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AN ENHANCED WEIGHTED METHOD WITH UNIQUE PRIORITY VALUE FOR TEST CASE PRIORITIZATION IN REGRESSION TESTING

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By

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

AN ENHANCED WEIGHTED METHOD WITH UNIQUE PRIORITY VALUE FOR TEST CASE PRIORITIZATION IN REGRESSION TESTING

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Chairman : Salmi Baharom, PhD
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Regression testing is an important and expensive strategy in software testing. To reduce its cost, many methods were proposed including test case prioritization methods. The aim of prioritization methods is to define an ideal order of test cases that allows higher coverage and early fault detection with minimal amount of executed test cases. However, the problem with most of the existing test case prioritization methods is the random sorting of test cases when two or more test cases record equal priority values. In this research, an enhanced weighted method using unique priority value UniVal to prioritize test cases is presented. The proposed method combines five code coverage criteria with the order of test cases from the previous execution session to generate unique priority values. In addition, a controlled experiment was executed and results statistically analyzed to evaluate the effectiveness of the proposed method. The results show an improved performance in terms of prioritizing test cases and achieving higher APFD values. In future, a tool to automate the operation of UniVal would be developed and more experiments would be performed.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

SATU KAEDAH BERPEMBERAT DIPERTINGKAT UNTUK PRIORITI KES UJIAN DALAM PENGUJIAN REGRESI MENGGUNAKAN NILAI PRIORITI UNIK

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Abstrak Pengujian regresi adalah strategi penting dan memerlukan kos yang tinggi dalam pengujian perisian. Pelbagai kaedah telah dicadangkan bagi mengurangkan kos termasuk menggunakan kaedah kes ujian pengutamaan. Matlamat kaedah pengutamaan adalah bagi menentukan urutan kes ujian yang ideal yang membolehkan liputan yang lebih tinggi dan pengesanan kesalahan lebih awal. Walau bagaimanapun, masalah dengan kebanyakan kaedah pengutamaan kes ujian yang sedia ada adalah pengambilan ujian secara rawak apabila dua atau lebih kes ujian mempunyai nilai keutamaan yang sama. Penyelidikan ini membentangkan peningkatan kaedah pemberat menggunakan nilai keutamaan yang unik, iaitu UniVal, untuk mengutamakan kes ujian. Kaedah yang dicadangkan ini menggabungkan lima kriteria liputan kod termasuk susunan kes ujian dari sesi pelaksanaan sebelumnya, untuk menghasilkan nilai UniVal. Kajian terkawal bagi menilai keberkesanan kaedah UniVal ini telah dilaksanakan dan hasilnya dianalisis secara statistik. Hasil kajian ini menunjukkan prestasi yang lebih baik dari segi mengutamakan kes ujian dan mencapai nilai APFD yang lebih tinggi. Pada masa akan datang, satu sistem pengoperasian UniVal secara automatik akan dibangunkan dan lebih banyak percubaan boleh dilakukan.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Software testing is the process of validating and assessing the functionality of a software product. It has been proven that testing, analysing, and debugging would normally cost over 50% of the cost related to the development of large software (Beizer, 1990). Therefore, regression testing ought to be an essential phase of software testing. It deals with the changes that are often dynamic during software development life cycle. To enhance the efficiency of regression testing, three major methods have been considered by researchers in this field. They are test case selection, test case minimization, and test case prioritization. Test case selection attempts to detect test cases that are related to the recent changes while test suite minimisation strives to eliminate redundant test cases to decrease the number of test runs. Test suite minimisation mainly concentrates on metrics; for example, coverage recorded from a particular version of program under test (Yoo & Harman, 2012). Both approaches are working on picking a subset of test cases from the test suite. The main difference between the two is whether the concentration is upon the changes in the program.

Neglecting some test cases that could find faults will reduce the effectiveness of regression test. This explains an increased attention on developing test case prioritization techniques. According to the survey of Yoo and Harman (2012), the field of regression testing approaches continues to grow between 1977 and 2009, and the importance of test case prioritization has gradually risen since the late 90s. For this reason, researchers have developed many techniques, algorithms, and methods to prioritize test cases (Yadav & Dutta, 2017), (Tanwani & Waghire, 2016), (Wang & Zeng, 2014), (Hashini & Varun, 2014), (Kaur & Mahajan, 2014), (Muthusamy & Seetharaman, 2013), (Korel et al., 2007). These techniques rank test cases based on specific criteria, to increase the probability of fault uncovering in early phases of testing. According to Roongruangsuwan and Daengdej (2010), prioritization techniques fall into four main categories: customer requirements based techniques, coverage-based techniques, cost effective-based techniques, and chronographic history-based techniques.

Customer requirements based techniques concentrate on the customer requirements that have been documented during requirement collection phase. The factors that are used in the techniques are assigned property of customer (CP), complexity of requirement (RC), and volatility of requirement (RV). Besides that, coverage-based techniques deal with maximizing the coverage in different aspects such as requirement coverage and statement coverage. According to Badwal and Raperia (2013), most research used code coverage information to develop prioritization techniques. Cost effective approaches required the cost to be diminished in general. Cost may include

the requirement collection cost, regression testing cost, execution and authenticating cost of test cases. In the history-based approach, the behaviour of test cases in previous testing sessions whether increases or decreases is of importance in the current session.

In spite of the differences in factors, test case prioritization techniques calculate the value or the weight of all test cases and use these values to decide which test case should be executed first.

1.2 Research motivation

The importance of software testing in Software Development Life Cycle (SDLC) motivates many researchers to conduct research in this field. The number of research papers on regression testing has been gradually growing and many challenges have been faced by researchers in this area. The selection of test case prioritization results from the ranking of executing test cases affects: (1) the rate of fault detection, and (2) the rate of code coverage. A good ranking of the test cases reveals faults earlier and gives satisfactory confidence in the system reliability. It also meets the required coverage level with a minimal amount of executed test cases. Since the faults revealed by a test case are unknown until the test case is executed and its output is evaluated, the need for a good test case prioritization technique is raised.

1.3 Research Problem

Most of the existing prioritization methods, regardless of their ranking criteria, share a common issue that should not be neglected. As these methods calculate the value or weight of test cases, some test cases might hold equal values. To deal with this issue, most references choose the random technique. Rothermel et al. (2001a) states: "When multiple test cases cover the same number of statements, the additional strategy is necessary to select one of these test cases, generally by random selection". Roongruangsuwan and Daengdej (2010) stated that "existing techniques randomly prioritize all test cases with the same weight values, without any systematic algorithm". However, this random approach is known as the least effective approach in revealing faults. (Felderer & Fourneret, 2015), (A. Kumar & Singh, 2014), (Muthusamy & Seetharaman, 2014), (Gupta et al., 2012), (Roongruangsuwan & Daengdej, 2010).

A key question arises at this point: *Does it important to look for alternative method to prioritize test cases with equal weights?* The answer to the question is that a random sorting may not have noticeable effect on small test suite. However, larger test suites mean the probability of more test cases have equal weights will reduce the effectiveness of the prioritization algorithm in case of using random sorting. Therefore, Several researchers including Gupta et al. (2012) and Roongruangsuwan & Daengdej (2010) proposed additional procedures to sort out these test cases that have

the same priority values. Unfortunately, these proposed techniques are complex and still have the possibility to generate the same priority values.

1.4 Research Objectives

The objective of this research is to propose a method to prioritize test cases based on unique priority value and to enhance the effectiveness of the weighted method of Prakash (2013) in terms of the average percentage of coverage.

1.5 Research Scope

This thesis concentrates on test case prioritization in regression testing. Test case prioritization has been discussed in the literature and many prioritization procedures have been proposed. However, one issue remains with most of the existing prioritization methods is in dealing with multiple test cases with equal weight values. Hence, this study discusses the issue by providing a detailed literature review, proposing an enhanced weighted method for test cases prioritization using unique priority value, UniVal. The proposed method focuses on two factors: code coverage and history of test cases. Under the code coverage factor, five criteria, which employed by UniVal, are statement coverage, function coverage, branch coverage, path coverage, and fault coverage. Moreover, the order of test cases from the last execution is used to generate unique priority values. Thus, the order of test cases from previous execution assists in prioritization of test cases in the current session in collaboration with the five code coverage criteria mentioned above.

1.6 Organization of the Thesis

This chapter provides an overview of the research by identifying the problem and the situations in which the problem manifests itself. Then, the research objective and scope are defined to explicitly set the course of the research. The next chapters of the thesis are structured as follows:

Chapter II presents the background information on the issues of multiple test cases with equal weights that provide crucial inputs to this research and consequently leads to the formulation of the thesis.

Chapter III discusses the research methodology used in this study which includes the research design and process of the experiment.

Chapter IV describes the design of the enhanced weighted method. This chapter also explains the algorithm for generating unique priority values and highlights the difference between the weighted and enhanced weighted methods.

Chapter V describes the experimental procedure for enhanced weighted method in terms of its effectiveness by comparing it with the weighted method. A statistical test, paired t-test has been employed to measure the significance differences between the methods under comparison.

Chapter VI concludes the thesis with a general discussion of the research outcomes, research contributions and suggestions for further research.

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