Requirements Maturation Analysis based on the Distance between the Source and Developers

Takako Nakatani
University of Tsukuba
3-29-1, Otsuka, Bunkyo
Tokyo, 112-0012, Japan
nakatani@gssm.otsuka.tsukuba.ac.jp

Toshihiko Tsumaki
National Institute of Informatics
2-1-2, Hitotsubashi, Chiyoda
Tokyo, 101-8430, Japan
tatsumaki@nii.ac.jp

ABSTRACT

The success of a project is often affected by imperfect requirements. In order to cope with this risk, a requirements analyst needs to communicate with a client. However, communication between the requirements analyst and the client is not enough to prevent requirements imperfection, since requirements come from various sources, e.g. environment, laws, documents, actual usage, etc. The process of requirements elicitation is affected by the requirements stability, the ability of a requirements analyst, and accessibility of the source of requirements. This paper focuses on the distance between the source of requirements and a requirements analyst, and clarifies how the distance influences the requirements maturation. Requirements maturation represents the degree to which the requirements are elicited completely. We define a measure for observing requirements maturation and analyzing the accessibility of the source of the requirements. Then, we define a hypothesis. A case is analyzed in order to verify the hypothesis. As a result, there is a correlation between the requirements maturation efficiency and the accessibility of the source of the requirements.

Categories and Subject Descriptors

D.2.1 [**Software Engineering**]: Requirements/Specifications—*Management*

General Terms

Measurement

Keywords

Requirements Accessibility, Requirements Maturation

1. INTRODUCTION

In software development, an engineers' geographic distance affects the quality of the software[3]. Similarly, the distance between stakeholders and a requirements analyst

(RA) affects the requirements quality and their maturation. Requirements maturation represents the degree to which the requirements are elicited completely. All requirements can reach maturation by the end of the project. Some requirements mature in the early stages of the project, while other requirements mature in the latter stages of the project.

Communication between the RA and the clients is a means to access the source of requirements. The sources are requirements specifications, meeting minutes, issue reports, end users, subject matter experts, etc. Social, organizational, and/or technical environments can also be sources. We define the distance between the source and the RA as the accessibility of the source of requirements. In this context, we assume that if the source of requirements is close to the RA, he/she can easily elicit requirements from the source. In other words, if the source of requirements is distant, the RA has to plan the elicitation process under the influence of hard elicitation of requirements.

The purpose of our requirement maturation analysis is to manage the requirements elicitation process. If we can manage the requirements elicitation process, we will be free from the risk of requirements changes. Thus, here is a null hypothesis.

- Null hypothesis
  Requirements maturation does not depend on the accessibility of the source of requirements.

This paper focuses on the accessibility of the source of requirements. If we reject the null hypothesis, it will be possible to manage the requirements maturation based on accessibility.

In order to verify the hypothesis, requirements maturation is measured by the requirements maturation efficiency, RME.

$$RME = 1 - \frac{l}{L} \tag{1}$$

In this equation, the project duration, L, is measured by days or months from the project initiation to its completion. The maturation period, l, is also measured by days or months from the project initiation to the requirements maturation. RME represents how fast the requirements mature. RME, little less than 1, means that the requirements are elicited completely in the early stage of the project. For example, when the development duration was 35 weeks, and a component matured on the 20th week, the RME of the component comes to 0.42 (= 1 - 20/35).

Accessibility is derived from the following equation.

$$Accessibility = \frac{1}{Max(NIF)} \qquad (2)$$

In this equation, NIF is the number of information flows from the source of the requirements to the RA. The NIF is 1 for a stakeholder with whom the RA can communicate directly. If the RA has to communicate with some other person before getting information from a stakeholder, its NIF should be greater than 1.

In order to verify the hypothesis, we show the requirements elicitation process of a case and, analyze the process statistically. The case was an education support system named p-HInT that was developed for improving classroom lectures [5].

This paper is organized as follows. In the next section, we introduce the related work. Section 3 presents the research approach and introduces three dimensions of requirements elicitation. In section 4, we address the results of the case study and verify the hypothesis. In the last section, we conclude the results.

2. RELATED WORK

In order to verify the hypothesis, we need to observe the requirements elicitation process quantitatively. Anderson et al. [2] observed the history of requirements changes in an avionics system. The number of requirements was defined as the sum of the number of added requirements, the number of deleted requirements, and the number of modified requirements. We adopted their definition. Each addition, deletion, and modification of requirements is counted as one elicited requirement rather than the number of requirements remained in the SRS for the development.

Requirements changes can be classified by their origins, which are related to the development environments, stakeholders, development processes, understanding of the requirements, and relations among requirements [12]. Nurmuliani et al. analyzed volatility [9] by collecting change request data. They identified the types, reasons, and origins of the changes and classified them. The origins of requirements are defect reports, project management considerations, developer's detailed analysis, design review feedback, technical team discussions, functional specification reviews, feature proposal reviews, and customer-support discussions. From managing views of requirements elicitation, we need to classify the origins of requirements by their distance from an RA.

Before eliciting requirements, an RA should identify stakeholders by the trinity of knowledge, person and role [10]. Stakeholders are one of the sources of requirements. They are categorized into the core team members and the peripheral stakeholders. The peripheral stakeholders are functional beneficiaries, regulators, negative stakeholders, end users, subject matter experts, etc. They participate in the project on an "as needed" basis of the RA. However, in an actual project, the RA sometimes faces difficulties when he/she needs to communicate with the stakeholders. The correlation analysis between the RA and the source of requirements can reveal the situation.

Alexander and Robertson proposed an onion model as a stakeholder map [1]. They proposed that before eliciting requirements, stakeholders should be identified according to the onion model constructed for the target project. How-

ever, identification of stakeholders is not enough. An RA should consider the way to access the stakeholders and make a plan to communicate with them. Our final goal is to manage the requirements elicitation process. We analyze and clarify the cause and effects of relationships between the RA and the source of the requirements.

The requirements elicitation process should be quantitatively observed. There are several measures of requirements changes. The Requirements Maturity Index, RMI [6], requirements stability [4], and requirements volatility [9] were proposed. In order to observe the maturation process, the measure needs to have a time variable. Nakatani et al. defined the requirements maturation ratio, RMR, with time as a variable [8]. $RMR(t)$ represents how the requirements were elicited during a certain period of time, t, as follows.

$$RMR(t) = \frac{R(t)}{R_T} * 100$$

In this equation, $R(t)$ is the total number of requirements: the sum of the number of added requirements, the number of deleted requirements and the number of modified requirements from the project initiation to the time, t. R_T is the total number of requirements at the end of the project since the project initiation. R_T does not mean of the total requirements that are actually designed and/or implemented in the system, but the number of requirements that are elicited. Therefore, when the project starts, its requirements maturation ratio $RMR(0)$ is 0, and when the project is completed, its requirements maturation ratio $RMR(end)$ is 100. This measure can be used to represent historical information concerning the requirements elicitation activities, although it cannot be used before the end of the project. We applied $RMR(t)$ to observe the case of p-HInT that was completed in 2010, March.

The categories of requirements maturation is also proposed [7]. There are E-type, M-type, L-type, and U-type. The type of requirements that reach maturity in the early, middle, and latter period of the project are E-type, M-type, and L-type, respectively. When U-type requirements mature, these are unexpected harmful periods to the project. We applied RME instead of the maturation types for validating the hypothesis statistically.

3. RESEARCH APPROACH

The requirements maturation depends on three factors: the soft skills of an RA, the distance between each stakeholder and the RA, and requirements stability.

In general, requirements are elicited from stakeholders via communication by the RA. Therefore, the quality of elicited requirements depends on the soft skills of the RA. The soft skills are as follows, communication skills, comprehension skills, knowledge of subject matter, personality, etc. Highly developed skills help the RA elicit requirements unambiguously and completely.

Physical and/or psychological distance harms the mutual understanding between stakeholders and an RA. We take into account the distance of a stakeholder as a function of the position of the stakeholder in the project structure, collaboration of the stakeholder with the RA, communication difficulties for the RA to the stakeholder, etc. The distance implies the time required for requirements elicitation. For example, if the communication needs someone who relays or translates requirements of other stakeholders to the RA, the
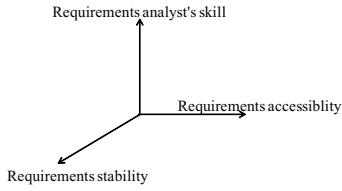
Figure 1: The three-dimensional space of requirements elicitation.

requirements elicitation will be delayed to the RA.

Before we observe the case, we identified the observation targets of the project. Then, the requirements elicitation process was observed. In the observation, each requirement addition, deletion, and modification of an observation target was counted as one elicited requirement. Therefore, if the requirements of the observation target are not stable, their RME comes to a small number.

We define a three dimension space of requirements elicitation in Fig. 1. It shows the space in three dimensions (i.e. RA's skill, source accessibility, and requirements stability). This paper focuses on the accessibility dimension. We will clarify the relationship between the accessibility and requirements maturation through the following case study.

4. CASE STUDY

This section discusses the requirements elicitation process of a case named p-HInT. It is an education support system developed in Hannan University and is used for improving classroom lectures that have 200 or more students within non-computer classrooms [5]. The most significant characteristic of p-HInT was that the students used gaming equipment or mobile phones with Wi-Fi interfaces. We observed the project since its initiation, for a period of 90 weeks. In the 29th week of the project, Hannan University contracted with the developer.

Fig. 2 shows the history of the requirements elicitation process of the system. The x-axis represents the project duration, while the y-axis represents the RMR. A "mtrP" mark represents the 100% maturation period in each development. During the observation period, three versions of the system were released. The three vertical lines in the figure represent the start period of each version's development. The denominator of the RMR is the number of requirements at the end of the development of version three. It has several observed maturation lines. Each line represents the maturation process of requirements of each observation target: strategic requirements, operational requirements, user interface requirements, etc.

The project was not influenced by social environmental changes. However, the Wi-Fi technology of gaming equipment was an unknown domain for both the clients and developers. We drew Fig. 3 as the stakeholder map of the project according to the interview with the clients of the project. In the stakeholder map, each stakeholder is represented as the source of requirements. The diagram used Stapel's FLOW notation [11]. The distance is represented by the number of information flows from the stakeholders to the RA.

Tab. 1 shows the results of the analysis. Seven observation targets were analyzed by their source and the number of information flows from the source to the RA. Each RME
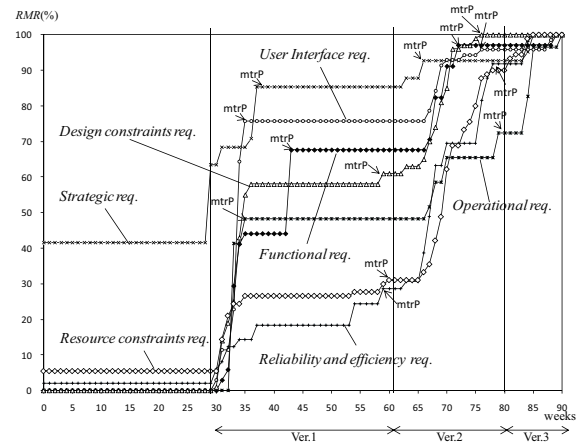
Figure 2: History of the requirements maturation ratio of seven observation targets.
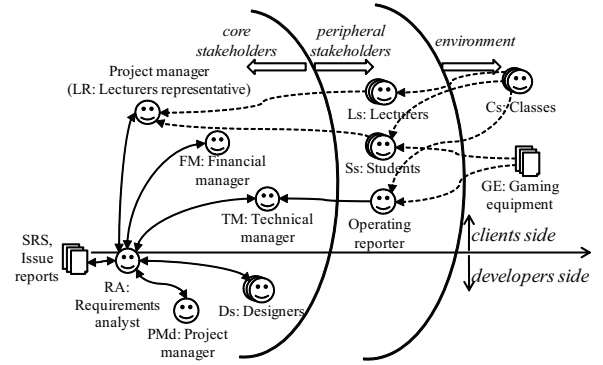
Figure 3: Stakeholder map of the project by accessibility.

was derived from within each version's development duration from the observed data shown in Fig. 2. In the table, a stakeholder with the key mark represents the farthest stakeholder of each observation target.

Fig. 4 shows the correlation between the RME and accessibility. The correlation efficiency between the RME and the accessibility was 0.820. Therefore, we can reject the null hypothesis.

The skipping data in Fig. 4 shows that other factors should be considered. We did not take into account differences between the solid information flows and the fluid information flows in the FLOW notation. The geographical and social distance between a stakeholder and an RA, and the personal characteristics of the stakeholder were also ignored. These factors should be considered in our future work.

5. CONCLUSION

We analyzed the relationship between the requirements maturation efficiency, RME, and accessibility of the source of requirements. As a result, we could conclude that the RME depends on the accessibility of the source of requirements.

Our final goal is to manage the requirements elicitation process. We can assume that when a project starts, the project can identify the source of requirements and the dis-

Table 1: Requirements and their characteristics for p-HInT.

Ver.	Observation Target	Source	Accessibility	RME
1	Strategic	†LR	1.0	0.73
	Operational	†TM	1.0	0.79
	UI	LR, †Ls, †Ss	1.0	0.79
	Design constraints	TM, Ds, †Cs	0.3	0.06
	Resource constraints	TM, FM, †GE	0.3	0.03
	Rel+Eff	LR, †Ls †Ss	0.3	0.06
	Functional	†LR	1.0	0.52
2	Strategic	†LR	1.0	0.75
	Operational	TM, FM, †Cs	0.3	0.10
	UI	LR, †Ls, †Ss	0.5	0.25
	Design constraints	TM, Ds, PMd, †Cs	0.3	0.25
	Resource constraints	TM, FM, †GE	0.3	0.15
	Rel+Eff	†GE, †Cs	0.3	0.15
	Functional	PMd, LR, †Ls, †Ss	0.5	0.45
3	Strategic	†LR	1.0	0.54
	Operational	TM, FM, †Cs	0.3	0.09
	UI	†Ls, †Ss	0.5	0.18
	Design constraints	-	-	-
	Resource constraints	TM, FM, †Cs	0.3	0.54
	Rel+Eff	LR, GE, †Cs	0.3	0.54
	Functional	PMd, FM, LR, †Ls, †Ss	0.5	0.18

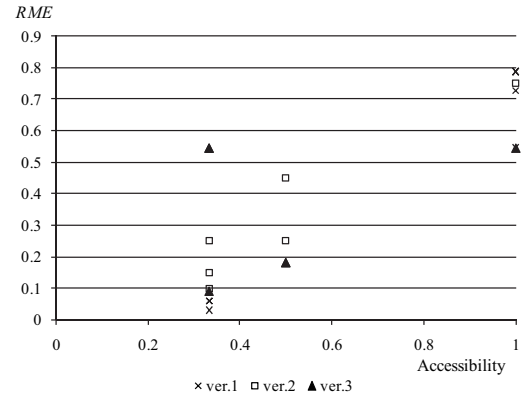**Figure 4: Accessibility versus RME.**

tance. This case study told us that it is not necessary to elicit all the requirements in the early period of the development, but we must determine the distance of the stakeholders from the RA. Then, we can estimate the period of the maturation of requirements by the distance.

6. ACKNOWLEDGMENTS

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