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

MAJDI ABDELLATIEF MOHAMMED MOHAMMED KHAIR

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By

MAJDI ABDELLATIEF MOHAMMED MOHAMMED KHAI

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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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 statistically 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
Majdi Abdellatif Mohammed

Mei 2012

Pengerusi: Abu Bakar Md Sultan, PhD
Fakulti: Sains Komputer dan Teknologi Maklumat

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 digunakan 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.
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In the name of ALLAH, the Beneficent, the Compassionate, and who always gives me strength and patience to complete my duties through many challenges situations.

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my research by proof reading, reviewing and providing excellent suggestions (i.e., Figure 2.1 and Section 2.4.5) and other suggestions for limitations overlooked at various levels during this research period, leading this research to its successful completion. The way she helped me in my research will always be appreciated and remembered. The prize for keeping this research practical should also go to the anonymous reviewers of *Journal of System and Software* for their constructive and practical feedback. I would also like to thank all those researchers whose works have been cited.

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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 Abdellatif,
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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School of Graduate Studies  
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Date:
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.

____________________________________________
MAJDI ABDELATIEF MOHAMMED

Date: 21 May 2012
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