E-Cost Estimation Using Expert Judgment and COCOMO II

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Abstract - The accuracy and efficiency of cost estimation methodology for web-based application is very important for software development as it would be able to assist the management team to estimate the cost. Furthermore, it will ensure that the development of cost is within the planned budget and provides a fundamental motivation towards the development of web-based application project. The literature review reveals that COCOMO II provides accurate result because more variables are considered including reuse parameter. The parameter is one of the essential variables in estimating the cost in web-based application development. This research investigates the feasibility to combine and implement COCOMO II and expert judgment technique in a tool called WebCost. In estimating a cost, the tool considers all variables in COCOMO II and requires expert judgment to key-in the input of the variables such as project size, project type, cost adjustment factor and cost driven factor. Developed in JAVA, WebCost is proven able to estimate cost and generate its estimation result. The usability evaluation conducted had shown that WebCost is usable when compared with other tools; it has its own advantages. WebCost is evidence suitable for everyone especially the project managers, software practitioners or software engineering student in handling the cost estimation tasks.

KEYWORDS

I. INTRODUCTION

Cost estimation is a prediction process of defining the cost required in order to get the most accurate cost possible of equipping facilities, producing goods or providing services. It is important in any managing projects, especially to the project manager when proposing a budget for certain projects.

The occurrence of common software failure was caused by the poor cost and schedule estimation [1]. That is why accurate cost estimation is needed for the web-based project or application. Current practices of cost estimation for web-based application process are mostly done manually, producing in accurate result in estimating cost [2]. Therefore, a cost estimation tool is needed to produce an accurate result in estimating the cost for web-based application or any software project development.

The objectives of this study are (i) to investigate the existing estimation method in general and cost estimation method for web-based application and (ii) to develop a cost estimation tool for web-based application.

The tool is expected to be more accurate and viable to conduct cost estimation process web-based.

II. COST ESTIMATION

In current practices of software development, people are clearly more interested in web-based application rather than the traditional development which is a stand-alone system. Consequently, web-based application had become the most popular application in all organizations because it increases the integrated business strategies for both small and
large companies, including organizations. Therefore, a web application development is a suitable approach in developing the cost-estimation tool to enable the estimation process to be as accurate as possible.

Cost estimation is a prediction process of defining the cost required in order to get the accurate cost of equipping facilities, producing goods or providing services [3]. It includes the process of considering the required cost, experiences, time constraints, risks, methods used, schedules, resources and other elements related to the project that is going to be developed. Hence, cost estimation is important in managing project, especially to the project manager when proposing a budget for certain project. In the software development field, the most widely used term is “software project estimation” where its function is to show the estimation process [4][5].

Cost estimation process also considers and determines utilizing experience by an expert, calculating and forecasting the future cost of resources, methods and schedule for any project development. It provides input to original baselines and changes to baselines which cost comparisons are made throughout the life of a project. It is performed at a certain point in time based on available information at the time. Normally, it includes cost estimation details, a cost estimation summary, basis of estimate which is description of the project and the details, estimation methodologies, type of cost estimation including risk, cost driven, cost adjustment and so on [2]. Software project estimation is a form of problem solving and in most cases; the problem that need to be solved is too complex to be considered in one piece [5]. In order to solve the problem, the complexity can be decomposed and restructured to become more understandable. There are many ways to decompose and restructure the problem; one of them is estimating software size. In order to do that, problem based estimation (which is line of code estimation and function point based estimation), process-based estimation, use-case based estimation and reconciling estimations can be used.

**A. Software Cost Estimation Technique**

There are several different techniques which can be used for software cost estimation whether in web-based application or traditional application [5]. There are eight types of cost estimation techniques namely Algorithmic Model, Expert Judgment, Estimation by Analogy, Parkinson Ian Estimation, Price To Win, Top-Down Estimation, Bottom-Up Estimation and Machine Learning [6][7][8][9][10][11].

Algorithmic Model provides one or more mathematical algorithms to produce a software cost-estimate as a function of a number of majors cost drivers. The cost drivers are factors, which influence the cost of a software project. Four of the most well known are Boehm’s COCOMO (1976), COCOMO II (1981), Putnam’s SLIM (1978) and Albrecht’s Function Points (1983). The most popular model is COCOMO II. It consists of several components or issues such as non-sequential and rapid development process models. It is also inclusive of reuse approaches, reengineering, and application composition and application generation capabilities where as Putnam’s SLIM and Albrecht’s Function Points did not offer reuse approaches. COCOMO II is suitable for both small and large projects, whereas Putnam’s SLIM only focuses on large projects. Putnam’s SLIM tend to estimate less than the COCOMO II for large size projects. For medium sized projects, both model estimations are similar. In order to get more accurate estimations from SLIM or COCOMO II, one has to reconfigure these tools each time a new project is started. This is necessary as the tools need to take into account all special conditions or requirements of a project. Albrecht’s Function Points is more to sizing technique. So, Albrecht’s Function Points is normally just a complementary to COCOMO II and Putnam’s SLIM in order to feed the estimation process. COCOMO is reasonably well-matched to custom, build-to-specification software projects; while COCOMO II is useful for a much wider collection of techniques and technologies. COCOMO II provides up-to-date support for business software, object-oriented software, and software created via spiral or evolutionary development models and software developed using commercial off the shelf application composition utilities. COCOMO II includes the Application Composition model (for early prototyping efforts) and the more detailed Early Design and Post-Architecture models (for subsequent portions of the lifecycle).

Expert Judgment is judgment provided by a subject matter expert in a specific application area, knowledge area, discipline, industry as appropriate for the activity being performed. Expert judgment involves consulting with one or more experts using
their experience and knowledge of the proposed project to arrive at an estimate of its cost [12]. This is often used as a complementary method to algorithmic model. An expert judgment is an estimation process made by the estimator based on what he or she had done in previous similar projects [13][14]. The experts give information based on their memories and experiences. Expert judgment can be relatively accurate if the estimator has significant recent experience in the software development and planning. By considering this method, it will help cost estimation process to produce an accurate result. However, expert judgment cannot be used on its own because it involves human experiences or opinions. Human sense is always biased. Therefore, in order to avoid from human bias in estimating process, it is good to use other techniques to complement the expert judgment technique.

Concerning the techniques used discussed in this section, COCOMO II is the best technique that can be used to estimate the cost for web-based application. It is because COCOMO II provides more parameters in order to estimate the cost and produce accurate estimation. Besides, COCOMO II also provides reusability. Since this study focuses on web-based application, reusability concept is more suitable. The software developer can apply reusability concept in coding, modules and interfaces. This research added expert judgment as an extra technique to estimate cost for web-based application. Based on the literature reviews, experiences gained by expert judgment are very valuable to assist in the estimating process.

B. Cost Estimation Existing Tool
There are many existing software cost estimation tool in the market named COCOMO II Application for Software Cost Estimation (CASE) developed by Dr. Joel Henry, COSTAR by Softstar System, Checkpoint by Software Productivity Research and USC COCOMO II by Centre of Software Engineering, University of Southern California. Most of the tools utilize COCOMO II to estimate the cost and only Checkpoint uses expert modelling. As a result, none of these existing tools are acceptable to become the most accurate tool in the market. These tools were developed by using only one type of estimating technique. This could be the reason why project managers are not able to provide a good estimation for software development projects.

III. RESEARCH APPROACH
A tool namely WebCost has been developed in this research by using Java programming language and Java Eclipse based on techniques selected which are combination of applying COCOMO II and expert judgment. The WebCost has been evaluated by 13 users in order to check the validity and accuracy of the tool. A set of questionnaire had been designed in order to test the tool by using Software Usability Measurement Inventory (SUMI).

IV. DEVELOPMENT OF E-SOFTWARE COST ESTIMATION
As discussed earlier, this research is combined the expert judgment and COCOMO II as a technique to do the estimation. In order to check the accuracy of the technique used, a tool called WebCost is developed by using JAVA language. This section discussed on the WebCost modelling and the proposed model.

A. WebCost Modelling
This study combines the expert judgment and COCOMO II as a technique to estimate the cost of web-based application. A few parameters were involved such as project size, project type, function point, cost adjustment, reuse, cost-driven and report. Figure 1 shows the interface of WebCost.

![Figure 1: Interface of WebCost](image)

The parameters used in WebCost are constructed from COCOMO II. The role of an expert is to give input based on their specific knowledge and experiences in the application area. The experts need to link the efforts and the features of the past projects with the proposed projects. As discussed earlier, without the combination techniques of expert judgment and COCOMO II, the chances of an accurate estimation is low. Due to that, the proposed tool is expected to produce more accurate estimation to improve the project manager’s ability to deliver projects within approved schedule and budgets.
B. Proposed Cost Estimation Model

The proposed model based on COCOMO II and expert judgment. The relationship of both technique shows in figure 2.

![Software Cost Estimation Diagram](#)

**Figure 2: Relationship between COCOMO II and Expert Judgment**

The study has proven that COCOMO II is the best model to estimate the cost since it considers more suitable attributes to be included in the calculation. Besides, expert judgment is also the most popular technique used to estimate the cost. So, in order to provide good tool for estimation process, COCOMO II is used in providing standard variables that has been defined and expert judgment play important roles in giving input to the variables provided in COCOMO II. It is because only the experts have experiences in dealing with previous projects.

V. RESULT OF ON VALIDITY AND ACCURACY OF WebCost

In order to check the validity and accuracy of WebCost, two evaluations are carried out which are usability evaluation and comparison with other tools.

A. User Evaluation

The usability evaluation is based on SUMI technique to analyze the user’s acceptance. 20 questions were selected from SUMI technique. Three options are used to capture user’s response which are agree (the scale is 1.00-1.99), undecided (the scale is 2.00-2.99) and disagree (the scale is 3.00-4.00). The average is gathered from the summation of input from the respondents based on the mentioned scale. If the result is between 1.00 and 1.99, it shows that users are satisfied and agreed with the specific measurements of WebCost. If the result is between 2.00 and 3.00, it shows that users are undecided. Finally, if the result is between 3.00 until 4.00, it shows that users totally disagreed with WebCost. Table 1 shows the details of result.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Result (Average)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respond Faster To Input</td>
<td>1.08</td>
</tr>
<tr>
<td>Instruction and Prompt Helpful</td>
<td>1.15</td>
</tr>
<tr>
<td>Easy in Learning to operate</td>
<td>1.54</td>
</tr>
<tr>
<td>Information is helpful</td>
<td>1.46</td>
</tr>
<tr>
<td>Take less time to learn the tool</td>
<td>2.00</td>
</tr>
<tr>
<td>Tool is Satisfying</td>
<td>1.00</td>
</tr>
<tr>
<td>Information Presented is Clear and Understandable</td>
<td>1.23</td>
</tr>
<tr>
<td>Enough Information When Needed</td>
<td>1.96</td>
</tr>
<tr>
<td>Tool is consistent</td>
<td>1.31</td>
</tr>
<tr>
<td>Can Understand and Act on The Information Provided</td>
<td>1.23</td>
</tr>
<tr>
<td>Tool is Norm</td>
<td>1.85</td>
</tr>
<tr>
<td>Less to Read</td>
<td>2.77</td>
</tr>
<tr>
<td>Tasks can be performed Straight away</td>
<td>1.38</td>
</tr>
<tr>
<td>Tool is not frustrating</td>
<td>1.23</td>
</tr>
<tr>
<td>Tool had overcome the problem</td>
<td>1.38</td>
</tr>
<tr>
<td>Organization of menu is logical</td>
<td>1.00</td>
</tr>
<tr>
<td>Can be economic of keystokes</td>
<td>1.46</td>
</tr>
<tr>
<td>Less step required</td>
<td>2.92</td>
</tr>
<tr>
<td>Easy to make the tool do exactly what we want</td>
<td>1.08</td>
</tr>
<tr>
<td>Accurate Result</td>
<td>1.15</td>
</tr>
</tbody>
</table>

Based on table 1, the feedback can be categorised into two: namely agree and undecided. No feedback goes to disagree group. Out of 20 questions, the respondents could not indicate the feedback in three questions which are take less time to learn the tool, less to read and less steps required. This is because WebCost deals with many parameters to be understand, to be read and to be entered.

Overall, the results show that respondents are satisfied with WebCost and they considered that WebCost is usable.

B. Comparison with Existing Tool

<table>
<thead>
<tr>
<th>CASE</th>
<th>COSTAR</th>
<th>Checkpoint</th>
<th>CCC</th>
<th>COCOMO II and Expert Judgment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Estimation Technique</strong></td>
<td>COCOMO II</td>
<td>COCOMO II</td>
<td>Expert Modelling</td>
<td>COCOMO II</td>
</tr>
<tr>
<td>Architecture</td>
<td>Mobility</td>
<td>Stand alone</td>
<td>Stand alone</td>
<td>Stand alone</td>
</tr>
<tr>
<td><strong>Project Size Parameter</strong></td>
<td>Source Line of Code</td>
<td>Line of Code</td>
<td>-</td>
<td>Source Line of Code</td>
</tr>
<tr>
<td>Include</td>
<td>Yes</td>
<td>Yes</td>
<td>-</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 2: Comparison with Existing Tool
Table 2 shows the comparison on estimation technique, architecture, project size parameter and reusability parameter of the estimation tool. Most of the model uses algorithmic model which is COCOMO II as estimation technique and were developed as a standalone application.

VI. CONCLUSION

This study focuses on developing cost estimation tool for web-based application. This tool (namely WebCost) is developed by using Java as the development language and Java Eclipse as the development tool. Besides, this study had also conducted a survey on current practices of software cost estimation process. The survey result shows that the current practice in cost estimation was done manually. It is hoped that by developing WebCost, project managers, students and those who are involved in cost estimating will benefit from it to produce accurate results in their work. It also considers the input of expert judgment in cost adjustment and reuse. The cost estimation tools engage the calculation of function point, cost adjustment and reuse. This information is needed in the calculation of effort, schedule and total cost for the project. In order to check for the validity and accuracy of WebCost, the usability evaluation and comparative analysis with other similar tools were conducted. The result shows that users are satisfied with WebCost because it provides the most accurate estimation. For future research, it is highly recommended that other cost estimating method is considered such as Price-to-Win as an added method to cost estimation for web-based application. Besides, we can apply web object or use case to define the effort in cost estimation. Also, another part that can be enhanced is to develop the tool in web-based architecture.

VII. REFERENCES


