

The Implementation of Adaptive Requirements Engineering Process Based on Case-Based Reasoning

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Abstract—One major reason of failure in IT projects is a problem in requirements given by stakeholders, such as incomplete, inconsistent, and incorrect requirements. Requirements Engineering (RE) is a phase in software development life cycle that plays a critical role in determining software requirements from user requirements. Therefore RE could be very influential in determining software quality. Factors that influence the process of RE are organization culture, application domain, and the characteristics of the project. Characteristics and attributes of the IT project should determine the choice of RE processes and techniques. In this paper we present the adaptive process of RE which is based on IT projects characteristics and attributes. We believe conducting RE process based on the right IT projects characteristics and attributes will give more benefits in terms of effectiveness and efficiency. Case-based reasoning approach was adopted for the adaptive process of RE in this study. The IT project parameters that used are project size, complexity, requirements volatility, project category, degree of safety criticality, time and cost constraints. Output of adaptive process of RE is a RE process model recommendation. To evaluate the RE adaptive process, prototype software were developed and used three IT projects as case studies. Results from the experiment showed that the RE process model recommendation helps developer in conducting RE process and the output recommendation satisfied its users.

Keywords—Requirements Engineering, Case-based Reasoning, Adaptive, Process

I. INTRODUCTION

Requirements engineering are systematic approach which is conducted by software engineer with gather all requirements from many different source and implemented at software development process[1]. Factors that influence the process of requirements engineering are involvement between engineering and managerial disciplines, organization culture, application domain, and the characteristics of the project. Characteristics and attributes of the IT project should determine the choice of RE processes and techniques. According to Jiang and Eberlein, suitable choice of RE processes and techniques can give positive result of software quality[2].

Not all software project member understand RE processes and techniques[3]. One of the reasons is that the team thinks that RE phases are less technical compared with other software engineering processes[4]. Another reason is that they do not find the guideline of selection of good RE process model that suitable with their project. We developed an adaptive system for selecting RE process model and techniques called TAPFREE[3]. Because when selecting a RE process model, we

must considering about the criteria of successful development of software project such as size of projects, type of projects, or the number of person involved. There is no single technique can cover all RE problems [5]. Therefore, the software project team must select RE process models based on different criteria for different software projects.

This paper is organized as follows. Project characteristics and Requirements Engineering processes are explained at section II. The TAPFREE is described at section III. Case study is discussed at section IV. Last section is Conclusion and Future Works.

II. PROJECT CHARACTERISTICS AND REQUIREMENTS ENGINEERING PROCESS

In this section, we describe about project characteristics and the relation between project characteristics and requirements engineering process.

A. Project Characteristics

The selection of RE process models and techniques for a specific project is based on their project characteristics. Jiang find there are 21 project characteristics that can be used to determined RE process models and techniques[6]. In this research, we used seven project characteristics which has strong influence for selecting RE process models and techniques[5]. Table I shows about the attributes of project characteristics that used in the system.

TABLE I
PROJECT CHARACTERISTICS

No	Attribute Name	Description
1	Project Size	This attribute is defines the size of the project (X) based on the number of the requirements.
2	Project Complexity	This attribute is defines the factor that influence the project like number of the requirements, the complexity of the project, and the various of stakeholder.
3	Requirements Volatility	This attribute is defines the change of the requirements while the development phase.
4	Project Category	This attribute is defines the category of the project based on COCOMO model
5	Degree Safety of Criticality	This attribute is defines the method that use in requirements analysis and documentation
6	Time Constraint	This attribute is defines the time-to-market as the main issues for software projects.
7	Cost Constraint	This attribute is defines the cost that spends in software projects.

B. Requirements Engineering Process

Requirements Engineering Process is seen as a collection of activities, techniques, and transformations that developer use to develop requirements of a system[5]. The main objective of Requirements Engineering is to provide a requirements that clear, consistent, modifiable, and traceable for product[1]. Requirements Engineering Process consists of five main phase: requirements elicitation, requirements analysis and negotiation, requirements documentation, requirements verification and validation, and requirements management. Each of phase has a technique and method that designed to use by the developer. In this paper, the recommendation of RE process model are Extreme Programming (XP), Volere, and Rational Unified Process (RUP). XP model can be used for a small scale software project[7][8]. Volere model is suitable for a medium scale software project[6]. RUP model is suitable for a large scale software project because software artifacts in RUP are complete[9].

III. TAPFREE

The design of TAPFREE is shown in Fig. 1. TAPFREE consists of three parts: User Environment, Intelligence Support and RE Tools Based On Process Model. Input for TAPFREE is attributes value of the project. Then the system processed the input to be output, which is RE process model for an IT project. From the recommendation of RE process model, user can used the technique that has guideline for developing based on RE process model.

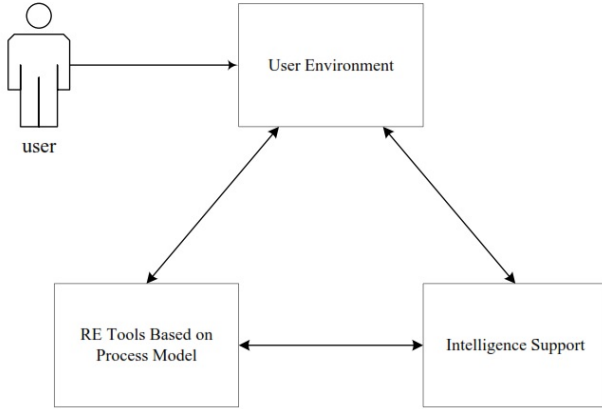


Fig. 1. System Architecture

A. User Environment

User Environment consists of features that support users in using TAPFREE such as sending a message to another user, project dashboard to manage a project created and a project followed by users.

B. Intelligence Support

TAPFREE can provide recommendation of RE process models and techniques. Intelligence Support is designed for supporting recommendation of process model based on values

of project attributes. TAPFREE is an adaptive system that can give recommendation based on knowledge stored in the system. Case-based reasoning is used to give recommendation of RE processes based on previous cases in a stored knowledge system [10]. Fig. 2 shows the flow of intelligence support that run in requirements engineering phase and provide assistance for manage requirements from software project.

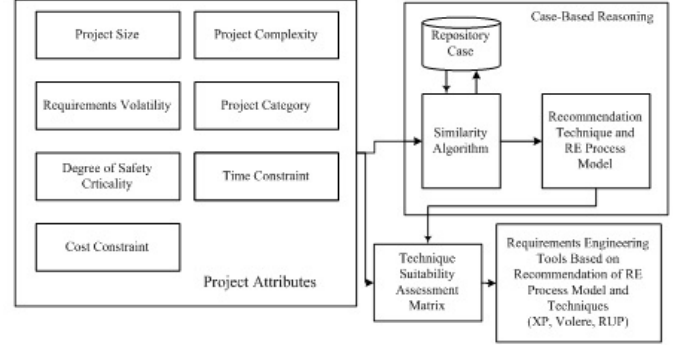


Fig. 2. Intelligence Support

1) *Project Attributes*: The attributes are used to calculate similarity value of a project with previous projects that stored in TAPFREE repository. The selection of project attributes is based on identification of main attributes of a software project[6]. Based on previous research [11], TAPFREE uses seven project characteristic attributes for selecting RE process model. The project attributes that shown in Table I can assist the selection of the RE process model. The recommendation of RE process model may not be suitable with project characteristics. One of the reasons is the lack of understanding of project characteristics.

2) *Case-Based Reasoning*: In case-based reasoning, the first step that we do is calculate the similarity value of project attributes of software project with TAPFREE repository. the equation to calculate similarity value is :

$$Similarity(N, K) = \frac{\sum_{i=1}^n w_i * sim(f_n, f_k)}{\sum_{i=1}^n w_i} \quad (1)$$

Where N is the new project from user inputs, K is previous project that stored in TAPFREE repository project, f_n is attribute value from user input, and f_k is the attribute value that stored from TAPFREE repository project. w_i is the value for each attribute which are owned by the project (see Table I and Fig. 2).

In $sim(f_n, f_k)$, to calculate the value, we use distance matrix between the attribute value of new project and attribute value of old project that stored in repository case that used for comparing the recommendation results.

The result are used to provide recommendation requirements engineering process based on similarity value with previous cases. Fig. 3 shows the the recommendation given by TAPFREE using Case-Based Reasoning and Techniques Suitability Assessment Matrix.

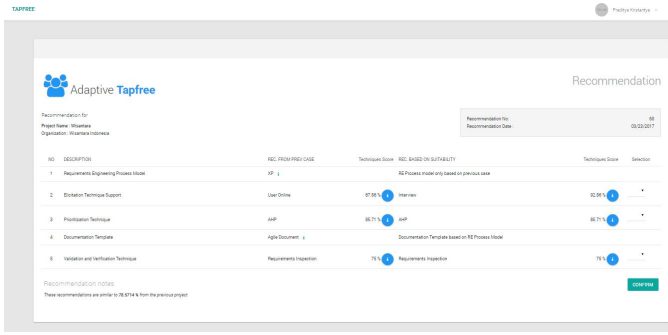


Fig. 3. Recommendation Result From TAPFREE

3) *Repository Cases*: Repository Cases is one of the component within the case-based reasoning approach that used for giving recommendation of RE process models and techniques for software project. The cases consist of attributes project, RE process models, techniques, and scores resulted from technique suitability assessment matrix in requirements elicitation, prioritization, and validation and verification phases. The selection of the aforementioned requirements phases is that they can be managed in the requirements management tools. Cases that saved in repository are cases at industrial and academic project that has been running and evaluated by experts [6].

4) *Techniques Suitability Assessment Matrix*: The recommendation of RE techniques in each RE phases is given twice. The first is based on case-based reasoning for recommendation of RE process model. The second is based on Technique Suitability Assessment Matrix (TSAM). The aim of these approaches is to provide the best recommendation according to inputted value of project attributes. Technique Suitability Assessment Matrix is a method that used to measure the technique that will be used in requirements engineering phases so that the techniques are suitable with the project characteristics. Based on research [2][12], this matrix contains information about technique that suitable with seven attributes of software projects that mention earlier. This matrix can be represented as the following function:

$$F : T * A * V \rightarrow R', R' = [0, 1] \quad (2)$$

where:

T: represents all current techniques in the Suitability Assessment Matrix.

A: represents the project attributes.

V: represents possible values of project attributes.

In most cases, a specific a specific software project situation is determined by a set of such tuples $(A_m, V_{n,k})$. with these definitions, a project P_s can be represented as a subset of $A * V$, i.e. for any software project $P_s \subset A * V$.

C. RE Tools Based On Process Model

After TAPFREE give the recommendation of RE process models and techniques, the system will give tools requirements management based on process models and techniques. In this

research, the recommendation consist of three process models, which are XP, Volere, and RUP.

1) *XP Requirements Management Tools*: Requirements Engineering in Extreme Programming phase starts with release planning and continued with iteration planning. Release planning is the gathering of user stories and iteration planning is gathering tasks that developer team must complete in a software project[7].

2) *RUP Requirements Management Tools*: Requirements Engineering in RUP process model starts with construction artifact that consist in RUP. The phases are document vision, functional requirements, use case specification, non-functional documentation and other requirements artifacts[13].

3) *Volere Requirements Management Tools*: Activity in Volere consists of project blastoff, trawling requirements, designing system scenario, and other requirements artifacts[14].

IV. CASE STUDY

This section describes the result of validation test of TAPFREE.

A. Case Study Analysis

In case study analysis, we conduct an experimental test to validate TAPFREE provide advantages to users. We select three projects with different characteristics that shown in Table II as case studies. First project, Website Lab TEL-C, is project that committed to improve their software process. The second and third project, Expert System TEL-C and Kemenhub, is another project which selected for comparison with first project and has some similarities characteristics. For every selected case studies, we asked the participants to used TAPFREE for their project. During using of TAPFREE, we conducted survey to 22 persons that involved in the projects. The participants divided based on their roles in projects. Demographics of participants are shown in Table III, Table IV, and Table V.

TABLE II
SELECTED CASE PROJECT CHARACTERISTICS

Project Attributes	Website Lab TEL-C	Expert System TEL-C	Kemenhub Project
Project Size	Very Small	Small	Very Small
Project Complexity	Medium	High	High
Requirements Volatility	Medium	Medium	Medium
Project Category	Organic	Organic	Organic
Degree of Safety Criticality	Low	Medium	High
Time Constraint	Medium	High	Medium
Cost Constraint	Medium	High	Medium

TABLE III
PROJECT MANAGER DEMOGRAPHY

Project Manager	
Total Respondent	3 Persons
Gender	Male (100%)
Age	22-24 Year
Educational Degree	Bachelor Degree
Project Experience	4-5 Year

From the survey, 85.71% project managers are agree that TAPFREE provides efficient in project management, as shown

TABLE IV
DEVELOPER DEMOGRAPHY

Developer	
Total Respondent	15 Persons
Gender	Male (66.67%), Female (33.33%)
Age	18-25 Year
Educational Degree	Senior High School - Vocational High School
Project Experience	1-3 Year

TABLE V
SYSTEM ANALYST DEMOGRAPHY

System Analyst	
Total Respondent	4 Persons
Gender	Male (75%), Female (25%)
Age	20-22 Year
Educational Degree	Diploma Degree - Bachelor Degree
Project Experience	3-4 Year

TABLE VI
PROJECT MANAGER EVALUATION RESULT

Indicator	Question	SA	A	N	D	SD
Suitable RE Process Model	Recommendation of RE process model are suitable with the project	0	2	1	0	0
Efficiency	Recommendation of RE process model are help to reduce rework of the project	0	3	0	0	0
	TAPFREE help monitoring requirements that include in project	0	3	0	0	0
Timelines	Recommendation of RE process model are help to reduce delays in IT project execution	0	3	0	0	0
User Satisfaction	Final requirements specification has high satisfaction form customer in overall aspect	0	2	1	0	0
Clear Scope	The range of project doesn't increase or decrease	0	3	0	0	0
Cost or Benefit	Cost obtained meet with the effort in RE process	0	2	1	0	0
Total		0	18	3	0	0

Note: SA: Strongly Agree, A: Agree, N: Neutral, D: Disagree, SD: Strongly Disagree

in Table VI. It means that TAPFREE provides suitable recommendation of RE process model. TAPFREE provides more clear scope of project, that means it will reduce project delays and rework of the project. Final requirements specification that included in TAPFREE has high satisfaction rate from customer in overall aspect, as shown in Table VI.

The result of evaluation test for developer shows that 46.67% developers understand both requirements of the project and RE process model that is used for the project that used TAPFREE. Developer understand the notation from documentation and requirements specification. TAPFREE features also help developers to track requirements specification, as shown in Table VII.

As shown in Table VIII, 37.5% analysts think that notation from documentation are compatible with modeling requirements. Half of the analysts are agree that TAPFREE provides significant helps in RE phase and quarter of them think TAPFREE could be useful to help reducing the delays in project management. We summarize that TAPFREE helps system analyst understand RE phase.

TABLE VII
DEVELOPER EVALUATION RESULT

Indicator	Question	SA	A	N	D	SD
Shared Understanding	RE process model can be understand easily	2	7	3	2	1
	Requirements can easily understand	2	8	4	1	0
Efficiency	Recommendation of RE process model are help to reduce rework of the project	3	5	2	3	2
	Requirements specification can easily tracked	0	2	7	4	2
Architecture Quality	Modeling notation from documentation can easily understand	0	4	5	4	2
	Diagram in requirements specification can be accepted and easily to understand	2	7	4	2	0
Total		9	33	25	16	7

Note: SA: Strongly Agree, A: Agree, N: Neutral, D: Disagree, SD: Strongly Disagree

TABLE VIII
SYSTEM ANALYST EVALUATION RESULT

Indicator	Question	SA	A	N	D	SD
Specification Quality	Notation from documentation is compatible for modelling requirements	0	3	1	0	0
Efficiency	TAPFREE features facilitates execution in requirements engineering phase	0	2	2	0	0
	TAPFREE helps at requirements engineering phase	0	0	3	1	0
Timeliness	TAPFREE features reduce delays in project development	0	1	3	0	0
Total		0	6	9	1	0

Note: SA: Strongly Agree, A: Agree, N: Neutral, D: Disagree, SD: Strongly Disagree

B. RE Knowledge Test Analysis

Analysis has been conducted with purposes to evaluate that TAPFREE can give knowledge to the user and TAPFREE can provide guideline for requirements engineering activity based on project characteristics. Question formulated based on best practice RE that developer must know[15]. First question is about the users' knowledge or understanding about requirements engineering. The second question is about the users' knowledge related to steps to identify stakeholders' requirements for develop IT project. And the last question is about users' knowledge related to RE process models. For this survey, we asked 22 persons that using TAPFREE. We conducted two type tests, the first test was given to the participants before use TAPFREE, and the second one after participants using TAPFREE. The result are shown in Table 4 and Table 5.

From Fig. 4 and Fig. 5, we found that most of participants before using TAPFREE still did not know about the concept of requirements engineering. After using it, most of the respondents gain knowledge about concept of requirements engineering. We summarize that TAPFREE can provide guideline about requirements engineering for its users.

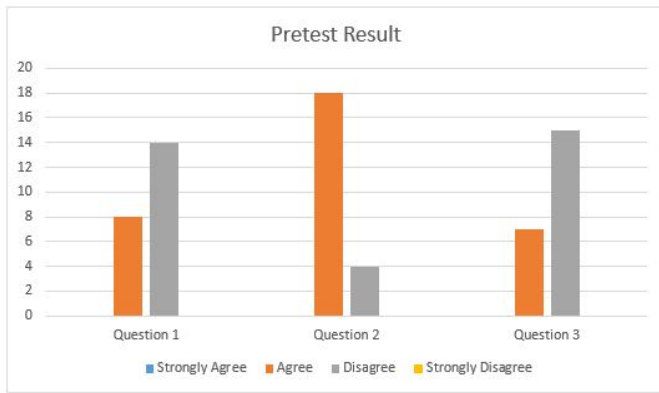


Fig. 4. Pretest Result

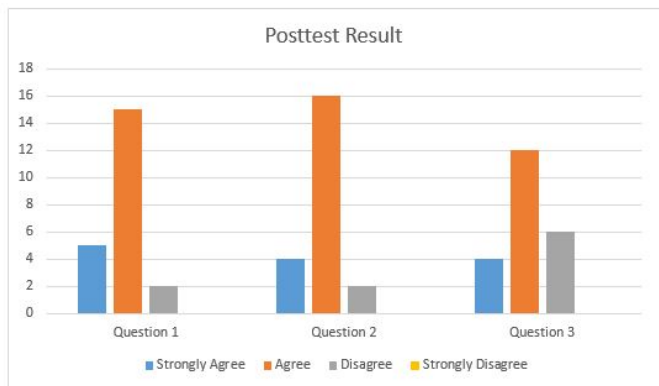


Fig. 5. Posttest Result

V. CONCLUSION AND FUTURE WORKS

Based on the analysis in testing phase, we summarize four points from this research:

- 1) TAPFREE system using Case-Based Reasoning to find suitable RE process model and techniques based on similarity values of past projects that stored in repository cases.
- 2) To validate TAPFREE, we conduct two type testing. First testing to validate the suitability of the recommendation given by TAPFREE. And the second testing to evaluate TAPFREE can provide guideline for requirements engineering activity based on project characteristics.
- 3) TAPFREE can provide recommendation that is suitable with project characteristics using defined parameter. Also, the requirements engineering activities are fit with RE goals based on result from qualitative testing.
- 4) TAPFREE provides knowledge assist about requirements engineering to the users based on the result form RE knowledge testing.

For this research, we only use three recommendations RE process models. For next study, we need to expand some RE process model to case repository for recommendation.

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