Abstract - Requirements elicitation is concerned with the extraction of users’ requirements, which involves cognitive, social, communication, and technical issues. There are many techniques to elicit requirements each having its strengths and weaknesses. However, some of them are misused, others are never used and only a few are applied again and again. The reason is that analysts have a difficulty of deciding what elicitation techniques to use in a particular software development project due to lack of information regarding the available elicitation techniques, their usefulness, and how suitable they are to the project. This paper presents a framework, which will assist analysts in the selection of elicitation techniques that best fit the goal of elicitation session, the project environment and the problem domain. When applied, this framework provides ranked list of elicitation techniques which are suitable for the project.

Keywords: Requirements Engineering, Requirements Elicitation, Elicitation Techniques Selection.

1. INTRODUCTION

Requirements elicitation is concerned with the extraction of users needs from different sources. Users requirements are not out on a surface, they are rather in the depth of the social and organizational structure of organizations [6]. To aid the elicitation process, there are a variety of elicitation techniques proposed each with its strengths and weaknesses. This is due to the fact that there is no single technique, which can be effectively used for every problem [7]. Projects can be characterized by different factors which can affect the selection of elicitation techniques. The right technique must be chosen that fits the existing situation.

One of the challenges for analysts is the selection of appropriate requirements elicitation techniques that best fit their project characteristics from the plenty of available techniques [6, 11]. One of the reasons could be that requirements engineers are not aware of the available techniques and even if they are aware, it is difficult to find comprehensive information regarding the techniques that indicates when to use a particular technique or a combination of techniques. For this reason, some of them are misused, others are never used and only a few are applied again and again. Many requirements engineers have been choosing elicitation techniques and applying to their projects based on their intuition and experience. In addition, the advantages of using one elicitation technique as opposed to another in a given situation are not very clear.

Many studies have been conducted on specific elicitation techniques [2, 5, 8, 11, 12] and little is done to relate techniques with project situations. Recently, some frameworks appear in the literature with the objective of providing technique selection guideline [11, 14]. The frameworks provided in these works address important issues in elicitation techniques selection such as the characterization of elicitation techniques. However, the characterization of elicitation techniques needs to be integrated with factors that affect elicitation techniques selection. For example, Cysneiros [2] suggested a number of techniques that can be used for projects in a health-care domain. However, different projects in a health care domain can employ different techniques due to the differences in the nature of the environment, users/stakeholders, and the requirements engineers involved. The other issue is associated with decision-making subjectivity. For example, the term applicable means different things for different requirements engineers. For one person, the term applicable may mean less costly to use and for others it may mean more effective. Such factors should be incorporated into the elicitation techniques selection.

In this paper, we discuss the approach we have taken to developing a guiding mechanism to help analysts decide which elicitation techniques should be used under certain circumstances. We propose a probe-based framework, which is designed to help analysts in the process of requirements elicitation technique selection. The proposed framework takes the goal of an elicitation session, the project environment and the problem domain as an input and generates a list of suitable elicitation techniques with their rank of applicability.

The remainder of this paper is organized as follows. Section 2 discusses related works. Section 3 presents the classification of factors that affect the selection of elicitation techniques. A ranking technique is
presented in sections 4 and 5. Section 6 describes the conclusions and future works.

2. RELATED WORKS

There are some works that address some of the issues in the provision of elicitation techniques selection frameworks. In addition, there is also work in the area of software testing which deals with a similar problem that is, selecting an appropriate testing technique for a software system under certain circumstances.

Firstly, in the software testing techniques area, the selection of testing techniques is similar to ours though in a different area. Vegas et al. [15] propose a characterization scheme for testing techniques selection by collecting and combing information from testing techniques users, techniques producers and researchers. Even though it does not propose a ranking scheme, it is a generic framework that can provide developers information for choosing the best technique suited to the project.

Secondly, in the requirements elicitation area, there have been some works on characterizing elicitation techniques. Hickey and Davis [8] presented a model that shows the role of situational information in the process of requirements elicitation techniques selection. In their work, it is indicated that the elicitation techniques selection is driven by problem, solution, and project domain characteristics as well as the currently known requirements. They provided a general framework that models the requirements elicitation and elicitation techniques selection. However, their model doesn’t indicate any mechanism on how to perform an objective analysis on the considered factors to get a set of applicable elicitation techniques. In another work, Hickey and Davis [7] made interviews to experts on how they performed requirements elicitation techniques selection. However, in their analysis, the relations between elicitation techniques and project situations are not presented in a coherent manner. Tsumaki et al. [14] proposed a framework to characterize requirements elicitation techniques that can be used in the selection of appropriate techniques. They considered four typical techniques to study the properties of requirements elicitation techniques. In order to match elicitation techniques to project characteristics, they considered five factors: application domain, requirement engineer types, information resources, user involvement, and requirements properties. Though the five project characteristics are very useful, they are not adequate to capture the necessary characteristics of projects. In addition, it is not clear how this framework can be used to objectively assess the applicability of an elicitation technique to a particular project.

Maiden and Rugg [11] presented a framework, which assists requirements engineers to choose methods for requirements acquisition. This framework provides two main steps, namely, determining acquisition needs and choosing acquisition methods. The proposed framework consists of tables to be used in selecting requirements elicitation methods. The tables contain six facets and the elicitation techniques where each entry to the table is a check or a symbolized weight. This framework introduced the idea of relating elicitation techniques to the six facets by indicating whether an elicitation technique is applicable or not.

This work focuses specifically on identifying situational variables for elicitation techniques selection and developing a ranking technique that can be used to select elicitation techniques in such a way that techniques best suite for a software project can be selected.

3. THE TECHNIQUES SELECTION FRAMEWORK

An elicitation technique could be effective in one situation, incomplete in some other situation and even inappropriate in another situation. Thus, the main challenge in requirements engineering process is deciding which technique to use in the existing situation [5]. Most analysts, especially the novice ones, in addition to lack of complete knowledge on available elicitation techniques, have a problem on what factors to consider for deciding which techniques to use for a specific situation [8, 11].

In this framework, we describe the types of questions that analysts would ask in order to get the set of techniques that are more appropriate to the project at hand. The framework is developed after a three-phase study that identified and categorized the different factors that affect the selection of elicitation techniques for a given project at a given time. In the first phase, environmental factors which relate to the environment in which the problem is situated and potential goals of elicitation sessions are identified, categorized and compiled. The second phase was a study on domain factors which relate to the application domain. The third phase was a study on the characteristics of available elicitation techniques. About twenty techniques [3, 5, 9, 11, 12, 13] are studied which are believed to be the most common and representatives of the majority of elicitation techniques. The list consists of Document Analysis, Questionnaires, Structured interview, Unstructured Interview, JAD session, Video and Audio, Observation,
Next, we discuss the factors that affect the selection of elicitation techniques which are categorized into three groups, namely goal of elicitation session, project environment and problem domain.

3.1. Goals of elicitation session

The goal of an elicitation session refers to the type of requirements that is expected from an elicitation session. The goal of an elicitation session deals with extraction of project mission or clarifying ambiguous requirements or resolving conflicting requirements, etc. An elicitation technique which is appropriate for one elicitation goal may not be applicable for another goal. For example, JAD is more suitable for the resolution of conflicting requirements that involved more than two stakeholders [2]. However, this technique may not be suitable for other goals.

From different studies on requirements elicitation activities [1] and our own experience, goals can be categorized into groups. The following seven common types of goals are identified:

- a. Identification of organizational context
- b. Identification of boundaries of a system
- c. Identification of features of a system
- d. Detail investigation of a given feature
- e. Identification of rationales for requirements
- f. Clarification of uncertainty or ambiguities in requirements
- g. Requirements conflict resolution

The responses gathered from analysts regarding this set of goals are applied on the set of available techniques to get a set of techniques, which are applicable to the selected goals.

3.2. Project environment

The project environment encompasses the client’s space, the developer’s space, and the specific project space. Among the existing elicitation techniques, some of them may be more suitable for one particular situation than others. Requirements elicitation occurs as part of the requirements engineering process. This process determines the context in which elicitation takes place, and imposes some constraints on the use of the techniques and the selection [2]. In project environment, we consider factors such as communication among stakeholders, cost / schedule constraints, skill of analysts, relationship between clients and analysts, characteristics of a given project, etc. For example, the technique that we use when stakeholders do not want to spend a long time during the elicitation session is different from the technique that we use when stakeholders have time for the elicitation session. Similarly, if requirements engineers are under time pressure, they cannot apply techniques like ethnographic methods even though this technique enables them to observe activities that users may not be able to explain. Based on studies in [1, 4, 10], we group factors from the project environment into the following sub-factors.

- a. Stakeholders size
- b. Purpose of the project (e.g., is it to maintain an existing system or to develop a new system?)
- c. Interactive nature of the prospective system
- d. Analyst - client relationship
- e. Skill/experience of analysts
- f. Documentation culture of the client organization
- g. Availability of key stakeholders
- h. Users expressiveness
- i. Computer skill level of users
- j. Degree of project schedule constraint
- k. Degree of financial constraint
- l. Degree of constant flux of stakeholders
- m. Diversity of stakeholders
- n. Relationship among stakeholders
- o. Availability of communication technology
- p. Availability of reusable requirements
- q. Availability of information resource
- r. Degree of manpower constraint on developers

3.3. Problem domain

The problem domain refers to the domain to which the current project belongs. Domains have their own special characteristics, which favor some of the elicitation techniques and discourage others [2]. For example, if we take the health-care domain, using techniques like protocol analysis and interview is not encouraged [2]. On the other hand, some techniques might be applicable partially for a certain group of stakeholders. Cysneiros [2] indicated that Questionnaire technique is not applicable for extracting requirements from nurses and physicians but found it suitable for upper management. In other cases, a technique or set of techniques may be totally inapplicable for a certain domain. For example, using video and audio techniques during interviews as well as in the working areas in the domains of military may be discouraged due to legal and security problems.

Similarly, the techniques that can be used when analysts are familiar to the domain may not be applicable
if the analysts do not have any knowledge of that application domain. For example, to elicit requirements in an unfamiliar application domain, goal-oriented and brainstorming type approaches are more suitable [14]. Of course, this choice also requires considering other factors. Therefore, in the problem domain, we can consider factors such as familiarity to the domain, type of domain knowledge, and other factors associated to domains.

4. RANKING TECHNIQUES

The proposed framework is a four-step probe-based framework. It collects information from the analyst and filters out elicitation techniques that are suitable for the targeted requirement in the existing situation. In the first step, information about the goal of an elicitation session will be collected, which will be used to filter those techniques that suite the goal. The responses gathered from the first set of probes are applied on the set of available techniques, (say T_A) to get another set of techniques T_G, where T_G ⊆ T_A and T_G contains all techniques, which are applicable to the selected goals. This set is used as an input to the second step. In the second step, the responses about the project environment factors are collected and used to further filter T_G to get another set of techniques, (say T_E) that suite the project environment. Thus, T_E is a set of techniques that are appropriate to the goal and project environment, and T_E ⊆ T_G. In the third step, information about domain constraints is collected and used to further filter T_E to get the final set of techniques T_D, which is the set of applicable techniques to the goal, project environment and domain.

In some cases, there is a possibility for a given problem to belong to more than one domain. If the given problem belongs to two or more domains, then it is necessary to consider all domains, to which the problem belongs. In cases where more then one domain is selected, the framework gives list of elicitation techniques applicable to all involved domains. The same is true for the goal, since a given elicitation session may have more than one goal. Each elicitation session targets on the extraction of some information and, after holding the session, there will be another set of requirements that call for another session. Therefore, the goal factor of the selection process may vary for each session.

In order to rank elicitation techniques according to their suitability for a particular project, the analyst is expected to answer those probes corresponding to each of the selection factors, goal of elicitation, project environment, and application domain.

The appropriateness of techniques to a given situation is rated numerically using the studies made on the project environment, elicitation goals, domain constraints and the elicitation techniques. In the future this value needs to be gathered and compiled by a group of experts. In most studies, the applicability of techniques to situations is expressed using natural language terms such as highly or strongly applicable, fairly applicable, moderately applicable, etc. In our work, we use a similar form of assignment of linguistic terms.

5. APPLICABILITY RANKING

For the computation of applicability values of elicitation techniques, we consider fuzzy membership function and weighted average. Computation of applicability values in our previous work [16] was a pessimistic approach, which tries to make sure that for a technique to be applicable, it needs to have some degree of applicability in all the sub-factors. For example, if a technique has a weight of zero for one of the sub-factors, then it was not considered as a potential candidate for that session.

The computation of applicability values of techniques to the factors goal, project environment, and domain requires different treatment. The reason is that in the current work, goal and domain do not have rating scales that enable the analyst to rate each sub-factor. Instead, the analyst simply selects the sub-factors to be considered for a particular elicitation session. On the other hand, the project environment factor requires the analyst to rate each sub-factor on a five rating scale of linguistic values: “very low”, “low”, “average”, “high”, “very high”.

Techniques with applicability value 0 as determined by experts for one of the sub-factors are totally inapplicable for that specific elicitation session and are removed from the candidates list.

After the analyst completes all the probes, the following applicability values are computed.

a. Total Applicability to a Session (TAS) - the degree of applicability of a technique to a given elicitation session.
b. Total Applicability to Goal (TAG) - the degree of applicability of a technique to the selected goals of an elicitation session.
c. Total Applicability to Project Environment (TAPE) - the degree of applicability of a technique to the environment in which the technique will be used.
d. Total Applicability to Domain (TAD) - the degree of applicability of a technique to a domain to which the application belongs.
Since the computation of total applicability to goal, project environment and domain is similar, here we consider only the project environment factor. Suppose we have project environment sub-factors \( f_1, f_2, f_3, \ldots, f_n \) and techniques \( t_1, t_2, t_3, \ldots, t_n \) and \( w_{ij} \) refers to the degree of applicability of technique \( t_i \) to sub-factor \( f_j \). Ideally, this weight needs to be extracted from a knowledge-base. Suppose \( y_{ik} \) represents weights corresponding to the analyst’s \( k \)-th rating for the environmental sub-factor \( f_i \). Thus, TAPE of a technique \( t_i \) for a given elicitation session can be computed as follows:

\[
TAPE_{ij} = \min \{ y_{ik} w_{1j}, y_{ik} w_{2j}, \ldots, y_{nk} w_{nj} \}
\]

where \( w_{ij} \neq 0 \) for all \( i=1..n \) and \( j=1..s \).

Finally, total applicability of technique \( t_i \) for a given elicitation session, TAS, can be computed as follows:

\[
TAS_{ij} = \min \{ TAG_{ij}, TAPE_{ij}, TAD_{ij} \}
\]

For a given elicitation session, having higher value of TAS means that the technique is the best candidate for the session. As can be seen from the above computation for the project environment sub-factors, the rating is a subjective issue and it does not entertain the possibility of having a rating between two consecutive linguistic values. Therefore, we introduce the idea of fuzzy sets corresponding to each linguistic value for each project environment sub-factor.

5.1. Fuzzy-logic based Computation

Each sub-factor is measured using a rating scale of five linguistic values: “very low”, “low”, “average”, “high”, and “very high”. For example, for the sub-factor “availability of stakeholders”, these linguistic values can be interpreted as follows:

Very Low - “Stakeholders are not available at all”
Low-“Stakeholders are available once in a blue moon”
Average – “Stakeholders are fairly available”
High- Stakeholders are available most of the time”
Very high - “Stakeholders are always available”

A similar interpretation can be given for the linguistic values of the other sub-factors. In our previous work [26], the assignment of linguistic values to the sub-factors uses conventional quantization where the values are intervals. The rating values that we had used for the sub-factors were: very low – 0, low – 0.25, nominal – 0.5, high – 0.75, and very high – 1. Then a linguistic value is assigned to each sub-factor by the analyst. The problem with that approach is that no sub-factor can occupy more than one class of linguistic values and the transition from one linguistic value to the next is abrupt instead of being gradual. In our current work, we use fuzzy sets rather than classical intervals to represent the linguistic values (“very low”, “low”, “average”, “high”, “very high”). This is mainly useful for sub-factors in the project environment factor since the assignment of linguistic values for each sub-factor and the use of intervals for the decision of linguistic value assignment only works for this factor. However, we understand that more work needs to be done in the future for the other sub-factors too.

The advantage of the fuzzy set approach is that it is more general and mimics the way in which humans interpret linguistic values. In fuzzy logic, these linguistic values can be mapped to values between 0 and 1. For example, in the case of “availability of stakeholders” sub-factor, linguistic value assignment is made based on the duration (interval) of the time that stakeholders can commit for the elicitation process. That is, if stakeholders can commit 1 – 3 hours, then we say their availability is low; if they can commit 4 – 7 hours, we say their availability is average; if they can commit 8 – 10 hours, we say their availability is high; if they can commit more than 10 hours, we say their availability is very high. It is important, however, to note that the hours are not yet agreed on by practitioners and researchers in this area. Different researchers proposed different durations. This requires more empirical study. In such a situation, we can define a fuzzy set for each linguistic value with a trapezoidal membership function. This can be done for each sub-factor.

Next, let’s define the fuzzy applicability multipliers using a similar approach to software development effort estimation [17]. The following formula is adapted from [17].

Let \( C_{ij} \) represent the applicability multiplier associated with the \( j \)-th selected rating for \( i \)-th sub-factor in the classical linguistic value assignment. Let \( F_{-C_{ij}} \) represent the applicability multipliers based on fuzzy sets. \( F_{-C_{ij}} \) can be computed as a function of the classical applicability multipliers \( C_{ij} \) and the membership functions \( \mu \) defined for the various fuzzy sets associated with the sub-factors.

\[
F_{-C_{ij}} = F(\mu_{A_{S_{ij}}}(T), \ldots, \mu_{A_{S_{ij}}}(T), C_{i1}, \ldots, C_{ij})
\]

where \( \mu_{A_{S_{ij}}} \) is the membership function of the fuzzy set \( A_{S_i} \) associated with the sub-factor \( S_i \). For simplicity, \( F \) can be considered as a linear function. Therefore, the fuzzy applicability multiplier can be computed as follows:
\[ F \_ C_j = \sum_{j=1}^{S} \mu_{A_j}^S (T) \times C_{ij} \quad (1) \]

Finally, the applicability of a technique to a particular session can be expressed in terms of its ranking. The rank of an elicitation technique can be computed as the weighted average of all applicability weights of the technique to the sub-factors.

\[ R_j = \frac{\sum_{j=1}^{n} \sum_{j=1}^{n} w_{ij} x_{ij}}{\sum_{j=1}^{n} w_{ij}} \quad (2) \]

where \( 0 \leq w_{ij} \leq 1 \), and \( x_{ij} \) represents fuzzy applicability multiplier of technique \( T_i \) to the \( j \)th sub-factor, \( w_{ij} \) represents weight assigned by experts for the applicability of technique \( T_i \) to \( j \)th sub-factor.

Using the above ranking technique, analysts can evaluate elicitation techniques to choose one or more elicitation techniques that best fit for the project at hand. It is important to note that this framework doesn’t suggest the use of only one highly applicable technique. Among those applicable techniques, a combination can be used since each technique may be insufficient in isolation for reasons outside of the framework to capture complete requirements.

6. CONCLUSION

In this paper we have presented a framework that helps requirements engineers in deciding which factors to consider in selecting elicitation techniques for a particular project. The framework incorporated three factors – goal of elicitation, project environment, and application domain and under each factor, there are different sub-factors which the requirements engineer can select for a particular elicitation session. This framework provides a basis for systematic decision-making regarding elicitation techniques that can be used for an elicitation session.

We have also provided a ranking technique based on fuzzy logic and weighted average which can simplify the subjective decision of elicitation techniques selection. As a future work, we understand that there is a need to incorporate ideas and views from requirements engineers (practitioners) and requirements elicitation techniques producers (who propose elicitation techniques).

REFERENCES


