are carrying empirical investigations of projects in other domains and having varying product sizes (e.g., lines of codes). They are part of our ongoing future work on the RE-Conflicts.

Finally, investigation of the impact of RE-Conflicts on only one aspect, i.e., risks associated with the requirements can also be considered as a limitation.The impact of RE-Conflicts on other aspects such as RE-Success factors (e.g., the clarity of the business process in the architecture, the extent of user consensus on the recommended solution, the completeness of coverage of the cost/benefits analysis, etc.) (El Emam & Madhavji, 1995), costs (e.g., documentation costs, development costs, rework costs, etc.), other project risks that are not associated with requirements (e.g., risks associated with following dimensions: planning and control, project complexity, organizational environment, etc.), etc. was not investigated. These aspects were in the scope of this thesis due to resource and time constraints. Therefore, we have created emerging hypotheses based on this limitation (see hypotheses H 3, § 5.3.1 and H4, § 5.3.2). Further empirical investigations can be conducted to investigate them.

Despite the above discussed limitations, the importance of the results of our study cannot be diminished as it lays a foundation for future analogous studies which can help in building emergent mid range theories (Carroll, 2000) on the RE-Conflicts.

6.2 Conclusions

Interpersonal conflicts have been extensively explored in several fields such as general managerial projects (e.g., Kerzner, 1992; Posner, 1986 etc.), SE projects (e.g., Liang et al., 2010; Karn & Cowling, 2008), etc. In the SE field, researchers have found that interpersonal conflicts have an impact on several factors such as project’s success (Gobeli

et al., 1998; Robey et al., 1993), quality of a product (Liang et al., 2010), team's performance (Karn & Cowling, 2008), etc. Yet in the field of RE, to our knowledge, there is no scientific study on the characteristics and impact of interpersonal conflicts. In this thesis, we have conducted a case study of an industrial project to determine the characteristics and impact of RE-Conflicts on project risks, specifically those associated with requirements.

The findings show that RE-Conflicts over administrative procedures (47%) had the highest frequency count and the RE-Conflicts over schedules (8%) had the lowest frequency count (see Figure 7, § 4.1.1). The highest numbers of RE-Conflicts accounting to 70% were between users and analysts (see Figure 9, § 4.1.3). 77 % of the RE-Conflict incidences in the case study were unresolved and 80% of those unresolved RE-Conflicts were between users and analysts (see Figure 12, § 4.1.5). Around half of the RE-Conflict incidences (46%) were associated with high severity levels, i.e., 5 and 6 in the ordinal scale ranging from 1 to 6 (see Figure 8, § 4.1.4). It was observed that 'forcing' (39%) was the most widely adopted conflict management strategy in the case study whereas the 'collaborating' conflict management strategy was never used (see Figure 12, § 4.1.6).

The elicitation (46%) and negotiation (31%) RE-Activities encountered maximum number of RE-Conflicts (see Figure 8, § 4.1.2). The case study also reported a significant impact of RE-Conflicts on the project risks associated with requirements. The following risks were the most affected risks by the RE-Conflicts: misunderstanding of requirements (80%), continually changing requirements (80%), late changes to requirements (80%) and development of wrong software functions (60%) (see Figure 13, § 4.2).

Both the lack of *conflict management* (Sherif et al.,2006; Gobeli et al., 1998) as well as the lack of *risk management* (e.g., Svensson & Aurum, 2006; Cerpa & Verner, 2009) have been independently stated as major factors leading to project failures. Thus, our results have implications in the industry as the knowledge obtained from the case study about the RE-conflicts affecting risks can aid in conducting risk-management in the RE

phase by managing those RE-conflicts. The practitioners might also utilize this knowledge to create strategies for the mitigation and avoidance of RE-Conflicts.

Since to the best of our knowledge, there are no scientific studies yet conducted to explore the characteristics and impact of conflicts in RE, therefore, this study is expected to act as stepping stone towards conducting further research on interpersonal conflicts in RE.

While these findings contribute new scientific knowledge in RE, it is important to note that the case study was exploratory in nature. Therefore, despite our validation through industrial associates and researchers (§ 3.4.1), a caution is advised while making project decisions solely based on the findings of this study.

The basing of the investigation based on the small number of RE-Conflicts could be considered a limitation of the study. However, this can be justified from the findings of Elam and Walz (1988) who reported that quantitatively the conflicts typically form a fairly small percentage of team interactions. Our ongoing work is also intended to overcome this limitation as we aim to gather data from other projects having different domains and durations.

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Appendix A: Summary of related work on conflicts

Table 14 and table 15 give the summary of the work done on conflicts in SE and RE since last 25 years in the chronological order (starting with the latest work) respectively. The summary of the works cover the following five aspects: (i) *dimension (D)* of the conflict on which the work has focused , (ii) *study purpose (SP)*, (iii) *methodology (M)* adopted, (iv) *results (R)* or findings and (v), *future work (FW)* either planned or suggested by the researchers.

Table 14: Summary of the related work on conflicts in SE

Reference	**Summary** **D=Dimension, SP=Study Purpose, M= Methodology, R= Results, FW=Future Work**
Liang et al.(2010)	**D:** Impact of interpersonal conflicts **SP:** The impact of diversity, conflicts in project teams on the software quality **M:** Survey of 299 members of 75 development teams **R:** Task-related conflicts aid in improving the software quality by increasing the learning opportunities whereas the relationship conflicts have negative impact on the software quality **FW:** Not applicable
Karn (2008)	**D:** Impact of interpersonal conflicts **SP:** Whether certain forms of conflict in SE teams can be either constructive or destructive **M:** Ethnographic study involving observing seven software engineering teams **R:** Task conflicts were found beneficial when they were based on the core project or technical issues. Process conflicts were slightly more destructive whereas the relationship conflicts were overwhelmingly destructive. **FW:** Mechanisms for resolving conflicts in SE teams needs to be developed. How and why conflict mutations occur needs to be explored. For example, mutation of a constructive task conflict to destructive relationship conflict. Relationship between teams and clients with emphasis being put on the conflict episodes needs to be explored. Levels and types of conflicts in teams due to following different SE methodologies also need to be explored.
Karn & Cowling (2008)	**D:** Impact of interpersonal conflicts **SP:** Effects of different forms of conflict on the performance of team during the feasibility, requirements analysis, and design phase of SE projects. **M:** Observational methods were used on 3 teams consisting of master of science (MSC) students at the University of Sheffield as they worked through the feasibility, analysis, and design phases of the SE life cycle. **R:** Developed a template that aids researchers to record details of any conflicts

	that occurred. The analysis showed that the team that experienced moderate levels of task conflicts in comparison with other teams performed the highest. **FW:** Not applicable
Laurindo & Moraes (2006)	**D:** Management of interpersonal conflicts **SP:** Identify major sources of conflicts in IT projects and the most common conflict management strategies adopted. **M:** Survey having sample size of 25 elements comprising of managers and members of development teams. **R:** Occurrence of conflicts caused by priorities and the adoption of compromising conflict management strategy were found to be the most frequent. Only the "Responsibilities" and "Inter-personal" sources of conflicts showed variation during the different stages of the life cycle. The frequency of adoption of resolution strategies was not found to vary with the phases of the project. **FW:** Not applicable
Sherif et al. (2006)	**D:** Management of interpersonal conflicts **SP:** Management of conflicts in disruptive information technology innovations (one that requires changes in the architecture of work processes) **M:** Model uses the existing theories of conflicts, coordination and learning. To validate the model, study of software reuse programs was conducted in four organizations. **R:** Presents a model depicting the peer-to-peer conflicts that are likely to generate due to the introduction of disruptive technologies. Results show that companies implementing appropriately devised managerial interventions experienced greater success with their software reuse programs than the companies who did not implement them. **FW:** Not applicable
Barki & Hartwick (2001)	**D:** Management of interpersonal conflicts **SP:** How people involved in the information system development (ISD) perceive conflicts. Examine relationships between interpersonal conflicts, their management and ISD outcomes **M:** Data obtained from 265 IS staff and 272 users working on 162 ISD projects by mailing them questionnaires was analyzed **R:** Overall negative perception was found among individuals regarding the impact of interpersonal conflicts. Conflict management was not found to substantially mitigate the negative effects on the outcomes **FW:** Research regarding antecedents and prevention of interpersonal conflicts needs to be undertaken.
Sawyer (2001)	**D:** Factors affecting interpersonal conflicts and management of interpersonal conflicts **SP:** Factors affecting intra-group conflicts and the effect of these factors on the performance of packaged software development teams **M:** The presence of intragroup conflicts, the level of conflict management, and the performance of software development team were analyzed from the data of 40 packaged software development teams.

	R: Nearly one-half of the variance was found between the most successful and the least successful software development teams based on how the conflicts are effectively managed. **FW:** To test larger sample and assess the industry/ organization-level issues surrounding intra-group conflicts
Gobeli et al. (1998)	**D:** Management of interpersonal conflicts **SP:** To perform a multilevel analysis regarding managing conflicts in software development teams **M:** Survey comprising of 117 software professionals and managers **R:** Unresolved conflicts have a strong, negative effect on overall software product success and customer satisfaction. Confronting and give and take conflict management strategies have beneficial impacts on the project success whereas smoothing, withdrawing, and forcing have dysfunctional effects **FW:** Not applicable
Lewis et al. (2008)	**D:** Factors affecting interpersonal conflicts **SP:** The impact of dominance of problem solving style on the group conflict **M:** Case study comprising of 38 students enrolled in two 15-week SE courses **R:** A negative relationship exists between the dominance of problem solving style and group conflicts **FW:** To increase the applicability of the case study findings, authors are in process of extending the current study into a multi-institutional study.
Robey et al. (1993)	**D:** Factors affecting interpersonal conflicts **SP:** Test the model of conflict during system development proposed by Robey, Farrow, and Franz in 1982 and 1989. Extension of model to include project success as an outcome variable. **M:** Survey from 17 system development projects in 3 organizations comprising of 84 participants. **R:** Strong positive relationship between conflict resolution and project success and a modest positive relationship between participation and project success was found. **FW:** How the behavioral differences between effective and ineffective project leaders stimulate and resolve conflicts needs further research.
Robey et al. (1989)	**D:** Factors affecting interpersonal conflicts and management of interpersonal conflicts **SP:** Relationships among conflict, influence, user participation and conflict resolution **M:** Questionnaires, interviews, recorded transcripts of group meetings and archival data from the development of an information system in an insurance company were analyzed. **R:** Over the time-span of 22 months, participation was consistently found to positively affect the influence which further positively affected both conflict and conflict resolution. **FW:** Further research is required to explore the patterns of communication and conflict common to the system development settings.

Robey & Farrow (1982)	**D:** Factors affecting interpersonal conflicts and management of interpersonal conflicts **SP:** Explore the relationships among conflict, influence, user participation and conflict resolution **M:** Analysis of the data captured by interviews and questionnaires from 8 organizations from different countries comprising of 62 MIS users was performed. **R:** User participation results in the influence and the influence further leads to both conflict and resolution. However, it was found that it does not lead to successful conflict resolution in the 3 development stages (initiation, design and implementation phases) analyzed in the study. **FW:** Two key variables need further study as they have not been covered; Success criterion and more detailed description of the mechanism for participation. Further research on how influence and conflict are elicited and how conflict is resolved needs to be undertaken.

Table 15: Summary of related work on conflicts in RE

Reference	**Summary** **D=Dimension, SP=Study Purpose, M= Methodology, R= Results, FW=Future Work**
Sullabi et al.(2012)	**D:** Interpersonal conflicts **SP:** How conflicts among the group members can be managed in order to produce a correct software formal specification document **M:** Z formal notation is used for writing the specifications. Spiral approach is used for resolving conflicts between writers and reviewers. The model introduces new tool, SNL2Z used for translating an informal structured software specification into formal specification **R:** Presents a web-based model of Computer Supported Cooperative Work (CSCW) that supports in collaborating on preparing correct formal software specification document and it gives the way for them to communicate, edit and correct the shared document **FW:** Not applicable
Khan et al. (2011)	**D:** Interpersonal conflicts **SP:** How changing the sequence of communication media impacts conflict resolution in DSD setting **M:** Controlled experiment was conducted in DSD setting with 5 teams comprising of students from 2 different universities wherein the customer and development teams were from different universities and the artifact used was SRS. **R:** The change of sequence of communication medium has a positive impact on the conflict resolution. **FW:** Conducting the study in the GSD setting to explore the impact of changing

	the sequence of communication medium on the conflict resolution in GSD environment.
Liu et al. (2011)	**D:** Interpersonal conflicts **SP:** Investigate the relationship among interpersonal conflict, requirements uncertainty and the performance of software project. **M:** Survey of top 1600 companies in Taiwan. **R:** The requirements instability leads to potential interpersonal conflicts which in turn is negatively associated with the final performance of the project. **FW:** The authors suggest that future work should consider different software processes and can also conduct cross-cultural comparisons.
Maxwell et al. (2011)	**D:** Conflicts in requirements **SP:** Study conflicting compliance requirements due to cross-references **M:** Case study of the U.S. Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule **R:** Identified five sets of conflicting compliance requirements and recommend strategies for resolving these conflicts. Developed a legal cross-reference classification taxonomy which could be used by requirements engineers to classify the effect that a legal cross-reference has on requirements. **FW:** Authors plan to do further studies using other legal texts to refine and further validate the taxonomy. They are also interested in determining if circular cross-references exist, and if they can introduce dependency conflicts. They also plan to conduct a human subject experimentation to measure the taxonomy's affect on requirements engineers' ability to classify cross-references and identify conflicts.
Liu(2010)	**D:** Conflicts in requirements **SP:** Analysis of conflicts among non-functional requirements **M:** A domain independent NFR ontology, 7 kinds of metadata for modeling non-functional requirements and 7 conflict detection rules for non-functional requirements have been used for the conflict analysis method. **R:** Conflict analysis method for non-functional requirements of information systems has been proposed. **FW:** Authors intend to develop an automatic tool for detecting non-functional requirements using C# to implement the rules
Sardinha et al. (2009)	**D:** Conflicts in requirements **SP:** Automation of conflict detection in aspect-oriented requirements M: Compositions are defined using RDL specifications (Chitchyan et al. 2007) Application of a Bayesian learning method, called Naive Bayes (Mitchell 1997) is done to aid the tool in learning the nature of composed concerns and consequently detect conflicts **R:** An automated tool, EA-Analyzer for identification of conflicts in Aspect-Oriented Requirements. **FW:** Not applicable
Kim et al. (2007)	**D:** Conflicts in requirements **SP:** Management of requirements conflicts

	M: Requirements are partitioned in natural language and are supported by a tool. **R:** Present an approach for systematic identification and management of conflicts **FW:** Authors plan to extend their approach to identify and manage conflicts not only between functional requirements but also between non-functional requirements
Sadana et al. (2007)	**D:** Conflicts in requirements **SP:** Analysis of Conflicts among Non-Functional Requirements **M:** Analysis of conflicts among non- functional requirements is performed using the integrated analysis of functional and non-functional requirements. Seven inputs (e.g., high-level NFR resulting in abstract conflicts, quality attribute hierarchy, functionality hierarchy, etc.) are fed as inputs to the framework and a conflict hierarchy is obtained as output. **R:** Framework for analysis of conflicts among NFR **FW:** NA
Damian & Zowghi (2003)	**D:** Interpersonal conflicts **SP:** How culture, conflict and distance interplay in globally distributed requirements negotiations **M:** Case study of two multi-site organizations with headquarters in US and development sites in Australia **R:** Presents a model of the impact on RE activities due to various challenges such as cultural diversity, time and distance differences, etc. in GSD **FW:** Researchers need to develop RE process that address these crucial issues of interplay between culture and conflict and the impact of distance on the RE activities in GSD
Egyed & Grubacher 2004	**D:** Conflicts in requirements **SP:** Identifying requirements conflicts and cooperation **M:** Trace analysis technique is used to identify conflicts and cooperation among requirements. **R:** Presents an automated and tool-supported approach that identifies requirements conflicts and cooperation **FW:** Not applicable
Poort & De With (2004)	**D:** Conflicts in requirements **SP:** Resolving requirements conflicts **M:** The conflicting requirements are transformed into system decomposition by mapping the NFR onto the functional requirements for the architecture design. **R:** Presents a framework that provides a model and a repeatable method to transform the conflicting requirements into system decomposition. **FW:** Exploring other areas in which NFD can be deployed and further application of NFD in technically complex projects.
In et al. 2001	**D:** Conflicts in requirements **SP:** Effectiveness of tools , QARCC (Boehm & In, 1996) and S-COST (Boehm & In, 1996) in quality requirements conflicts, analysis of conflict resolution process, stakeholder's roles and their relationships to quality artifacts **M:** Case study of library projects comprising of 15 teams of 86 graduate students

	as developers and the USC library staff as customers **R:** QARCC and S-COST tools were found to surface larger number of quality requirements conflicts and options than performed manually by the stakeholders. Analysis results showed that stakeholders usually go for satisfactory resolutions rather than optimal resolutions. The developers are more active in working toward resolutions whereas customers in stating win conditions. **FW:** Not applicable
Lamswe erde et al. (1998)	**D:** Conflicts in requirements **SP:** Management of conflicts in Goal-Driven Requirements Engineering **M:** The methodology includes a specification language, an elaboration methodology and meta-level knowledge used for local guidance and validation during the elaboration process **R:** A formal framework for clarifying various types of inconsistency that might arise in RE process and various formal techniques and heuristics for conflict detection has been proposed. **FW:** Authors plan the integration of proposed techniques in the KAOS/ GRAIL (Darimont et al. 1998) environment in order to conduct large-scale experimentation on the industrial projects
Boehm & In, 1996	**D:** Conflicts in requirements **SP:** Identify quality requirement conflicts **M:** Examination of the quality attribute tradeoffs involved in the software architecture is performed and appropriate strategies are processed (e.g., implementing portability via a layered architecture is usually done at some cost in performance) **R:** Presents an exploratory knowledge-based tool for identifying potential conflicts named as Quality Attribute Risk and Conflict Consultant(QARCC) **FW:** Further refinement of QARCC is required to avoid overloading users with insignificant quality-conflict suggestion
Hartwell (1991)	**D:** Conflicts in requirements **SP:** Resolving Conflicts in system requirements **M:** Expands upon the traditional systems engineering methods such as analyzing system requirements, performing functional allocation, examining trade-off issues, etc. **R:** Presents various techniques for evaluation of conflicting requirements. Analysis methods for resolving conflicts, impact of technology trends and trade off analysis are also discussed. **FW:** Not applicable
Elam and Walz 1988	**D:** Interpersonal conflicts **SP:** Examine the interpersonal conflicts within a software design team which took place during the requirements definition phase of an actual software development project **M:** Observational methodology involving videotaping and analyzing 43 meetings of 2 hours duration of the customers who established the requirements and the development team that actually designed the system over the time span of five

	months **R:** Developed a descriptive conflict model having four dimensions-content, time, people and process. The analysis showed that conflict is a consistent but fairly small percentage of the group interaction. Issues are not resolved in a top-down manner and tend to resurface at later meetings **FW:** Not applicable

Appendix B: Case Study questionnaires

The following questionnaires were used in the case study:

i. **Closed questionnaires, CQ 1 and CQ 2:** Two closed questionnaires were used in the case study to determine the background of the participating organization and members.

ii. **Questionnaires for semi-structured interviews, SQ 1 and SQ 2:** Two questionnaires were prepared for conducting semi-structured interviews with the participants of the case study. The first questionnaire, SQ 1 was designed to gain knowledge about the P&P project with focus on RE. The second questionnaire, SQ 2 intended to gather data about the conflict incidences that took place in the P&P project while performing RE.

iii. **Questionnaires for NGT, NQ :** This questionnaire was prepared for investigating questions Q1.2, Q1.4, Q1.5 and Q1.6 (§ 3.1) dealing with the RE-Activities in which RE-Conflicts were encountered, severity of RE-Conflicts, frequency of resolved and unresolved conflicts and types of conflict management strategies adopted for resolving RE-Conflicts respectively.

Closed questionnaire 1, CQ 1: This was filled by all the members of the development team of the P&P project.

1. What was your role in the project?
    a. Programmer
    b. Requirements Analyst
    c. Software Architect/ Designer

   d. Quality Assurance Engineer
   e. Project Manager
   f. Tester
   g. Other : Specify
2. What is your work experience in the field?

   Answer the following questions if your role in the project was either Requirements Analyst or Project Manager.
3. What is your work experience in the Ecologic Corp.?
4. How many prior ERP projects have you developed?
5. Name the business functions of the P&P project that were assigned to you for the elicitation of requirements.

Closed questionnaire 2, CQ 2: This was filled only by the owner of the organization.

1. In which year was the organization established?
2. How many employees do you have?
3. What are the typical project durations?
4. What are the typical project budgets?
5. What are the typical sizes of team for a project?
6. What is the most frequent software development lifecycle model followed by your organization?
   a. Waterfall
   b. Iterative
   c. Spiral
   d. Agile-extreme programming
   e. Agile Scrum
   f. Feature-driven development
   g. Other: Specify

Semi-structured interview questionnaire 1, SQ 1: This interview was conducted with the project manager of the P&P project

1. What was the project goal?

2. Was the project ahead or late from the anticipated date of completion?
3. Did you use any special format for writing requirements?
4. What percentage of time you spent in performing requirement engineering?
5. Did you involve coders, testers, architects in the requirement engineering process?
6. Did you work with the clients in prior projects?
7. How was the relationship of development team with the clients?
8. Did the clients bring any new requirements or asked to do some changes to the requirements document after the document had been finalized?
9. How did you deal with the changing requirements that were introduced after the RE phase?
10. Did you use requirement tracing?
11. Did you involve clients in prioritizing requirements?
12. Did you develop product in releases? Did you give presentations? Who all used to attend them?
13. What was the main difficulty that you faced to carry out the project?
14. Was any non-disclosure agreement signed?
15. What were the feelings of the staff at the client's site for the new software under development?
16. Is all the documentation regarding this project still available?
17. Were there distance and time problems between the clients and developers site? If yes, then what was the impact of large distance between clients and developers site?

Semi-structured interview questionnaire 2, SQ 2: These interviews were conducted with all the requirement analysts of the P&P project

1. Do you encounter conflicts in your organization? If yes, then briefly explain various types of conflicts encountered along with an example.
2. For each of the conflicts given below, please answer the following questions.
    - Conflict over administrative procedures
    - Conflicts over technical subjects

- Personality conflicts
- Conflicts over costs
- Conflicts over schedules
- Conflicts over responsibilities
- Conflicts over human resources
- Conflicts over equipments and facilities
- Conflicts over priorities

a. Did you encounter this type of conflict? If no, then jump to the next conflict; else answer the questions 2(b).
b. Did you encounter it in RE? If no, then jump to the next conflict; else give all the examples from your project wherever you encountered it.
c. Did it have impact on any of the following risks? If yes, then give examples.
    - Continually changing requirements
    - Requirements not adequately identified
    - Unclear requirements
    - Incorrect requirements
    - Development of wrong software functions
    - Development of wrong user interface
    - Late changes to requirements
    - Misunderstanding of requirements

NGT Questionnaire, NQ: This was answered by all the requirement analysts and the project manager of the P&P project. This questionnaire also contained 4 tables having the following data:

i. 13 RE-Conflict incidences identified in the P&P project (table 17)
ii. Conflict management strategies (table 5)
iii. Ordinal scale for the severity of conflicts (table 4)
iv. RE-Activities (table 10)

We have not shown the tables in this questionnaire and have given their references to avoid duplicity.

For all the 13 RE-Conflict incidences, answer the following questions

1. Which conflict management strategy was used to resolve the conflict incidence?
2. What was the final state of resolution of the conflict incidence?
3. What was the severity of the conflict incidence?
4. In which RE-Activity the conflict incidence was encountered?

Appendix C: Condensed Results of the Case Study

This section gives the following intermediate results of the case study:

i. **Project risks:** A list of project risks and their associated dimensions were developed by performing literature review of risks (table 16). 6 dimensions of the risks were identifies such as requirements, planning and control, team, etc. Our study focused on the *requirements* dimension of project risks.

ii. **RE-Conflict incidences:** 13 RE-Conflict incidences in the P&P project were identified from the interview data and are given in table 16.

Table 16: Project risks and their associated dimensions

Dimension of risk	Risks (Example References)
Requirements	• Continually changing requirements/ Lack of frozen requirements (e.g.,Wallace and Keil, 2004; Han & Huang, 2007; Schmidt et al., 2001;Addision & Vallabh, 2002) • Requirements not adequately identified (e.g., Han & Huang, 2007; Wallace & Keil, 2004) • Unclear requirements (Han & Huang, 2007; Wallace & Keil, 2004) • Incorrect requirements (Han & Huang, 2007; Wallace & Keil, 2004) • Development of wrong software functions (Addision & Vallabh, 2002; Boehm, 1991) • Development of wrong user interface (Boehm, 1991) • Late changes to requirements (Boehm, 1991) • Misunderstanding of requirements (Addision & Vallabh, 2002; Schmidt et al., 2001; Addision, 2003) • Unnecessary requirements (Kotonya & Sommerville, 1998) • Requirements non-conforming to business goals (Kotonya & Sommerville, 1998) • Unrealistic requirements (Kotonya & Sommerville, 1998) • Non-testable requirements (Kotonya & Sommerville, 1998) • Redundant requirements (Kotonya & Sommerville, 1998) • Requirements lacking traceability (Kotonya & Sommerville, 1998)
Planning & Control	• Lack of effective project management methodology (Wallace & Keil, 2004 ;Schmidt et al., 2001; Addision & Vallabh, 2002; Han

	& Huang, 2007) • Project progress not monitored closely enough (Wallace & Keil, 2004 ; Han & Huang, 2007) • Inadequate estimation of required resources (Wallace & Keil, 2004 ; Han & Huang, 2007) • Poor project planning (Wallace & Keil, 2004; Schmidt et al., 2001; Han & Huang, 2007) • Project milestone not clearly defined (Wallace & Keil, 2004) • Unclear/Misunderstood scope/objective (Wallace & Keil ,2004) Schmidt et al. 2001 (Addision & Vallabh, 2002) • Inexperience project managers (Wallace & Keil, 2004) • Ineffective communications (Wallace & Keil, 2004) • Unrealistic time and cost estimates (Boehm, 1991; Addision & Vallabh, 2002) • Gold plating (Boehm, 1991;Addision & Vallabh, 2002) • Shortfalls of external supplied components (Boehm, 1991) • Shortfalls of external performed tasks (Boehm, 1991) • Not managing change properly (Schmidt et al., 2001) • Changing scope/objective (Schmidt et al., 2001) • Artificial deadlines (Schmidt et al., 2001) • Absence of declared business benefits (Addision, 2003) • Project ambiguity (Pare et al., 2008) • Misalignment of system with local practices and process (Pare et al., 2008) • Insufficient resources (Pare et al., 2008)
Team	• Inexperience team members (Wallace & Keil, 2004) • Inadequately trained development team members (Wallace & Keil, 2004) • Team members lack of specialized skill required by the project (Wallace and Keil ,2004; Schmidt et al., 2001; Addision & Vallabh, 2002; Pare et al., 2008) • Personnel shortfalls (Boehm, 1991) • Lack of project champion (Pare et al., 2008) • Changes to the membership on the project team (Pare et al., 2008)
Project complexity	• Project involves the use of new technology (Wallace & Keil, 2004; Han & Huang, 2007) • High level of technical complexity (Wallace & Keil, 2004) • Immature technology (Wallace and Keil, 2004) • Project involves the use of technology that has not been used in prior projects (Wallace & Keil, 2004) • Real-time performance shortfalls (Boehm, 1991)

	• Straining science capabilities (Boehm, 1991)
Organizational environment	• Corporate politics with negative effect on the project (Wallace & Keil, 2004; Han and Huang, 2007; Pare et al., 2008) • Organizational instability (Wallace & Keil, 2004; Pare et al., 2008) • Lack of users commitment to the project (Schmidt et al., 2001; Addision , 2003) • Organization undergoing restructuring during the project (Wallace & Keil, 2004) • Lack of senior management committee (Addision & Vallabh, 2002) • Change to ownership of senior management (Schmidt et al., 2001)
User	• Lack of adequate user involvement (Schmidt et al., 2001; Addision & Vallabh, 2002; Addision, 2003) • Failure to manage end-user expectations (Schmidt et al. 2001; Addision 2003) • Lack of cooperation from users (Wallace & Keil 2004; Schmidt et al., 2001) • Users resistance to change (Wallace & Keil, 2004) • Users with negative attitudes toward the project (Wallace & Keil, 2004) • Lack of commitment from upper management (Pare et al., 2008) • Poor perceived system usefulness (Pare et al., 2008)

Table 17: RE-Conflict incidences in the case study

RA (s) = Requirements Analyst(s), PM= Project Manager, Users= Members of clients team (Chairman, manager and departmental heads), Analysts=RAs and PM

Conflict ID	Type of RE-Conflict	Description
REC 1	Conflicts over administrative procedures	There were disagreements between chairman and analysts over administrative procedures regarding allocation of resources such as people for the requirements elicitation process. Analysts wanted that during the elicitation sessions, chairman, manager and departmental head whose department's requirements were being elicited should be present together so that the elicited requirements were of mutual consent. Also, by following this process, the analysts wanted to gather everyone's perspectives. But the chairman of the client's team disagreed over this process. He wanted that only he or at the most manager should be present in the RE process. The reason for doing so was that the chairman

		wanted his technical staff to focus on the tasks of the organization. He wanted the analysts to consult managers or department representatives only when required and that too with special appointment and permission.
REC 2	Conflicts over administrative procedures	There were disagreements between the chairman and analysts over administrative procedures regarding the allocation of resource such as cost formula sheet. This sheet contained the formulas for calculating costs of all the business functions of the client's organization. Analysts wanted to keep a copy of the cost sheet for referring it during requirements analysis process. The chairman disagreed to give it for security purposes.
REC 3	Conflicts over administrative procedures	There were disagreements between the chairman and the manager of client's team over administrative procedures regarding the allocation of responsibility. Chairman wanted only himself or at the most manager should be responsible for requirements elicitation. The reason for doing so was that the chairman wanted his technical staff to focus on the tasks of the organization. The manager disagreed with the chairman and wanted that departmental heads should also be present because only they knew the minute details of business functions.
REC 4	Conflicts over administrative procedures	There was disagreement between the chairman and analysts over the administrative procedures regarding allocation of resource such as office space. The client's team and developing team were located in different cities. RAs started working at their own place and started the RE process from there through video and audio interviews. Based on the first SRS that the RAs created, the developers built the first prototype. The development team went to the client's site for presentation of the first prototype. The prototype did not have various functionalities that users wanted. From the feedback, the RAs realized that they should gather the requirements on-site to elicit better requirements. Therefore, they requested for an office at the client's site for developing the project. But the chairman disagreed over this administrative procedure of resource allocation. They said that they do not possess sufficient resources (office space) to allocate them.
REC 5	Conflicts over administrative procedures	There were disagreements between PM and RAs over allocation of responsibility regarding who should elicit requirements for the Pasting module. PM assigned the task of carrying RE process for the Pasting module to a new member because he did not want the other RAs to get involved in a new module without finishing the previous modules because deadline was already over. Team members did not want a new member to do this job because that person was not aware of other modules and the Pasting module was highly interdependent on the Foiling module.

REC 6	Conflicts over administrative procedures	There were disagreements between chairman and analysts over the outsourcing process of the Artwork module. Client's team used to outsource some portions of Artwork module in order to save costs. This outsourcing process was not standardized. Sometimes they used to outsource whereas sometimes they did not. When they used to outsource, then the requirements regarding the jobs that got outsourced used to get eliminated. When the outsourcing did not take place, then those requirements used to get added. Therefore, the analysts wanted the clients to standardize this process to which the chairman disagreed.
REC 7	Conflicts over costs	There were disagreements between chairman and analysts over costs regarding the budget of the project. The clients business was expanding and the clients wanted developers to implement new requirements within the budget that was initially fixed. However, analysts disagreed to implement new requirements within the same budget as it was not feasible.
REC 8	Conflicts over costs	There were disagreements between chairman and analysts over costs in the negotiation process of RE. The analysts sometimes used to disagree with the clients regarding the implementation of a requirement given by the clients as it was costly and perhaps could not fit into the overall budget.
REC 9	Conflicts over priorities	Disagreements over prioritizations regarding importance of requirements existed between the manager and department representatives due to their different perspectives. For managers, the requirements that intended to decrease the costs of business functions were significant whereas for the department representatives, the requirements that intended to ease their tasks were significant.
REC 10	Conflicts over priorities	There were disagreements between users and analysts over prioritizations regarding which requirements should be implemented first in the next release of prototypes. The analysts had different criteria for the prioritization of requirements than the clients. The analysts wanted the requirements having less functionality, require less efforts and less dependent on other requirements to be implemented first whereas the users wanted the requirements associated with the functionality that they wanted more to be automated, to be implemented first.
REC 11	Conflicts over schedules	There were disagreements between users and analysts over schedules regarding the RE process. The schedules of users were conflicting. The client's organization was preparing for a certification and was also expanding its business. Therefore, same people for requirement elicitation were not always available. For example, a requirement was elicited on day 1 from stakeholder 1. Now the developers got doubt in that requirement. In the second

		meeting which took place after few days, stakeholder 3 was present for elicitation instead stakeholder 1 due to the schedule issues. Stakeholder 3 explained it differently than stakeholder 1 which led to more ambiguity in the elicited requirement.
REC 12	Conflicts over technical subjects	There were disagreements between users and analysts over technical subject regarding the standardization of cost formulas. These formulas were used to calculate the cost of the business functions. However, the users kept on changing the formula parameters as it was not standardized and they used to vary depending on several factors such as market competition, change in costs of materials due to change in seasons, outsourcing process, etc. Therefore, the analysts wanted the clients to standardize the parameters of the formulas to which the chairman disagreed.
REC 13	Conflicts over technical subjects	There were disagreements among RAs regarding whether the stakeholder from whom the requirements were elicited should be logged or not. Three RAs did not want as they thought it would waste time whereas one RA wanted to ensure traceability.

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