A Method for Navigating Interview-driven Software Requirements Elicitation Work: Effectiveness Evaluation of the Method from the Viewpoint of Efficiency

Tatatoshi Yamanaka, Seiichi Komiya

***Abstract*—** A software development task is performed in accordance with requirements specification. Therefore, requirements elicitation work in order to prepare requirements specification is a very important task. However, it is very difficult to elicit user requirements for software development without omissions or errors, mainly because customers are often ignorant for software development technologies, and novice SEs do not have enough knowledge of the business contents for the software development. In order to solve this problem, the authors recognize requirements elicitation work as interview techniques, and are proposing a method to navigate interview-driven software requirements elicitation work conducted by SEs to customers so that SEs are able to elicit user requirements without omissions or errors [16]. Then, the effectiveness of the proposed method was proven by conducting the experiment to compare completeness and accuracy of the elicited requirements. This paper discusses effectiveness of the proposed method from the viewpoint of efficiency of requirements elicitation work by conducting the comparative experiment in regards to the cases that the method proposed in the Reference [16] was used and not used.

***Keywords*—**Interview, *R*equirements elicitation, Interview-driven software requirements elicitation, navigation of software requirements elicitation work, navigation rules, efficiency of software requirements elicitation work

I. Introduction

There are various life cycle models for software development, including "waterfall model" and "spiral model." Whatever life cycle model is used, however, development progresses in accordance with requirements specification that summarizes user requirements. Therefore, if there are omissions or errors in the requirements specification prepared through requirements analysis work, the software completed would include omissions or errors, possibly creating the software that does not match customer's intention. As a result, the software requirements elicitation work would have to be redone, causing delay in the process which may result in an increase of budgeted development costs. The software development project, then, incurs fatal damages due to this process delay. In this regard, requirements elicitation work to find out user requirements for software to be developed is considered to be very important. However, it is not an easy work to elicit user requirements for software without omissions or errors, and to prepare requirements specification without omissions or errors in accordance with requirements elicited, mainly because customers are often ignorant for software development technologies, and novice SEs do not have knowledge of the business contents for software development. Consequently, omissions or errors occur in the requirements specification, resulting in significant damage to software development. This is the reason why development of a system to support these tasks is desired.

In order to solve this problem, we considered requirements elicitation work as interview techniques, and proposed a method to navigate interview-driven software requirements elicitation work conducted by SEs to customers so that SEs are able to elicit user requirements without omissions or errors. After conducting the comparative experiment in regards to the cases that the requirements elicitation work was conducted by both using and not using this method, we found that we were better able to elicit user requirements without omissions or errors in the case of the former rather than the latter. Therefore, the proposed method was proven to be effective [16].

This paper discusses the effectiveness of the proposed method from the viewpoint of efficiency of the interview work by conducting the comparative experiment in regards to the cases that the method was used and not used. This paper consists of the following chapters. In Chapter 2, the importance of and issues in requirements elicitation work are explained. In Chapter 3, the objectives and positioning of this study as well as related studies are described. Chapter 4 provides the method to navigate interview-driven software requirements elicitation work. Chapter 5 discusses the effectiveness of the method proposed in Chapter 4 from the viewpoint of the efficiency of requirements elicitation work. Chapter 6 describes the conclusion.

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II. The Importance of and Issues in Requirements Elicitation Work

A. The importance of requirements elicitation work

Requirements analysis is the first work for software development no matter what kind of life cycle model is adopted. In other words, software development progresses in accordance with a requirements specification that summarizes user requirements obtained through this work for software to be developed, regardless of the adopted life cycle model. Therefore, if requirements specification contains omissions or errors, complete software would end up as something that contains omissions or errors. Thus, the process of requirements elicitation is the most important work in software development.

B. The problems of requirements elicitation work

In software development, developed systems might not conform to the system required by the customer in many cases. One of the reasons includes difficulties in requirements elicitation work. Difficulties in requirements elicitation work can be divided mainly into two categories: difficulties attributable to customers and developers (SEs.).

(1) Difficulties attributable to customers

The essential difficulty attributable to customers is because customers are often ignorant for software development technologies For this reasons, customers often do not know what kind of information should be given to SEs to develop software. As a result, the requirements provided from customers to SEs are only part of the necessary conditions to materialize the system, but do not meet sufficient conditions. Moreover, the expression for requirements is not concrete but abstract. For example, requirements for the system presented by the customer would be the following:"I want to have inventory control software developed; I want to process as easily and quickly as possible; and I want to reduce the labor costs to half by reducing the manpower as much as possible." All these requests are ambiguous, and the level of requirements is inconsistent.

(2) Difficulties attributable to developers (SEs)

The essential difficulty attributable to SEs is because novice SEs do not have knowledge for business contents, which customers are familiar with, for system development. For this reason, it is difficult for novice SEs to decide what kind of and how many functions would be required for the software to support customers' businesses for system development. Moreover, if errors are accidentally included in elicited requirements, novice SEs might not be able to figure errors out. As a result, novice SEs do not know where to start and how far they should ask for the required functions until they feel that they elicited all the information of customers' business contents for system development. In addition, novice SEs do not know whether information from elicited requirements is correct or incorrect. Consequently, omissions or errors occur in elicited requirements. However, only few experienced SEs, even in large organizations, are able to elicit user requirements for software to be developed without omissions or errors. It is not rare that there is no experienced SEs at all in some corporations. Under such circumstances, most requirements elicitation work is conducted by novice SEs.

III. Purpose of This Study

A. Purpose

As it was explained in Chapter 2, if requirements elicitation work is conducted by novice SEs, the risk that requirements specification contains omissions or errors would be high.However, only few experienced SEs, even in large organizations, are able to elicit user requirements without omissions or errors so that there is no choice but most requirements elicitation work is conducted by novice SEs. In order to solve this problem, it is necessary to develop a supporting technology that helps novice SEs to elicit user requirements without omissions or errors. Based on this concept, we recognized requirements elicitation work as interview techniques, and developed a technique to navigate interview-driven software requirements elicitation work conducted by SEs to customers [16]. Then, we proved the effectiveness of the proposed method by conducting the experiment to compare completeness and accuracy of the elicited requirements [16].

This paper shows the effectiveness of the proposed method from the viewpoint of efficiency of the interview work by conducting the comparative experiment in regards to the cases that the method proposed in the Reference [16] was used and not used, and analyzing the data obtained from the experiment.

B. Positioning of the study

The requirements elicitation techniques [1, 10, 11, 12] include the following:

(1) Method of collecting materials
(2) Method of surveying (questionnaire method)
(3) Interview method
(4) Brainstorming method
(5) Method of using worksheets
(6) Method of using cards
(7) Method of using objective tree (or goal-oriented)
(8) Method of using an analysis diagram of clerical procedures or icons
(9) Method of eliciting requirements through the conference for requirements elicitation
(10) Method based on scenario

[12] is an example of requirements elicitation by "Method based on scenario".The contents of this paper is as follows. A generation method of scenarios using difference information between normal scenarios is presented. Behaviours of normal scenarios belonging to the same problem domain are quite similar. The authors derive the difference information between them and apply the information to generate new alternative/exceptional scenarios. Their method will be illustrated with examples. This paper describes (1) a language for describing scenarios in which simple action traces are embellished to include typed frames based on a simple case grammar of actions, (2) introduction of the difference scenario,

and (3) examples of scenario generation using the difference scenario.

In this paper, requirements are elicited by using the interview method among various requirements elicitation techniques. The reason why this technique is adopted is because it is widely used in practice and easy to use.

C. Difference between similar studies in the past and this study

(1) Development procedures proposed by mainframers

"The standard system development procedure" has been developed mainly by mainframers. They include IBM BSP (Business System Planning) [2], Hitachi HIPACE (Hitachi Phased Approach for high productive Computer system Engineering) [2], Fujitsu EPG (End-user oriented Planning Guideline) [2], C-NAP (Customer-needs Analysis) [2], NEC STEP/E (Standard Technology & Engineering for Programming Support) [2], Toshiba TUPPS (Tool, User and Project-Planner System) [2] and UNISYS NUP (Nippon Unisys Problems Solver) [3]. Among them, BSP adopts the interview method, PPDS (Planning Procedure to Develop System) [2] which is HIPACE's requirements analysis procedure adopts the brain-writing and the objective tree, STEP/E adopts the KJ method, and NUPS mainly adopts the brainstorming as "excavate problems" techniques. Some of them are written in a manual including the rules for interviews in order to adopt the interview method although none of them support the interview-driven requirements elicitation process on computers.

(2) Study in regards to interview-driven requirements elicitation support system

Lafourche and others are proposing a framework to elicit software requirements by mutually-driven conversation using natural language (English), claiming that "the conversation control method exchanged between a user and system has not been paid much attention in the software requirements elicitation support system where the conversation is in natural language (English)." [4] They are also discussing that how the conversation theory can be applied to software requirements elicitation and how the conversation theory can be incorporated in the form to cooperate with the rules for requirements elicitation in addition to the necessity of conversation theory in natural language. However, technologies by themselves that support interviews are not mentioned.

Leite and others developed FAES [5] the interview-driven requirements elicitation support system, based on the idea of being a general interview assistant. FAES's knowledge database is developed based on BSP (Business System Planning), CSF (Critical Success Factors), and E/M (End Means Analysis), and is integrated in accordance with the concept model. In FAES, 22 kinds of question sentences are automatically generated in order to generate an instance for the concept model. These question sentences consist of the fixed part and the variable part. The variable part is generated by incorporating answers already obtained from other questions, and a chain of questions is established by generating the variable part. In addition, the heuristic is activated at the end of the interview or for specific questions so that a question is presented. When a user answers it, accuracy of the answer, the relationship between two answers, and the need for further questions are checked with the activated heuristic. Objectives of FAES are to automate interview-driven requirements elicitation and automatically check the accuracy of requirements specification.

(3) Study in regards to interview-driven requirements elicitation

There are various findings as a result of the comparative experiment between experienced SEs and novice SEs in regards to interview-driven requirements elicitation. The differences between SEs with less practical experience (novice SEs) and SEs with a lot of practical experience (expert SEs) are clarified by comparing the contents and progresses of interviews in the requirements elicitation work as well as the ways of description in requirements specification [1].

Topics for requirements elicitation adopted by SEs can be categorized into nine topics as indicated in Fig. 1 [1].

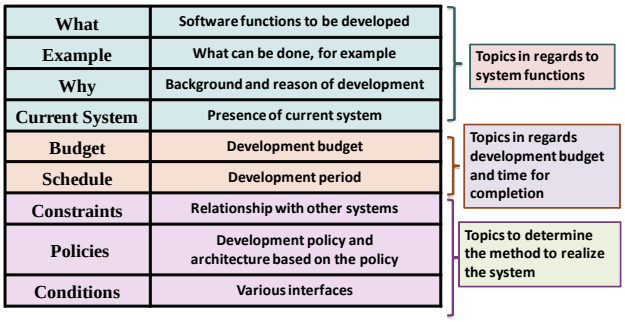

Fig. 1 Categorization of topics

In the interview-driven requirements elicitation, the novice SE did not show clear transition pattern in the transition method of topics, while the experienced SE provided a clear transition pattern as indicated in the following [1]:

① Pattern1(customers with alienated relationship)
{What | Example | Why | Current System}
> {Constraints , Policies , Conditions}
> {Budget | Schedule}
② Pattern 2 (customers with close relationship)
{Budget | Schedule}
> {What | Example | Why | Current System}
> {Constraints , Policies, Conditions}
③ Pattern 3 (customers with normal relationship)
{What | Example | Why | Current System}
> {Budget | Schedule}
> {Constraints , Policies, Conditions}

{A, B, C} means that the topics are adopted in the order of A, B and C, and only after the topic in the first category is over, the topic in the subsequent category is discussed. This kind of transition method of topics is called serial type.

{A | B | C} means that topics in the other categories might be discussed before topics in the first category end. This kind of transition method of topics is called parallel type.

The transition pattern of topics toward the customer in a normal relationship (Pattern 3) will be indicated in Fig. 2 in the form of a flow chart.

The method to navigate the interview-driven requirements elicitation efficiently without omissions or errors in customer requirements is not mentioned in Reference [1].

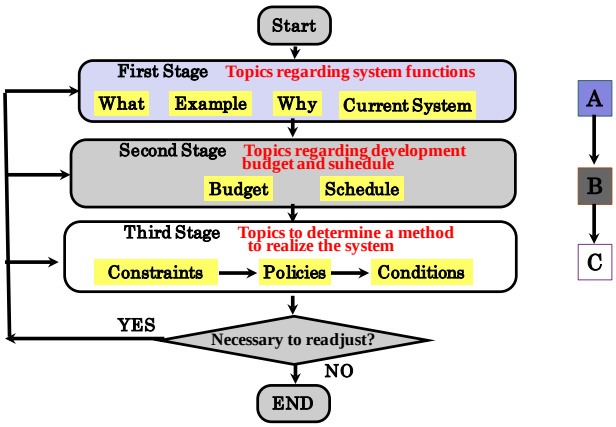

Fig. 2 Transition pattern of topics

(4) The experiment and its result in regards of accuracy and completeness of the interview-driven requirements elicitation work [16]

The comparative experiment is conducted in the process of interview-driven requirements elicitation in order to reveal the difference of elicited user requirements resulted from the difference of business experiences, and the effectiveness of the proposed method to navigate the interview. In this experiment, 5 novice SEs who have no experience as a SE, 3 mediocre SEs who have worked less than 5 years, and 2 experienced SEs who have worked more than 15 years were selected as testees in order to clarify the repercussion resulted from the difference of their business experiences. They were assigned a common issue to perform requirements elicitation twice in which the cases whether they used the interview navigation method or did not use it.

Table 1 shows the results of the experiment in regards to accuracy and completeness of the interview-driven requirements elicitation work[9].

Table 1 The result of the experiment in regards of accuracy and completeness of the interview-driven requirements elicitation work

		Novice SEs	Mid-level SEs	Experienced SEs
Without navigation	Accuracy	78%	96%	99%
	Completeness	9%	43%	70%
With navigation	Accuracy	100%	100%	100%
	Completeness	99%	99%	99%

In terms of the accuracy of requirements elicitation work, the table 1 shows each categorized testees score, 78% for novice SEs, 96% for mid-level SEs, and 99% for experienced SEs, and the accuracy improves as the duration of business experiences gets longer. Nonetheless, this result indicates that the accuracy of novice SEs is considered not too bad [16]. Table 1 reveals that when the method to navigate interview-driven requirements elicitation work was used, all different levels of SEs were able to perform the requirements elicitation work more accurately than any level of SEs without the method [16].

On the other hand, the completeness of requirements shown in Table 1 indicates that it is very hard for all different levels of SEs to elicit all user requirements without using the method to navigate interview-driven requirements elicitation work. All novice, mid-level, and experienced SEs could elicit only 9%, 43%, and 70% of user requirements respectively. It means that even experienced SEs with more than 15 years of business experience still missed 30% of user requirements. However, once the method [16] to navigate interview-driven requirements elicitation work was used, all different levels of SEs were able to elicit 99% of user requirements, and the rest of 1% was caused by the omission of the preparation of navigation rule.

IV. Interview-Driven Requirements Elicitation Method

In order for novice SEs to be able to elicit requirements as experienced SEs do, we recognize the requirements elicitation work conducted by a SE to a customer as an interview work, and consider how to navigate the interview work by novice SEs.

A. Two-tiered model of topics and questions

In order for novice SEs to be able to elicit requirements as experienced SEs do, support (navigation) is provided for novice SEs to interview in accordance with the transition pattern of topics adopted by experienced SEs. However, it is still difficult for novice SEs to navigate the interview work by simply imitating the transition pattern of the topic categories adopted by experienced SEs. This is because SEs need to navigate the work to ask questions within one category. For this reason, the two-tiered model is adopted which consists of a class where the transition pattern of topic categories is the same as experienced SEs and a class where the work to ask questions is navigated within one category, as shown in Fig. 3.

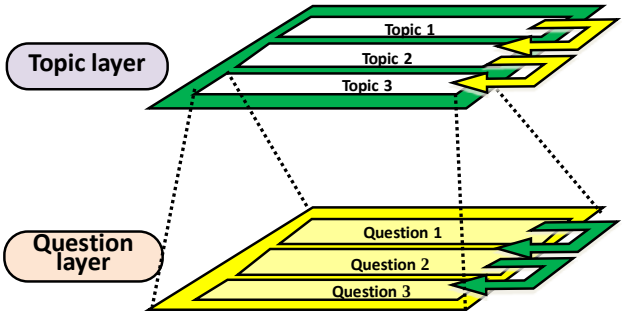

Fig. 3 Two-tiered model of topics and questions

B. The method to navigate transition of topic categories in the upper tier

In the topic layer at the upper tier, the method uses the transition pattern of topic used by experienced SEs as the scenario to navigate the transition pattern for novice SEs. It also use the progress management table in order topics to shift by following the scenario to make novice SEs' transition pattern of topic categories the same as experienced SEs' transition pattern. In the process of interview-driven requirements elicitation, it is possible to manage how much the interview-driven software

requirements elicitation work progresses along the scenario by proceeding with the interview in accordance with the scenario, and by managing the interview progress with the progress management table. Table 2 shows an example of progress management with the progress management table.
The Progress column in this table indicates the following:
0: The topic has not been discussed yet.
1: The topic is in the course of discussion.
2: The discussion on the topic is complete.
3: It is not necessary to discuss on the topic. In the case of new implementation, for example, since there is no current system, it is not necessary to adopt the topic for the current system.
The progress status for each category is determined by the SE (or a leader of SEs if several SEs are in charge), and information is set in the progress management table. Therefore, it is possible to manage the progress of requirements elicitation work by using the progress management table as indicated in Table 2.

Table 2 The progress management table

Category	Order	Type	Progress
What	1st	Parallel	2
Example	1st		
Why	1st		
Current System	1st		
Budget	2nd	Parallel	1
Schedule	2nd		
Constraints	3rd	Serial	0
Polices	3rd		0
Conditions	3rd		0

C. The method to navigate interviews on each stage

The transition pattern of topics is the pattern based on the way experienced SEs proceed with the interviews and consists of three stages. Using the pattern 3 in which the relationship between SEs and customers is normal as an example, the method to navigate interviews from the 1st to the 3rd stages is clarified in the following:

(1) The method to navigate questions in the 1st stage

The interview begins by asking about functions of the system to be developed at "What" in order to elicit requirements effectively. At this time, if the system functions presented by the customer are unclear, questions in regards to "Examples" (specific examples of system functions) are given to ask the customer to present specific examples. Functions presented by the customer can be understood by asking him or her to present specific examples of system functions.

Next, the background of developing the system functions as well as their objectives and reasons are asked and understood at "Why" in order to understand why the system functions presented by the customer are necessary.

Subsequently, questions about the system currently in operation are asked with "Current system," in the case that there is any system currently in operation. This will be very important information that determines what kind of approach should be taken to system functions to be newly developed. Thus, four categories of "What," "Examples," "Why" and "Current system" are used simultaneously.

At this time, the method to navigate questions in the "What" category (questions on functions required for the software to be developed) is clarified. Questions in the "What" category relate to software functions to be developed, and necessary functions vary for each application area. Therefore, it is necessary to design a versatile structure that can be used in any application area. If the application area is narrowed down, the function options required there will be narrowed down as well. Accordingly, the application area is narrowed down until all the variations of the function required by the customer can be expressed in the form of options. In this case, each function option can be considered as an answer expected from the customer to the question of what kind of functions are desired. Fig.4 shows the structure.

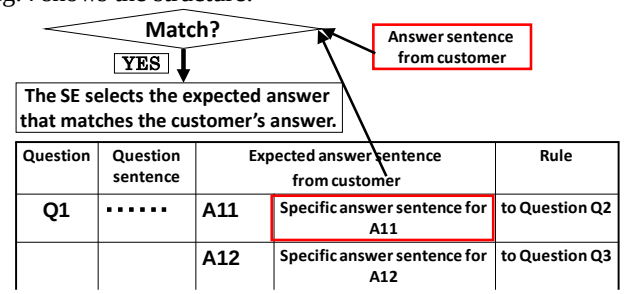

Fig. 4 Structure to automatically determine the next question based on a question and selection of an expected answer to the question

① The system presents a question sentence to the SE who asks the question to the customer by forwarding the question sentence to the customer.
② The customer gives the answer to the SE.
③ The SE seeks an answer that seems to match the customer's answer among expected answers presented by the system in terms of the meaning. Then,
  A) If it is difficult to judge whether or not the customer's answer matches any of the expected answers, questions are repeated until the SE can identify the expected answer that matches the customer's answer. Subsequently, the expected answer that matches the customer's answer in its meaning is selected.
  B) If there is an expected answer that matches the customer's answer in its meaning, select the answer.
④ The system automatically determines the next question sentence in accordance with the expected answer selected.
⑤ The system presents the next question sentence to the SE.
⑥ Repeat ① to ⑤ until there is no more question to ask.

In this manner, question sentences to be interviewed by the SE to the customer and expected answer sentences by the customer are established. In the case that an expected answer comes back, set the next question to the selected expected answer. In this manner, set the rule to navigate the interview-driven requirements elicitation work.

(2) The method to navigate questions in the 2nd stage

What is discussed in the 2nd stage is about the development budget and period.

First of all, ask about "the idea toward the development budget and period" to the customer. Furthermore, the SE asks questions in regards to "details and basis of the budget," "whether the budget amount is still uncertain or fixed" and "constraint in the development schedule" sequentially to put the interview together at this stage.

(3) The method to navigate questions in the 3rd stage

What is discussed in the 3rd stage includes topics in regards to system architecture and interface, including how to achieve these functions on what conditions. Topics that belong to "Constraints," "Policies" and "Conditions" are relevant in this case. Topics are explored in the order of these three categories: "Constraints," "Policies" and "Conditions." Once topics in one category are completed, topics in the next category are discussed subsequently. The SE asks questions sequentially to put the interview together at this stage.

V. Experiment and Evaluation in Regards to the Interview-driven Requirements Elicitation Work

A comparative experiment was conducted in regards to the cases in which the method to navigate interview-driven requirements elicitation work explained in Chapter 4 was used and not used in regards to elicit requirements work required for the medical image information system [13,14] through interviews by the SE to the customer.

A. The method to prepare a navigation rule for the medical image information system

Authors have actually conducted a requirements definition of the medical image information system for hospitals, and defined the superset of user requirements for the medical image information system based on the experience of the system development, implementation, and application using the requirements specification.

Medical images generated by a medical photographic device in a medical facility are digitally stored and managed in the medical image information system. It is also the information system to observe images using a medical monitor on a computer to support diagnostic imaging. By comparing with various images (multiple medical devices and previous examinations) as well as with advanced image processing, highly accurate diagnostic imaging is created. This system also materializes improvement of service to patients by disclosing to them treatment information (informed consent), as well as cost reduction by reducing film costs and storage space without using film [13].

In addition to navigate in the upper layer of the two-tiered model defined in Chapter 4 as a method to elicit requirements for the medical image information system by using the interview method, it is not possible to navigate requirements elicitation work unless interviews to specific parts on each application area (which is medical image information system in this case) are successfully navigated. This is because each application is considered to have different requirements. Therefore, based on the business knowledge and experiences of an experienced SE who has the experience to develop, implement and apply the medical image information systems, a rule to navigate interviews for eliciting user requirements required to realize the objectives was prepared in accordance with goal orientation [6, 15].

The rule to navigate interviews was set by repeating the relevant question sentences to be interviewed by the SE to the customer, and expected answer sentences by the customer. The relationship between a question and an expected answer is the goal-oriented relationship that can be expressed with the AND/OR tree [6]. At this time, not only confirming that there is no contradiction between a question and an expected answer, but also confirming that there is no contradiction between all questions asked by the SE and all expected answers from the customer is crucial.

Moreover, when preparing the navigation rule, the order of presentation for questions were summarized based on the scenario [8,12] of user requirements in regards of the medical image information systems in order to elicit user requirements efficiently. Table 3 shows the concrete example of the navigation rule prepared with the terms above.

Table 3 Example of navigation rule

Question		Candidate answer		Rule
Q1	What is the systematization requirement for diagnostic imaging?	A11	To store images for more than 5 years according to the standard specification form	To Q2
		A12	To display finalized image used for diagnosis under the same condition as the time of diagnosis	
		A13	To display stored image within one second	
...	....			...
Q10	What is the requirement to system functions in diagnostic imaging?	A101	To display image	To Q11
		A102	To measure image	To Q20
		A103	To output image	To Q30
Q11	Is it necessary to adjust brightness and contrast?	A111	Necessary	To Q12
		A112	Not necessary	To Q15
Q12	Is the function to automatically adjust brightness and contrast necessary?	A121	Automatic adjustment by testing area	To Q13
		A122	Automatic adjustment by disease	To Q14
...	....			...

B. Requirements elicitation support system

The requirements elicitation support system is a system to support the requirements elicitation work, which can be directly utilized by SEs and customers.

This system presents the SE who conducts the requirements elicitation work candidate questions to be asked to the customer by utilizing the rule of the order to present questions stored in question sentences. It is also a system to navigate the work procedure. The requirements elicitation support system is also constructed as the application program. The overall picture of the system is indicated in Fig. 5.

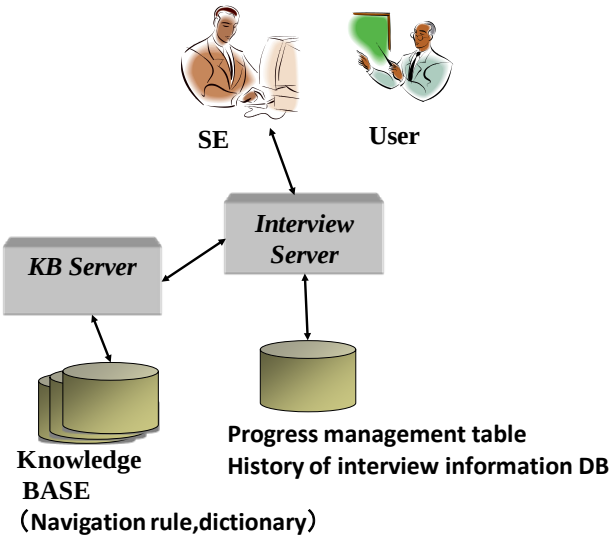

Fig. 5 Overall picture of the system

The requirements elicitation support system has five characteristics. First of all, the navigation rule is taken out of the KB Server during an interview, and the Interview Server presents the SE the best question sentence and candidate answers navigated from the question in accordance with the navigation rule. Next, the SE selects one that seems to match customer's answer out of candidate answers. The KB Server then automatically determines the following question sentence, and presents the SE the following question sentence and candidate answers navigated from the question. The example of the navigation rule is indicated in Table 3.

Since the navigation rule varies by business system, each is prepared by a expertised SE, and added and registered onto the requirements elicitation support system. The added navigation rules can be changed or revised as necessary.

The second characteristic is automatic storage of interview history (e.g. questions asked by the SE, decision on candidate answers, etc.). The interview history can be referred to for confirmation.

The third characteristic is the ability to manage how the interview is progressing, by managing the progress by phase and category.

As a result, the requirements elicitation support system prepares the progress management table corresponding to the scenario, to manage the progress of interview-driven requirements elicitation work. The example of progress management is indicated in Table 3, and the status of the progress at the time of question Q11 is indicated in Table 5. The fourth characteristic is that in the case that an answer to the SE's question changes after the interview is completed, the interview can be continued by going back to the point where the change occurs.

The fifth characteristic is the ability to prevent variance in topics for the requirements elicitation work by establishing a dictionary function for comments on professional terms as well as for difficult business terms.

C. Outline and method of the comparative experiment

(1) The method of requirements elicitation without using the method to navigate interviews

In this requirements elicitation method, requirements for the medical image information system are elicited through the interview by the subject (role of the SE) to the experimenter (role of the customer) in reference to materials provided in advance. At this time, the subject records the content of the question and the answer from the customer, fills the requirements elicited from the customer in the format of specification provided in advance, and prepare the requirements specification[7]. Also, the experimenter gives the answer to the question from the subject in reference to the sample requirements specification prepared for this experiment in advance. Prior to the experiment, each subject is given a document summarizing the experiment, and materials to refer to at the time of the interview work, and also receives prior explanation about the format of the experiment. The time to end the interview is when the subject himself determines the completion by eliciting all information to be described in the specification from the customer.

(2) The method of eliciting requirements by navigating interviews

In this requirements elicitation method, experiment was conducted by using the requirements elicitation support system. This system presents the candidates of questions for the subject (role of the SE) conducting requirements elicitation work to be asked to the customer by using the rule of the order to present questions stored in question sentences.

Candidate questions to be asked to the customer are presented to the subject (role of the SE) who conducts the requirements elicitation work, by using the rule of the order to present questions stored in question sentences from the requirements elicitation support system. The content itself is asked to the experimenter. The experimenter gives the answer to the question from the subject in reference to the material of candidate answers to the question prepared in advance. Since the subject is presented candidate answers to the question from the requirements elicitation support system, he or she selects the candidate answer in the case that the expected answer comes back from the experimenter.

Next, a candidate for the next question is presented by the requirements elicitation support system so that the selected questions are asked to the experimenter repeatedly. The time to end the interview is when all candidate questions from the requirements elicitation support system are asked. The subject then fills the requirements elicited from the customer in the format of specification provided in advance and prepares the requirements specification.

(3) Members of the experiment

Members of the experiment are 10 subjects (all of them are SEs), including two experienced SEs with more than 15 years of experience, three mid-level SEs with less than 5 years of experience and five novice SEs with no experience in information system development for the requirements analysis work, and both the experiment using the method to navigate interviews and the experiment without using the method to navigate interviews were conducted. The experiment without using the method to navigate interviews conducted first, and then the experiment with using the method to navigate interviews was conducted in non-overlapping periods in order

to make the results of the experiment fair. The same person did the role of the customer for both experiments with and without using the method to navigate interviews. The same person did the role of the customer for the all subjects. It was obligated that the identical answer was provided to the same question. In the experiment, the deal between a subject and the customer was alienated so that other subjects could not see them.

D. Analysis of the experiment data

When using the method to navigate interviews, the subject (role of the SE) conducted the interview work to the experimenter (role of the customer) through the requirements elicitation support system. During the experiment, candidate questions to be asked to the customer are presented to the subject who conducts the requirements elicitation work by using the rule of the order to present questions stored in question sentences in the system. The history of the content itself asked to the experimenter (system log) is the interview process, and the specification presented is the end product of the experiment. Both of them were combined as the experimental data and were used in the analysis.

(1) Analysis results

User requirements elicited through the interview were analyzed from the viewpoint of efficiency.

In terms of efficiency, assume that the number of interview conducted is "N," and the method with or without using the navigation is technique "X." The efficiency is calculated by the following formula where the number of correct data elicited from user requirements using the technique "X" is "C."

$$E(Efficiency) = \frac{C}{N}$$

We use the reciprocal of the efficiency "E" defined at the formula above, also recognized as the number of interviews in order to elicit one correct user requirement (the average number) for analyzing the results of experiment. Table 4 shows the results of the experiment in regards of the reciprocal of the efficiency of requirements elicitation work by interviews. Table 5 shows the results of the experiment without using the method to navigate interviews, which is the reciprocal of the efficiency on each subject. Table 6 shows the results of the experiment using the method to navigate interviews, which is the reciprocal of the efficiency on each subject.

(2) Analysis of the experiment results

a) Requirements elicitation work without using the method to navigate interviews

The efficiency indicates that the longer the work experience, the more efficiently the user requirements are elicited since the average numbers of times that novice SEs, mid-level SEs and experienced SEs asked to the customer gets lower. The figures are 2.01, 1.43 and 1.09 respectively.

Experienced SEs organized the condition upon presentation of each question item as well as the order of presentation, and successfully elicited user requirements based on the scenario that encourages SEs to ask only one question to elicit user requirements On the other hand, novice SEs did not organize the condition upon presentation of each question item as well as the order of presentation very well that resulted in asking more questions and getting lower efficiency comparing with experienced SEs. Consequently, novice SEs failed to elicit user requirements efficiently. This is considered as the difference of knowledge and experience between novice SEs and experienced SEs.

b) Requirements elicitation work with using the method to navigate interviews

Regardless of the SEs' work experiences, efficiency was 1 time, which is the best score to be obtained. This suggests that the requirements elicitation work using the navigation rule can be conducted more efficiently than any form of requirements elicitation work without using the navigation rule, regardless of SEs' experiences.

Consequently, also from the viewpoint of efficiency of requirements elicitation work, the effectiveness of the method to use the proposed navigation rule for requirements elicitation work by conducting interviews was proved from the results of a) and b).

Table 4 The result of the experiment in regards of the reciprocal of the efficiency of the interview-driven requirements elicitation work

		Novice SEs	Mid-level SEs	Experienced SEs
Without navigation	The average number of interviews	60.8 times	214.3 times	264.5 times
	Requirements elicitation Correct data	31	150	243
	Reciprocal of efficiency	2.01 times	1.43 times	1.09 times
With navigation	The average number of interviews	343 times	343 times	343 times
	Requirements elicitation Correct data	343	343	343
	Reciprocal of efficiency	1.00 time	1.00 time	1.00 time

Table 5 The results of the experiment without using the method to navigate interviews (the efficiency on each subject)

Method	Method not utilizing the structure for the navigation rule: Method X									
Group	Inexperienced group (group of novice SEs)					Experienced group (group of Mid-level SEs and Experienced SEs)				
Experience	Novice SEs					Mid-level SEs			Experienced SEs	
Subject	c1	c2	c3	c4	c5	b1	b2	b3	a1	a2
Number of interviews	34	90	64	60	56	219	230	194	304	225
	(34 + 91 + 64 + 63 + 56) / 5= 61.6					(219 + 230 + 194) / 3 = 214.3			(304+225) / 2 = 264.5	
						(219 + 230 + 194 + 304 + 225) / 5= 234.4				
Elicited data (Correct data)	16	47	30	33	27	154	165	132	285	201
	(16 + 47 + 30 + 33 + 27) /5 = 31					(154 + 165 + 132) / 3 = 150			(285 + 201) /2 = 243	
						(154 + 165 + 132 + 285 + 201) /5 = 187				
Reciprocal of efficiency	34 / 16 = 2.13	91 / 47 = 1.94	64 / 30 = 2.11	63 / 33 = 1.91	56 / 27 = 2.07	219 / 154 = 1.42	230 / 165 = 1.39	194 / 132 =1.47	304 / 285 = 1.07	225 / 201 = 1.12
	(34 + 91 + 64 + 63 + 56) / (16 + 47 + 30 + 33 + 27) = 2.01					(219 + 230 + 194) / (154 + 165 + 132) = 1.43			(304+225) / (285 + 201) = 1.09	
						(219 + 230 + 194 + 304 + 225) / (154 + 165 + 132 + 285 + 201) = 1.25				

Table 6 The results of the experiment using the method to navigate interviews (the efficiency on each subject)

Method	Method utilizing the structure for the navigation rule: Method X2									
Group	Inexperienced group (group of novice SEs)					Experienced group (group of Mid-level SEs and Experienced SEs)				
Experience	Novice SEs					Mid-level SEs			Experienced SEs	
Subject	c1	c2	c3	c4	c5	b1	b2	b3	a1	a2
Number of interviews	343	343	343	343	343	343	343	343	343	343
	(343 + 343 + 343 + 343 + 343) / 5 = 343					(343 + 343 + 343) / 3 = 343			(343+343) / 2 = 343	
						(343 + 343 + 343 + 343 + 343) / 5 = 343				
Elicited data (Correct data)	343	343	343	343	343	343	343	343	343	343
	(343 + 343 + 343 + 343 + 343) /5 = 343					(343 + 343 + 343) / 3 = 343			(343+343) / 2 = 343	
						(343 + 343 + 343 + 343 + 343) /5 = 343				
Reciprocal of efficiency	343 / 343 = 1.00	343 / 343 = 1.00	343 / 343 = 1.00	343 / 343 = 1.00	343 / 343 = 1.00	343 / 343 = 1.00	343 / 343 = 1.00	343 / 343 = 1.00	343 / 343 = 1.00	343 / 343 = 1.00
	(343 + 343 + 343 + 343 + 343) / (343 + 343 + 343 + 343 + 343) = 1.00					(343 + 343 + 343) / (343 + 343 + 343) = 1.00			(343+343) / (343 + 343) = 1.00	
						(343 + 343 + 343 + 343 + 343) / (343 + 343 + 343 + 343 + 343) = 1.00				

VI. Conclusion

As explained in the above, the requirements elicitation work to determine the requirements from the customer is a very important task in software development. However, it is not an easy work to elicit user requirements for software efficiently, to analyze requirements elicited accurately, and to summarize them into a specification.

In this paper, requirements for the medical image information system for hospitals were actually defined, and the order of questions to the customer was clarified to effectively elicit user requirements. Also, the conditions to present each question item elicited as well as the order of presentation were summarized, and the navigation rule was prepared.

Then, the comparative experiment was conducted in regards to the case in which the SE conducts the requirements elicitation work for the medical image information system through interviews to the customer by using the method to navigate interviews as well as to the case without using the method. As a result, it was clarified that the user requirements elicitation work depends on the business knowledge and work experience of each individual, resulting in difference in the efficiency of requirements elicitation. Furthermore, it was also clarified that user requirements can be efficiently elicited with consistent quality regardless of the SEs' business knowledge and work experience by using the method to navigate interview-driven requirements elicitation work, and the effectiveness of the proposed method was successfully verified.

References

[1] Seiichi Komiya, Junzo Kato, Morio Nagata, Atsushi Onishi, Motoshi Saeki, Shuichiro Yamamoto and Hisayuki Horai, "How to Realize System to Navigate Interview-Driven Requirements Elicitation Work," Paper presented in the 19th IPA Symposium, pp.37-48, Oct. 11-12, 2000.

[2] Toshiyasu Kunii and Issei Fujishiro, "Chapter 2: System Design Theory," System Theory 14th Edition, Compiled by the Information Processing Society of Japan, Information Processing Handbook, pp.1216-1225, 1990.

[3] "Problem Solving Technique in Requirements Definition Stage," Nihon Unysis, Ltd., 1991.

[4] R. Lecoeuchi, C. Mellish and D. Robertson, "A Framework for Requirements Elicitation through Mixed-Initiative Dialogue," Proceedings of 4th International Conference on Requirements Engineering, pp.190-196, 1998.

[5] Julio Cesar Sampaio do Prado Leite and AnaPaula Pinho Gilvaz, "Requirements Elicitation Driven by Interviews: The Use of Viewpoints," Proceedings of 18th International Workshop on Software Specification and Design (IWSSD-8), pp. 85-94, 1996.

[6] Shuichiro Yamamoto, "Goal-Oriented Requirements Management Technique," Soft Research Center, 2007.

[7] IEEE Recommended Practice for Software Requirements Specifications, IEEE Std. 830-1998.

[8] John M. Carroll, "Design Based on Scenario – Secret for Successful Software Development Project," Kyoritsu Shuppan, 2003.

[9] Takeo Nagashima, "Proposal of Risk Identification Method Based on Improved Kepner-tregoe Method and Evaluation of Effectiveness," Journal of the Institute of Electronics, Information and Communication Engineers, Vol. J91-A, No.9, pp.883-897, 2008.

[10] Seiichi Komiya, Junzo Kato, Morio Nagata, Shuichiro Yamamoto, Motoshi Saeki, Atsushi Ohnishi, Hisayuki Horai, "A Method for Implementing a System to Guide Interview-driven Software Requirements Elicitation, " Proc. of the 4th *Joint Conference on Knowledge-Based Software Engineering (JCKBSE'2000)*, Brno, Czech Republic, pp.175-182, Sep. 2000.

[11] Deniss Kumlander, "Communication Gaps and Requirements Uncertainties in the Information Systems Design, " Proceedings of the 6th WSEAS International Conference on Applied Informatics and Communications, pp.400-405, Elounda, Greece, August 18-20, 2006.

[12] Atsushi Ohnishi, "Scenario Generation with Differential Scenario, " Proceedings of the 6th WSEAS Int. Conf. on Software Engineering, Parallel and Distributed Systems , pp.45-50, Corfu Island, Greece, February 16-19, 2007.

[13] Takatoshi Yamanaka, "A Solution Service Business in the Medical Image Field, " The Development Engineering Society of Japan, Vol. 9, No.1, pp.35-42, 2009.

[14] Juan Antonio Pernas, Santiago Pellit, Francisco Javier Novoa, Jose Manuel Vazquez, Ruben Grande, Javier Pereira, Jorge Teijeiro, Alejandro Pazos, " E-Health application: Development of a Web Framework for the creation and application of metric systems to the digital medical image, " 6th WSEAS International Conference on E-ACTIVITIES, pp.328-332, Tenerife, Spain, December 14-16, 2007.

[15] Zhiqi Shen, Chunyan Miao, Robert Gay, Chor Ping Low, "Personalized e-Learning – a Goal Oriented Approach, " Proceedings of the 7th WSEAS International Conference on Distance Learning and Web Engineering, pp.304-309, Beijing, China, September 15-17, 2007.

[16] Takatoshi Yamanaka, Hajime Noguchi, Shimon Yato, Seiichi Komiya, "A Proposal of a Method to Navigate Interview-driven Software Requirements Elicitation Work, " WSEAS TRANSACTIONS on INFORMATION SCIENCE and APPLICATIONS, Issue 6, Volume 7, pp.784-798, June 2010.

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