An Empirical Study on Requirement Management Process for Implementation Project of Information System

Dong Seok Oh and Sung Yul Rhew

Abstract—When there are strict delivery date and limited budget for implementation project of information system, users’ ambiguous needs and their frequent changes cause the schedule delay and cost overrun on project. Therefore, practical process for requirement management is needed to analyze users’ ambiguous needs quickly and correctly, register them as requirements for information system, and manage them continuously and effectively. In this study, a requirement management process is proposed, based on the standards and guidelines of requirement engineering, and this process can complement previous studies and be applied to practical field. The effectiveness of the process proposed was confirmed through an empirical case study of applying to the public sector project of company ‘O’. The process is also compared and verified with finding from previous studies and standards.

Index Terms—Requirement, management, requirement management process, requirement quality assurance.

I. INTRODUCTION

All projects have fixed delivery time and budget [1]. Users’ first needs are often ambiguous, lots of efforts are consumed to define and detail them. The requirements defined in this way, are also often changed during the procedure of the project [2]. Without controlling of these changes, project failure could be caused due to schedule delay and cost overrun. Therefore, the organization who carries out a project, has to define and detail the users’ ambiguous needs into requirements, then has to manage and control these detailed requirement continuously and efficiently [3], [4].

Therefore, this study suggests effective procedures and methods that how to set the baseline of requirements and how to manage the requirements as accepting the result of case study on practical field. The effectiveness of the process proposed was confirmed through an empirical case study of applying to the public sector project of company ‘O’. The process is also compared and verified with finding from previous studies and standards.

II. THEORETICAL BACKGROUND AND RELATIVE RESEARCHES

A. Theory of Requirement Engineering

Karl E. Weigers defines the entire procedure about requirements as requirement engineering and classifies the range into Requirement Development and Requirement Management [5].

IEEE (The Institute of Electrical and Electronics Engineers) Computer Society developed SWEBOK(The Software Engineering Body of Knowledge) which includes comprehensive knowledge about software engineering and has been distributing and managing it [6]. Software Requirements area again consists of 7 major topics and their sub-topics. The process of requirements management proposed in this study builds the basic frame from Karl’s requirement engineering theory and Software requirements knowledge area of SWEBOK so that it can be shown that process comes from the theoretical background.

B. Complements the Previous Researches

Hwang provided the framework which can combine and manage software requirements in his study [7]. He showed processes of requirements management under the environment where multiple parties can cooperate, method of requirements management for effective execution of the process, and practically applicable prototype of requirement management tool which is web-based. However, it is based on requirements management process of CMM(Capability Maturity Model) so needed to reflect the process of Requirement Management(REQM) and Requirement Development(RD) from the most recent model, CMMI, and has to be complemented.

Shin complemented the process of requirement analysis, and suggested the requirement management process which can be combined with software development process [8]. However, the method or process to validate the developed requirements is not sufficient and there is no clear method to get associated the activities of requirements management and project management each other.

D Pandey, U. Suman, A. K. Ramani showed the requirement engineering process model for software development and requirement management [9]. But, the model is presented, however, no practical example is mentioned for the application of this model. And it is insufficient about association with project management. There is lack of consideration on the activity for requirements quality assurance and the activity for closing a project.

In addition, many researches were done for various fields, such as improvement of requirement changes management, improvement of traceability for requirements and documents, and management system of requirements, etc. But additional studies are still needed because they are concentrated to a certain management, or empirical studies are not sufficient.

C. Processes about Requirements in CMMI

CMMI arranges the process area according to maturity
level, each process area has Specific Goal and Specific Practice [10]. This is the reference to evaluate that the process has been executed correctly toward to the goal assigned. In the research of Justin J. Y. Lin and Yung-Sung Lin, a process was designed that follows the specific goal and specific practice of requirement management of CMMI (REQM) and system which supports this process was developed [11]. This study selects processes directly related to requirements and uses their specific goals and specific practices as conditions, of requirement management process proposed.

III. PRACTICAL REQUIREMENT MANAGEMENT PROCESS

A. Introduction of Entire Process

Based on existing requirement engineering theory and guideline, this study will complement previous researches, build a process as reflecting the current task procedure being carried out and the experiences in actual field, and propose a practical requirement management process which will be applicable in the field as shown in the Fig. 1. Proposed process consists of 6 activities and 30 tasks.

Fig. 1. Proposed requirement management process for implementation project of information system.

B. Activity 1: Structuralizing Requirements

In this activity, tasks will be carried out to structurelize users’ needs to management as project requirements. The request for proposal document which reflects the users’ needs, includes the contents of needs’ ranges, detailed needs are reflected in each range. Even though recent request for proposal shows that contents and ranges of requirements are much more detailed, based on new criteria and classification of requirements [12], than one in the past, still ambiguity presents and there is lack of detailed description about their needs. Therefore, structuralizing and hierarchizing the needs. This activity includes 6 tasks, 1) Hierarchizing users’ needs 2) Dividing needs 3) Assigning requirements’ attributes 4) Identifying the requirements’ actor 5) Identifying requirements 6) Prioritizing requirements

C. Activity 2: Establishing Requirement Baselines

In this activity, followings would be done, specifying the requirements based on the requirement list made in activity 1, and negotiating with stakeholders then establishing the baseline of initial requirements of a project. This activity consists of 4 tasks, 1) specifying requirements 2) negotiating requirements 3) verifying requirement specification 4) distributing requirement baseline.

D. Activity 3: Supporting Project Planning

This task provides the data from the baseline, which is needed for establishing the plan of 1) scope management 2) time management 3) cost management 4) quality management 5) human resource management 6) communication management 7) risk management 8) acquisition management.

E. Activity 4: Controlling and Monitoring Requirements

Activity 4 includes controlling the requirement changes due to various reasons, tracing whether requirements are reflected correctly, monitoring requirement status in a various points of view, when project is being executed according to the plan established in activity 3. This activity consists of following 4 tasks, 1) Changing requirements 2) Repeating previous activities 3) Tracing requirements 4) Monitoring requirement status periodically.

F. Activity 5: Assuring Quality of Requirements

In this activity, quality evaluation is done regarding for the requirement managed by from activity 1 to activity 4, and detailed requirement specification to solve these requirements. Activity 5 includes following 5 tasks, 1) defining criteria for quality evaluation 2) evaluating requirements 3) evaluating software requirement specification 4) evaluating requirements and requirement specification periodically 5) Reporting final result of quality assurance.

1) Task 5.1: Defining criteria for quality evaluation

In this task, criteria is defined for evaluating baseline which is the major result of requirement management process and quality of requirement specification. The criteria of evaluating the quality for each requirement and requirement specification is according to ‘Guidelines for Quality Evaluation of Soft- ware Requirements Specification (TTAK.KO- 11.0091)’ provided by Tele-communications Technology Association (TTA) [13]. Quality evaluation of each requirement has 6 characteristics as Completeness, Correctness, Unambiguity, Modifiability, Understandability, Verifiability. Each characteristic has evaluation criteria and sub-items for evaluation. For each characteristic, scores is given to evaluation criteria and sub-item. 5 points scale is applied for scoring as shown in Table I. The ranges of sub-item might be adjusted according to project environment.

<table>
<thead>
<tr>
<th>Point</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Fully Satisfied</td>
</tr>
<tr>
<td>4</td>
<td>Satisfied</td>
</tr>
<tr>
<td>3</td>
<td>Common</td>
</tr>
<tr>
<td>2</td>
<td>Poorly Satisfied</td>
</tr>
<tr>
<td>1</td>
<td>Not Satisfied</td>
</tr>
<tr>
<td>0</td>
<td>Not Available</td>
</tr>
</tbody>
</table>

2) Task 5.2: Evaluating requirements

This task evaluates the quality of requirement list which is...
the result of task 1.6 with criteria defined in task 5.1. Through this activity, quality of initial requirement baseline is evaluated and the result of the evaluation becomes the quality reference. Degree of quality improvement for requirement list is measured as doing the appropriate corrective measure.

3) Task 5.3: Evaluating software requirement specification

In this task, we evaluate the quality of requirement specification which the result of task 2.4. with the evaluation criteria defined in the task 5.1. Through this activity, quality of initial requirement specification is evaluated and the result of the evaluation becomes the quality reference. Degree of quality improvement for requirement list is measured as doing the appropriate corrective measure.

4) Task 5.4: Evaluating requirements and software requirement specification periodically

This task periodically evaluate the quality that change request on requirements is reflected on requirement list and the result of detailed requirement specification. Initial quality scores measured in task 5.2 and 5.3 becomes the quality reference, and quality scores are measured continuously as continuous evaluation on this. This gives an idea for the trend of quality score change.

5) Task 5.5: Reporting final result of quality assurance

In this task, evaluation activities for quality of requirement management process, which are executed during the project life time, are reported in the final report. The quality scores continuously measured in task 5.4 is used to report the changes of quality scores for requirement and requirement specification.

G. Activity 6: Closing requirement management process

In this activity, after reporting the execution result of requirement management process, process execution of requirement management will be close as well as closing the project. This activity must be executed with consideration of environment and conditions for organizations and companies who apply this process. For organizations which have organizational process improvement activity such as CMMI, lively, the execution of this activity will be helpful for improvement activity of process. This activity contains 3 tasks, 1) Reporting result of process execution 2) Evaluating results of process execution 3) Storing reusable requirements.

H. Developing a tool for Suggested Process Execution

Outputs for requirement management varies depending on situation and manager’s plan. In this study a tool based on Microsoft Excel is developed to integratively manage the process suggested. This tool provides the management function for the tasks from the 3 activities (Activity 1: structualizing requirements, Activity 2: establishing requirement baseline, Activity 4: controlling and monitoring requirements) more functions are being added continuously.

IV. APPLICATION OF REQUIREMENT PROCESS PROPOSED

A. Introduction of Application

In this study, requirement management process suggested was applied to public domain project of company ‘O’. The project was not information system for general business but advanced project to build a system which creates various analysis results, complicated current image, and manages the system processes through scientific theories and algorithm. Nevertheless, users’ needs were very ambiguous, there were many cases that the person in charge from user side, didn’t have clear answers for interpreting the need sentences, ranges of needs, word around. Because this project was defined as high risk one. And the suggested process of requirement management was applied.

B. Result of Process Application

A tool was developed, which was mentioned in chapter 3.8. As shown in the Fig. 2, users needs were hierarchized, divided and requirement attributes were assigned to them, then finally, requirements were identified and prioritized.

As shown in Fig. 3, after identifying requirement’s actor, prioritizing requirements and writing the initial requirement specification, final requirement baseline was established through the negotiation with the person in charge at user side, verification for requirements at the project manager and quality manager’s point of view.

As seen in Fig. 4, the process set the plan for defining
requirement, setting specification, verifying the requirement specification and managed the progress for that.

As shown in Fig. 5, it is possible to monitor the number of requirements and progress of its change in forms of table and graph, according to project scopes.

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C. Effectiveness of Process Application

To evaluate the effectiveness of requirement management process proposed in this study, before applying the process, measured the quality for developed requirement through task 5.1. Then, after providing the training about process in the field, and applying the process, 2nd measurement was done and 3rd measurement was done at the end of analysis of project requirement. As a result of an evaluation, it was confirmed that there was an improvement for quality of requirement.

Fig. 6 shows the result of requirement quality evaluation before and after applying the suggested process for the parts of requirements within this project.

As a result of first evaluation for detailed 11 quality attributes, average score was 2.5, they had the middle score of quality. The quality about the requirement attribute (Attribute Information, TBD Information, REQ Clarity, REQ Priority) was relatively lower than the one about the interpretation of requirement itself. Especially, the overall insufficient part was the verifiability part which evaluation criteria and explanations about the success or failure of the requirements have to be described. This means the systematic education about the development and the management of requirements was not enough for project members selected as samples. Project team members had meeting and shared the first evaluation result. Then the education about development and management of suggested process was given to them. In 3rd evaluation result, average score was 4.5. This shows that the process suggested was effective for the development and management of requirements.

V. EVALUATION OF PROPOSED REQUIREMENT MANAGEMENT PROCESS

A. Comparison with Previous Studies

This study complement previous studies related to process management, designed practical requirement management process which can be applicable in the field. In this regard, it can be confirmed through comparing with previous researches such as in Table II

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Act. 1 Structurize REqs</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Act. 2 Establish REQ Baseline</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Act. 3 Support Project Planning</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Act. 4 Control &amp; Monitor REqs</td>
<td>O</td>
<td>X</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>Act. 5 Assure Quality of REqs</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Act. 6 Close Process</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

O : Complemented. X : Absence

TABLE III: SATISFIED OF CMMI’s REQM PROCESS

<table>
<thead>
<tr>
<th>Special Practices</th>
<th>Related Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP 1.1 Understand Requirements</td>
<td>Task 1.1 – 1.6</td>
</tr>
<tr>
<td>SP 1.2 Obtain Commitment to Requirements</td>
<td>Task 2.3 – 2.4</td>
</tr>
<tr>
<td>SP 1.3 Manage Requirements Changes</td>
<td>Task 4.1 – 4.2 Task 4.4</td>
</tr>
<tr>
<td>SP 1.4 Maintain Bidirectional Traceability of Requirements</td>
<td>Task 4.3</td>
</tr>
<tr>
<td>SP 1.5 Ensure Alignment Between Project Work and Requirements</td>
<td>Task 3.1 – 3.8</td>
</tr>
</tbody>
</table>
B. Evaluation of CMMI Process through SG/SP Comparison

Suggested requirement management process in this research satisfies specific practices of REQM process and RD process as seen Table III and Table IV

<table>
<thead>
<tr>
<th>Special Practices</th>
<th>Related Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP 1.1 Elicit Needs</td>
<td>Task 1.1 – 1.2</td>
</tr>
<tr>
<td>SP 1.2 Transform Stakeholder Needs into Customer Requirements</td>
<td>Task 1.3 – 1.5</td>
</tr>
<tr>
<td>SP 2.1 Establish Product and Product Component Requirements</td>
<td>Task 1.5, 2.4</td>
</tr>
<tr>
<td>SP 2.2 Allocate Product Component Requirements</td>
<td>Task 1.5, 2.4</td>
</tr>
<tr>
<td>SP 2.3 Identify Interface Requirements</td>
<td>Task 1.3 – 1.5</td>
</tr>
<tr>
<td>SP 3.1 Establish Operational Concepts and Scenarios</td>
<td>Task 2.4</td>
</tr>
<tr>
<td>SP 3.2 Establish a Definition of Required Functionality and Quality Attributes</td>
<td>Task 2.4</td>
</tr>
<tr>
<td>SP 3.3 Analyze Requirements</td>
<td>Task 1.5, 2.2</td>
</tr>
<tr>
<td>SP 3.4 Analyze Requirements to Achieve Balance</td>
<td>Task 2.2 – 2.3</td>
</tr>
<tr>
<td>SP 3.5 Validate Requirements</td>
<td>Task 2.3</td>
</tr>
</tbody>
</table>

VI. CONCLUSION

The requirement management process proposed in this study, actively reflects the needs for general requirement management activities in practical field, high effectiveness could be achieved. In addition, as shown in the case study, because actual execution method for REQM and RD of CMMI are considered, it will give effectiveness to the improvement of organization process maturity related to the development and management of the requirements

But after applying the process into actual field, further studies are needed in the future because some points that should be improved were found as below.

Firstly, automated supporting tool is needed so that contents of requirements can be managed exactly. Actual workers don’t experience enough for the effectiveness and efficiency of the project. Without the automated tool support, it causes the wastage of human effort. To contribute efficient process execution, the effort of the developing and managing the requirements has to be reduced. For this reason, the tool have to provide not only the management of the contents itself such as new registration, editing, deleting but also the features for systematic supporting of the information of requirement attributes.

Secondly, for proposed process execution, detailed process which clearly describes stakeholders roles has to be established. Currently, the proposed process emphasizes the requirement management point of view. However, as the size of project gets bigger, the roles get various within the project, the clear classification of management authorities and the specified classification of executed processes according to the each authority will be needed.

Lastly, to support project planning, clearer association with requirement baselines and project plans is needed as well as direct relation with software development process. For this, additional method and process of quality evaluation have to be improved that they evaluate whether developed requirements are reflected in the project management plan as well as in the analysis of software, in a design and in a product

REFERENCES

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