

A CHANGE EFFORT ESTIMATION MODEL  
USING IMPACT ANALYSIS  
FOR THE SOFTWARE DEVELOPMENT PHASE

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A CHANGE EFFORT ESTIMATION MODEL  
USING IMPACT ANALYSIS  
FOR THE SOFTWARE DEVELOPMENT PHASE

MEHRAN HALIMI ASL

A master project report submitted in partial fulfillment of the  
requirements for the award of the degree of  
Master of Software Engineering

Advanced Informatics School  
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JANUARY 2013

## DECLARATION

I declare that this project report entitled “A CHANGE EFFORT ESTIMATION MODEL USING IMPACT ANALYSIS FOR THE SOFTWARE DEVELOPMENT PHASE” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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## **DEDICATION**

To my beloved parents

## **ACKNOWLEDGEMENT**

In preparing this project report, both my academic and industrial mentors have helped me a lot. I wish to express my sincere appreciation to my academic mentor Dr Mohd Naz'ri Mahrin for his kind guidance, critics and encouragements; and my industrial mentor Dr Mohd Nazri Kama for his guidance, advices and motivation. Without their continued support and interest, this project would not have been the same as presented here.

My sincere appreciation also extends to all lecturers and staff in AIS faculty; Librarians at UTM; my fellow postgraduate students for their support and assistance. Unfortunately, it is not possible to list all of them in this limited space. I am also grateful to all my friends and family members.



## **ABSTRACT**

Change effort estimation and change impact analysis are two important methods for realizing the consequences of requested changes and make effective change acceptance decisions. Accepting too many changes in the software development phase causes additional cost and delay in the completion. On the other hand, rejection of the changes may cause customer dissatisfaction. There are very few works have been done to support effective change decisions in the software development phase compared to the software maintenance phase. The challenge of estimating the change effort in the software development phase is the existence of partially developed artifacts. In this report, we reviewed two selected current techniques; change impact analysis for the software development phase; and the well-known effort estimation model (COCOMO II). Afterwards, we introduced our new change effort estimation model for the software development phase which we name as COCHCOMO (Constructive Change Cost Model). It is developed to estimate change effort using impact analysis and initial COCOMO II estimated effort. Additionally, a prototype tool is developed to support our new model. The implementation of our model has been used to evaluate the accuracy of the model. The initial evaluation results on four case studies showed that this model is accurate.

## ABSTRAK

Perubahan anggaran usaha dan perubahan analisis impak adalah dua kaedah penting untuk mengenalpasti kesan perubahan yang diperlukan dan membuat keputusan penerimaan perubahan yang berkesan. Menerima terlalu banyak perubahan dalam fasa pembangunan perisian menyebabkan kos tambahan dan kelewatan dalam penyiapan. Sebaliknya, penolakan perubahan boleh menyebabkan rasa tidak puas hati pelanggan. Terdapat sangat sedikit kerja-kerja yang telah dilakukan untuk menyokong keputusan perubahan yang berkesan dalam fasa pembangunan perisian berbanding dengan fasa penyelenggaraan perisian. Cabaran menganggarkan usaha perubahan dalam fasa pembangunan perisian adalah kewujudan sebahagian artifak yang dibangunkan. Dalam laporan ini, kita mengkaji dua teknik semasa; perubahan analisis impak bagi fasa pembangunan perisian; dan terkenal dengan nama usaha anggaran model (COCOMO II). Selepas itu, kita memperkenalkan model baru perubahan anggaran usaha bagi fasa pembangunan perisian yang dinamakan sebagai COCHCOMO (Constructive Change Cost Model). Ia dibangunkan untuk menganggarkan usaha perubahan menggunakan analisis impak dan usaha anggaran awal Cocomo II. Selain itu, alat prototaip dibangunkan untuk menyokong model baru kami. Pelaksanaan model ini telah digunakan untuk menilai ketepatan model. Keputusan penilaian awal ke atas empat kajian kes menunjukkan bahawa model ini adalah tepat.

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## LIST OF ABBREVIATIONS

AIS	-	Actual Impact Set
AT	-	Affect Type
BFS	-	Breadth-first Search
CDF	-	Class Dependency Filtration
CDG	-	Class Dependency Graph
CIAT	-	Change Impact Analysis Tool
CIP	-	Class Interactions Prediction
CIP-IPF	-	Class Interactions Prediction with Impact Prediction Filters
CIS	-	Candidate Impact Set
CM	-	Change Management
COCHCOMO	-	Constructive Change Cost Model
COCOMO	-	Constructive Cost Model
CR	-	Change Request
CTF	-	Change Type Factor
DAG	-	Directed Acyclic Graph
DBDD	-	Database Design Description
DFS	-	Depth-first Search
DIS	-	Discovered Impact Set
FP	-	Function Point
FPIS	-	False Positive Impact Set
IA	-	Industrial Attachment
IAM	-	Impact Analysis Module
IC	-	Impacted Class
IPF	-	Impact Prediction Filters

ISF	-	Impact Size Factor
LOC	-	Lines of Code
MDA	-	Method Dependency Addition
MDF	-	Method Dependency Filtration
MRE	-	Magnitude of Relative Error
NR	-	Number of relations
RE	-	Relative Error
RUP	-	Rational Unified Process
SCM	-	Software Change Management
SDD	-	Software Design Description
SDLC	-	Software Development Life Cycle
SDP-CIAF	-	Software Development Phase Change Impact Analysis Framework
SIS	-	Starting Impact Set
SLOC	-	Source Lines of code
SRS	-	Software Requirements Specification
UML	-	Unified Modeling Language



# **CHAPTER 1**

## **PROJECT OVERVIEW**

Software undergoes changes not only in the requirement phase, but also throughout the software development phase. Changes could happen at all stages of software development life cycle (SDLC). Accepting too many changes causes additional cost and delay in the competition. On the other hand, rejection of the changes may cause customer dissatisfaction. Consequently, it is essential for the software project managers to make effective decisions on change acceptance during software development to keep the evolving needs of the customer satisfied.

Impact analysis and effort estimation are two types of information to help make more effective decisions, by knowing the potential consequences of a software change. It is critical for the risk analysis, developer effort estimation, and regression testing of evolving software to have the prediction of the effects done to the software by the change, or change impact analysis.

## 1.1 Project Background

The main goal of impact analysis is to detect the consequences or the effects of proposed project changes. It identifies the potential consequences of a change and estimates what should be modified to implement that change (Arnold and Bohner, 1993). Basically there are two categories impact analysis techniques, which are static analysis and dynamic analysis techniques. The static analysis technique develops a set of potential impacted classes by analyzing program static information that is generated from software artifacts (i.e., requirement, design, and test artifacts). On the contrary, dynamic analysis technique develops a set of potential impacted class by analyzing program dynamic information or executing code.

To predict the cost of a change with respect to required effort; the required effort must be estimated for a typical project where the change is not introduced and for a typical project where the change is introduced. This means that the required effort must be estimated for a number of sub-processes where we do not have any experience.

Software effort estimation is the process of predicting the most accurate amount of effort required to develop or maintain software based on a large number of variables. Surveys indicate that the average effort overrun of software projects seems to be in the range 30 to 40 percent (Molokken and Jørgensen, 2003). Because of these inaccuracies, software project managers find it difficult to trust the effort estimation results. Further studies (Jørgensen and Molokken, 2004) show that, the most important reasons of inaccurate effort estimation result are change request in requirement specification, and not enough effort for the estimation process. Moreover, Jørgensen and Molokken-Ostvoldstudy (2004) study suggests that the most effective way of increasing the accuracy of effort estimation is to have flexibility on implementation of requirement specifications; and correspondingly having a better respond to change will increase the effort estimation accuracy.

Based on these complications, some researches have been done to improve the techniques of both impact analysis and effort estimation, but formerly effort estimation has been done independently from impact analysis. Now in this project, we want to identify the most practical impact analysis and change effort estimation techniques for the software development phase; integrate them into a unified technique; and at last, implement this technique in a change acceptance analysis tool.

## 1.2 Problem Statement

The decision of accepting or rejecting change requests has always been a complex process. This decision would be more uncertain during the software development, because of the large number of variables under dynamically changing requirements. Many software project managers have failed to reach a reliable decision on change acceptance during the software development phase. Chua *et al.* (2008) study underscores the risks of not having an effective cost estimation model. Moreover, Chua (2010) stated that a tool supported change effort estimation model is a solution for current software change risks.

Effort estimation and impact analysis are two of the important processes to support the decisions of software project managers. The challenges with the current effort estimation techniques are that first their results have to be revised each time a change in the requirements happens; and second, change effort estimation should have a method to accurately estimate the software size after the change is implemented. One method to estimate the software size after change is to use change impact analysis results. However, current impact analysis techniques do not provide effort estimation with all the information it needs for estimating the software size. In other words, lack of association of impact analysis with effort estimation may decrease the usefulness and effectiveness of both effort estimation and impact analysis results for change acceptance decisions in the software development phase.

### **1.3 Research Question**

The main goal of this project is to find a solution to develop a new change effort estimation model which can predict the required change effort and impacts of software change requests in the software development phase; towards more useful and effective change acceptance decision.

Accordingly, this project deals with the main research question of “How to improve the change approval decisions for changes in the software development phase by predicting the required change effort and change impacts”. To provide an effective solution for the main research question, several sub-questions are constructed:

- 1) What are the current techniques for software change impact analysis and change effort estimation in the software development phase?
- 2) How to formulate new change effort estimation model using impact analysis in the software development phase?
- 3) How to implement the new change effort estimation model in an automated software tool?

### **1.4 Project Objectives**

This project has four objectives as below:

- 1) To identify and review an effort estimation model and a change impact analysis technique for the software development phase.
- 2) To formulate a new change effort estimation model for the software development phase.
- 3) To develop a tool to support the new change effort estimation model.
- 4) To evaluate the new change effort estimation model.

## 1.5 Project Scopes

The scopes of this project are as follow:

- 1) For reviewing, the concepts related to effort estimation and impact analysis shall be studied. Five impact analysis techniques shall be studied and compared; however, only the techniques which are specifically developed for the software development phase shall be examined with detail.
- 2) An impact analysis technique and a technique for effort estimation shall be identified, which are both applicable for development phase and are able to be combined into one change impact analysis technique. These two techniques shall be formulated into a new unified technique.
- 3) For developing the prototype tool, three-layer software architecture shall be used. The focus shall be on performing effort estimation as well as static & dynamic impact analysis on the developed class interaction prediction model (CIP); but not creating the CIP.
- 4) In this project, Software Requirements Specification, Software Design Document, and Database Design Description shall be developed as the software engineering documents. The documents shall use IEEE software standard documentations and formations.
- 5) For evaluation, an analysis method needs to be provided that can be used to measure the accuracy of the prototype tool.

## 1.6 Project Plan

This project will be implemented in three stages sequentially and in totally eight months. The stages are: “IA1”, “IA2”, and “Master Project Report”, and all the research and software development activities will be completed in IA1 and IA2 stages. During IA1, the background research on the research objectives will be

performed, and the first three chapters of the project report plus the initial findings and conclusions will be prepared. In IA2, the new model shall be developed, implemented and evaluated. At last in Master Project Report stage, the final project report will be prepared. Table 1.1 shows the schedule of phases in this project. For reviewing details of the project plan, please refer to the Appendix A.

**Table 1.1 : Master project plan**

Phases	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Inception Phase	■							
Elaboration Phase 1st Iteration		■	■	■				
IA1 Project Report Preparation	■	■	■					
Elaboration Phase 2nd Iteration				■				
Construction Phase 1st Iteration					■	■		
Construction Phase 2nd Iteration							■	
Transition Phase							■	
IA2 Project Report Preparation				■	■	■	■	■
Master Project Report								■

## 1.7 Significant Contribution

Our work in this research will contribute to the software change management and software change impact analysis by creating a new change effort estimation model. This model integrates change effort estimation with impact analysis for the software development phase. It is expected that this new technique will be able to develop accurate and effective effort estimation results; which will help the software project managers to make more reliable change approval decisions, and therefore reduce the cost of software development.

## 1.8 List of Deliverables

The deliverables for this project are as below:

- 1) Log Book
- 2) Master Project Report
- 3) Prototype Change Effort Estimation Tool
- 4) Prototype Change Effort Estimation Tool Source Code <sup>1</sup>
- 5) Software Requirements Specification (SRS)
- 6) Software Design Document (SDD)
- 7) Database Design Description (DBDD) <sup>2</sup>

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<sup>1</sup> The software and its source code of this tool are available in the CD attached to this document.

<sup>2</sup> SRS, SDD, and DBDD documents are also available in the attached CD.