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Effort Distribution to Estimate Cost in Small to Medium Software Development Project with Use Case Points

Putu Linda Primandari A[1)] and Sholiq[2)]

Information Systems Department, Faculty of Information Technology, Institut Teknologi Sepuluh Nopember (ITS) Surabaya, Indonesia

Jl. Arief Rahman Hakim, Surabaya 60111 Indonesia

e-mail: lindaprimandarigmail.com[1)] and sholiq@is.its.ac.id [2)]

Abstract

The Use Case Points (UCP) has been a method that often used as a reference to calculate effort estimation, the amount of worker and time required in software development project. In Reality, software project planning has not been only effort estimation, but also cost estimation to estimate how much cost of resource allocation spent in software development. Result of the effort estimation using UCP is the number of effort required to develop the software as a whole. In fact, the determination of the cost of software development is based on the cost per activity of pay rate different in each phase of software development. Therefore it requires the distribution of effort per activity to get the cost of software development.

To produce cost estimation in the software development project, we need to know the percentage of each phase of software development, in this case called the effort distribution. The percentage of effort distribution was obtained through the collection of empirical data of governance's software development in small to medium scale. In this study, it was used 15 small and medium-sized projects of software development in Indonesia that was completed.

The findings of this study was the value of the percentage of effort to the three categories of phases of the software development, namely: the percentage of the phase of software development at 72.6%, the percentage of the phase of the on-going life-cycle activities amounted to 17.5%, and a phase of quality control and testing amounted to 9.9 %. While the percentage of detail presented in this paper. Another result of this study was the steps to determine the estimated costs for software development with UCP method.

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Keywords : Effort Distribution; Software Cost Estimation; Use Case Points; Software's Phases Development

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1. Introduction

The rapid growth of software necessary in government of Indonesia unfortunately did not accordance by the successful of software development process. Based on Standish Group Study (CHAOS) report on 2012 until 2012, only 39% information technology projects were successful [1]. The failure of software development projects majority caused by the poor of software project planning. This judgment was in the result of research that noticed if the thing that caused software development failure was the lack of accuracy while estimation planning. The level of uncertainty effort estimation and poor of data about effort distribution value in each phase of software development made project manager oftentimes feel difficulty to estimate the number of staff and other resources.

The launched of Presidential Regulation of Republic of Indonesia number 70 of 2012 about Procurement of goods or services also provide a new regulation on government procurement activities. This regulation established the rule of Owner Estimate Cost (OEC) in government procurement activities [2] [3]. According the presidential regulation the term 'goods' are defined as objects either tangible or intangible, movable or immovable, which can be traded, used, used or exploited by Users. Noting the definition given above presidential decree, the software is also categorized as goods, so that the procurement of software for government agencies to be treated equally with the procurement of goods in general.

Therefore, for the procurement of the software required prevailing price/cost. Unfortunately for custom software project no standard price/cost can be used. Thus, the use of UCP method to estimate the effort of software development projects need to be expanded to estimate software development costs. Expansion of the use of UCP method to software development cost estimation requires knowledge of the distribution of effort per activity of software development projects. It is necessary to get the effort per activity. Further the effort per activity multiplied by the standard rate of charge per activity to get the cost of software development.

This research aims to determine the value of effort distribution at each phase of software development in percentage. That value of effort distribution can be used as the basic to cost estimation using UCP by researches or practitioners in government's software development projects. Research conducted by Kassem Saleh has gained distribution effort, but for a software development project medium-large scale. This value can be applied to the UCP method or Function Points [4]. The result of percentage of effort distribution was not suitable to be a reference for small-medium software indeed government project in Indonesia. In contrast to research conducted by Kassem Saleh, this research focuses on the development of small and medium-scale software which has different distribution effort. This research focused on the determination of the value of effort estimation in each phases of software development activities through using empirical studied in small to medium government software development projects that has been running. The result of this research can be used as a reference to calculate the cost estimate of software development project in the future.

Furthermore, to get the project cost for custom software development, it is first necessary to know the needs of effort required to complete the software project. The One of the effort estimation methods that has been used widely was the UCP. The UCP was a method to estimate the amount of effort is based on the complexity of the use case [5].

Some previous studies of UCP provide the following results: (1) Comparison between the UCP with the actual effort has deviation of 19%, while estimates by experts to have a 20% deviation [6]. (ii) In another study, it was reported that the UCP has a deviation of 6% [7] and 9% [8] compared with the actual effort. In the above explanation can be said that the UCP reliably used to estimate effort.

In contrast to previous studies, this research focuses on determining the distribution of effort (in percentage) obtained from the practices of software development project in Indonesia. The purpose of this study was to get a percentage of the distribution of effort to be used as a first step of determining the estimated cost for software development projects of small and medium scale. Similar research has been conducted by Kassem Saleh with the percentage distribution as presented in Table 2, but he did it for medium to large scale projects, while this research focused on small to medium-scale projects.

2. Software Phases and Effort Estimation

2.1. Software Phases and Activities

To properly allocate effort estimation, the various phases and activities that must be undertaken in a typical small to medium software development project need to be identified. There are two types of activities that performed to complete the project namely, the phased activities and the ongoing life cycle activities [4]. In the following, Table 1 describes detail of two activities type that be used in this research.

Table 1 Activities in software development [4].

Type	Activities	Type	Activities
Software phases	Requirements	**Ongoing life-cycle activities**	Project management
	Specifications		Configuration management
	Design		Quality assurance
	Implementation		Documentation
	Integration testing		Training and support
	Acceptance & deployment		Evaluation and Testing

2.2. Effort Distribution

The activities in phased software activities exist in typical software development life cycle models. In addition to the phased activities, ongoing life cycle activities are activities that are performed continuously while the phased activities are performed. Reported experience on the time and budget spent on the different software development activities, Kassem showed the details of the effort distribution for each type of activity and approximate pay rate for medium and large software development project. Table 2 shows effort distribution on activities and relative pay rate.

Table 2 The effort distribution of activities and the relative pay rate are in medium to large software development project [4].

Activities	% effort	Activities	% effort
Software phases		**Ongoing life-cycle activities**	
Requirements	7.5	Project management	8.34
Specifications	7.5	Configuration management	4.16
Design	10	Quality assurance	8.34
Implementation	10	Documentation	4.16
Integration testing	7.5	Training and support	4.16
Acceptance & deployment	7.5	Evaluation and Testing (V &V)	20.84

2.3. Use Case Point Methods

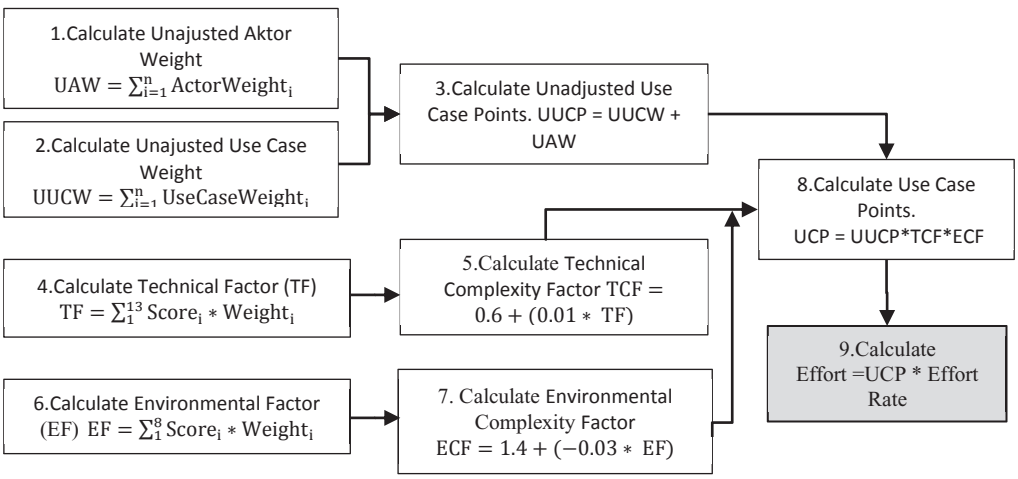

Figure 1 Step by step of Use Case Points Method

The UCP was the first developed by Gustav Karner, which was a derivative or adaptation of Function Point Analysis method [9]. This method aimed to provide a simple estimation method that adapted to the orientation of the object of a software project. Lately UCP was known popularly as the effort estimation method of software development. Several studies have reported that the UCP provides a level of accuracy of the estimate was good enough. Some research on UCP reported that this technique was an estimate of the development of reliable software, for example: (1) estimates of UCP better than the estimates by experts [6], (2) the estimate of the UCP has a deviation of 9% [8], (3) the estimate the UCP has a deviation of 6% [7].

Most estimates made by UCP just get the value of the total effort required to develop the software, most researchers have not reached the estimated costs. Only studies conducted Prassida, et.al which used UCP for cost estimation module of ERP software [10]. This study used the division of effort into each activity using the results of research conducted by Kassem Saleh. Activities were grouped into 3 categories, namely: software development, on-going activity, and quality & testing [4].

The steps of UCP method is shown at the following illustration in figure 1 [11] [12]. There are eight steps to get the effort (in man-hours) using UCP (see figure 1). The first step is to get Unadjusted Actor Weigh (UAW). For each actor in the system are classified into 3 categories: simple, average and complex. External actors interact with the system using the application programming interface (API), it is categorized as a simple actor and value of complexity equal to 1. If the external system associated with the system that is being built using a standard protocol and data stores, it can be considered an average actor and complexity equal 2. A user associated with the system that is being built using a Graphical User Interface (GUI), it is classified as complex actor and complexity equal 3. The UAW is got by the sum of complexity values assigned to each actor.

The second step is to get unadjusted use case weight (UUCW). Each use case calculated the amount of the transaction or the number of steps in the use case description. Based on the number of transactions or the number of steps in the use case description, a use case can be categorized into simple, average, or complex. A use case is categorized into a simple, if the number of transactions in the use case is less than or equal to 3. If the transaction amount 4 to 7, a use case is considered average. Meanwhile, if the transaction amount is more than 7, then a use case is categorized into the complex. For a simple use case, the value of complexity equal to 5. For use case on average, the value of complexity equal to 10, while for the use case complex, complexity value equals 15. The UUCW is the sum of the values assigned to the complexity each use case. The third step is getting unadjusted Use Case Points. (UUCP) which UUCP = UAW + UUCW.

Based on Figure 1, the fourth step is to obtain the Technical Factor (TF). TF obtained from the sum of all the weight values for each of the 13 factors multiplied by the related score. The score has a range of values 0 to 5 depending on the complexity of the related technical. The TF is thus obtained using the formula $\mathrm{TF} = \sum_1^{13} \mathrm{Score_i} * \mathrm{Weight_i}$. Furthermore, in the fifth step is computed Technical Complexity Factor (TCF) using equation TCF = 0.6 + (0:01 × TF). Similar to the fourth step, in the sixth step calculation of the value of Environmental Factor (EF) which is the sum of the weights value for 8 environmental factors were multiplied by the score of each factors. The score has a range 0 to 5. In the same way the value of EF can be calculated using the formula $\mathrm{EF} = \sum_1^8 \mathrm{Score_i} * \mathrm{Weight_i}$. The next step seventh Environmental Complexity Factor (ECF) is obtained using the formula ECF = 1.4 + (- 0:03 * EF). The eighth step to get the Use Case Points (UCP) using the formula UCP = UUCP * TFC * ECF. The final step is to obtain effort using formula Effort = UCP * Effort Rate (ER).

The ER value is set equal to 20 man-hours [9]. Several other researchers basing the value of the ER to the complexity of the project by providing the ER = 20 man-hours for a simple project, 24 project man-hours for medium, and 36 man-hours for complex projects [13]. The ER value is set 15 to 30 depending on the quality of the personnel of the development team [7]. Recent research was conducted Subriadi give ER = 8.2 man-hours for software development projects in Indonesia [12]. ER value for the website

development project in Indonesia by 4.41 man-hours [14]. Lastly, the ER may be based on historical value, if the development team has historical data for similar projects.

3. Research Method

The method used in this study began collecting data using questionnaires to fifteen of the government project software for small-to-medium-scale. The data were collected using questionnaire addressed to three project manager in software developer. Table 3 shows profil projects be used in this study.

Table 3 Profile fifteen software projects used in this study

Project ID	Name of Project	How to get a project	Time to complete (month)	Model used
A	Building Permits Application	given	2	Extreme Programming
B	Planning, Developing, and Rehabilitation Street Application	given	3	Waterfall
C	Integrate Service Counter Application	given	2	Incremental
D	Information System User Satisfaction	given	2	Unified Process
E	E-RAB Application	auction	7	Waterfall
F	Estate Application	given	3	Waterfall
G	Population Administration Arranging Application	given	2	Incremental
H	Information System of SEWAKA Dharma Building	given	3	Waterfall
I	Electronic - Scripts	auction	3	Waterfall
J	Online Referral Application	auction	3	Waterfall
K	PRO Denpasar	given	2	Extreme Programming
L	Collection Script and Proposed Implementation of Development Recapitulation Application	given	4	Waterfall
M	Government Resources Management System	given	2	Extreme Programming
N	Officialdom Information System	auction	3	Extreme Programming
O	Facility and Infrastructure Information System	auction	3	Extreme Programming

The second step was to calculate the distribution of effort per each activity development project. The result of effort distribution was obtained from questionnaires in fifteen government software projects that have been completed by the developer. Distribution of effort expressed as a percentage which the percentage value of each activity is obtained by taking the average value of the actual effort per activity. After the effort distribution obtained, in the third step we validated the effort distribution using five small to medium projects as data tested. This percentage of effort distribution was used as a reference to calculate cost estimate using Use Case Points (UCP) method. Then, the result of cost estimation will be compared with the actual cost in the projects as test data.

4. Results And Analysis

Based on the research that has been conducted on fifteen government software project in small to medium scale, we got the result of effort distribution in each phase of software project development. Table 4 shows the result percentage of effort distribution and also compare with previous research by Kassem Shaleh for medium-large software project [4]. If the quality and testing phases that include

integration testing, quality assurance, and evaluation & testing was grouped to be phases separeted, then procentage of the software development phases amounted 72.6%, on going life-cycle activities phases amounted 17.5%, and quality and testing phases amounted 9.9%.

Table 4 Result of Effort Distribution (%) per activity

Activities	% Effort (this research)	% Effort (medium-large) [4]	Activities	% Effort (this research)	% Effort (medium-large) [4]
Software Phases			Configuration management	4.3	4.16
Requirements	1.6	7.5	Documentation	8.4	4.16
Specifications	7.5	7.5	Training and support	1.0	4.16
Design	6.0	10	**Total**	**17.5**	**20.82**
Implementation	52.0	10	**Quality and testing phases**		
Acceptance & deployment	5.5	7.5	Integration testing	7.0	7.5
Total	**72.6**	**42.5**	Quality assurance	0.9	8.34
Ongoing life-cycle activities			Evaluation and Testing	2.0	20.84
Project management	3.8	8.34	**Total**	**9.9**	**36.68**

There were several factors that affect the result of effort distribution had different percentage with previous research. The possible factors are: (1) Size of Project: In research of Kassem Saleh, software size of development projects that use was medium to large. Otherwise, this research used software development project of small to medium size. (2) The scope of the project: The number of software development project which was the object in this research amounted to fifteen projects and the software project governance in the field of business, while the software project object in an earlier study did not set out general software studied. (3) Software Development Methods: The previously research was not described software development methods that was used. Selection of software development methods had seen from the level of ease in the creation of software developers. (4) Project Time: Processing time for each phases of the software development in previous research were not addressed by researchers therefore found no great effort was done each phases in each software project. (5) Number of Workers: In previous research didn't discuss the number of workers at each phases of software development project, therefore the aspect of the number of workers has a great influence for the value of the effort distribution.

After the result of effort distribution was obtained, we validated the result to determine the deviation of effort distribution. The validation was performed in four governance software project that has been known the actual effort of each projects. The validation was used in this paper consist of two type: cost estimation validation and effort validation. The following table 5 is shown UUCP, TCF, ECF, and UCP for four project used validation. The UCP was used to get the value of effort estimation.

Table 5 The UUUCP, TCF, ECF, and UCP for project used validation

No	Project	UUCP	TCF	ECF	UCP
1	Industry List Attribute Application	552	0.97	0.86	460.5
2	Industrial Permit	567	0.97	0.86	473.0
3	Principle Approval	552	0.92	0.95	482.4
4	Company List Attribute Application	498	1.075	0.935	501.5

After that, we calculated the following values: (1) Effort Estimation, (2) Hours of Effort, (3) Cost Segmentation (person/hour). Furthermore it could be found the value of cost estimate in software development projects. Table 6 show the result of validation of projects.

Table 6 Deviation for project used validation

No	Projects	Cost Deviation	Effort Deviation
1	Industry List Attribute Application	12.2%	2%
2	Industrial Permit	9.1%	5%

3	Principle Approval	11.4%	7%
4	Company List Attribute Application	12.0%	11%
Average		11.18%	6.25%

In validation that conducted on the software project cost estimation, we get a result that is: deviation costs by 11.8% and the deviation effort 6.25%. These results are rational enough to be used as a reference to calculate the estimated cost of the effort estimation.

To get an estimated cost for software development projects were preceded by the estimated effort required using UCP. The effort that has been get is the overall effort for software development projects. Further effort is divided into some effort per activity using distribution effort generated by this study. The estimated cost of software development is obtained by multiplying the effort per activity and the pay rate each activity. Therefore, to calculate the cost of software development is used different rates for each activity in the project. Finally the overall costs obtained by software development costs are added other costs. Thus, the results of this study can be used as a reference to obtain estimates of the cost of software development projects small to medium size.

5. Conclusion

In this research, we have gained the distribution effort for software development projects of small to medium scale. The efforts distribution presented in the percentage of effort was obtained from the average of fifteen projects that have been completed. The percentage of each phase in software development was 72.6%, percentage of ongoing activity was 17.5%, quality and testing phases was 9.9 %.

Tests on the results was obtained deviation rate of 11.8% for cost and 6:25% for effort. This deviation to provide knowledge for project managers about effort and cost estimation for software projects of small to medium scale. With this knowledge, practitioners and researchers can make adjustments to the estimation process which he did.

Project managers can use this research as a reference to estimate the cost or effort estimation for software projects as a basis for planning the resources required to execute the project. For researchers in the field estimated costs or effort estimation of software projects, this research can be developed further to the factors that influence the cost estimation on software projects of small to medium scale. In addition, the following studies can be done to make a model and / or framework to estimate the cost of software development projects of small to medium scale using UCP.

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