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Software Engineering Cost Estimation using COCOMO II Model

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ABSTRACT

Estimating the software cost and price to customer is vital role for software engineering. Accurate Software development cost estimation is important for effective project management such as budgeting project planning and control. Before software development processes begin, software cost and duration for any project should be agreement between developers and customers.

In this paper, the effort required to develop the system, schedule needed to complete and the required average staff are estimated by using COCOMO (constructive cost model) model that is one of the algorithmic models. A mathematical formula is use to predict effort based on estimate of project size, thousands of sources of code (KSLOC). First, this KSLOC must be calculated for the exiting project or other projects. Then ,the require effort, duration and averaging staffing are continued to calculate for each of three types of projects which are organic, semi- detached and embedded All these estimates are implemented with Java Programming Language and Microsoft Access.

KEYWORDS: *COCOMO, KSLOC, Effort Estimation*

1. INTRODUCTION

Software cost estimation process becomes one of the biggest challenges and the most expensive component in software development. While software cost estimation may be simple in concept, it is difficult and simple in really. Software cost estimation involves the determination of one or more of the following estimates, effort (person-months), project duration (calendar time), and cost.

One of the famous models used to estimate the software effort, cost and schedule is the constructive cost model (COCOMO). The COCOMO cost estimation model is used by thousands of software project manager, and is based on a study of hundreds of software projects. The most fundamental calculation in the COCOMO model is the use of the Effort equation to estimates the number of person-months requires to develop a project. Most of COCOMO results including the estimate for requirements and maintenance are derived from this quantity. COCOMO calculations are based on the estimation of a project's size in source of line of code (SLOC). In the COCOMO II model, some of the most important factors contribution to a project duration and costs are Scale Drivers and Cost Derivers. The purpose of this paper is to estimate the software cost and schedule based on the effort required. COCOMO is constructed to establish a relationship between the cost and size of software. COCOMO was originally published in (COCOMO 81) [2], was developed with the assumption that a waterfall process would be used and that all software would be developed from scratch.

This paper is organized as follows; section2 describe related work and section 3 is background theory of the system. Section4 explain about the system implementation and Section5 present the conclusion.

2. RELATED WORKS

Software cost estimation is the process of preceding the effort required to develop a software engineering project. This project becomes one of the biggest challenges and the most expensive component in software development. The paper is implemented to estimate the software cost using COCIMO model. In this model, the require effort is primarily based on the estimate of the software project. (such as KSLOC)[9]. A simple size/productively formula is used to estimate the effort required. It is estimated by using effort adjustment factor derived from the cost drivers (EAF) five scale factors and thousands of sources of line of code(KSLOC) that is reported in Brand Clark, "COCOMO II"[8]. This paper also predicts the number of months require to complete the software project. The duration of a project is based on the effort predicted by the effort equation. For project duration, the schedule exponent is also used based on the three type of the project: organic project, semidetached project, embedded project. When the require effort and duration has been calculated, the system continues to predict the average number of the people required in one month for the project.

3. THEORETICAL BACKGROUND

Section 3 describes about background theory of the project. COCOMO model is presented as section 3.1 and COCOMO II models for the software market place sectors are discuss as section 3.2. The detail models are explained in the sub headings.

3.1. COCOMO Model
A number of algorithmic models have been proposed as the basic for estimating the effort, schedule and cost of a software project. These are conceptually similar but use different parameter values. In COCOMO model, the data from a large number of software projects were analyses to discover formulae. These formulae were the best fit to the observations. These formulae link the size of the system and product, project and team factors to the effort to develop the system.

3.2. COCOMO ll model
COCOMO ll model expresses the predicted effort in the unit of Person Months (PM).

Effort (PM)=A*Size $\prod_{i} EM_i$

Its input can be divided in to three class items, which are specific to the development process, and determine the value of the exponent. The formula 17effort multipliers (EM) related to the target software and to the development environment the estimated size of the software to be developed in unit of thousands of source lines of code (KSLOC). Here, the exponent is estimated by considering five scale factors. The factors are rated on a six-point scale from very low to Extra high.

3.3. Three Modes of Software Development
Table1. Three mode of software development

Project Mode	Average of Five Scale factors($\sum Sfi$)/5	Size
Organic Project	$\sum Sf_{i/5 \Leftarrow 2.37}$	$\Leftarrow$50KSLOC
Semi-Detached Project	$\sum Sfi/5 \Leftarrow 2.37$&& $\sum Sfi/5 \Leftarrow 3.37$	$\Leftarrow$300KSLOC
Embedded Project	$\sum Sfi/5 \Leftarrow 3.37$	Any size

COCOMO is applied with three classes of software projects: organic mode, semi-detached mode, embedded mode. Organic mode small software teams develop software in a highly familiar, in-house environment. Semi-detached Mode is intermediate between the organic and embedded modes. Embedded mode is needs to operate within tight constraints.

In this paper, if the value of average scale factors is less than or equal to 2.37, it is the organic project. If the average scale factors value is the range between 2.37 and 3.37, this project is specified as semi-detached project. Whereas, the average value which is greater than or equal to 3.37, is specified as embedded project.

To defied on each mode, the average of scales factors is specified with an appropriate value is shown in Table l COCOMO ll Effort Equation.

The most fundamental calculation is the COCOMO model is the use of the Effort Equation is estimate the number of the Person Months requires the development project. The COCOMO LL model estimates require effort (in Person Months PM), based primarily on estimates of the software project's size (KSLOC);

Effort=2.94*EAF*(KSLOC)^{E}…………(1)

In this paper assign with 2.94, EAF is the effort Adjustment Factor derived from the Cost Drivers. E is an exponent derived from the five Scale Drivers KSLOC, which is the size of project is the number of thousands of lines of sources code.

3.4. Project Duration
The COCOMO model includes a formula to estimate calendar time (Duration) require to complete a project. COCOMO ll also predicts the number of the methods required to complete the project is based on the effort equation. The time computation equation is

Duration = 3.67*(Effort)^{SE}…………(2)

In this equation, Effort is value gained from equation 1. SE is the schedule equation derived from Scale Drivers equation which based on these projects. SE values are 0.38 for organic project, 0.35 for Semi- detached project, and 0.32 for embedded project.

In the paper, some of the most important factors contributing to project duration and cost are the Scale Drivers that determine the exponent used in the effort equation.

The selection of Scale Driver is based on the rational that they are significant source of exponential variation on a project's effort on productivity variation each scale driver has a range of rating levels, from very low to Extra High. The weight values of these levels can be seen is Table 2.

W(i)	Very Low	Low	Normal	High	Very High	Extra High
PREC	4.05	3.24	2.46	1.62	0.81	0.00
FLEX	6.07	4.86	3.64	2.43	1.21	0.00
RESL	4.22	3.38	2.53	1.69	0.84	0.00
TEAM	4.94	3.95	2.97	1.94	0.99	0.00
PMAT	4.54	3.64	2.73	1.82	0.91	0.00

The cost drivers including 17 multiplicative factors that determine the effort required to complete software project. The effort multipliers can be derived into four categories Product, Computer, Personal and project.

Product performance can be measured with five factors. These are required system reliability (RELY), Complexity of system modules (CPLX), Extent of documentation (DOCU). Size of database used (DATA), Required percentage of reusable components (RUSE).

Using factor such execution time constraint (TIME), Volatility of development platform (PVOL), Memory constraint (STOR), can measure the performance of the computer. Personal performance can also be measured with five factors that are Capability of project analysts (ACAP), Personal continuity (PCON), Programmer capability (PCAP), Programmer experience in project domain (PEXP), Analyst experience in project domain (LTEX).

The factors that are use of software tools (TOOL), Development schedule compression (SCED), Extent of multisite working and quality of inter-site communications (SITE), can be used to measure the performance of project. The level of cost drivers with each category are expressed in Table 3. For example, in this project (Effort Estimation) the required software reliability cost driver is set to Very High. That rating corresponds to effort multiplier of 39.12.

Table 3.Rating and value cost driver

Size	Costing	Very Low	Low	Nominal	High	Very High	ExtraHigh
1	RELY	0.75	0.88	1.00	1.15	1.39	
2	DATA		0.93	1.00	1.09	1.13	
3	CPLX	0.75	0.88	1.00	1.15	1.30	1.66
4	RUSE		0.91	1.00	1.14	1.29	1.49
5	DOCU	0.89	0.95	1.00	1.06	1.13	
6	TIME			1.00	1.11	1.31	1.67
7	STOR			1.00	1.06	1.21	1.57
8	PVOL		0.87	1.00	1015	1.30	
9	ACAP	1.50	1.22	1.00	0.83	0.67	
10	PCAP	1.37	1.16	1.00	0.87	0.74	
11	PCON	1.24	1.10	1.00	0.92	0.84	
12	AEXP	1.22	1.10	1.00	0.89	0.81	
13	PEXP	1.25	1.12	1.00	0.88	0.81	
14	LTEX	1.22	1.10	1.00	0.91	0.84	
15	TOOL	1.24	1.12	1.00	0.86	0.72	
16	SITE	1.25	1.10	1.00	0.92	0.84	0.78
17	SCED	1.29	1.10	1.00	1.00	1.00	

4. System Design and Implementation

In this section, flow of the system is described in figure.1 and also explained with some example.

4.1 Overview of the System

Software cost estimation is the process of predicting the effort required to develop and software engineering project. COCOMO ll models, the calculation with algometric cost modeling method.

The software cost estimation for this project used COCOMO ll models which algometric cost modeling method.
In this paper, the user must first specify the KSLOC which is the size of lines of source code by entering or by choosing any project. Then required effort, time duration and average staffing are calculated by using KSLOC, scale factor and cost drivers extracted from database. The software effort estimation system design is Figure (1)

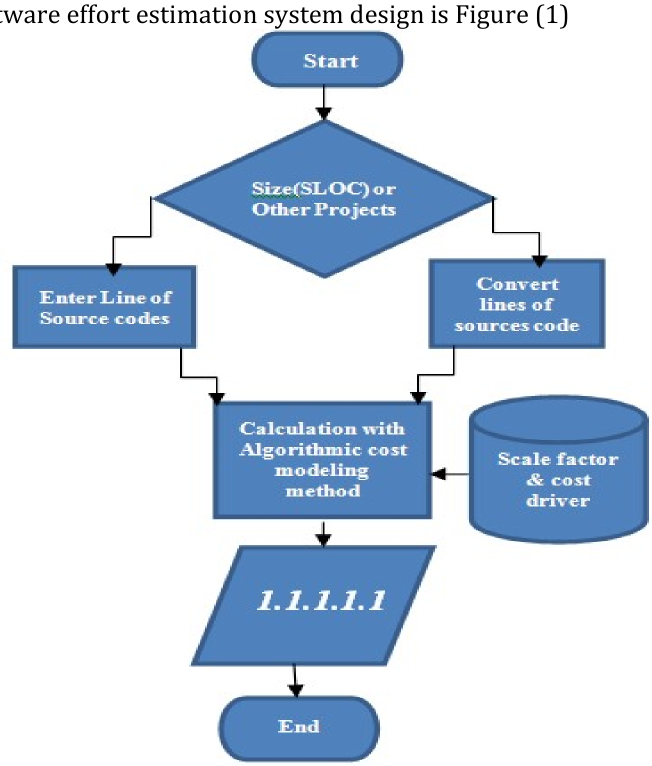

Figure1. System Design for the Software Estimation

In this paper, the software cost is estimated by using algorithmic cost models. Software cost considering person month (Effort), required time to complete the software project (Duration), and average staff, calculated according to the scale factor and cost driver are arrange from very extra high. The require time to complete the software project is also base on three projects which are organic project, semi-detached project, and embedded project.

The following experimental results are show with KSLOC which is 6647 for exiting project, and considering the nominal level for scale factors and drivers.

$Effort=2.94*EAP*(KSLOC)\ E$

$E=1.01+0.01*\Sigma SF_i$

$E=1.01+0.01*14.3=1.153$

$Effort= 2.94*1*(6647)1.153$

$=38.536$

For organic project: Duration=3.67*(Effort)SE
=3.67*(38.536)0.38
=14.699

Average staffing=Effort/Duration
=2.621

For semi-detached project:
Duration=3.67*(Effort)SE
=3.67*(38.536)0.35
=13.174

Average Staffing=Effort/Duration
=2.925

For Embedded project:
Duration=3.67*(Effort)SE
=3.67*(38.5360)0.32
=11.809

Average Staffing=Effort/Duration
=3.2364

4.2. Advantages and Limitations
According to this paper, project managers, business analysts and team leaders can easily estimate effort required, the development time person per month to develop by saving time and cost. They can contract customers depending on their prices and requirements. Moreover, any exiting project can easily be converted to lines of sources code which is used in software cost estimation.

However, the user must know the knowledge of the software and what the cost of software is, must specified the weight value of scale factors and cost drivers. So, this project is not intended normal users. This paper cannot estimate the cost of individual level of COCOMO ll, is the overall. Furthermore, this paper is tested with only Java langue and Access 2003, cannot permit with another.

5. CONCLUSION
The accurate prediction of the software development is critical for the good management decision and accurately determining how much effort and require time for the project to complete as well as system analysts and developers. This paper estimates the effort (person-months), and the project schedule that the time required to complete is estimated and the average staffs per month is also calculated.

In this paper, the existing project called "Effort Estimation '' is used for the case study to count the lines of source code. For this project, the system must specify the levels of the scale factors and cost drivers and counts the total lines of sources code(SDLOC).

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