UNIVERSITI PUTRA MALAYSIA

FRAMEWORK FOR AGGREGATING INTERACTIVE MULTI-CRITERIA FOR WEB-BASED APPLICATIONS USING FUZZY MEASURE AND 2-ADDITIVE CHOQUET INTEGRAL

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FSKTM 2010 8

HAZURA ZULZALIL DOCTOR OF PHILOSOPHY 2010

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By

HAZURA ZULZALIL

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Doctor of Philosophy

November 2010

Alhamdulillah.
Segala puji bagi Allah kerana dengan limpah rahmatNya
dapat saya menyiapkan tesis ini.

Tesis ini didedikasi untuk suami,
anak-anak dan
keluarga yang tersayang.
Segala pengorbanan, kesabaran
dan doa kalian
amat dihargai serta besar ertinya.

Kejayaan ini adalah milik kita bersama.

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

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Chairman: **Professor Abdul Azim Abd Ghani, PhD**

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Web-based Application (WBA) quality is hard to evaluate because it consists of multiple criteria to be measured. Researchers have developed software quality models that were intended to be comprehensive and applicable to all software development. However, most of the works that focus on the quality model do not reference the aggregation methods used to calculate the values of the different element of the model. In fact, the aggregation methods are not really discussed in the literatures related to software quality. Although the need for a sound methodology is widely recognised, previous researchers generally avoid the use of multi-criteria decision method and mostly dealt with the simplest form of aggregation, which is categorized under additive approach. This approach presents some drawbacks, some do not posses all desirable properties and some seem to be restrictive. As a result they tend to construct independent criteria, or criteria that are supposed to be so, which caused some bias effect in the evaluation.

The purpose of this research is to establish a multi-criteria aggregation framework to evaluate WBA that would allow evaluator to incorporate interaction behaviour in the aggregation process. Firstly, the relationships between quality criteria were investigated using survey and correlation studies. The studies have confirmed that there exist positive, negative or neutral relationships between software quality criteria. Based on the relationships identified, the interactions of quality criteria are modelled using fuzzy measure approach. Secondly, the produced fuzzy measures are integrated into the 2-additive Choquet Integral to aggregate the multi quality criteria values. Besides that, the relative importance of each quality factor and the Web preference also play an important role in determining the overall evaluation. Case studies of three different domains of WBA were conducted to validate the proposed aggregation procedure. The overall results of 2-additive Choquet integral are compared against the additive model approach. Consequently, results of the 2-additive Choquet integral have shown that the ranking of overall evaluation results reflect the earlier preference stated by the evaluator compared to the additive model approaches. The fuzzy measure modelling has allowed the incorporation of interaction exist between the quality criteria to be considered in the aggregation process. The results are also consistent with the additive model approach when no interaction exists.

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

RANGKAKERJA UNTUK MENGAGRIGASI MULTI-KRITERIA BAGI APLIKASI BERASASKAN WEB YANG INTERAKTIF MENGGUNAKAN UKURAN KABUR DAN *2-ADDITIVE CHOQUET INTEGRAL*

Oleh

HAZURA ZULZALIL

November 2010

Pengerusi: **Profesor Abdul Azim Abd Ghani, PhD**

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Aplikasi berasaskan Web adalah sukar untuk dinilai kerana terdapat beberapa kriteria yang perlu diukur. Para penyelidik telah membangunkan model kualiti perisian yang direka agak menyeluruh dan boleh digunakan untuk semua pembangunan perisian. Walau bagaimanapun, sebahagian besar karya yang menjurus kepada model kualiti tidak merujuk kaedah agregasi yang digunakan dalam mengira nilai elemen yang berbeza bagi model tersebut. Bahkan, kaedah agregasi tidak benar-benar dibincangkan dalam literatur yang berkaitan dengan kualiti perisian. Walaupun keperluan untuk kaedah yang jelas diakui secara meluas, pengkaji terdahulu umumnya mengelakkan penggunaan kaedah membuat keputusan multi-kriteria dan sebahagian besar ditangani dengan agregasi dalam bentuk yang paling mudah, yang dikategorikan dalam pendekatan aditif. Pendekatan ini menyajikan beberapa kelemahan, antaranya tidak memiliki semua sifat yang dikehendaki dan memiliki beberapa sifat yang terhad. Akibatnya, mereka cenderung membina kriteria

yang dikatakan bebas, atau yang seharusnya, yang menyebabkan beberapa kesan di dalam penilaian.

Tujuan penyelidikan ini adalah untuk membentuk suatu rangka kerja agregasi multi-kriteria untuk menilai aplikasi yang berasaskan Web yang akan membolehkan penilai memasukkan perilaku interaksi dalam proses agregasi. Pertama, hubungan antara kriteria kualiti diselidiki melalui kaedah tinjauan dan kajian korelasi. Kajian ini telah mengesahkan bahawa terdapat hubungan positif, negatif atau neutral di antara kriteria kualiti perisian. Berdasarkan hubungan yang dikenalpasti, interaksi kriteria kualiti perisian yang wujud dimodel menggunakan ukuran kabur. Kedua, ukuran kabur yang dihasilkan kemudiannya diintegrasikan ke dalam *2-additive Choquet Integral* untuk proses agregasi nilai kriteria kualiti perisian. Selain daripada itu, kepentingan bagi setiap faktor kualiti dan keutamaan Web juga memainkan peranan penting dalam menentukan penilaian secara keseluruhan. Kajian kes dari tiga domain aplikasi Web yang berbeza dijalankan untuk menilai prosedur agregasi yang dicadangkan. Keputusan keseluruhan agregasi menggunakan *2-additive Choquet Integral* dibandingkan dengan pendekatan model aditif. Hasilnya, keputusan *2-additive Choquet Integral* menunjukkan kedudukan keputusan penilaian secara keseluruhan telah mencerminkan keutamaan yang telah dinyatakan oleh penilai sejak awal berbanding pendekatan model aditif. Permodelan ukuran kabur telah membenarkan kemasukan interaksi yang wujud di antara kriteria kualiti diambilkira di dalam proses agregasi. Keputusan juga didapati konsisten dengan pendekatan model aditif apabila interaksi tidak wujud.

ACKNOWLEDGEMENTS

The completion of this thesis was made possible by the valuable assistance I received from many people.

Foremost, I would like to express my deep and sincere gratitude to my supervisor Professor Dr. Hj. Abdul Azim bin Abd Ghani for his constructive comments, suggestions, support and encouragement during this thesis work. Beside my supervisor, I wish to express my warm and sincere thanks to my co-supervisors, Associate Professor Hj. Mohd Hasan bin Selamat and Associate Professor Dr. Hj. Ramlan bin Mahmod for their kind support and guidance during my study.

I would like to take this opportunity to convey my sincere gratitude to members of the Faculty of Computer Science and Information Technology for supporting me to accomplish my research. Special thanks to my friends (too many to list here but you know who you are!) for providing support and friendship that I needed.

Finally, and most importantly, I owe my loving thanks to my husband Khairul Anuar Awang Abu @ Ayub, my sons Khairul Aiman, Khairul Naim and Khairul Imran. Without their encouragement and understanding it would have been impossible for me to finish this work. My special gratitude is due to my parents, mother in-law, brothers, sisters and in-laws for their loving support and prayers. May Allah (SWT) bless all of us.

I certify that a Thesis Examination Committee has met on 22 November 2010 to conduct the final examination of Hazura binti Zulzalil on her thesis entitled “Framework for Aggregating Interactive Multi-Criteria for Web-Based Applications using Fuzzy Measure and 2-Additive Choquet Integral" in accordance with the Universities and University College 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 Doctor of Philosophy.

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Date: 22 February 2011

DECLARATION

I declare that the thesis is my original work except for quotations and citations, which 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 other institutions.

_____

HAZURA BINTI ZULZALIL

Date: 22 November 2010

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