# Effective Requirements Development–A Comparison of Requirements Elicitation Techniques

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# Effective Requirements Development - A Comparison of Requirements Elicitation techniques

Zheying Zhang

Department of Computer Sciences
University of Tampere
FIN-33014 Finland
+358 3 35518571

Zheying.Zhang@cs.uta.fi

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## 1 INTRODUCTION

Requirements engineering process is a human endeavor. People who hold a stake in a project are involved in the requirements engineering process. They are from different backgrounds and with different organizational and individual goals, social positions, and personalities. They have different ways to understand and express the knowledge, and communicate with others. The requirements development processes, therefore, vary widely depending on the people involved. In order to acquire quality requirements from different people, a large number of methods exit. However, because of the inadequate understanding about methods and the variability of the situations in which requirements are developed, it is difficult for organizations to identify a set of appropriate methods to develop requirements in a structured and systematic way. The insufficient requirements engineering process forms one important factor that cause the failure of an IT project [29].

The diversity of people involvement in requirement engineering is an objective phenomena. It is impractical to limit the diversity of people involved. However, the methods to develop requirements are under the engineer's control. Instead of developing requirements passively, the requirements analysts shall proactively identify and foresee the potential problems in the requirements development process and select a proper method to diminish the problems to some extent. Therefore, an overall knowledge about the requirements development methods is important for engineers to predict the requirements development process and select a proper method.

In this paper, we elaborate on an extensive comparison of requirements development methods, and identify common factors that affect the method selection. Furthermore, we discuss the generic guideline that can be used as a starting point for method selection. Requirements elicitation occurs at an early stage of requirements development. As it is a critical but error-prone stage in the requirements development, our discussion focuses on the methods for requirements elicitation.

The remainder of the paper is organized as follows. The next section presents the motivation to develop a comprehensive framework for requirements method selection by illustrating the variation of a requirements engineering process and reviewing the research on requirements elicitation methods. Section 3 concerns the category of requirements methods, and distinguishes between four types of requirements elicitation methods based on the means of communication. Section 4 discusses the main factors that influence on method selection at the requirements stages. On the basis of method category and the factors regarding method selection drawn out from section 3 and section 4, section 5 further illustrates the level of applicability of different methods in different situational context in a matrix and presents the strategies to select proper methods for requirements elicitation. Section 6 summarizes our research and highlights the further research.

## 2 RESEARCH BACKGROUND

In Figure 1, we illustrate main activities in the requirements development process: elicitation, analysis, specification, and validation [18].

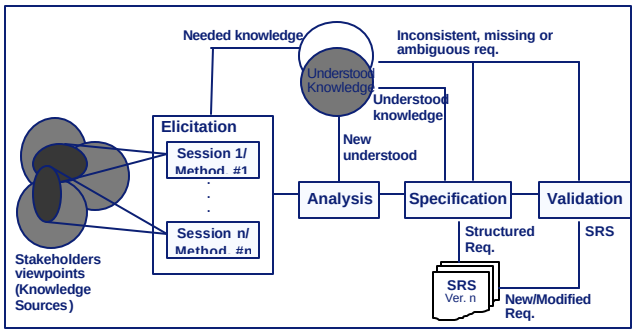


**Figure 1 Requirements development process**

Requirements are elicited through consultation with stakeholders. The stakeholders not only refer to human being, such as end users, customers, decision-makers or developers, but also refer to the physical, organizational, or legislation environment where the desired system is to be used [18, 28, 32]. Because different stakeholders have distinct ways to store, recognize and express their knowledge about the problem domain, a single method is unlikely enough to elicit requirements from different stakeholders. In addition, because the situational context changes during the elicitation process, and the requirements analysts' experience and knowledge varies, it is hard to use a single generic-purpose method to elicit all needed requirements in one elicitation session. Therefore, requirements elicitation takes place in a set of sessions, in parallel or in sequence. Each session includes a (set of) method(s) in line with the situational context. New understanding about the desired system is extracted, recorded and analyzed. These activities are repeated until the problem domain and the

desired system are well understood and documented in a structured way - system/software requirements specification (SRS). The SRS will be further validated before it is baselined as the contract between customers and the development team. During the validation process, omitted, redundant, and inconsistent requirements are identified, negotiated, and compromised by iterating the same activities.

Requirements development, therefore, is an iterative and incremental process, in which eliciting requirement from various sources is the most challenging activity, and shall be performed in a proactive manner. The development team shall not only well understand every requirements elicitation method, but also select methods that fit into the situational context and the characteristics of stakeholders.

Understanding requirements elicitation methods and foreseeing the need to use them in different contexts are essential for requirements elicitation. In order to help engineers understand and select different methods, many framework regarding requirements development methods are discussed in literature. Many frameworks highlight the communication and the user involvement as the key issues in method selection. For example, Byrd et al. [2] compare knowledge elicitation techniques suitable for two identical research disciplines: requirements analysis and knowledge acquisition. The comparison demonstrates the match between elicitation techniques and communication obstacles, and the match between certain elicitation types and problem domain categories. The authors' objective is to seek the categorization scheme to facilitate the merging of research across these two research disciplines. Instead of a specific framework for requirements development methods comparison, the framework is built on the basis of common aspects covered by both research disciplines. Coughlan and Macredie [4] study socially oriented methodologies for requirements elicitation by using a four-dimensional framework: user participation and selection, user-designer interaction, communication activities, and techniques, and further classify methodologies on the basis of user control and scope of design problem. As pointed out by authors, the framework is theoretical in nature. It lacks practical guidance for method selection.

Many existing framework lacks an extensive study of a wide variation of methods for requirements development. For example, the ACRE framework presented by Maiden and Rugg [21] is concerned with assisting analysts in acquiring requirements from stakeholders. The framework guides the method selection by defining a set of facets to evaluate the strengths and weaknesses of each method. It, however, only focused on requirements acquisition from human-being and left out the methods for extracting requirements from physical environments. Hudlicka [15] compares the effectiveness of requirements elicitation methods, but the discussion is limited to indirect knowledge elicitation methods, such as repertory grid analysis, multi-dimensional scaling, and hierarchical clustering. Christel and Kang [3] study several methods in relation to problems faced in requirements elicitation practice, and illustrate the level of applicability of methods to address those problems. Because the discussed methods are classified based on the activities to which they are applied rather than the nature and characteristics of methods, the classification is somehow confusion and insufficient.

In summary, requirements elicitation is a synthetic process consisting of social communication and information mining. Most literature only focuses on the communication and user involvement perspective to evaluate a set of requirements development methods, and lacks extensive discussion of a wide range of methods. Besides, the literature does not address specifically, in any substantial way, how requirements elicitation methods are deployed in different contexts to develop customer-centered products. In order to support analysts to understand and select methods for requirements development, the following sections categorize requirements methods based on their underlying nature, and discuss the guidelines and facets to evaluate them.

# 3 REQUIREMENTS ELICITATION TECHNIQUE CATEGORY

This section concerns the category of requirements methods. As requirements development is an intensive interaction process between stakeholders and the analysts, we distinguish between four types of elicitation methods according to the means of communication: observational, conversational, analytic, and synthetic. Each type presents a specific interaction model between analysts and stakeholders, and reflects the nature of a method herein. Understanding the method category helps engineers understand different elicitation methods and guides them to select an appropriate (set of) method(s) for requirements elicitation. Furthermore, it provides an enriched base for us to predict the trends in requirements elicitation method, and to provide strategies for requirements development.

## 3.1 Conversational methods

The conversational method provides a means of verbal communication between two or more people. Because conversation is a natural way to express needs and ideas, and ask and answer questions, it is effective to develop and understand the problems and to elicit generic product requirements. Methods in this category are also referred as verbal methods [1]. A typical conversational method is interviews. It is commonly used in requirements elicitation [18]. Other methods under this category include workshop, focus groups, brainstorming, etc. as illustrated in Table 1.

**Table 1 List of conversational methods**

| Method | Conductor | Description |
|---|---|---|
| Interviews [8, 18, 19] | An experienced analyst with generic knowledge about the application domain | Analyst discusses the desired product with different groups of people and builds up an understanding of their requirements. If the interview is conducted with pre-defined agenda and questions, it is called structured interview; otherwise, it is an open-ended interview.<br><br>+ Product features |
| Workshop, focus groups [8, 19] | An experienced outside facilitator | Stakeholder representatives gather together for a short but intensely focused period to create or review high-level features of the desired products.<br><br>+ Product features |
| Brain-storming | An experienced | Stakeholder representatives gather together and rapidly develop a large and broad list |

| | | |
|---|---|---|
| [19] | outside facilitator | of ideas. It encourages "out-of-the-box" thinking without normal constraints, and involves both idea generation and idea reduction.<br><br>+ Product features<br>+ Innovation/new ideas regarding products |

Conversation is one of the most prevalent yet invisible forms of social interaction. People are usually happy to describe their work and difficulties they face. The verbally expressive demands, needs and constraints are often called non-tacit requirements [21]. Because verbal communication is practical and efficient to collect non-tacit knowledge [21], conversational methods form the primary approach to non-tacit requirements elicitation. By conducting interviews, workshops or brainstorming, the requirements are articulated by stakeholders and communicated with the analysts.

Conversational methods are very commonly used in requirements development. However, they are labor intensive [3, 8]: meeting setup and transcript producing and analyzing from records of a live interaction take time. Meanwhile, it is challenge to facilitate the elicitation process, especially when workshop or brainstorming is used, e.g. scheduling the meeting and ensuring that the representatives to be present in the meeting [18].

## 3.2 Observational methods

The observational method provides a means to develop a rich understanding of the application domain by observing human activities. In addition to non-tacit requirements, some requirements are apparent to stakeholders, but difficult to verbalize. We call them tacit requirements [21]. Verbal communication is often helpless when collecting tacit requirements. Therefore, observing how people carry out their routine work forms a means of acquisition of information which are hard to verbalize. Methods under this group include ethnographic studies, as illustrated in Table 2.

**Table 2 List of Observational methods**

| Method | Conductor | Description |
|---|---|---|
| Social analysis, Observation, Ethnographic study [18, 21, 24] | The observer must be accepted by the people being studied as a "kindred spirit" and must be sufficiently familiar that they carry on with their normal practices as if he was not there. | An observer spends a period in a society or culture on making detailed observation of all their practices.<br><br>+ Initial understanding of the system and the application domain<br>+ Detailed understanding of social/organizational cultures, work setting (team interaction and collaborative work), and work flow<br>+ Information relevant to design solutions |
| Protocol analysis [8, 21] | | A subject is engaged in some task, and concurrently speaks out loud and explains his thought.<br><br>+ Interaction problems in existing systems<br>+ Work context and work flow |

Observational methods appear to be well suited when people find it difficult to articulate their needs and when analysts are looking for a better understanding of the context in which the desired product is to be used [30]. Examples of tacit information include the routine work that people perform daily in an intuitive way and the organizational or social contexts that potentially affect the requirements. As people are familiar with the context and situation of their work, they do not consciously think about the routine and the working environment. It is difficult for them to articulate how work is done, although the routine work sometime is easy to show to others [18]. Therefore, to be immersed in the real work situation to obtain the observational evidence can help engineers understand in depth the pattern of work, the social group, the organization, and the broader context within which the product is used.

As observation methods fall into the category of longitudinal studies, it, in general, takes longer period than the other methods [23], which forms a main disadvantage of such methods, especially when the project has tight schedule at the requirements stage. Besides, Observation requires sensitivity and responsiveness to the physical environment. It is easy for observers to perceive a rich picture about the work context, but it is normally hard to specify and analyze their perception.

In addition, observational methods are used for understanding complex societies rather than making judgments about how ways of working could be improved or supported [18]. They are good to uncover basic aspects of routine order, such as the typical pattern of work, and provide the information most relevant to designing solutions [16]. Therefore, it is often a good practice to start with an observational method to get an initial understanding of the desired product when the development team lacks experiences of product development in a given domain.

## 3.3 Analytic methods

By using the conversational methods or the observational methods, requirements are directly extracted from people's behavior and their verbalized thought. Besides, the knowledge implied though not directly expressed, such as the experts' knowledge or the information about regulations or legacy products, also provides engineers rich information in relation to the product. Analytic methods provide ways to explore the existing documentation or knowledge and acquire requirements from a series of deductions. They are illustrated in Table 3.

**Table 3 List of analytic methods**

| Method | Source | Description |
|---|---|---|
| Requirement reuse [6, 17, 18, 31] | Documentation | Reuse of the glossaries and specification of legacy systems or systems within the same product family to identify requirements of the desired system<br><br>+ Domain requirements<br>+ User interface characteristics<br>+ Organizational policies, standards, legislation, etc. |
| Documentation studies /content analysis | Documentation | A common method consisting of reading and studying available documentation for content that is relevant to and useful on the requirements elicitation tasks.<br><br>+ Organizational policies, standards, legislation, etc.<br>+ Market information<br>+ Specification of legacy systems |

| | | |
|---|---|---|
| Laddering [25] | Expert's knowledge | It involves the creation, reviewing and modification of hierarchical content of expert's knowledge, often in the form of ladders (i.e. tree diagrams).<br><br>+ Organizational culture<br>+ Domain knowledge |
| Card sorting [26] | Expert's knowledge | The expert is asked to sort into groups a set of cards each of which has the name of some domain entity written or depicted on it.<br><br>+ Domain knowledge |
| Repertory grid [2, 9] | Expert's knowledge | Stakeholder is asked for attributes applicable to a set of entities and values for cells in entity-attribute matrix |

A variety of documentation may shed light on requirements of the desired product. It includes problem analysis, organizational charts, standards, user manuals of existing systems, survey report of competitive systems in market, and so on. By studying it, engineers capture the information about the application domain, the workflow, the product features, and map it to the requirements specification. Also, they identify and reuse requirements from the specification of the legacy or similar products. It is always worth probing and rummaging for reports and recorded information relevant to the desired product.

In analytic methods, the mapping techniques are useful for knowledge acquisition. As discussed in [2], multidimensional scaling [2, 33] enables users to acquire conceptual structure, cognitive mapping [2, 22] to identify factors and determine cause-effect relationships of a task or process, and variance analysis [2, 10] to use existing system as a basis for determining new system requirements. These techniques are commonly regarded as knowledge acquisition technique, but also are adaptable in requirements elicitation.

Instead of requirements reuse, documentation studies, and the related mapping techniques where documentation forms a main source of requirements, the deducted information from experts' knowledge and experience form another source of requirements in analytic methods. Requirements can be dug up from domain experts' knowledge. As illustrated in Table 3, laddering [25] is used to elicit explanation and clarification of technical terms or subjective terms, and to elicit how experts structure their knowledge about a domain, and card sorting [26] and repertory grid [2, 9] provide ways to elicit attributes that are not immediately and easily articulated by the expert.

In general, the analytic 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 products is reusable.

## 3.4 Synthetic methods

No single method is enough to requirements development. Considering the context and the circumstances involved, different methods can be selected at distinct elicitation sessions (as shown in Figure 1), even within one session. For example, it is often a good idea to start with an informal open-ended interview or documentation study before an analyst starts the ethnographic study [18]. The combination of open-ended interview and the ethnographic studies helps the engineer uncover the basic aspects and gain a generic knowledge of the application domain, which supports the follow-up ethnographic study.

Instead of combination of individual methods, the synthetic method forms a coherent whole by systematically combining conversation, observation, and analysis into single methods. Analysts and stakeholder representatives communicate and coordinate in different ways to reach a common understanding of the desired product. They are also referred as collaborative methods [11]. Examples of synthetic methods are illustrated in Table 4.

**Table 4 List of Synthetic methods**

| Method | Conductor | Description |
|---|---|---|
| Scenarios, passive storyboards [5, 18, 19] | Analysts and stakeholder representatives communicate and coordinate to reach a common understanding of the requirements | It is an interaction session to describe a sequence of actions and events for a specific case of some generic task which the system is intended to accomplish.<br><br>+ Clarified system requirements related to procedures and data flows of a task.<br>+ In a highly uncertain situation, an effective and relatively inexpensive way to develop an initial set of requirements. |
| Prototyping, Interactive storyboards [18, 19, 24] | | It provides stakeholders with a concrete (although partial) model or system that they might expect to be delivered at the end of a project. It is often used to elicit and validate system requirements.<br><br>+ Product feature and detailed specifications – an early and realistic view of what was feasible |
| JAD/RAD sessions | | It stands for Joint Application Development/Rapid Application Development and emphasizes user involvement through group sessions with unbiased facilitator. |
| Contextual inquiry [14] | | It is a combination of open-ended interview, workplace observation, and prototyping. This method is primarily used for interactive systems design where user interface design in critical. |

The synthetic methods combine different communication channels, and provide models to demonstrate the system feature and interaction. They provide good cues for requirement recognition in the form of rich semantic models [21]. For example, the prototypes provide users an initial version of the system which can remind them of the fine grained functions which are often otherwise overlooked. Storyboard is a method between scenarios and prototyping. It offers a continuum of possibilities ranging from sample outputs to live interactive demos [19].

Instead of methods restricted at the requirements stage, the synthetic methods are often deployed at other stages of the

product development life cycle. Because the objective of synthetic methods is to improve the communication between developers and the customers, they are suitable for different stages of the development process. They effectively harmonize the requirements stage with the rest development activities.

## 3.5 Summary

No matter what development project is, requirements development nearly always takes place in the context of a human activity system, and problem owners are people [24]. It is essential for requirements engineers to study how people perceive, understand, and express the problem domain, how they interact with the desired product, and how the physical and cultural environments affect their actions. The four types of techniques present different approaches to these questions. The conversational methods provide a direct contact channel between engineers and stakeholders, and the requirements are mainly non-tacit. The observational methods provide an indirect channel by observing user's interaction with his work setting and context, and the requirements fall into tacit knowledge. The analytic methods form one complementary indirect contact channel to extract requirements proactively. The synthetic methods focus more on collective effort on clarifying the features of desired products, and the communication channel is therefore a mix of direct contact and indirect contact. Each type of techniques has trade-offs. In reality, of course, the boundary between different types of method is blurred. Some methods are used synthetically, like the example of open-ended interview and ethnographic study mentioned in section 3.4. The method selection should be done according to the understanding of the nature of each method, the problem domain, the organizational context, types of requirements source, etc. The analyst needs to learn several if he wants to become adept at eliciting requirements.

# 4 PERSPECTIVES OF METHOD SELECTION

Having studied the nature of the requirements elicitation methods, this section further discusses the factors that affect the method selection. The factors are presented mainly from four perspectives: the abstraction level of requirements, the requirements source, the communication obstacles, and the level of certainty.

## 4.1 Requirements abstraction level

In general, requirements engineers go through two phases in requirements elicitation: problem analysis and product specification. The former phase is to perceive the problem domain by understanding the situation of concern and setting boundaries [1], while the latter to focus on features of the product by collecting complete and concise requirements. Accordingly, requirements can be distinguished between two abstraction levels: the generic knowledge of problem analysis and the specific knowledge of the product description. The generic knowledge is on a higher abstraction level than the specific one. It mainly refers to the business requirements such as the product vision, project scope, and the constraints. The specific knowledge mainly refers to the product features including functional and nonfunctional requirements. The specific requirements are aligned with the context and objectives established by the business requirements.

Taking into account the nature of requirements on different abstraction levels, a proper set of elicitation methods have to be chosen. For example, as business requirements identify the primary benefits from the desired product, they should be gathered from individuals who have a clear sense of the ultimate value the product will provide to business and its customers. Therefore, conversational methods are good options for knowledge acquisition from project managers or customer representatives. However, if the desired product is a brand-new one in market, due to the limited understanding of product domain, observational methods can be applied for generic knowledge acquisition from the environment where the product is put into use. Furthermore, synthetic methods can be regarded as a comprehensive approach to eliciting product features, and the analytic methods form a good complementary approach if similar products have already been produced by the organization.

## 4.2 Requirements source

Stakeholders form the sources of requirements. As discussed in section 3.3, stakeholders not only refer to human being, but also the physical, organizational, or political environment in which the desired product is put into use. Therefore, the source of requirements exists in different forms: knowledge embedded in human being and the knowledge embedded in the physical environments. Accordingly, different elicitation approaches shall be applied. The engineer shall ensure that the selected method can effectively utilize the requirements sources in terms of the data available and the process to acquire the knowledge.

The knowledge of human being is the primary source of requirements and accessible by using almost every method: conversation, observation, analysis, and synthetic methods. Most ideas for product development and improvement come from customers and end users [12].

Besides, because human being not only have individual knowledge about the problem domain and the desired products, but also hold a social position in organizations or departments where there are subtle power and influence relationships between the different people [18], they play different roles in a variety of projects and influence them, and their goals and desires are conformed to the organizational business objective. Due to the diverse social positions, it is difficult to extract all needed knowledge from stakeholders. For example, the organizational knowledge might be difficult to elicit by using interviews primarily because of political and social factors [18]. Identifying a method that fits into the elicitation context is therefore important to elicit concise and complete requirements.

In general, a high-level strategy for requirements development can be summarized based on features of the different types of methods. The conversational methods are effective for developing an understanding of the problem and the desired product from different stakeholders. The observational methods are suitable for understanding customers or end users' work when they find it difficult to articulate the work setting, the work flow, and the social and organizational factors that influence the problem. The synthetic methods are more effective for intensive communication and collaborations between stakeholders and engineers, which inspires stakeholders to recognize the omissions, errors and

inconsistencies of existing requirements and identify further requirements. The analytic methods are relatively effective for eliciting requirements from existing documentation and domain experts. Besides, requirements engineers shall understand the organizational and political context, the stakeholder knowledge background, their characteristics, and their social positions when adapting a method for requirements development.

The environment in which the product is put to use forms another form of the requirements source. They include legislation, standards, organizational structure, characteristics of the systems coexisting with the desired system, as well as the specification of legacy systems. Most of them are presented in the form of documentation, which is accessible by analytic methods, such as social studies, documentation studies and requirements reuse. Analysts are main actors when acquiring requirements from the environment.

## 4.3 Communication obstacles

A product is not independent but exists in an environment containing many other products which affect its functionality. Method selection within managerial, organizational and political constraints is a complex and subjective decision [21], and this paper does not attempt to provide a complete guidance. Instead, we discuss the communication barriers in stakeholder and analyst interaction.

The importance of communication between stakeholders and analysts at the requirements stage has been widely studied [2, 7, 13, 18]. Various communication barriers are discussed. For example, Valusek and Fryback {Valusek, 1987 #452} categorize barriers into within the individual, between a user and an analyst, and among users. This category has been widely used in the related research {Valenti, 1998 #450}. As software development projects become a global collaboration across national borders, organizations face challenges in enabling effective requirements elicitation from multi-site organizations. Besides the existing research results, this paper takes into account the globalization phenomena and addresses obstacles caused by the nature of different communities, societies, or individuals, i.e. culture diversity. In detail, we analyze the culture diversity on three levels: national culture, organizational culture, and individual cognitive limitations.

The national culture defines " a collective mental program" of people [7, 13]{Damian, 2003 #451}. Individuals from different cultural backgrounds may have different languages, beliefs, values, attitudes, competencies, and perceptions of priority, which results in different behaviors in cooperation. Accordingly, analysts shall using an appropriate method to interact with stakeholders from different nationalities. For example, brainstorming or workshops are much less effective for idea generation if the participants are habitually reserved in speech, while observations are appropriate for collecting information from reticent people.

The organizational culture covers many facets of organizational operation [27], such as management structure and style, common work habit and interaction patterns. Besides, the nature of the work place, norms, values inherent in an organization can also be considered as organizational culture [18], such as the terminologies used within an organization, the product development maturity levels, the sources available for requirements development, etc. The organizational culture influences the features of the desired product, and is worth studying. However, it is implicit and embedded in the organizational operation. Therefore, observational methods and analytic methods are more effective than conversational methods. Meanwhile, scenarios and storyboards can facilitate effective communication by providing a tangible reference that all stakeholders could use to express their thought.

The individual cognitive limitations refer to cognitive shortcomings of human as information receiver, information processor and problem solvers [2]. At the requirements stage, they mainly refer to the ability of comprehension, the capacity of memory and recall, the information processing activities, and the decision-making processes. The cognitive limitations vary from people to people, so different methods may be suitable for different people to elicit requirements within the same context. For example, the experts and novices have apparently different cognitive capability, because of the different working experiences, knowledge backgrounds and mind sets. It results in different views and scopes to perceive and solve the problem domain. Therefore, interview may be suitable for an expert to elicit domain information, while prototyping is a more likely method for a novice. Furthermore, the tangible information is easy for individuals to perceive and analyze. Most synthetic methods deliver concrete concept or process models, which is an effective support to alleviate the individual cognitive limitations.

In addition, the international cooperation highlights the problem of communication across space and time [20] {Damian, 2003 #451}. Global teams use a variety of techniques to diminish communication barriers caused by space and time, such as phone, email, videoconference, and groupware tools. These techniques are applicable for requirements elicitation and can be used together with most requirements elicitation methods.

## 4.4 Level of certainty

When selecting a method, an important factor influences on method selection is whether the organization is acquainted or unfamiliar with the application domain. An acquainted domain implies a higher level of certainty with the problem than the new domain.

An acquainted domain reflects a relatively mature problem situation. The problem in existing domain is easy to understand and structure, which means the product vision and the scope are well stated, the domain knowledge has been existing between engineers and stakeholders, and the glossary of specific terminologies is available, etc. On the basis of a clearly defined business objective and the vision and scope statements, the engineers can easily start eliciting requirements with conversational methods, such as interviews, or some synthetic methods like evolutionary prototyping. The level of uncertainty is relatively low.

However, a brand-new product implies a higher level of uncertainty. The application domain is not as well-understood as the domains for which products have been developed, and problems emerge in the domain which may not be faced by the

requirements analysts before. Before composing the high-level business objective and product vision, the engineer have to acquaint himself with the domain. In such a context, observational and analytic methods are more effective than the conversational methods at the initiation stage of requirements elicitation. Meanwhile, as the problem domain is unstructured, synthetic methods such as prototyping and scenarios fit well to improve the understanding and communication between stakeholders and engineers. More specifically, scenarios or storyboards provide an effective and relatively inexpensive way to communicate specific system features in situations of highly uncertainty {Holbrook, 1990 #449}.

## 4.5 Summary

We have discussed four perspectives for requirements method selection. These four perspectives are not mutually exclusive and there are obviously interrelationships between them. For example, the abstraction level is reflected in the perspective of level of certainty, and requirements resource is closely related to the communication environment. Besides, there are many other trivial factors that influence the method selection. They are more related to a specific situation or context. The discussion does not, by any means, aspire to reject or overwrite the existing frameworks [2-4, 15, 21] to guide the selection of requirements development methods. Rather, we aim at providing a simple and feasible in-practice alternative for methods selection, and guidance on when a specific elicitation technique should be used, based on which the engineers can gain more experience on method selection in practice.

# 5 MATRIX OF METHOD SELECTION

In an attempt to understand the appropriate use of different types of requirements methods, a matrix is constructed to summarize the level of applicability of methods in different situational contexts. The perspectives influencing on method selection form the situational contexts of requirements development, and are listed in the left column of the matrix. The method category, listed in the top row of the matrix, represents different channels to acquire requirements. In different situational contexts, distinct communication channels are created between analysts and stakeholders. Accordingly, a set of methods can be selected to meet the needs of a specific situational context, as shown in Table 5.

**Table 5 Matrix of method selection**

| ***Perspective*** *+++: Methods strongly recognize the issue and provide a means to deal with it, ++: Methods support the issues, but not as strongly as the previous one, +: Methods address the issues, but weak or indirectly, -: Methods do not address the issues.* | | ***Conversational methods*** | ***Observational methods*** | ***Analytic methods*** | ***Synthetic methods*** |
|---|---|---|---|---|---|
| ***Abstraction level*** | *Problem analysis* | ++ | +++ | ++ | + |
| | *Product description* | ++ | + | ++ | +++ |
| ***Requirements source*** | *Human being* | +++ | + | + | ++ |
| | *Other* | - | +++ | ++ | - |
| | *environments* | | | | |
| ***Comm. obstacles*** | *National culture* | ++ | + | + | +++ |
| | *Organizational culture* | + | +++ | ++ | + |
| | *Cognitive limitation* | ++ | + | + | ++ |
| | *Geographically distributed environment* | ++ *teleconference* | - | + *email* | + *groupware tools* |
| ***Level of certainty*** | *Existing domain* | +++ | + | +++ | ++ |
| | *New domain* | ++ | ++ | + | +++ |

The matrix represents different levels of applicability the methods address in different situational contexts. It is illustrative, rather than comprehensive, so method types rather than every individual method are presented. On the basis of the matrix, a set of guidelines for method selection is summarized as below.

- The conversational methods are handy and commonly used throughout the requirements development process. It is applicable in almost every situation when stakeholders are people.
- The observational methods are less effective than the others. However, they work perfectly at the beginning of a development project to achieve the basic understanding of the physical, organizational, political and cultural environment where the desired product is put in use.
- The analytic methods provide approaches to acquiring corporate knowledge from exiting documents and the experts. In contrary to the observational methods which are more suitable for requirements elicitation in an unfamiliar application domain, analytic methods provide effective support of requirements elicitation in application domains where the domain related documentation and experts are available. Its underlying principle is to reuse the corporate knowledge that exists in different forms.
- The synthetic methods are more comprehensive than any individual methods, and of course consume more resource to perform. It is always a good choice when the project resources allow. Meanwhile, the synthetic methods are effective to refine the functional requirements.

The matrix is rooted in theory and empirical findings from decision-making and cognitive psychology. It provides a practical starting point for organization to select appropriate methods at the requirements stage. In practice, as organizations' business objectives and their development strategies vary, the different situational contexts influence on the development activities and method selection differently. The level of applicability of every method has to be further adjusted and customized in different organizations and their work settings. For example, the method selection at the requirements stage shall conform to the development method deployed by organizations. That is to say, prototype is a rather good choice for organizations that apply the prototype model for the product development; while analytic methods might not be appreciated in organizations that deploy agile development methods which emphasizes more interactions with end users than analysis of existing documentation.

## 6 CONCLUSION

Requirements elicitation is a critical step in the requirements development process. It is consequently imperative that requirements engineers apply appropriate methods to perform the process sufficiently. This paper has attempted to present meaningful insights into the feature of different types of requirements elicitation techniques, based on which a practical guideline for method selection is suggested. The classification of requirements elicitation methods is based on the nature of the techniques. It reveals the different communication channels for the analysts to elicit requirements, and provides the contextual situation for method selection.

It is worth outlining that the techniques discussed in this paper are based on the implicit assumption that the human stakeholders and the requirements analysts are cooperative and sincere. The stakeholders are willing to share knowledge with the analysts and the analysts prepared carefully before conducting an elicitation session. Requirements engineering is a complex social interaction process, the techniques discussed in our paper provide analysts a proper and contextual means to perform the process. Besides, the analysts should possess interpersonal skills to help build consensus between heterogeneous groups of stakeholders. Such social skills are as important as the techniques used in the engineering process.

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