

**AN ENHANCEMENT OF SLICING TEST ALGORITHM FOR INTEGRATION
TESTING OF EMBEDDED SYSTEM**

AHMED SHEIKH ABDULLAHI MADEY

A dissertation report submitted in partial fulfillment of the
requirements for the award of the degree of
Master of Science (Computer Science)

Faculty of Computing
Universiti Teknologi Malaysia

MAY 2014

I declare that this dissertation report entitled “An Enhancement of Slicing Test Algorithm for Integration Testing of Embedded System” is the result of my own research except as cited in the references. The dissertation report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : Ahmed Sheikh Abdullahi Madey

Date : 18 May 2014

This dissertation is dedicated especially to my beloved parents and also not forgetting my beloved brothers and sisters for their endless supports and encouragements.

ACKNOWLEDGEMENT

In preparing this dissertation report, I wish to express my sincere appreciation to my supervisor Assoc.Prof. Dr. Dayang Norhayati Binti Abang Jawawi for the guidance, advice and encouragement during my studying. The support and suggestion that Assoc.Prof. Dr. Dayang gives inspired me to going through in this dissertation.

Finally my special thanks to my parents for their love and care for their support and cheering me up at those difficult time.

ABSTRACT

The complexity of testing the software of Component Based Software Development (CBD) for Embedded Real Time (ERT) software development highlight the challenges of designing, analyzing and testing ERT software. From this standpoint, the complexities of CBD for ERT in software testing require suitable software algorithms. Against these claims, a number of software testing algorithms have been formulated such as slicing algorithm, incremental algorithm, firewall algorithm, genetic algorithm as well as simulated annealing algorithm. Generally, not all of these algorithms support CBD and ERT software testing of the system. By applying slicing algorithm into ERT software testing, the complexity of ERT software development can be decreased and at the same time promote high degree of reuse through software testing based on component behavior. Currently, testing algorithm based on slicing does not directly support ERT software. In this research, the integration testing algorithm for CBD and ERT system has been proposed to represent a promising way to test ERT software in terms of algorithm refinement. The slicing algorithm called slicing architectures using service edges (SASE) has been enhanced to support a component oriented programming (COP) framework for CBD and ERT integrated system. The results shows that COP framework can be applied into SASE algorithm definitions and it has been mapped with the SASE algorithm based on the similarities and differences definitions. Thus, the quality of the enhanced SASE algorithm is better in terms of algorithm criteria based on Normative Information Model-based Systems Analysis and Design (NIMSAD) evaluation in support of ERT and CBD.

ABSTRAK

Kerumitan yang terdapat semasa menguji perisian Komponen Berdasarkan Pembangunan Perisian (CBD) untuk Masa Nyata Terbenam (ERT) menunjukkan cabaran-cabaran dalam mereka-bentuk, menganalisa, dan menguji perisian ERT. Dari pandangan ini, kerumitan yang terdapat pada CBD untuk ERT memerlukan algoritma perisian yang sesuai. Pada tuntutan ini, beberapa algoritma ujian perisian telah dirumuskan seperti algoritma penghirisan, algoritma penambahan, algoritma firewall, algoritma genetik dan juga algoritma penyepuhlindapan. Pada amnya, tidak semua algoritma-algoritma ini menyokong sistem ujian perisian CBD dan ERT. Dengan mengaplikasikan algoritma penghirisan ke dalam ujian perisian ERT, kerumitan pada pembangunan perisian ERT boleh dikurangkan dan pada masa yang sama menggalakkan penggunaan semula pada tahap yang tinggi menerusi ujian perisian berdasarkan perilaku komponen. Pada masa kini, algoritma ujian berdasarkan penghirisan tidak menyokong perisian ERT secara langsung. Di dalam kajian ini, integrasi ujian algoritma untuk sistem CBD dan ERT telah dicadangkan untuk menunjukkan cara yang lebih berpotensi untuk menguji perisian ERT di dalam istilah penghalusan algoritma. Algoritma penghirisan telah ditingkatkan untuk menyokong rangka kerja pengaturcaraan berorientasikan komponen (COP) untuk sistem integrasi CBD dan ERT. Hasil menunjukkan bahawa COP boleh digunakan di dalam definisi algoritma SASE dan telah dipetakan dengan SASE algoritma berdasarkan definisi persamaan dan perbezaan. Oleh itu, kualiti algoritma SASE yang ditingkatkan adalah lebih baik dari segi algoritma berdasarkan kriteria dan Normatif Maklumat Sistem Analisis dan Reka bentuk berdasarkan Model (NIMSAD) untuk menyokong ERT dan CBD.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xi
	LIST OF FIGURES	xii
1	INTRODUCTION	
	1.1 Overview	1
	1.2 Problem Background	4
	1.2.1 CBD Software Integration Testing	6
	1.3 Problem Statement	8
	1.4 Research Aim	8
	1.5 Objectives of the Research	9
	1.6 Scope of the Research	9
	1.7 Significance of the Research	9
	1.8 Thesis Organization	10
2	LITERATURE REVIEW	
	2.1 Introduction	11
	2.2 Software Test	11
	2.2.1 ERT Software Testing	13

2.3	Component Based Software Development	16
2.4	The Test Level of CBD for ERT	18
2.4.1	Component Testing	19
2.4.2	Integration Testing	24
2.5	Testing Algorithms of CBD and ERT	26
2.6	Comparative Evaluation of CBD Testing Algorithms for ERT System	29
2.7.1	Slicing Member Functions	34
2.7.2	Overview of the Original Slicing Algorithm	35
2.8	Component Oriented Programming Overview	44
2.8.1	Component Development	45
2.8.2	Component Integration	46
2.9	Discussion and Summary	49

3**RESEARCH METHODOLOGY**

3.1	Introduction	50
3.2	Research framework and Processes	50
3.2.1	Phase One	53
3.2.2	Phase Two	53
3.2.3	Phase Three	54
3.2.4	Phase Four	55
3.2.5	Phase Five	56
3.3	Case Study	57
3.3.1	An Autonomous Mobile Robot Case Study (AMR)	57
3.3.2	Wheelchair Motor Control	60
3.4	Summary	61

4	THE ENHANCEMENT OF TESTING ALGORITHM BASED ON SLICING FOR COP	
4.1	Introduction	62
4.2	The Mapping of Slicing Algorithm and Component Oriented Programming	62
4.3	Adapting COP for SASE Algorithm	66
4.4	Applying the Enhanced SASE Algorithm Phases to Wheelchair Case Study	74
4.4.1	WCH Architectural Components	82
4.4.3	Slicing Integration Testing Algorithm for WCH Components	83
4.5	Summary	84
5	THE VALIDATION OF THE ENHANCED SASE TEST ALGORITHM	
5.1	Overview	85
5.2	Applying the Enhanced SASE Algorithm Phases to AMR Case Study	85
5.3	Applying the Original SASE Test algorithm On AMR	94
5.4	The Evaluation of Enhanced SASE	101
5.5	Summary	105
6	CONCLUSION AND FUTURE WORK	
6.1	Introduction	106
6.2	Summary	106
6.3	Research Contribution	107
6.4	Future Work	109
REFERENCES		111