



**UNIVERSITI PUTRA MALAYSIA**

***ARCHITECTURAL DESIGN METRICS AS INDICATORS OF  
CHANGEABILITY OF COMPONENT-BASED SOFTWARE SYSTEMS***

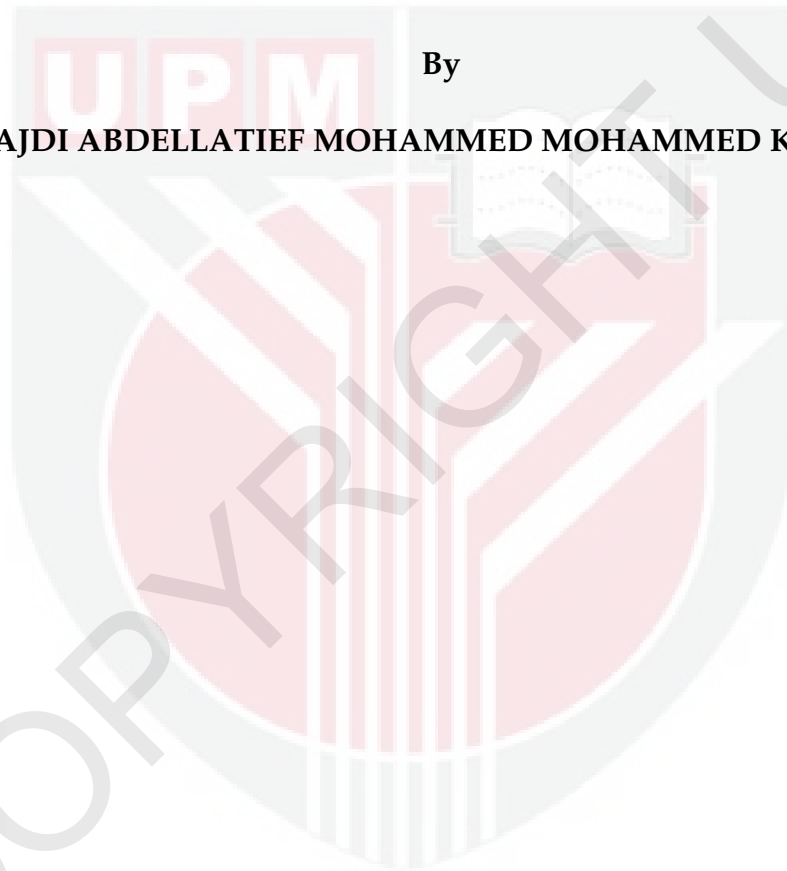
**MAJDI ABDELLATIEF MOHAMMED MOHAMMED KHAIR**

**FSKTM 2012 30**

**ARCHITECTURAL DESIGN METRICS AS INDICATORS OF  
CHANGEABILITY OF COMPONENT-BASED SOFTWARE SYSTEMS**

By

**MAJDI ABDELLATIEF MOHAMMED MOHAMMED KHAIR**



**Thesis Submitted to the School of Graduate Studies, Universiti Putra  
Malaysia, in Fulfillment of the Requirements for the Degree of  
Doctor of Philosophy**

**May 2012**

## DEDICATION

to:

My Mother,

Your love is always with me no matter where I go.

My Father,

You enlighten me to do all right things and only the right,  
reminding me that there can be no gain without pain.

My Brother,

Your unconditional support is treasured for always.

My wife,

For all that you have been, for all that you are and will always be,  
I am grateful.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

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CHANGEABILITY OF COMPONENT-BASED SOFTWARE SYSTEMS**

**By**

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**May 2012**

**Chairman: Abu Bakar Md Sultan, PhD**

**Faculty: Computer Science and Information Technology**

Component-based Software Development (CBSD) aims at designing and building a system using pre-existing components. CBSD is employed to reduce lifetime process, development costs and to increase the quality of the software. However, component-based software system (CBSS) developed by CBSD must be designed not only to meet the current customer requirements, but also to be receptive to future changes. Usually, designers may not know what the future state looks like. Thus, most often, one or more components of the system may need to be modified. This modification may be compromised by changing reusable software components, but perhaps the system architecture comprises components or interfaces that are difficult to change. The need for changeability keeps on increasing as technology evolves and there are changes that take place after a software system becomes operational, thus affecting maintenance routine. An essential method for

managing and controlling such processes is to develop metrics as an indicator of changeability. Previous researches conducted on CBSD metrics have concentrated extensively on the assessment of complexity, reusability and dependency attributes for integration of software components. However, the literature still lacks appropriate metrics for measuring changeability attributes of component-based software system (CBSS). For this reason, the aim of this research was to propose measurements that allow designers to assess the changeability of CBSS architectures.

In this research, the relationships between components and size of components were considered as major factors affecting CBSS architectural design. Component information flow-based measures and multidimensional approach were used to handle each factor respectively. Three sets of metrics namely, Component Information Flow Complexity (CIFC), Component Coupling (CC), and Multidimensional Design Size Measures (MDSM) were proposed as indicators of changeability of CBSS architectural design. Two types of evaluation were used to validate the proposed approaches. While the theoretical validation study was conducted based on Briand's framework, the empirical validation study was tested under controlled experimental conditions based on eighteen components. Further study was also conducted to help the practical application of the proposed metrics.

The theoretical evaluation results indicated that the proposed metrics are theoretically sound and valid internal measures. The empirical results show that the proposed metrics have a positive statistical significant relationship with changeability attribute. The results of the application demonstrated the intuitiveness of the said approach. The overall results indicate that the proposed metrics can be used as indicators of changeability of CBSS architectural design. These measurements were proposed in the light of an extensive systematic literature review conducted by the researchers. Therefore, when the metrics are used in the context, we believe that the results of the metrics will be quite rich in identifying some architectural design problems. The results obtained from the theoretical and empirical evolution of the proposed metrics are of great significance and worth consideration for further research in the field.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**PENGUKURAN REKABENTUK SENIBINA INDIKATOR  
KEBOLEHUBAHAN SISTEM PERISIAN BERASAS KOMPONEN**

Oleh

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Pembangunan sistem berasaskan komponen (CBSD) bermatlamat mereka bentuk dan membina sistem menggunakan komponen sedia wujud. CBSD dipakai untuk mengurangkan masa proses pembangunan, mengurangkan kos dan meningkatkan kualiti perisian. Bagaimanapun sistem yang dibangunkan oleh CBSD bukan saja perlu memenuhi keperluan pengguna semasa tetapi juga boleh menerima perubahan dimasa hadapan. Biasanya pereka sistem tidak boleh meramal perubahan masa depan yang mungkin berlaku. Oleh itu, kebiasaannya beberapa komponen mungkin perlu diubah dimasa hadapan. Perubahan ini boleh berlaku dengan mengubah komponen perisian guna semula, tetapi mungkin komponen senibina sistem atau antaramuka sukar diubah. Keperluan untuk kebolehubahan semakin meningkat bila berlaku perubahan teknologi dan rutin senggaraan yang dijalankan selepas sistem dilaksanakan. Kaedah yang sesuai untuk

mengurus dan mengawal proses-proses seperti ini adalah membangunkan metrik yang secara extensive menjurus untuk menilai kekompleksan, kebolehgunaan semula dan pengantungan atribut-atribut untuk mengintegrasikan komponen perisian. Bagaimanapun, masih kekurangan literatur berkaitan metrik bersesuaian untuk mengukur kebolehubahan atribut Sistem perisian berasaskan komponen (CBSS). Atas sebab ini, matlamat penyelidikan ini adalah mengusulkan pengukuran yang membolehkan pereka-pereka untuk menilai kebolehubahan senibina CBSS.

Dalam penyelidikan ini, hubungan antara komponen-komponen dan saiz komponen dipertimbangkan sebagai faktor utama yang memberikan kesan ke atas rekaan senibina. Pengukuran berasaskan aliran maklumat dan pendekatan pelbagai dimensi digunakan untuk mengurus setiap satu faktor berkaitan. Tiga set metrik iaitu Kekompleksan Aliran Maklumat Komponen (CIFC), Padanan Komponen (CC), dan Pengukuran Saiz Rekabentuk Pelbagai Dimensi (MDSM) diusulkan sebagai petunjuk kebolehubahan rekabentuk senibina CBSS. Dua jenis penilaian telah digunaka untuk mengesahkan kaedah yang diusulkan. Sementara kajian pengesahan secara teori dijalankan berasaskan rangka kerja Brian, Kajian pengesahan empirikal diuji dalam persekitaran terkawal terhadap lapan belas komponen. Kajian lanjutan juga dilakukan untuk membantu aplikasi praktikal ke atas metrik yang diusulkan.



Keputusan penilaian teoritikal menunjukkan metrik yang diusul adalah selari dan pengukuran dalaman yang sah. Keputusan empirikal memaparkan metrik yang diusul mempunyai hubungan statistik yang signifikan dengan atribut kebolehubahan. Keputusan aplikasi menggambarkan keberkesanan kaedah yang dinyatakan. Keputusan keseluruhan menunjukkan metrik yang diusulkan boleh digunakan sebagai petunjuk kebolehubahan ke atas rekabentuk senibina CBSS. Pengukuran ini diusulkan selari dengan sorotan bersistematik literatur yang dijalan oleh penyelidik. Oleh itu, bila metrik digunakan mengikut konteks, kita percaya keputusan metrik boleh mengenalpasti pelbagai masalah rekabentuk senibina. Keputusan yang diperolehi secara teoritikal dan evolusi empirikal oleh metrik yang diusul adalah signifikan dan boleh dijadikan kajian lanjutan yang berfaedah.

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Last but by no means least, it has been a privilege for me to study at the Department of Software Engineering at University Putra Malaysia, where the excellent environment to perform this research was provided. I am also thankful to my fellows at the Faculty of Computer Science for making my stay interesting and enjoyable.

Majdi Abdellatief,  
May 2012

I certify that a Thesis Examination Committee has met on 21. May 2012 to conduct the final examination of Majdi Abdellatief Mohammed Mohammed Kair on his thesis entitled “Architectural Design Measures as Indicators of Changeability of Component-based Software System” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the degree of Doctor of Philosophy.

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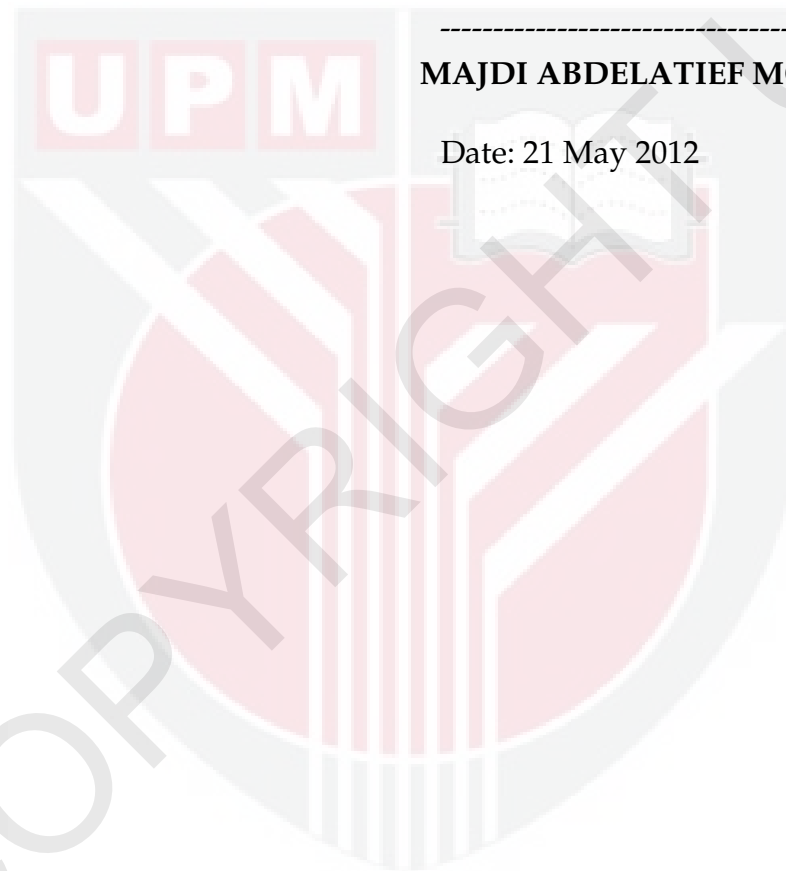
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## DECLARATION

I declare that the thesis is my original work except for quotations and citations that have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.



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