A Requirements Engineering Process Model for Software Development

Mona Batra[1], Dr. Archana Bhatnagar[2]

[1]Research Scholar, Department of Computer Science and Engg., Birla Institute of Technology, Mesra, Ranchi, Jaipur Campus, India

[2]Asst. Professor, Department of Computer Science and Engg., Birla Institute of Technology, Mesra, Ranchi, Jaipur Campus, India

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Abstract - *Present complexities and higher level of client's expectations from an application leads to software development process to be more alignment towards technical specialists and managerial techniques. Software progression is incessantly put into practice by practitioners in order to meet up the dynamic stakeholder's requirements. Due to globalization, software and technology both become a fragment of any automated entity. Every organization body supposes to build a decent and reliable working software. It has also been inspected that for successful software system, requirements engineering is very crucial phase. This makes a growth in the scope of the requirements engineering process, apart with new challenges of gathering, prioritizing and preprocessing the requirements. Requirements Engineering is well-thought-out as a collection of processes that functions on different levels, which includes organizational, product and project level. In any field, building an application is a thought-provoking task due to the absence of right requirements engineering technique and due to developer's understandability of the actual needs of the client. There are various tools are available to gather requirements from the clients. The major faults are occurred in choosing the right requirements engineering technique which is considered a delicate task, any faults or wrong selection may lead to major catastrophic for the final product. In this paper, we have proposed a requirement engineering process model that produce quality requirements for software development. The proposed framework tries to bridge the gap between theoretical and practical aspects of requirements engineering process. It helps the software experts and analyst to choose a right technique for selected requirements engineering phase. We have thoroughly comprehended and evaluate all the existing requirements engineering techniques with respect to analyst preferences, client experiences, project attributes, software process model characteristics. The successful implementation of proposed requirements engineering process can have a good impression on the creation of qualitative software product.*

Key Words: *Requirement Engineering, Requirement Analysis, Requirement Elicitation, Requirement Development, Requirement Management. Requirements Elicitation, Requirement Engineering Process, Requirement Engineering Practice, Research Framework, etc.*

1. INTRODUCTION

Since mid-1970s, Requirements Engineering (RE) was known as a discrete arena of investigation and practice, its application has initially being related with software systems [1][2] to a wide-ranging perspective that covers to include all facets of software, hardware systems and organizations[3][4][5][6][7]. Requirements Engineering (RE) is a significant phase in the development of software systems that deals with identification of the stakeholders and their amplification into specific statements of desired services and behavior. It has been stated in [8] that Requirements Engineering is a systematized procedure of discovering and developing requirements through an iterative process of investigating a problem, documenting the outcome, and examining the correctness of gained understanding. Requirements Engineering (RE) offers the suitable mechanism to understand what the stakeholders actually wants, their desires, analyze their needs, authenticating the feasibility, conveying solutions, agreeing the unambiguous elements and supervise any changes [2]. According to Kotonoya et al. utmost problems are connected with requirements engineering are derived from the incompleteness or contradiction of requirements and the discrepancies among the stakeholders [3].

Furthermost industries in this technological period are running large or medium scale systems and with the evolvement of technology requirements also turns out to be dynamic that demand existing system to meet growing business needs. Overall challenges faced by IT industries are mostly capture due to requirements changes and choosing appropriate technique for each phase of requirements engineering.

Industries are more and more identifies the importance of using appropriate Requirements Engineering (RE) techniques in specific software projects domain. Due to multidisciplinary nature and increasing complexity of software projects necessitates requirements engineer to thoughtfully select effective requirements engineering techniques for gathering, analyzing and prioritizing stakeholder's requirements. Though, in many information technologies companies' selection of RE techniques is reliant on personal likeness for the technique or current company practice. Unfortunately, very limited study exists that evaluate and guide for the selection of RE techniques. We have performed in depth literature review in this area and

believe that selection of RE technique should consider features of the project, analyst experience, stakeholder knowledge or any other organizational social factors. Most of the studies and research work that are exists for selecting RE techniques lacks actual implementation. Requirements engineering is completely following theoretical aspects but now we are trying automate the process.

The focus of this paper is proposed a requirement engineering process model that bridges the gap between theoretical and practical aspects. Apart from introducing a general framework we are also generate an automated tool that act as a decision support system. The generated automated tool receives number of parameters as input like software project domain attributes, organizational characteristics, stakeholder experiences etc. and evaluate all present RE techniques with respect to various parameters and generate a recommendation set of alternate suggestion of RE techniques. The proposed requirements engineering framework aids requirements engineers to create a link between the attributes and the characteristics of RE techniques. This paper gives an overview of proposed requirements engineering. It outlines baseline of proposed methodology that helps requirements engineer to select appropriate RE technique and follow requirements engineering model that considers problem domain knowledge, organization social aspects, various constraints and priorities for a particular project.

2. CHALLENGES & DIFFICULTIES OF EXISTING RE PROCESS

There are number of requirements engineering process models exists in literature. We have performed in-depth literature review [11][12] and performed survey analysis [13] to identify challenges and difficulties in current RE scenario. It has been found that there are no specialized requirements engineering model designed for requirements engineering which provide inclusive strategy for selection of appropriate requirements engineering technique for a particular problem domain. Some of the Challenges and difficulties of existing RE Process Model:-

- There are no exact criteria to define and perform requirements preprocessing.
- There are no criteria for selecting application specific elicitation technique.
- How to choose right prioritization technique from a set of techniques for a given software project.
- Lack of implemented tool that bridges the gap between theoretical and practical aspects of requirements engineering.
- Lack of decision support tool to select appropriate technique for specific requirements engineering phase.

- Lack of classification schema that identify requirements engineering techniques with respect to problem domain, project characteristics, analyst's characteristics, stakeholder's characteristics, process model characteristics and organization characteristics.

3. PROPOSED REQUIREMENTS ENGINEERING PROCESS MODEL

In order to propose and develop requirements engineering process model, we have adopted a constructive research methodology. The constructive research methodology can be applied in the research area of software engineering and computer science. The key objective of constructive research is to develop an innovative solution of the problems via constructing models, diagrams, executable plans, and frameworks, etc. [1][2]. The five phases to conduct constructive research are:
(1) Identify the problem that needs to be solved.
(2) Obtain appropriate understanding of the problem.
(3) Implementation of a solution idea. This may possibly be a heuristic method.
(4) Validation of proposed solution. Validation is one of the hardest parts of constructive research as it preferably done through industrial case study or action research.
(5) Examine the scope of applicability.

To propose an effective RE model we have first identified and examined existing RE process model. Major issues and problems of existing models and their impact are analyzed. The main objective of proposed requirement engineering model is to bridge the gap between theoretical and practical aspects of requirements engineering process. The outcome of the proposed model is set of techniques for each phase of requirements engineering that helps to discover qualitative requirements to implement software system. The discovered requirements essentially be clear, reliable, changeable and traceable that results in a qualitative product. In this paper, we have proposed a requirement engineering process model for software development. Which is depicted in figure 1. It consists of mainly four phases, namely:

- Understanding and identification various attributes of problem domain.
- Requirements Preprocessing
- Application specific requirement elicitation technique selection
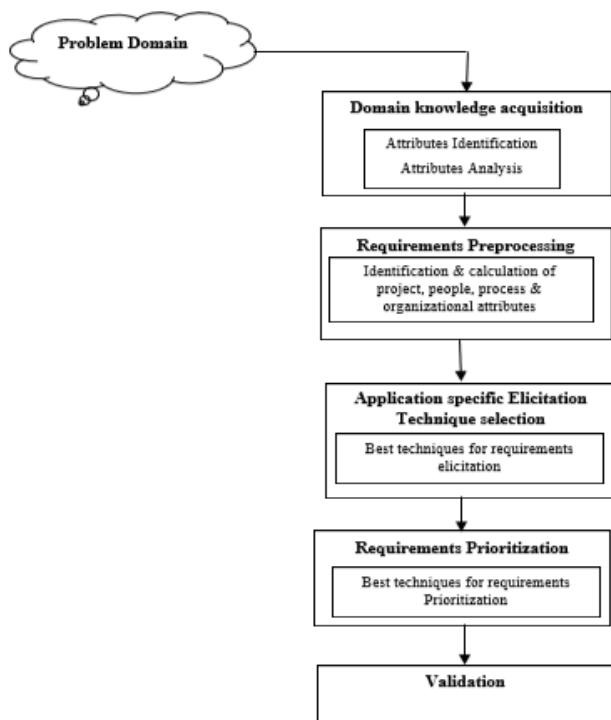- Support for Requirement Prioritization
- Validation

Fig 1 Proposed Requirements Engineering Process Model

Each of these phases is further described in the following sub sections. The proposed model describes requirements engineering for software development in which requirements engineering must be a portion of whole software development process.

4. Domain Knowledge Acquisition

Domain knowledge acquisition phase focus on identifying relevant attributes related to problem domain. In order to perform perfect requirements engineering process and select appropriate technique for a particular application categorization and classification of RE techniques along with well- defined list of attributes are required. In this phase RE techniques are identified and related attributes are explored. We have identified 55 techniques along with 38 attributes for each RE techniques research and literature. There are some contemplations while selecting RE techniques. They are as follows:

- **Systematic technique** – A systematic technique have definite organized systematic steps or having support to predefined notations. A systematic technique also been used in industrial projects. Techniques that possess above mentioned conditions helps us to have adequate information to evaluate them. Moreover, we needed to consider only systematic techniques that are completely used for industrial usage.
- **Handle one of the phases of the RE process-** Our focus is to produce best set of techniques for each phase of requirements engineering process. We

have selected RE techniques that sufficiently covers most of the phases of RE process.

- **Possess industrial consciousness and practitioners should have knowledge about the technique-** We have selected techniques that are well known in industries. This results in academician, researchers and practitioners can able to score the techniques with respect to their attributes.
- **Well-defined Scope-** All techniques should have designated role with respect to requirements engineering phase. We can able to analyzed and evaluated each technique from RE perspective rather than evaluate on basis of software development.
- **Diversity with different software development methodologies-** We have identified and selected those techniques that supports traditional software development practices as well as agile software development.

5. Requirements Preprocessing

This phase emphases on analyzing identified RE techniques and related attributes with respect to our five major factors- software process model features, project characteristics, stakeholder's characteristics, analyst characteristics and organizational features. Each attribute is defined with a list of measures. Weight Assignment Method is used to measure all attributes. The weight assignment method uses an ordinal scale. The attribute first categorized as not relevant, very small(low), small (low), medium, large(high) and very large (high) then an ordinal value is assigned to it. The weight assignment method is shown in Table 1 describe weight assignment method.

Table 1 Weight Assignment Method

Very High	1
High	0.8
Medium	0.6
Low	0.4
Very Low	0.2
Not Related	0

In our automate tool of RE process model all identified techniques and their mapping with attributes are organized in the form of database. This database is created from: -

a) Results of existing studies
b) Results of several process models
c) Expert group opinion

The above two phases are interlinked with each other as both phases deal with identification of requirements engineering techniques and its related attributes. It also

analyzes RE techniques with respect to project characteristics, process features, stakeholders' characteristics and analyst characteristics and organizational features.

6. Application Specific Elicitation Technique Selection

The third phase of our model selects application specific elicitation technique. Requirements elicitation is most important phase in whole requirements engineering as it deals with gathering of requirements from stakeholders. Loucopoulos et al. define requirements elicitation as the practice to find all suitable aspects to develop a baseline of a problem related to specific domain [25]. Requirement elicitation phase primarily concentrate on investigating and collecting desired requirements and objectives of the system from number of viewpoints (like stakeholders, users, constrictions, operating environment, marketing and standard etc.). This phase commences with recognizing all the stakeholders of the system and gathering raw requirements from different viewpoints. Raw requirements are those that have not been analyzed and have not yet been noted in a well-formed requirement representation.

There are various requirements elicitation techniques have been engaged and accepted from fields like social sciences but only restricted number of techniques have been carefully chosen for requirements elicitation [14]. Requirements development is done via number of thought exchanges between stakeholders and requirements engineer [15]. By means of communication requirements gathering/elicitation techniques are characterized into four types: Conversational, Collaborative, Analytic, and Contextual techniques [15][16][17][18][19][20][21][22][23][24]. Each category signifies a particular interaction model between stakeholders and requirements analyst and also depicts the nature of a method.

To develop an automated tool, we have studied all in and out of requirements elicitation techniques with respect to software project, software development process, organization culture, stakeholders' characteristics and analyst attributes with the help of research work of academicians, experience reports of software experts, project reports and experts' advices. We have recognized number of aspects of all the five factors that impact the selection process. In the proposed automated tool of requirements engineering process we have created a database for set of elicitation technique and their attributes. When requirements come problem domain is constructed. Problem domain comprises of some known characteristics that comes from feasibility study before requirements elicitation process begins. After that clustering is used that will produce set of techniques according to the known features of problem domain and cluster of techniques are generated that are best known for our application.

7. Requirements Prioritization

Requirement prioritization phase is additionally most vital aspect of requirements engineering that identify most important requirements for a software system [27]. In this phase decision about which requirements contained within in a certain release [28]. The principal challenge of present informational organizations is to meet stakeholder's needs and likely increase probable prospects in financial, security, timely and very useful way [29]. Due to deadline and resource restriction it's a challenging task for requirements engineer to come to a decision to arrange or prioritize the requirements in a way which in turn leads to high customer satisfaction.

In order to improve the cost benefits and meet deadlines of a software system, it is essentially required to first keep high priority requirements into consideration before low-priority requirements. It's a growing need to incorporate prioritization technique and practices in software requirements development [27]. Many researchers are working in this area but it is very difficult to choose and use right technique or framework at right time. There are number of prioritization techniques exists in literature. Proposed RE model overcome the difficulties of selecting suitable prioritization technique with respect to various factors that affect software development.

8. Requirements Validation

When the whole requirements are gathered and described in the SRS then all the individuals involved have to reach an agreement upon its nature. Every person should establish that the accurate requirements are specified (validation) and these requirements are correctly stated (verification). Validation and verification actions comprises validating the system requirements with respect to raw requirements and authenticating the accuracy of system requirement documentation. The validation of proposed automated tool has been done through industrial case studies.

9. DISCUSSION

The key significance of proposed model bridges the gap between theoretical and practical aspects of requirements engineering process. The proposed RE model act as a decision support system that produce set of techniques for each phase of requirements engineering those usage in actual requirements engineering results in quality requirements. We have implemented an automated tool for requirements engineering process. The other existing requirement engineering processes have limited coverage on dimensions of requirement engineering such as requirement elicitation, requirement specification and requirement verification and validation [10]. Our proposed RE model acquaint with all vital and hidden facets of requirement engineering process such as software process model, project

attributes, analyst characteristics, stakeholder's expressiveness etc. We relate all essential aspects that effect the whole software development in the foremost phase of software development i.e. requirement engineering in order to strongly improve the initial stage of development to avoid re-engineering and ease the management. As current software requirements are dynamic in nature if project attributes or any other attributes have changed during the course of time then it will again produce set of techniques for requirements process. The proposed framework supports both functional and non-functional requirements. It will also guide requirements engineer to select suitable technique for each phase of requirements engineering.

10. FUTURE SCOPE

The proposed requirements engineering model can be used in small or large software development process, where the requirements are dynamic in nature. It offers the new insight in requirements process by providing set of appropriate RE techniques. The requirement engineering activities in the model such as elicitation, analysis, prioritization, documentation and verification & validation are tightly interconnected to the software development phases. This model not only follows the step by step process of requirements engineering but also provide set of RE techniques for each stage of software development. The proposed model is iterative in nature and support dynamic requirements. By employing this model, organization can permit users further changes in requirements while developing software system. Future work may be done by incorporating more process models, software project case studies, and description of further rules based on a more comprehensive analysis of RE techniques and process models. To explore more merits and effectiveness of proposed framework, it can be applied to different software projects.

11. CONCLUSION

Requirements Engineering is the foremost phase of software development. Success and failure of entire development process hinge on effectual requirements engineering stage. The primary focus of this phase is to gather, understood, and define requirements for developing quality standardized software products. The requirements engineering process reasonably required powerful attention in industrial practices. Researches shows that opt for right RE techniques mainly contributes to successful implementation of software project. In order to get the effective technique for each step of requirements engineering demands in-depth understanding of each RE techniques and the associations

between them. In this paper, we proposed a requirement engineering process model that support core features of requirements engineering and works as a structured automated tool for selecting the most appropriate RE techniques for particular software project that results in increased software requirements quality and that in turns leads to successful software project. The proposed model act as a decision support system that takes problem domain attributes from stakeholders and provide the best set of techniques for each phase of requirements engineering. In case of dynamic problem domain, it automatically changes the values and again provide set of technique for all RE phases. It's a powerful process model that can be used in software development for producing high quality software product.

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BIOGRAPHIES

Mona Batra currently pursuing Ph.D. in the Department of Computer Science, Birla Institute of technology, Mesra, Ranchi, Extension Center Jaipur, India. She has completed her B. Tech from Rajasthan Technical University in 2011 and M. Tech (Computer Science) from JaganNath University, Jaipur. She is having four years of teaching experience. She has published various national and international papers on requirements engineering and security. Her research area includes: Vulnerability Assessment, Formal Methods, effort estimation and Requirements Engineering etc. Currently, she is working in the area of Agile Requirements Engineering.

Dr. Archana Bhatnagar is currently working in Birla Institute of technology, Mesra, Ranchi, Extension Center Jaipur, India. She is having more than 25 years of teaching experience. She has published various national and international papers in reputed journals. Her areas of interest are Software Engineering, Computer Networks, Computer Architecture, Data Structures, Design & Analysis of Algorithms.