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Survey on Requirement Elicitation Techniques: It's Effect on Software Engineering

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ABSTRACT: Requirement Elicitation is one of the important factors in developing any new application. Most of systems fail just because of wrong elicitation practice. A requirement may be defined as a demand or need. In software engineering, a requirement is a description of what a system should do. System may have dozen to thousands of requirements. Without the elicitation techniques it is impossible to find out requirements and the needs of the developing system. It provides base for the developer to construct a structure of proposed system keeping in view the wish list of stake holders. This paper is based on understanding elicitation techniques and their usage in real time applications, by implementing the Elicitation techniques for knowing the needs of stakeholder so that system developer can get clear view of requirement for the developing system. Furthermore this paper provide the flexibility to requirements engineers to know the characteristics and effectiveness of every techniques, it will serve as a guideline in selecting a particular elicitation technique in respect to the type of application and situation.

KEYWORDS: Software, Requirements, Elicitation, Stakeholders.

I. INTRODUCTION

Requirement elicitation is an important aspect of requirement engineering with its benefits within the software development world long established and highlighted and yet neglected. The elicitation of requirements represents an initial and critical stage in the development of computer based system. For a computer based system, activities involved in discovering, documenting, and maintaining a set of requirements are covered by requirement engineers. Software systems failures due to wrong elicited requirement have arises, some of which leads to the delay of the system to be delivered or the system may be more costlier than originally estimated, above all, stakeholders and customers will not be satisfied with the delivered system due to system defects which makes it inefficient and unreliable [1].

The requirement of system spread across many sources; these include knowledge domain, the customers/users, the stakeholders, social factors and other existing systems documentations, because of the nature of communication of requirement elicitation techniques, many of the techniques involved in requirement elicitation were not originated from the traditional areas of software engineering or computer science research but mostly derived from the social factors involved in the system, organizational structure and hierarchy, expertise involved and knowledge engineering.

The process of requirements elicitation is widely accepted as one of the critical activities in the requirement engineering process. Reference [2] stated that "getting the right requirement is considered as vital but difficult part of software development projects". An effective and efficient elicitation of requirements was arguably among the important requirement engineering practices thus the selected requirement elicitation technique also have has its effect on software project and the software development world.

The failure of system due to wrong requirements elicitation has alarming effect on the rate of software project success as the success of the requirements elicitation activity gives high impact on the achievement of the goals set for



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requirement engineering. Therefore, the development of any software is appropriate selection of requirement elicitation techniques and good practice of requirement engineering.

Reference [3] defined requirements elicitation as a practice of collecting the requirements of a system from users, costumers and other stakeholders. The practice is also sometimes referred to as requirement gathering. Requirements elicitation goal is to clearly distinguish between the customer and stakeholders requirement in order to control conflicting requirements should they arise so also to find out the requirement of a system to be developed throughout its development phase.

The importance of this work is to clearly define requirement elicitation techniques so as reduce project failure on this basis in software engineering. This paper is aimed at solving the challenges faced during the process of developing computer based system due to failures of requirements elicitation or improper requirements elicitation. This paper will serve as a tool for enquiry not only to researchers but also system developers about requirement elicitation techniques.

Finally this paper also aims at analyzing existing requirement elicitation technique with their effect on software project success, and propose a process model to help carry out requirement elicitation in a bid to aid developers in getting the accurate and vital requirements of a system.

II. RELATED WORK

Requirement Engineering is an essential part of any software development project that specifies, analyzes, and defines the product goal, functionality, and limitations of the product [4]. The fact that elicitation requirements have a significant impact on software product quality implies that it is reasonably well documented [5]. Usually requirement engineering can be described as a common series of stages including elicitation, analysis, specification, validation, and management [6].

Requirement elicitation is a discipline that arose when it became evidence that the quality of requirements specification was the key factor in preventing, with the least possible cost, many of the causes leading to software failure [7]. Thus, efforts in this direction employed at an early stage of a project have great repercussions, and are also more profitable than other efforts carried out afterwards. The problem of the “software crisis” has therefore, to a great degree shifted to requirements. Requirements elicitation is recognized as one of the most critical activities of software development [8]. Poor execution of elicitation will almost certainly guarantee that the project is a complete failure. Since project failures are so uncontrolled [5], it is quite likely that improving how the industry performs elicitation would have a dramatic effect on the success record of the industry. Improving requirements elicitation requires us to first understand the stakeholder identification phase [9]. In the case of requirements elicitation activities in which the problem to be solved is identified, the most important thing is that the stakeholders should be correctly identified and the user too, so as no conflicting need between them with eliciting for the system requirement shall arise. Relationships and ways of communicating between the development team and the customer are established at this time [10].

Despite the importance of requirements elicitation, the identification of stakeholders including the identification of their need and expectations is poorly achieved in software projects. One probable cause is that this process is mistakenly viewed as a self-evident task in which direct users, clients and the development team are the only stakeholders. The aim to identify and characterized different approaches to provide a comprehensive outline and discussion of method, standards and techniques used in requirement engineering, specifically in requirement elicitation. In the area of requirements elicitation, it is critical to describe the stakeholder identification process in order to provide correct, consistent and complete requirement specification.

The Role of Requirement Elicitation in Project Failure

This proposition to be examined is that requirement elicitation is an important aspect of failure in projects. There is no valid evidence here that requirement elicitation is the only or most crucial factor in project’s failure, but that, as an individual factor is important when compared with other cumulative factor that sums up the project. The contention can be broken into two propositions:

- The greatest contribution to system failure comes from poor requirement elicitation
- The cost of fixing requirement elicitation problems is higher than other sources of error.

There is a general agreement that poor requirement elicitation is an important and potentially damaging part of building a system.



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The Standish reports are used to justify a claim that more than half of overruns and failures occur due to poor requirements elicitation. This finding is replicated in other studies in Europe [2] and in studies by [12]. After several attempts have been made to constructively measure adverse effect of poor requirement elicitation in software engineering, yet it has not been achieved as this tends to yield unsatisfying results or figures to draw reasonable conclusions to its findings.

Fixing of failures related to wrong requirement elicitation doubles the original cost incurred on the entire project as this has not only affected the requirement engineering but the whole system development. Recent research into computer-related project failure has been conducted using the general framework of project management, in this research the importance of requirement elicitation is highlighted from the initial phase of the project to the final phase with respect to the cost of rectifying and implementation changes to the wrong requirement elicitation first carried out. It's convincing enough from this general agreement that requirement elicitation is highly relative to project success or failure.

A Classification of Problems in Requirements Elicitation

Survey of the literature generated the list of possible problems/factors identified as leading to poor requirements elicitation. This list comes from both those who have summarized the journals of requirements elicitation and those writers who use their own judgment as to some underlying causes of poor requirements elicitation and proceed to investigate some solution to those causes. It is clear from the wide variety of sources and range of reported problems that requirements elicitation is a complex and difficult task. It is uncertain that a simple "solution" exists to such a complex and wide spread problem in software engineering. Assumption and perceptions about problems relating to requirement elicitation have been brought up with no viable proof to qualify them or encountered measure to control or minimize these problems. These problems can be categorized into eight:

a. **Simple Communication between stakeholders and Client**

Communication between stakeholders and client are mostly not put in place or arranged to help figure out conflicting requirements and understand each other's view concerning the project. Therefore, the project scope developed might suit the purpose of one party concerning the system i.e either the stakeholders or the client. Lack of simple communication between the stakeholders and client arises to problems of variation of scope which will affect the developer in actualizing the scope of the system. This problem arises from human limitations in communication. A proper way to address this issue is to use procedural prompts when framing questions to ask both parties involved.

b. **The Language of Humans Is Not Always Suitable for Technological Solution:** Apart from communication being a major problem in requirement elicitation, language use in elicitation of requirements has to be checked as the language used are not easily understandable and converted to a well-defined technically robust specification in regards to a system. Understanding and converting English into a well-defined technically robust specification sums up a problem of misinterpretation of the problem involved in the system and its gathered requirements. Most problems involved in the system cannot be used to literally sum up a question technically in a bid to find the solution as the form of the language cannot be represented to reflect its specification.

c. **Requirements Change as the Project Proceeds:**

Inconsistency of gathered requirements is a major factor that leads to continuous found during project development as the required requirements were not stated completely or the project scope is altered by stakeholders which requires more requirements to be addressed, the system is not delivered with adequate requirements because in a business where dynamism exist, requirements are expected to change as the dynamism is exhibited by the stakeholders of the system as the project progress.

d. **Clients will Sometimes Ask for Requirements out of scope:** Requirements can be identified, classified and gathered through direct conversation with the clients. This has always seem ineffective as the clients have different views about the system and also will to ask for requirements that is negligible and probably out of scope to the system in view and give it priority which it's does not warrant.

e. **The Client Cannot Say What the Business Needs:** clients are so concerned with their benefits from a system that they hardly try to be on par with the business needs of a system. In some cases the requirements to the clients are tacit knowledge which cannot be easily expressed or unfolded to address the system business needs. Some clients only have ideas or perspective about a section(s) of the business that needs to be fixed which might not be as important as the problem being targeted to be solved in view with the system.



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f. Presence of dormant stakeholders of the system:

in a situation where business oriented stakeholders whose main priority is the profit target is their main aim, they tend to reluctantly deliver unreliable requirements because of their interest in conflict in other stakeholders aim or priority of the system. Therefore in this scenario, incomplete requirements elicitation is presented.

g. Improper process of requirement elicitation carried out: Another important type of problem is improper application of requirements elicitation process model used. This problem arises to incomplete requirements gathered and an un-structured format or requirements elicitation wrongly practiced which are not in accordance to the theories of software engineering.

h. Defects That Are Not Problems Are Often Reported: in situation where existing systems are to be study and corrective measures concerning the defects of that system is to be reported, some defects which are not problems are often reported as they are either the case if user mal-operation of the system.

THE PROCESS OF REQUIREMENT ELICITATION

The requirements elicitation process involves a set of iterative tasks that must provide room for communication, prioritization, negotiation, and collaboration with all the relevant stakeholders concerning the system. This process should be able to provide strong foundations for discovery, gathering, and evaluation of requirements as part of a highly interactive elicitation process. Requirements elicitation involves activities that are mainly communicative. These activities increase in significance when one considers the “culture gap” [13] or basic semantic differences dividing the problem owning and the problem solving communities when attempting to engage in meaningful dialogue [14]. However what is generally accepted is that elicitation is the initial stage within the requirement engineering process which is an iterative and integrated one. Typical activities of the requirements elicitation process can be divided into five fundamental types as described below:

- i. **Understanding the application domain**—the application domain or application environment the application is going to be situated should be considered first as all relating factors concerning this domain should be studied in detail to enable the requirement engineers investigate the application domain in order to get proper requirements required. The environment needs to be thoroughly explored including organizational and social aspects related to the system. Problems arising from under this aspect need to be identified in respect to their key business benefits and limitations.
- ii. **Identifying the sources of requirements** –Requirements may be spread across many sources and exist in a variety of formats [15]. In all software development projects a number of possible sources for requirements have to be identified. The first on the list of requirements sources have to be the stakeholders as they tend to be goal driven with business purpose and have insights about the system to be developed more that the users despite the usage of the system is mostly done by the users. In this case, stakeholders are identified as the most effective and most obvious source of requirements for the system. Existing systems and documentation of legacy systems represent another source for eliciting requirements, particularly when the project involves replacing a current or legacy system.
- iii. **Analyzing the stakeholders** –One of the initial phases in requirements elicitation consequently is to investigate and include all the important stakeholders, stakeholders are individuals who have influence directly or indirectly upon the system; they are mostly concerned with the project’s success as this has great effect on their investments concerning the system. Stakeholder’s needs to be studied and understood by the requirement engineer in a bid to know the upmost priorities of each of them in regards to the system as each stakeholder would always try to secure his benefit or interest to be derived from the system. A broad rundown of potential stakeholders that ought to be counseled amid the venture exercises ought to be drafted and kept accessible.
- iv. **Selecting of techniques to be applied** – In most cases, some stakeholders may suggest that just one elicitation technique or methodology is adequate enough to carry out all activities of requirements engineering which may not be effectively applied in all cases of system development as objectives of a project is subjective in this regard. The choice of techniques to be applied is relatively dependent on the scope of the project and is highlighted as a critical factor in the success of the elicitation process [9]. Investigations have suggested that a technique or varieties of techniques are adopted on the basis of the under listed reasons. These reasons are:
 - (a) The technique selected is the only one the analyst knows.
 - (b) The technique selected is the analyst’s favorite



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(c) The selected technique is the one prescribed by a specific methodology that is being followed for the system development.

(d) The choice of technique is governed solely by the intuition of the analyst to be effective in the current context. Clearly requirements elicitation is best practice through the application of various techniques. In most projects several techniques/methods are employed during the project and at different stages in the software development life cycle to ensure that effective requirements are clearly stated and defined.

- v. **Eliciting the requirements from stakeholders and other sources** –identification of requirements sources and respective stakeholders of a system is an essential step to requirements elicitation; hence elicitation of requirements is initiated using the selected technique or methodology adopted. The process of eliciting requirements has to be carefully carried out as the scope of the system is identified and investigated thoroughly to know the needs of the stakeholders and users. It is also significant to identify the processes of the system that would yield the realization of the projects objective.

ANALYSIS OF EXISTING REQUIREMENT ELICITATION TECHNIQUES

With subsequent grow in the world of software engineering amidst the high quality standards of software product, currently there is very little certainty in Requirement Engineering research and practice concerning a well detailed definition of requirements elicitation in regards to a system. Requirements elicitation is all about facts findings, understanding the needs of users and stakeholders with the ultimate aim of documenting these requirements in a user specification document (URD) which will serve as a tool to aid communication with the system developers about the needs of system. Requirements elicitation is concerned with the discovering, extracting and definition of the needs of all affected stakeholders, reference [16] refers to this process as “trawling for requirements ” to highlight the fact that through this process you are likely to get more requirements than expected. This implies that gathering a few meaningful requirements at an initial phase of requirement engineering is always better than gathering fewer requirements concerning the system as requirements might take cannot be easily predicted or quantified. This is one of the reasons why prioritization and negotiation are highlighted as significant parts of requirements elicitation, especially within market driven requirements elicitation where an overload of needs from affected stakeholders sums up to be a large amount of requirements which becomes is a serious issue to easily resolve. More recently the concepts of inventing and creating requirements have been used to highlight the role of creativity and to emphasize what really goes on during requirement elicitation [17].

Requirements elicitation is known to be the initial stage of any requirements engineering process model. Its success always indicates a high positive impact on the achievement of the objectives set for requirement engineering phase of a project, which leads to the development of software projects with required deliverables or requirements. Therefore, the development of any application is in indispensable from incorporating good practices of requirements elicitation. In fact the consideration has an impact to the usability of the application [18]. Therefore, requirement elicitation is defined as a process to understand a problem, its application domain and its cumulative factors that can possibly arises to the solution of that problem.

REQUIREMENT ELICITATION TECHNIQUES

Requirement elicitation techniques are means by which system analysts determine the problems, opportunities, and needs of the customers so that system developer can construct systems that will actually resolve these problems, leverage those opportunities, and address customer’s needs. The goal of elicitation technique is to find out as many problems as possible in order to ensure that it become easier for stakeholders to get the best suitable application to rectify those problems and satisfy customers according to the requirements.

Requirements can be derived by interacting with stakeholders and other viable resources. The process should be in a way that it should represent all the thoughts and requirement of stakeholders and all those involved in the system and could only be done by adopting the elicitation technique which is a difficult and intensive task. Requirements elicitation is performed by analyst (also known as systems analyst, requirements engineer, and requirement analyst) using elicitation techniques. Reference [2] estimated that there would be approximately 12 million software developers worldwide by late 90’s and early 2000’s. Assuming 5% growth per year, and assuming that 1 out of every 15 developers worldwide is an analyst, there were approximately 1 million practicing analyst in 2003, so it is clear that there are many potential users of requirements elicitation techniques. To better understand elicitation techniques, and



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why they are so important to product success, in response to a less than acceptable rate of failure of systems, hundreds of elicitation techniques have been created by researchers. But the majority of these techniques are rarely, if ever used by practitioners

A. TYPES OF ELICITATION TECHNIQUES

This classification of requirements elicitation is done under the basis of the nature of communications adopted. This can either be through direct or indirect approach to elicit requirements for a system. This classification is explained in details

i. Direct Approach

In direct approach, this signifies that the domain knowledge of the system to be developed is highly considered as this will aid system developers understanding the problems of the system. A few techniques which allow direct contact or communication with stakeholders or users of the system are interviews, brainstorming, case study and prototyping. Most notably this type of requirement elicitation will only be decisive and successful if the domain expert explicitly analyzes the system and share the information across parties involved.

ii. Indirect Approach

Indirect approach is used in situations where the information to be obtained cannot be easily resourced. In this approach it is important to clearly define the requirements in respect to the problems of the system as the techniques in this approach already assume the users or stakeholders have little knowledge concerning the system. Results obtained from this type of requirement elicitation involve analysis as the information is in large quantity and proper clarification must be adhered to. Questionnaires, documents analysis are examples of techniques available in this category.

B. REQUIREMENT ELICITATION METHODOLOGIES

Methodology is a process which can either be iterative or sequential in respect to the activities performed to achieve a common goal; these goals are set up for a project and in turn serve as a deliverable of methodology. In requirements elicitation methodology, the information obtained from the problem of the system helps the researchers to develop a solution which will yield the desired results and also helps other researchers to get benefit from experiences of the research. There are many methods which can be used for gathering information on how the current system is running, how it can be improved and how we can reach the exact problems. These methodologies are categorized based on its flow of communication and information obtained. They are:

- i. Conversational Method
- ii. Observational Method
- iii. Analytical Method
- iv. Synthetic Method

i. CONVERSATIONAL METHOD

Conversational method provides a means of verbal communication or interaction between stakeholders, users and the analysts. As conversation is a natural way of communication/interaction, it's also an effective means of expressing needs and ideas concerning a problem. This method is widely adopted in understanding the problems of a system and to elicit comprehensive product requirements. Existing techniques in this method are;

- a. Interviews
- b. Questionnaire
- c. Brainstorming

a. **Interviews:** An interview is generally known as a face-to-face meeting conducted by an experienced analyst, whom possesses generic knowledge about the problem domain of the system. In an interview, Analyst discusses the problem domain of the system with various affected stakeholders and users in order to develop an understanding of their requirements of the system. Generally interview can be categorized into two, namely:

- i. Closed Interview: in this interview, predefined questions are arranged and listed out in respect to the importance on the problem being confronted by the system.
- ii. Open-ended Interview: in this interview, predefined questions are not arranged as information is obtained concerning the system from the stakeholders in open discussions.



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Generally, the interviews commence with the predefined questions derived from the problem domain of the system. However, during interview, a lot of different considerable things may arise that leads to open discussion such as the interviewer's attitude towards the stakeholder/user. Interviews are effective for understanding the problems in the existing system, also its aids in knowing the general requirements of the stakeholders. Notwithstanding, it is difficult to decide the boundaries of the proposed system as different scope is discussed and analyzed. To make effective interview the requirement analyst has to be considerable of the following:

- i. Interviewer must exercise patients with stakeholders or users while eliciting for requirements.
- ii. He should be straightforward and clear about the questions.
- iii. The stakeholder should express their views in definite context of the system.
- b. **Questionnaire:** Questionnaires are one of the methods of gathering requirements in less cost. Questionnaires reach a large number of people, not only in less time but also in a lesser cost. The general factors which affect the usage of the questionnaire are:
 - i. The available resources to gather the requirements mainly depend on the availability of resources.
 - ii. Type of requirements that has to be gathered depends on the level of the respondent's knowledge and background.
 - iii. Anonymity provided to the respondent.
- c. **Brainstorming:** Brainstorming is another conversation method, in brainstorming stakeholders are gathered together for a short time period but in this short time they develop a large broad list of ideas. In this meeting "out of the box" thinking approach is encouraged thus brainstorming involves both ideas generation and ideas reduction. The members are from different departments and domain experts are also included. Brainstorming is a process where participants from different stakeholder groups engage in informal discussion to rapidly generate as many ideas as possible without focusing on anyone in particular. It is important when conducting this type of group work to avoid exploring ideas in great detail.

Conversation is one of the most prevalent yet invisible forms of social interaction. People are usually happy to describe their work and difficulties involved. Their verbally expressive demands, needs and constraints are often called non-tacit requirements. Conversational methods are very commonly used in requirement development. However, they are labor intensive, meeting setup and transcript producing and analyzing from records of a live interaction take time.

ii. **OBSERVATIONAL METHOD**

Observational methods are methods which deals with intense study and analysis of the system, they provides means to develop a better understanding about the problem domain of the system. Observation methods works by monitoring human activities at environment where system is expected to be situated or already situated, in the case of existing system. Furthermore, to state viable requirements, some requirements are apparent to stakeholders, but stakeholders find it very hard to verbalize thus bringing observational methods into play due to the limitations of communication concerning collection of tacit knowledge. Therefore, observing how people carry out their routine work forms a means of information gathering which are hard to be verbalized or truly justified by the user. Observational method appears to be the most appropriate when stakeholders or users find it difficult to state their needs concerning a system. Observational method helps the analyst towards a better understanding of the context in which the desired product is expected to be used. Existing techniques to be discussed under this method are:

- i. Social Analysis
- ii. Observation
- iii. Ethnographic study
- iv. Protocol Analysis
 - i. **Social analysis:** an observer spends some time in an environment and studies their culture in a bid to make a detailed observation of all their practices. This study tends to find reasons behind some of the practices toward the system as it gives prevailing facts and understanding of system in that environment.
 - ii. **Observation:** As the name suggests the analyst observes the actual execution of existing processes by the users without direct interference. This technique is sometimes used in conjunction with other techniques such as interview to help develop a peripheral understanding of the system. Observation is very expensive to



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perform and require significant skill and effort on the part of the analyst to interpret and understand the actions being performed in the situated environment of the system. The effectiveness of observation has limits to the point where users understand they are being monitored and tend to adjust the way they perform tasks with the system.

- iii. **Ethnographic study:** Ethnography is the study of people in their natural setting which involves the analyst participating in the normal activities of the users over a period of time whilst collecting information on the system actively or passively. This technique is significant while addressing contextual factors of a system such as usability, and also when investigating collaborative works settings where the understanding of interactions between different users with the system is indicated as significant. In practice, ethnography is particularly effective when the need for a new system is a result of existing problems with processes and procedures. It is also used in identifying social patterns and complex relationships between stakeholders and the users.
- iv. **Protocol analysis:** in this analysis, a stakeholder is observed when he is engaged in some task, and concurrently speaks out loud and explains his thoughts. In this analysis, a stakeholder is observed only when he is engaged actively or passively in some task relative to the system, and concurrently speaks out loud and express his/her thoughts. With protocol analysis it is easy to identify interaction problems in existing systems, also it gives a clear and close understanding of work context and work flow.

In observational Method, the observer must be neutral or unfamiliar to the people being studied so that the people being studied can carry on with their normal activities with no regards to the observer's presence. In both conversational and observational methods, requirement elicitation is done by studying some individuals but a variety of documentation may prove out to be useful for extracting the requirements of the desired system. This documentation may include problem analysis, organizational charts, standard user manuals of existing systems, survey report of competitive systems in market.

By studying these documents, requirements engineers capture the information about the application domain, the workflow, the product features and map it's to the requirement specification.

iii. ANALYTICAL METHOD

Analytical method provides ways of exploring expert's knowledge of existing system and acquires requirements from a series of deductions to provide requirements engineer rich information about the product. This method involves exploration into existing documents and facts about a system. Existing techniques in this method are:

- i. Requirement reuse
 - ii. Documentation studies
 - iii. Laddering
 - iv. Repertory grid
- i. **Requirement reuse:** in this technique, glossaries and specification of legacy systems or systems within the same product family is used to identify requirements of the desired system. It has been observed that many requirements in a new system are more, less or same as they were in a legacy system's requirements. So it's not a bad idea to reuse the requirement details of existing system on a new system.
 - ii. **Documentation studies:** in this technique, various available documents are studied, examined, and analyzed to find the contents that can be useful as requirements for requirements elicitation activities. Examples of such documents that can be examined are organizational policies, Market information, Specification documents and user requirements documents of the existing system.
 - iii. **Laddering:** this technique consists of three parts namely: creation, reviewing and modification. Laddering method is a form of structured interview that is used in the field of application domain elicitation activities to elicit stakeholder's needs and wants of a system. Analysts use this technique to create, review and modify the hierarchical contents of expert's knowledge which can be represented in the form of tree diagram. Laddering is mostly used to gather requirements that are tacit i.e requirements that are known by the stakeholders but cannot be expressed.



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- iv. **Repertory Grids:** Repertory grids [19] involve asking stakeholders to develop attributes and assign values to a set of domain entities. As a result the system is modeled in the form of a matrix by categorizing the elements of the system, detailing the instances of those categories, and assigning variables with corresponding values to each one. The aim is to identify and represent the similarities and differences between the different domain entities. These represent a level of abstraction unfamiliar to most users. As a result this technique is typically used when eliciting requirements from domain experts. Although more detailed than card sorting, and to a lesser degree laddering, repertory grids are somewhat limited in their ability to express specific

In general, the analytical methods are not vital to requirements elicitation, since requirements are captured indirectly from other sources, rather than end users and customers. However, they form complementary ones to improve the efficiency and effectiveness of requirements elicitation, especially when the information from legacy or related product is reusable.

iv. SYNTHETIC METHOD

Synthetic method is a combination of multiple requirement elicitation techniques from their respective methods, such as conversational, observational, or analytical methods. This method forms a coherent whole by systematically combining the techniques involved into a single method. Existing requirement elicitation techniques of synthetic method include the following:

- i. Scenarios
 - ii. Prototyping
 - iii. Joint application development/Rapid application development sessions
 - iv. Contextual inquiry
- i. **Scenarios:** in this session, a sequence of actions and events described for executing some generic task which the system is intended to accomplish is broadcasted and discussed as it's an interactive session. With this technique, clear requirements related procedure and data flow can be achieved and initial set of requirement can be prepared in cheaper cost. A substantial amount of work from both the research and practice communities has been dedicated to developing structured and rigorous approaches to requirement elicitation using scenarios. Scenarios are also useful for understanding and validating requirements and test case development. Scenarios of a particular system will give the working method of different interaction sessions or situations of the system. These scenarios are helpful for requirements elicitation because they analyze multiple sessions so as to provides flexibility to find requirements also provide user response after interaction with scenarios to yield requirements
 - ii. **Prototyping:** Providing stakeholders with samples of the system to support the investigation of possible solutions is an effective way to gather detailed information and relevant feedback about a problem domain [10]. It is common that the samples mostly described in this category as prototype are used in collaboration with other elicitation techniques such as interviews and brainstorming. Prototypes are typically developed using preliminary requirements or existing examples of similar systems. This technique is particularly useful when developing human-computer interfaces, or where the stakeholders are unfamiliar with the available solutions to a problem domain. There are a number of different methods of prototyping systems such as executable, throwaway and evolutionary prototypes, with varying levels of effort required. In many cases prototypes are expensive to produce relative to the time and cost involved. However, an advantage of using prototypes is that they encourage stakeholders, and more specifically the users, to play an active role in developing the requirements. One of the potential hazards when using prototypes for requirements elicitation is that users may become attached to them, and therefore become resistant to alternative solutions from then on. Despite this, the technique is extremely helpful when developing new systems for entirely new applications.
 - iii. **Joint application development (JAD):** this technique emphasizes user involvement through group sessions with a neutral analyst. Joint application development is conducted just like brainstorming, except that the stakeholders and the users are also allowed to participate and discuss on the design of the proposed system that will both serve their needs and want of the desire system. This discussion (involving the stakeholders and the users) will continue until the final requirements are gathered. Reference [20] stated that joint application development involves all the available stakeholders investigating through general discussion both the problems to be solved, and the available solutions to those problems.



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- iv. **Contextual inquiry:** this technique is a combination of open-minded interview, workplace observation and prototyping. This method is used for interactive systems design where user interface design is deemed critical. This technique is effective for eliciting of requirement with limitation to cost and time effectiveness.

All four requirement elicitation methods are commonly used but the selection of requirement elicitation method solely depends on the needs of a system, financial capabilities of the organization, and organizational structure. It is highly important for system analyst to examine how people perceive, understand and express the problem domain of the system, how they interact with the expected system, and how the social or ethnographic factors that tends to affects their actions towards the system.

The conversational method provides requirements that are easily expressed by both the users and stakeholders due to its strategic flow of communication. The observational methods provides requirements that not easily expressed by users and stakeholders, thus both having knowledge about the requirement. This knowledge can be termed as tacit knowledge. The analytic method is used to extract requirements proactively by exploration domain knowledge of the system through its documentation. Synthetic method lays more emphasis on collective effort of all affected users of the system on clarifying the problems, solutions and features of system. Each type of techniques has its benefits and limitations, in most cases the limitation of a method is by passed in another method thus making it a benefit of that method

BENEFITS AND LIMITATION OF REQUIREMENT ELICITATION METHODS

In order to understand each Requirement elicitation Methods and effectively use them in the real life scenarios, we have to focus on the advantages and disadvantages of different requirement elicitation methods namely: Conversational, Observational, Analytic and Synthetic one after the other.

- **Conversational method:** conversational methods are used massively because it is a natural and effective way of communication. Conversational methods include techniques such as: interviews, Questionnaire and Brainstorming.

Benefits of Conversational Method

Conversational techniques are tools in collection rich information about the requirements of a system because they uncover targets and goals of different individuals involved in the system. Conversational methods provide easy access to follow up about information gathered.

Limitations of Conversational Method

Along with its benefits, there are certain limitations of conversational methods as this skill is very hard to master. In conversational methods the contexts of conversation plays a very important role in getting required information thus conversational methods for requirement elicitation depend a lot on the behavior and attitude of conductor.

- **Observational methods:** are helpful in understanding the application domain by observing human activities Observational methods are inefficient when the project have a very tight schedule at requirement stages. Method like ethnography and protocol analysis methods falls under this category [21]. The Observational method involves: Social analysis, Observation, Ethnographic study and Protocol Analysis.

Benefits of Observational Methods

Observational methods are a good choice for uncovering basic aspects of routine order because they provide vital information for designing solution concerning the problem domain of the system. Observational Methods are very handy when the development team has lack of experience about product domain.

Limitations of Observational Methods

Along with its benefits, observational methods are not time effective and these techniques are not good choice when the schedule of a system is under pressure. They are also hard to master. Observational techniques require sensitivity and responsiveness to physical environment.

- **Analytical method:** Conversational or Observational methods are used to directly extracted requirements from people's behavior and their verbalized thought. But still there is a lot of knowledge that is not directly expressed. For extracting this kind of knowledge and information, analytical skills are used. Analytical Skills include Requirement Reuse, Documentation Studies, Laddering and Repertory Girds

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Benefits of Analytical Methods

Analytic Methods is beneficial to system analyst as people are not the only source of information in terms of requirements. They provide experts knowledge on the domain of the system and opinions about the system which plays an important role in requirement maturity. Analytical methods have effective time and cost control.

Limitations of Analytical Methods

Analytical method is highly limited to expert's knowledge based on the application domain of the system, without this it is difficult to elicit proper requirements concerning the system. Error replication is prone and stands to be a serious threat due to the fact that in analytical method, previous existing knowledge of the system is firstly examined. These methods are never a good choice when you are going to develop an altogether new system [22].

- **Synthetic method:** this method is particularly valuable for stakeholders such as, business owners and end users who might not understand the technical aspects of requirements, however, this will aid in relating to a visual representation of the end product to the stakeholders and end users.

Benefits of synthetic method

Synthetic methods are constructed upon the advantages of an organization, it aids in understanding requirements that are to be implemented on the system in view. They have optimistic influence on the affected individuals and groups involved in system development. In synthetic method, it is very easy to involve people, who do not generally get engaged (in this kind of activity of requirements elicitation), due to the fact that the conversational style of questioning specifies its focus on the participants [23].

Limitations of synthetic method

Synthetic method is not time effective during requirements elicitation activities, they need periodic commitment among stakeholders, development team and end users to flourish.

III. PROPOSED MODEL

In view of the limitations of the requirements elicitation process model developed by Robertsons' Volere which was introduced in 1995. This model has great limitation concerning time and cost effectiveness, because it shows each activity in the model with its suggested requirements elicitation technique. Most notably this model shows all activities and their deliverables in requirements engineering.

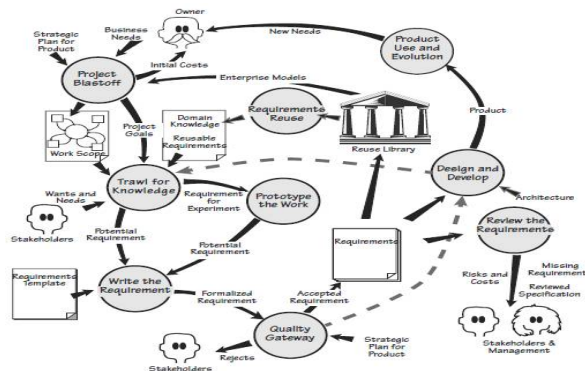


Figure 1.0: Robertsons' Volere Requirements Process Model.

This model is highly rigorous and flexible with its communication flow of information highly commendable. An activity in this model is represented by a bubble and its deliverable is represented with an identified arrow or formalized document. The dotted line in this model signifies how this model is used with iterative project. This model is generally a combination of various techniques to elicit for requirements concerning every activity in the model. Although some requirement engineers think that just one methodology or just one technique is applicable to all situations, but one methodology or technique cannot possibly be applicable to all problems of a system. Robertson's

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Volere model integrates the used of various techniques to bypass that limitation and reduce project failure concerning that regard. Most models of requirements elicitation focus on specific methodologies or techniques. For example, the Robertsons' Volere requirements methodology includes a well-defined process model of its requirements elicitation activities with inputs, outputs, and recommended techniques for each activity [16].

Reference [24] have developed specific process model that define how to use scenarios for requirements elicitation, this model is limited to a selected technique which does not serve requirements elicitation goal in all situation. [25] Presented a model of elicitation that combines scenarios, prototypes and design rationale with limitation to selective project but beneficial to project where design process is deemed critical.

Few general models of requirements elicitation process exist. Some authors provide general guidelines for requirements elicitation, e.g., [6], while others describe general approaches (e.g., top-down vs. bottom-up). Most of the models focuses on specific view of the process of requirement elicitation of a system such as the model developed by [26] which describes the influences of stakeholders and other relevant users during requirements elicitation by showing how analysts, domain experts, and customers interact to provide domain knowledge and use case requirements, which are used to produce business class and use case models. [27] Also take a model-centric view in their process model of collaborative requirements elicitation and validation (CREV), which defines how activity, data, and scenario models work together with prototypes to generate requirements for a system.

This section provides a requirement elicitation process model for requirements engineer to adopt while carrying out requirements elicitation techniques or methods effectively.

FDEPI REQUIREMENT ELICITATION PROCESS MODEL

This model is developed with the primary objective of overcoming the limitations of the models considered above. This model can be integrated into the requirements elicitation techniques to help identify the expected requirements constructively, thus making this model a process model as its effective throughout the requirements engineering phase of any software/system project. The model consists of the following phases:

- Facts findings and Requirement Gathering
- Definition and classification
- Evaluation
- Prioritization
- Integration and validation
- Inspection

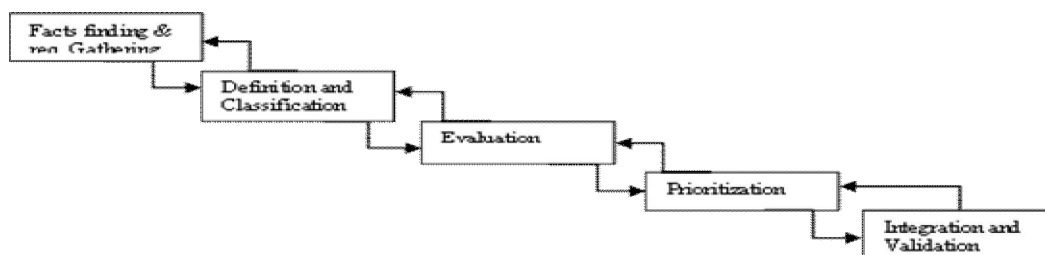


Figure 2: FDEPI Requirement Elicitation Process Model

A. Facts findings and requirements gathering: in this phase, the study of the system is carried out in order to generate information from the stakeholders of the system, users across multiple levels in the organization and developers concerned, also the technical features of the system is reviewed in the case of existing system . Requirement gathering is a formalized way to depict the results of facts findings because it does not just rely on the basis of requirements identification but documentation thereby presenting a scope of the proposed system, also requirements gathering aims at capturing from various users of a system. Notable activities involved in this phase are

- Identification system.
- Identification of requirements.



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- Identification of requirements sources.
- Constraint definition and its implication.

At the end of this phase, outputs to be expected are as follows:

- A statement of problem content
 - Scope of the proposed system
 - Limitations of constraints of the target system.
- B. **Definition and classification:** in this phase, definition of requirement is of high importance as the gathered requirements must be give clarity i.e. given appropriate meaning in-line with the proposed system including its characteristics where necessary. Classification of requirements has to be initiated at this stage in order to help identify what type of requirements type it falls into, whether it's a functional or non-functional requirement relative to the proposed system. A notable activity in this phase is a detailed definition and classification of requirements. See figure 2.
- C. **Evaluation:** after requirements have been gathered, evaluation needs to be carried out in order to solve the problem of inconsistencies of requirements, conflicting requirements from stakeholders and multi-level users of the system and also track requirements to make sure its fully acknowledged (i.e. For every requirement A, the reason behind that requirement A and how to fully implement that requirement is stated.). A notable activity in this phase is to fully carry out a structured risk analysis and cost benefits considering the technical and cost schedules in order to minimize cost and control risk as the cost of fixing errors in requirements elicitation processes is higher than its actual cost involved. See figure 2.
- D. **Prioritization:** after proper evaluation has been done, each requirement is prioritized in respect to four attributes namely: Benefit and limitations of the requirements, ease of development, ease of deployment and its dependency on other requirement.
- Benefits and Limitations of the requirements: if the stated requirements are achieved, its benefits to users is streamlined and if the requirements are not achieved, its consequences are stated in regards to the adverse effects it will bring to the system.
 - Ease of development of requirements: the clarity of requirements is checked in regards to available developments skills in order not to add delay to the development of the system
 - Ease of deployment of requirements: some requirements are not easily deployed because of their dependency on other hardware facilities to properly function but most importantly this has to do with how fast a requirement can be fixed into operation.
 - Dependency on other stated requirements: here requirements are checked whether they have a preceding or succeeding requirements attached to them, i.e the total outcome of the preceding requirement determines the scope of operation of the succeeding requirement.
- E. **Integration and validation:** integration of requirements ha to do with assembling the requirements into the desired system and validating them means to check if they have met the expected target or impact it's intended to have on the desired system. Since requirements cannot be thoroughly gathered at the same time, this model is structured to help analyze requirements at whatever stage of development and help achieve its goal before the development of the system is completed. Most notably using one requirement elicitation technique does not help achieve the purpose of requirements engineering neither does using a combination of techniques is guaranteed to succeed (but most likely it will). This model is structured to work iteratively with respect to the varieties of requirement elicitation techniques. See figure 2.
- transmit the packet. The proposed algorithm is consists of three main steps.

The process of requirements elicitation, including the selection of which techniques, approach, or tool to use during requirements engineering, is relative to a large number of factors including the type of system being developed, the problem domain, the project cost, and the project duration. Because of the relative strengths and weaknesses of the available requirements elicitation techniques and the type of information they provide, the reality is that in almost all projects a combination of several different techniques will be necessary to achieve a successful outcome subjective to the one the requirement engineer is most familiar with. This is justified by the fact that some of the techniques are intended to be used in-line with each other, and have complementary attributes towards each other. Most of the



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approaches require a significant level of skill from the analyst to be used effectively while eliciting for requirements. However from the range of existing techniques, despite attempts to come up with a definitive frameworks and guidelines on selecting elicitation techniques, requirements elicitation still remains more of an art than a science because of its attributing factors which cannot be controlled or properly quantified. Therefore proposing a requirement elicitation process model to be used during the process of requirements engineering is to help reduce the rate of project's failure, and help developers with a tool which will give them insights about the existing requirement elicitation techniques.

IV. CONCLUSION AND FUTURE WORK

The process of requirements elicitation, including the selection of which techniques, approach, or tool to use during requirements engineering, is relative to a large number of factors including the type of system being developed, the problem domain, the project cost, and the project duration. Because of the relative strengths and weaknesses of the available requirements elicitation techniques and the type of information they provide, the reality is that in almost all projects a combination of several different techniques will be necessary to achieve a successful outcome subjective to the one the requirement engineer is most familiar with. This is justified by the fact that some of the techniques are intended to be used in-line with each other, and have complementary attributes towards each other. Most of the approaches require a significant level of skill from the analyst to be used effectively while eliciting for requirements. However from the range of existing techniques, despite attempts to come up with a definitive frameworks and guidelines on selecting elicitation techniques, requirements elicitation still remains more of an art than a science because of its attributing factors which cannot be controlled or properly quantified. Therefore proposing a requirement elicitation process model to be used during the process of requirements engineering is to help reduce the rate of project's failure, and help developers with a tool which will give them insights about the existing requirement elicitation techniques.

For the future work, more field studies should be conducted to confirm these factors and to discover other relevant factors that contributes to the selection of requirements elicitation techniques by organizations and developers. Subsequently, a systematic and empirical strategy to select the appropriate techniques based on those factors should be developed. The proposed model should be deployed by the experts in the field of requirements engineering to see how best this techniques will perform.

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