

An Iterative Approach for Global Requirements Elicitation: A Case Study Analysis

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Abstract— Requirements Elicitation phase in Requirements Engineering (RE) is found to be very complex and demands more attention when software development is performed on the global scale. The available approaches of requirements elicitation require vigilant application in different scenarios of GSD and may need further improvement when considering challenges of distributed development. In this paper, a comprehensive survey of requirements elicitation approaches and challenges is performed which describes the limitations in applying the current elicitation approaches in GSD scenarios. Considering these constraints, an iterative framework for elicitation (IRE) in Requirements engineering is proposed. The case study analysis of the proposed model shows the effectiveness of iterative approach. The results show that IRE approach is more effective in satisfying the customer requirements than existing elicitation approaches.

Keywords- Requirements Engineering; Requirements Elicitation; Global Software Development.

I. INTRODUCTION

Over the last decade, business globalization has influenced the software development industry to adopt and work for the customers around the globe. Global Software Development (GSD) has therefore, emerged which undertakes the software development at geographically separate locations with efficient coordination and asynchronous interaction. GSD requires effective communication for information exchange between the distributed groups and entails coordination of these groups and activities so as to achieve an overall objective in the form of efficient software development. In GSD such coordination and communication may be performed in intra-organization, inter-organization also called outsourcing, or among non-organizations which involves open source software development. Such distributed software development causes many challenges for the developer and specifically for engineers in the requirements gathering phase. Figure 1 shows a distributed software development scenario.

Requirements engineering (RE) is a crucial activity in the software development process as it captures and processes user requirements and serves as the base for the overall project. It requires even careful attention when stakeholders are distributed and have different languages, unfamiliar cultures and are living in diverse environments. RE is concerned with considering the needs of the user to find the requirements of the system to be developed. It involves

understanding the constraints and adopting them in the process. The practice of requirements engineering in GSD is becoming a vital. As software development has progressed today, it can be said that problems that occur in the RE process are the major causes for the failure of most of the software [1]. Mostly development projects fail [2] because of inadequate requirements elicitation which involves social, political and cultural differences associated with the projects.

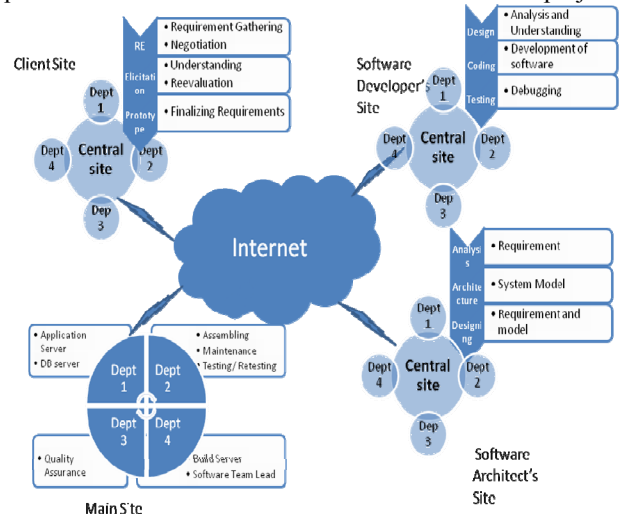


Figure 1. An example scenario of GSD

Requirements elicitation is the most affected phase by the intricacies of GSD. This is because; it primarily involves communication between stakeholders and requirements engineers, therefore it requires special care in coordination of these distributed groups. In addition, it requires proper managerial control to adhere to the goals and policies of the development organization. Distance makes it difficult to understand and interpret the requirements clearly. Even if the time zones are different too, makes the requirements engineering process more complex as both the teams would not be able to communicate at the same working time. One team has to suffer the time duration and has to wait for the other team. Hence leads to less communication across developer and customer sites, which results in poor development of software's. These and many other challenges require efficient approaches for requirements elicitation phase in GSD. In this paper, the authors have surveyed

existing approaches for eliciting requirements along with challenges and problems faced due to the distributed nature of GSD and have proposed Iterative Requirements Elicitation (IRE) approach in GSD.

Rest of the paper is organized as follows: section II has reviewed the background and existing literature of requirements elicitation in GSD. In section III, GSD and RE have been explained in detail along with challenges and intricacies faced. Section IV has reviews and comparisons of the existing approaches and techniques of requirements elicitation. In Section V and VI, Global Requirements Elicitation and its problems have been described. A case study of global requirements elicitation has been reviewed in section VII. Finally section VIII concludes the paper.

II. BACKGROUND

In software development process, RE is the phase which investigates the needs and requirements of the stakeholders to encompass them to new product or use them to update the previous range of product. In the success of software development process, requirements analysis play a critical role as the outcome of this phase affects all other phases. The gathered requirements should be related to stakeholders needs; these should be measurable, testable and actionable. This phase becomes even more important as software development process is adopted on a global scale. The process of requirements elicitation in global software development plays a vital role and much focus of today's research community.

The paper [3] is one of the classical papers in this field which surveys the techniques of requirements elicitation. The authors have focused on computer based systems dealing particularly with social issues. The surveyed methods for requirements gathering include introspection, interviews, questionnaires, interactions, discourse analysis and conversation.

The effectiveness of requirements elicitation techniques has been systematically reviewed in [4]. The authors have used aggregation analysis and found that structured interviews are the most effective technique in eliciting requirements.

In [5], the authors have analyzed that traditional techniques of face-to-face requirements gathering do not scale well to large scale projects. Therefore they have proposed a recommender system, which places stakeholders in higher level to generate the requirements with collaboration of analysts. The authors have analyzed the effectiveness of the system by series of experiments of requests from three different software systems. The work represents initial investigation of using the recommender system in requirements elicitation domain and requires further analysis and application of the proposed system in other areas of software development lifecycle especially in global software development.

The authors in [6] have described requirements elicitation and validation with the prospective of real world scenes. They have proposed an approach which captures the usage of the current system using multiple mediums including

pictures, audio, and video and then the observations have been analyzed related to the original requirements.

In [7], an asynchronous approach of gathering requirements has been adopted to enhance distributed software development. The authors have analyzed that in the distributed software development, analysts and designers usually focus on the collaboration in the later stages of software development. In this paper, the authors have devised a method to use collaboration, and discussion in requirements elicitation phase in asynchronous and distributed situations.

In [8] and [9], global software development lifecycle has been discussed. In [8], with the perspective of graduate course in three different universities, the requirements management techniques considering global software development environment and different time zones and languages has been discussed. In [9], Fujitsu has initiated the internet based infrastructure for global software development.

In [10], the authors have analyzed the challenges and problems faced due to lack of face-to-face communications in global software development. The paper has extended previous generic approaches for requirements elicitation with special focus on the detection and analysis of possible problems due to distributed requirements gathering and suggests the possible measure of cure.

III. REQUIREMENTS ENGINEERING IN GLOBAL SOFTWARE DEVELOPMENT

Requirements engineering is not a straightforward activity in software development especially when team members and stakeholders are distributed in different geographic locations. Without performing efficient requirements engineering, software development cannot take place successfully in local as well as global software development. As the software industry is progressing, it is mostly relying on the out sourcing of projects, hence leading to GSD. The stakeholders must be aware of high communication costs, travel costs, time constraints, availability of local staff, cultural differences to do GSD effectively [8, 11].

Early detection of problems due to poor requirements engineering can help carry out the rest of the software development phases easily. Table 1 lists the requirements problems and its rationale in GSD environment.

TABLE I. REQUIREMENTS PROBLEMS AND RATIONALE IN GSD

	Problems	Rationale
1	Incomplete Requirements	Poor understanding of requirements
2	Ambiguous Requirements	Unclear system domain
3	Un-stable Requirements	Frequent requirements change requests
4	Inconsistent Requirements	Requirements not clear and specific
5	Incomplete Domain Analysis	Stakeholders reluctant to reply
6	Missing requirements	Poor communication problem
7	Misconception of requirements	No direct contact of developers with customers
8	Difficult to understand requirements	Language Barrier
9	Less Communication, Less Requirements	Time differences; Developers assume requirements

10	Incorrect Requirements	Developers make assumptions
11	Ill-defined System Scope	Misunderstanding of system

Distance is the most important factor in requirements engineering phase for GSD. If the customers and stakeholders are located far away then there needs to be taken the requirements engineering process very carefully. Collaboration and communication is the most essential problem of GSD. Even very small distance can have severe effect on the software development process. Along with the time difference issue among the offshore teams, the policies and standards of one team cannot be imposed on other team and vice versa. Time differences affect the elicitation, specification, analysis, and negotiation and discussion process over the disputed requirements by the requirements team.

Cultural and Team differences is another major issue in requirements engineering during GSD which leads to language and terminology differences among the two teams. The teams might be unable to understand the language and terminology used to develop the software. Project management is also a crucial task in GSD. In case of ambiguous requirements at any stage, the teams might prefer to adjust the requirements then to request for its clarification or change from a distant client which may leads to a changed design. Disagreement can also take place among the stakeholders when the teams are not willing to change their tools for development.

IV. GLOBAL REQUIREMENTS ELICITATION AND TECHNIQUES

Requirements elicitation is the first step in the requirements engineering phase of the software development life cycle. It is concerned with extracting the correct requirements from the customer and communicating them to the developers of the system. It is the most critical activity of software development process as the success and failure of a project depends on it because understanding the requirements of the user is difficult and an ambiguous process. A small mistake at this stage can make the system unacceptable by the customer and may require a lot of rework, time, cost and budget overruns. However the best approach is to get the correct requirements initially to minimize rework and to get a successful product as desired by the customer.

There are various sources from where the requirements can be derived which makes the process more complicated. These sources are system stakeholders, problem domain, system documentation etc. The type of elicitation technique to be used for a specific product also depends on factors such as the type of system being developed, the system domain, the criticality of the system, time available to develop the system, the total cost of system, the expertise available and legal constraints etc. Moreover it also depends on the nature of the product being developed; e.g. development of legacy systems, implementation of web based systems, development of product using COTS and the development of systems

when the project teams are geographically located having language and cultural differences.

There are many techniques for the elicitation of requirements listed in literature so far; each having its own pros and cons and effectiveness in the particular scenarios. These include Interviews, Questionnaires, Ethnography, Prototyping, Collaborative Sessions, Team building, Data gathering from existing systems, Requirements Categorization, Conflict Awareness and Resolution, Role playing, Extreme Programming, Formal Methods, Model Development, Issue List, Task Analysis, Repertory Grids, Domain Analysis, Card Sorting, Introspection, Laddering, Group Work, Brainstorming, Requirements Workshop, JAD, Observation, Protocol Analysis, Apprenticing, Scenarios, Goal Based Approaches, and Viewpoints [12]. Some widely used and practiced techniques for eliciting requirements are described here briefly.

Interviews: It is the most commonly used and effective technique for elicitation of requirements. Interviews can be structured or unstructured depending on the situation. Useful and large amount of data can be gathered via a successful interview depending on the interviewee's communication skills.

Questionnaires: This technique of elicitation can only be used in the very beginning of the project to elicit requirements. Questionnaires can be open or closed depending on the type of product to be developed. Although it is a good approach to be used in GSD but it lacks the opportunity of expansion in answers. Therefore Questionnaires are not considered to be an effective technique in GSD.

Prototyping: In this type of elicitation technique, a prototype of the system is developed to get feedback from customer regarding the product. It can be a good approach to use in GSD as customers could be provided with various releases of the product as prototypes to elicit requirements.

Task Analysis: In task analysis, main tasks are divided into sub tasks and the knowledge is determined to carry out them efficiently.

Group Work: It involves all the stakeholders in the meetings that are somehow related to the project but it is difficult to organize specially for GSD. In this type of elicitation, every member is allowed to speak his ideas, hence make it an effective technique to get requirements.

Brainstorming: It involves different stakeholders to freely think and express their views related to an existing problem and discover innovative solutions. It is not a good technique for GSD as all stakeholders cannot be involved.

Scenarios: It is an efficient elicitation technique used to describe the interactions of system and users. They are helpful in the validation of requirements.

Viewpoints: It models the requirements of the system to be developed from different perspectives that can be user, operation, implementation etc. they help in the prioritization of requirements.

Protocol Analysis: In protocol analysis the tasks to be performed and the rationale behind them are discussed aloud by the team members. Not a very effective technique in distributed environment of GSD.

Observation: In observation, the existing processes are being observed without interference by the analysts. It is an expensive activity and cannot be done for GSD projects.

In Table 2 elicitation techniques used in GSD are categorized into Best (B), Fair (F) and Satisfactory (S) approach according to their competence in different problems.

V. CHALLENGES OF GLOBAL REQUIREMENTS ELICITATION

The global requirements elicitation process faces variety of challenges in the software development industry today. The major challenge is managing communication and coordination among the global teams. The development teams cannot have regular face-to-face meetings with the client which is an important factor for requirements elicitation in the development of a project; in that case the cost would get increased. Hence the developers start assuming requirements and so the project that is developed is not according to the needs of the customer. Since formal meetings cannot take place, hence coordination of activities is a difficult task to do [13, 14].

TABLE II. ELICITATION TECHNIQUE USED IN GSD

Techniques →	Interviews	Questionnaires	Prototyping	Scenarios
Problems ↓				
Communication Problem	B	F	B	B
Language Problem	F	F	B	B
Time Constraint	F	F	B	B
Cost Overrun	B	S	F	F
Domain Identification	B	F	S	B
Stakeholder Identification	B	B	S	S
Eliciting Requirements	F	S	B	B
Technique Selection	B	B	S	S
Tool Selection	B	F	S	S
Sources Identification	B	B	S	F

Communication in GSD is particularly less effective because of the time zones differences making face-to-face meetings more difficult. The teams are globally located far away from each other. The requirements team cannot elicit requirements on time. One team has to suffer and wait for the other team to deliver requirements on time to prevent the delays in the software development, otherwise the production will be postponed till new requirements are captured or previous requirements gets clarified. Communication is also made difficult by cultural differences and lack of awareness [10, 15].

Cultural diversity is another factor counting towards the challenge to global requirements elicitation. The

requirements team cannot understand the language of the client team. And so the requirements elicited could be ambiguous or wrongly done if interpreter is not available at any of the sides [10, 15, 18].

Another challenge to global requirements elicitation could be the communication channel through which both the teams communicate, if regular face-to-face communication is not present. In the absence of these meetings, the communication medium used could be email system which is not a very efficient medium in case of GSD as requirements would not be clear.

Knowledge management as a major success factor in GSD is a difficult matter faced by co-located organizations. Knowledge sharing for efficient knowledge management holds an integral place among software teams. It is a major success factor in software development influencing the quality of the software and the performance of the development team. The organizations have to cope up with many barriers for elicitation including language, cultural, social and legal barriers listed by many authors in literature [19, 20].

Other challenges to GSD are trust among the companies which is lead by cultural differences and lack of informal communication among the two. Because the team is not aware of the culture of the other team and so on hence decreasing productivity.

VI. EFFECTIVENESS OF REQUIREMENTS ELICITATION APPROACHES IN GSD: A CASE STUDY ANALYSIS

A number of case studies have been conducted by the researchers to find which elicitation technique is most effective in different GSD scenarios. As in distributed environment, face-to-face communication is not possible, therefore the elicitation of requirements becomes a tedious work and requires an approach which can effectively extract the correct requirements.

An empirical study has been conducted in [4] which surveyed the engineers and developers to find out their experience of the technique to elicit requirements. The authors have used a point scale in which the highest value represents the “outstanding effectiveness” and lowest value represents “no effectiveness”. The results show that Question and Answer methods and Use Case analysis is found the most effective method. The study has analyzed that Questionnaire and Prototyping are found to be less effective in distributed requirements elicitation.

The study conducted in [21] has found that application of combination of techniques can be applied in different conditions or scenarios. The recommended techniques for elicitation are focus group, interviews and ethnography each of which are effective in the situation where heterogeneous kind of stakeholders are observed. The findings of the study show that the application of such combination of techniques in requirements elicitation phase has left a positive impact on the collection and understanding of stakeholders requirements.

To find the effectiveness of requirements elicitation techniques in GSD, a number of software houses have been surveyed which are using GSD. The survey shows that most

effective elicitation techniques in GSD are prototyping, questionnaires interviews and scenarios. These techniques provide different levels of customer satisfaction on the outcome of the development process. Figure 2 shows a bar graph representing the effectiveness of the above mentioned elicitation approaches. The customer satisfaction is normalized at 0-1 scale. The graph shows that the use of prototyping is considered most effective in the elicitation of requirements and approximately satisfies 90% of the customers. This is because prototypes could represent a product earlier and can make customers more satisfied when situated in a distinct or distributed environment.

In global requirements elicitation, scenarios can play an important role for extracting requirements as shown in the graph. Approximately 70% of the customers are satisfied by scenarios which clearly show that scenarios can be used as an alternative approach to prototypes. These can replace prototypes where development of the prototype is found to be costly and requirements of customers are complex to extract.

Interviews are considered the third best approach in GSD. The survey shows that 60% of the customers are likely to be satisfied when interviews are used as elicitation approach in GSD. These interviews can be structured or unstructured depending on the type of customers, interaction and kind of software to develop.

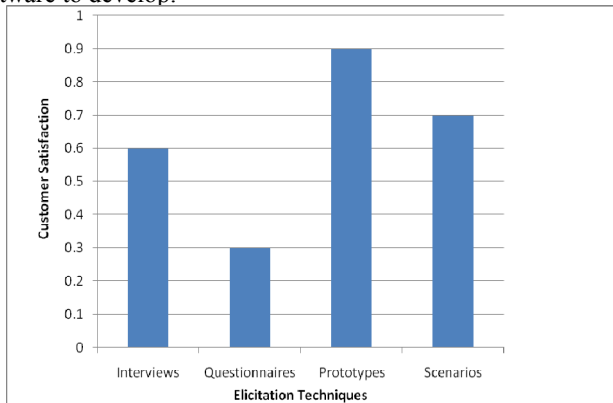


Figure 2. Effectiveness of Elicitation techniques in Global software development

Questionnaires are considered least effective for extracting requirements in GSD, because the questions can be open-ended or close ended and the measuring scale cannot effectively represent the customer's requirements.

VII. THE PROPOSED ITERATIVE GLOBAL REQUIREMENTS ELICITATION APPROACH

In this paper, the authors have presented Iterative Requirements Elicitation (IRE) approach for Global Requirements Elicitation. As discussed earlier, the existing approaches to requirements elicitation shows some limitations when used in Global Software Development for collecting requirements. The existing approach to requirements engineering worked in a linear fashion. It starts with requirements elicitation, requirements analysis and negotiation, then requirements specification leading to

requirements validation phase. The requirements engineers in this type of RE approach start assuming requirements when faced with ambiguities in later phases which leads to poor customer satisfaction ratios. In this paper, an iterative approach to RE has been developed, in which the elicitation and analysis phase of requirements engineering works iteratively to elicit requirements from the customers until an acceptable outcome of the process has been achieved.

In the analysis and negotiation phase when the requirements engineer finds any ambiguous or incomplete requirements, he can iteratively go back to elicitation phase where they can renegotiate the requirements with the customer or can review the data collected from customer using different elicitation approaches. In global requirements elicitation, interviews and prototypes are considered important to elicit requirements, whereas questionnaires and scenarios can also be used as backup or alternative approach. Therefore in our approach, we have considered interviews and prototypes as primary elicitation approach while questionnaires and scenarios can be used to gather customer's specification and requirements whenever requirements engineer is referred back to the elicitation phase due to incomplete requirements. He can use the data from these back up elicitation techniques to clear out the requirements or can renegotiate the customer for the specific ambiguous requirements. Figure 3 shows the framework of the proposed Iterative Requirements Elicitation (IRE) approach in GSD.

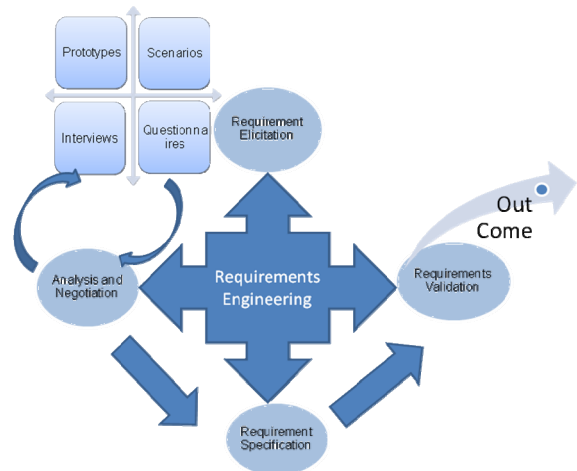


Figure 3. Iterative Global Requirements Elicitation Model

The comparison of the proposed iterative requirements elicitation model in the RE has been performed with the existing iterative RE phase as shown in Figure 4. The graph shows the effectiveness of the iterative approach. The approaches have been compared with respect to customer satisfaction in different phases of RE process. The data for the graph has been collected by applying the proposed approach in the GSD process conducted by a number of software companies surveyed as described earlier in the case study. The results clearly demonstrate that applying iterative process in the elicitation of requirements in the RE phase

increases the customer satisfaction and confidence on the output of different RE phases.

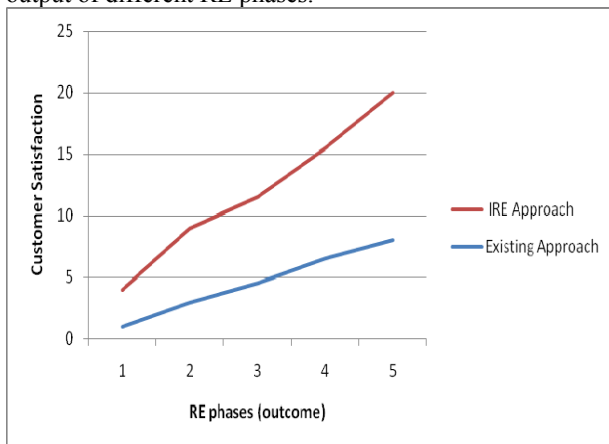


Figure 4. Comparison of IRE with existing approach

VIII. CONCLUSION

In this paper, a comprehensive survey of challenges and approaches of global requirements elicitation is conducted. The available approaches of requirements elicitation require vigilant application in different scenarios of GSD and may need further improvement when considering challenges of distributed development. An iterative model for global requirements elicitation is therefore proposed; the effectiveness of which is analyzed by performing a case study. The results show that by introducing iteration in the RE process can satisfy more number of customers in fulfilling their requirements.

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