The R2FM Method for Requirement Analysis in Software Product Line For E-Government Applications

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Abstract— **Requirement analysis phase has significant contribution in successfully software system in software development. Software development in e-government application is intended to support government business processes in order to achieve good governance. These business processes may derive features commonality and variability. Failure to recognizes these features in e-government software development may cause wasted resources and shortened software life time. This study explores 8 implemented Indonesia e-government applications in order to extract commonality and variability features. These applications cover area of budgeting, administration, accounting, and local tax. Government business processes determine by government regulations. The R2FM method is proposed to analyze the alignment of regulation, business process model (BPM), and feature model (FM). The study results show the applications that developed from successfully requirement analysis of government regulations and use them for BPM and FM will last longer and adaptable to change.**

Keywords: Requirement analysis, software product line, business process model (BPM), feature model (FM), e-government applications, R2FM method.

I. INTRODUCTION

Nowdays, the complexity of e-government applications is grown significantly in the government environment. The government regulations keep changed, whilst e-government applications cannot keep up with the changes. E-government application has variation of commonality and variability features. The commonality feature has the same function in various systems software. The variability feature has a variety functions in systems software due to locality. It is a challenge to re-use or modify parts of the features due to change in similar domain without distracting the whole system.

The ability to respond to government regulation changing is possible by software product line. Whilst software system developers use various approach to capture features through requirement analysis. This cause the diversity among software system is high. In order to keep up with the change, the commonality and variability features have to be identified and manage. This study explores how to keep alignment between the keep changing regulations as a primary sources government business processes, and requirement analysis of commonality and variability features in e-government application development.

II. RELATED WORKS

According to [1], the contribution of requirement analysis for the developing software systems within the scope of small, medium, and large is above 50 percent. The failure to conduct a proper requirement analysis leads to incomplete of commonality and variability features of software system. Furthermore, the failure to capture and maintain these features can lead to a high cost, a large effort, and re-invent frequently [2][3][4][5].

In the context of e-government, software system serves to support the activities of government business processes in order to create good governance. Business processes held in government are always set in the regulatory documents. To obtain business processes from existing regulations, it can use the Business Process Model (BPM). According to [6], BPM is an activity for elicitation, documentation, visualization and analysis of working procedures within organizations [6]. BPM tools can provide transparency into business processes, as well as the centralization of corporate business process models and execution metrics [7]. Software system features generated from BPM enables to have commonality and variability. Hence, BPM can accommodate specific needs as well as common needs of diverse organizations and automating the existing activities.

Variability is the ability of a system to be efficiently extended, changed, customized or configured for use in a particular context [8]. Another definition presents variability as the ability of a system or a development environment to support the production of a set of artifacts that differ from each other [9]. In this definition variability means the ability to adapt to usages in the different business processes that are within the domain scope. Managing variability in business processes have been done by Idarlan Machado. It is based on aspect oriented approach [10].

According to [2], the software systems that have commonality and variability features can be managed by Software Product Line Engineering (SPLE). SPLE is an approach to produce a software system with diversity software system. SPLE can be used to modify, customize and configure context [11][2][13]. This approach can minimize cost and time to develop software systems, to improve the reusability of commonality features, to manage variability feature, time to market, and to improve product quality. SPLE consists of two processes that are domain engineering and application engineering [2].

III. E-GOVERNMENT APPLICATIONS

A survey was conducted to Indonesia's e-government applications that have commonality and variability features. E-government applications composed of a function block, sub-functions block and application modules and can be grouped into a common application modules and specific applications based on regulations [13][14][15]. Applications sampled are budgeting application, administration/expense application, accountability and reporting application, and application of local tax revenue. Based on observations, commonality and variability features can be seen in Table 1 below:

Table 1. Commonality and Variability Features of E-government Applications

Application	Common Feature	Variability Feature	Observation	Questionnaire
Budgeting	26	19	▪ Cimahi local government,	▪ Pamekasan regency,
Administration/ Expense	53	30	▪ Bandung regency,	▪ Tojo Una Una regency,
Reporting and Accountability	37	11	▪ Provincial Government of West Java,	▪ Serang local government,
			▪ Provincial Government of Jakarta.	▪ North Padang Lawas regency.
Local tax revenues	47	14	▪ Cimahi local government, ▪ Bandung regency	-

Table 1 shows there are exist variations of application features in application domain for the same product from different software systems. This situation is vurnerable to government regulations change. Often the changing of regulations from central government as well as local government make these applications no longer functioned. Hence, a new requirement analysis method is needed in order to make the software product line in e-government applications based on regulation, called R2FM method.

R2FM method consists of two steps: R2BPM and BPM2FM as described in Figure 2. The regulatory documents as input and feature commonality and variability are represented in the Feature Model (FM) as output.

Step R2BPM arranges BPM of regulatory documents. Representation of BPM outlined in business use case, synopsis, and activity diagrams. This step consists of procedure in determining business use-case from regulatory documents, procedure in determining a synopsis process from business use case, and procedure in determining activity diagrams from the synopsis process.

Meanwhile, BPM2FM method used to generate FM, in this case is commonality and variability features of the BPM. This step consists of a procedure determines the list of features from activity diagram, procedure determines ranking of features, and procedure determines commonality and variability of features.
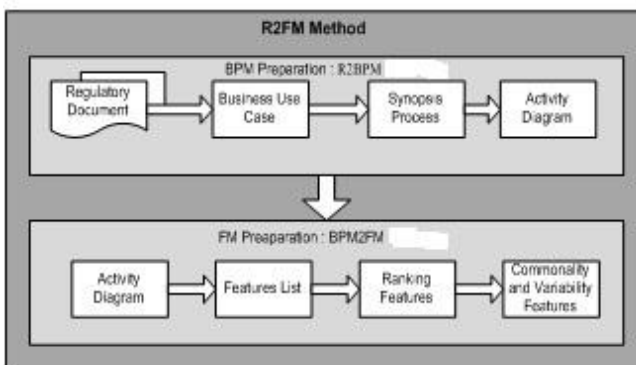

Figure 2. R2FM Method

Step BPM2FM involves user participation in providing an assessment of the features application concerned. The goal is to get a ranking/priority application features. S-AHP method is used to determine the ranking of application features [16][17].

In step R2BPM, regulatory documents are extracted into BPM, improvising some parts of PROMAP Framework developed by [6]. The procedures are preparing the necessary business use case of regulatory documents, compiled a synopsis of business use case, and compiled activity diagrams of synopsis process.

Furthermore, step BPM2FM extracts features from BPM and consists of three procedures: (1) The procedure determines activity diagram into a list of features, (2) The procedure determines the ranking of features from the list of features, and (3) The procedure determines commonality and variability feature of ranking feature.

After getting the list of features, the next step is doing the selection and grouping features contained in this procedure. This procedure is used to determine ranking features based on quantification the features value. Modified S-AHP method is used to rank the value of features (see Figure 3).
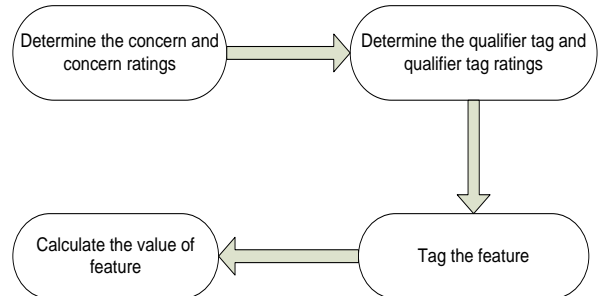

Figure 3. Modified S - AHP Method to Rank The Value of Features

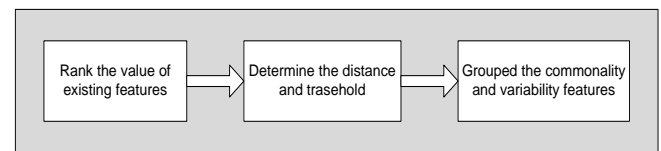The features rank becomes the basis to determine commonality and variability of features, as shown in Figure 4.
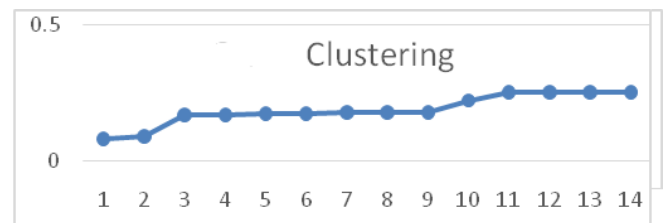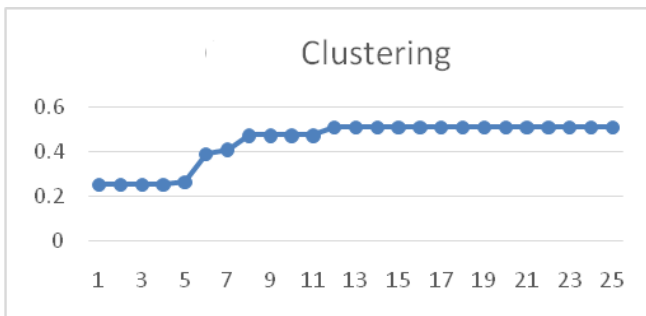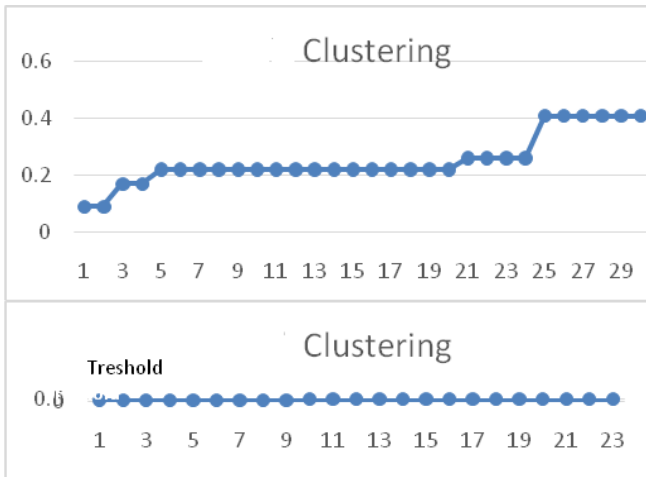

Figure 4. The Procedure Determines Feature Commonality and Variability from Features Ranking

IV. EXPERIMENTAL RESULTS

Experiment R2FM method consists of two steps: R2BPM and BPM2FM. The objects of experiment are related domain applications and their document regulations also related. We arranged workshop for 50 students which is consists of 10 groups. The results of experiment show that 8 groups able to arrange BPM. The next step is to distribute template S-AHP that will be fill with user in local government.The purpose is to get ranking of features application.The results of ranking of features application shows in 4 graphics below:

The evaluation of BPM2FM is divided into evaluation list of features, and comparative evaluation of methods. To evaluate the features list uses the expert domain, whereas for comparative evaluation, uses FMBP method of Jongsu as comparison. Based on the evaluation results, shows that all questions be answered in the form of a questionnaire in accordance with the results obtained the list of features. BPM2FM can be used to determine the features commonality and variability based on BPM. Meanwhile, for the comparative evaluation performed by comparing BPM2FM with FMBPM method was found by [3] in 2010. This method is used to generate FM from BPM. From Table 3, shows there are differences in the application domain. The method uses by [3] is for business application domain, whereas BPM2FM uses for specific domain of e-government applications.

Table 3. FMBPM Evaluation Method

Characteristic	FMBPM Method [3]	BPM2FM Method
Application Domain	Business Application Domain	E-Government Applications Domain
Condition application currently Implemented	Has not discussed	Discussed
Feature Extraction	Sourced from BPM, but not described grouping manual or computer business processes. Not explain the evaluation results of feature extraction.	Sourced from BPM, but not described grouping manual or computer business processes. Requires Domain Expert for feature extraction
Commonality and Variability Feature	Commonality and variability of features not explicitly discuss and describe focus of method is to get commonality and variability from business process.	Focus to get the commonality and variability of features.
Feature Ranking	Not discussed of determination and grouping feature commonality and variability.	Discusses selecting mechanisms and grouping feature commonality and variability

The evaluation of R2FM method divided into R2BPM evaluation and BPM2FM evaluation that shown below.

- **Evaluation of R2BPM**

From the experimental results BPM compiled by different local government and different regulatory document can be shows there are 2 groups could not arrange a business use case, synopsis process, and activity diagrams, and 8 groups can arrange an activity diagram. Nevertheless, it can be concluded that the R2BPM can be used to construct business use case and diagrams activity.The next stage is to evaluate BPM results by Expert Domain Business Process. The evaluation conducted by Expert Domain BPM in Bandung regency, Cimahi municipal government and the provincial government of West Java. The results show that BPM obtained from the R2BPM is in accordance with the business process to do a comparative evaluation of related methods, especially determining business use case. The synopsis and activity diagrams are used as comparative Martin S. (Promap Framework) and the Rational Unified Process (RUP) [18]. Results of comparative evaluation of related methods are shown in Table 2.

Table 2. Comparative Evaluation of Related Methods

Characteristics	Promap	RUP	R2BPM
Documents as a source of information	V	V	V
Arranging Guide of business use cases and synopsis process of reading the document	X	X	V
Arranging Guide of activity diagram of reading the document	X	X	V
Arranging Synopsis Process	V	X	V
Software Product Line Development	X	X	V

- **Evaluation BPM2FM**

- **Usability Analysis R2FM Methods.**

Based on the study, it can be concluded that usability R2FM methods are as follows : (1) If the organization has no working procedure in the form of SOP with BPM representation, then R2BPM method can be useful for preparing BPM**.** If the organization already has a BPM and want to develop a software product line, BPM2FM can be useful to determine commonality and variability features based on existing BPM. (2) If the organization have implemented applications, and have commonality and variability features, R2FM method can be used for a comparison features before building a software product line. In addition, R2FM method may be useful to get software product line requirements by using rules in

top-down, and bottom-up in implemented applications. (3) Developer of software systems can determine commonality and variability features in developing a software product line. (4) It can be used to the extent to which features of e-government application Implemented in accordance with regulations. (5) It can be a reference for developers of software systems to make the transition from single application development into a product family development.

Table 4 . The Results of Comparison of Feature Commonality and Variability

Applicati on Name	Implemented Application		R2FM Method	
	Commo nality Features	Variabil ity Features	Common ality Feature	Variability Feature
Budgeting	26	19	9	5
Administr ation/Exp ense	53	30	24	6
Reporting and Accounta bility	37	11	19	4
Local tax revenues	47	14	6	19

According to table 4, it shows the comparison between the results of feature commonality and variability of application currently implemented from R2FM method. Based on these results, the feature commonality and variability of software product line can be complementary and repaired. Because commonality and variability features obtained by top-down approach, which is based on regulatory document and bottom-up approach which is based on e-government applications have been implemented. Figure 5 below describes the role R2FM method in software systems development. It shows that the diversity of software systems developers with diverse technologies and designs to develop features of software system based on the results obtained by R2FM method. R2FM method is used to monitor the development of software systems by multiple software system developers to develop e-government applications. This method provides development flexibility in applying of design and technologies based on the regulatory requirement corridor.
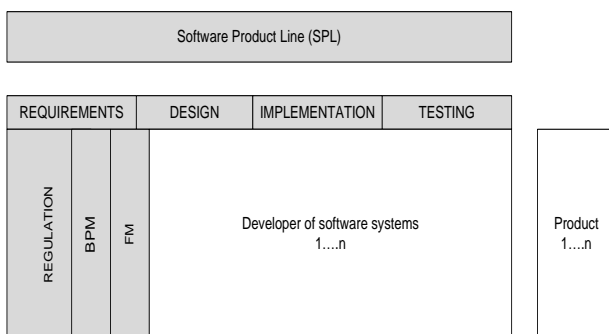

Figure 5. Implementation R2FM Method: Flexibility in Design and Implementation

V. CONCLUSION

This research focuses on Requirements Analysis phase in developing the Software Product Line (SPL). Premise of this research is features of e-government applications are not optimize and not fully in accordance with regulation. Another condition, difficulty in managing commonality and variability of features that developed by developers of software systems so diverse. This condition can be overcome by developing the software Product Line (SPL). So far, there has not been well accepted method to develop software Product Line (SPL). Especially in the requirements analysis, in order to get commonality and variability of features from the top down and bottom up implemented applications. Definition of top down is the commonality and variability of features is obtained based on regulatory document, while bottom up is the commonality and variability of features obtained by the application implemented. This method is called R2FM, which consists of two steps: BPM2FM and R2BPM. Step R2BPM consists of: (1). Procedure to collate a business use case from regulatory documents, (2). Procedure to collate a synopsis from business process use case, and (3). Procedure to collate activity diagram from synopsis process.

Based on research conducted Jongsu Bae et al in 2010, Features Model of Business Process (FMBP) is a method to generate features models of business process models for business applications. This method does not accordance with the characteristics of e-government application domain. Especially, if the application of e-government has been implemented. So, it is necessary to use BPM2FM, which consists of (1). Procedure in determining the list of features from activity diagram, procedure in determining of feature ranking from features list, and (2). Procedure in determining commonality and variability feature from feature ranking.

Suggestions for further research are: (1). Implementing R2BPM and BPM2FM become generator tools for the automation of input regulatory documents into business use case, synopsis process, activity diagram, list of features, ranking features and feature commonality and variability. (2). Considering dynamics change factor that impacted to variability advance. So, it can be anticipate and respond to dynamics change that can not be predicted. (3). Applying SOA to design and implementation phases in development of SPL, and (4). Multiply regulatory documents for different levels, and sample of e-government applications implemented.

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