HYBRID FUZZY BASED DECISION MODEL: A CASE STUDY OF WEB DEVELOPMENT PLATFORMS SELECTION AND EVALUATION

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With much love, I dedicate this thesis to my adorable late parents, my father *Alhajj Ramadhan Elias* and my mother *Hajjat Zubeda Ramadhan* may your souls rest in eternal peace.

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ABSTRACT

Software industries are resorting to the use of web platforms due to their ability to provide access to files and information locally, remotely and on mobile devices without software prerequisites. This has resulted in a multitude of software vendors and hence a large number of web development platforms with large number of conflicting merits classifying this problem among complex decision problems. Decision making frameworks that consist of models have been successfully applied to different decision problems and have delivered dependable solutions. Multi-criteria decision frameworks like Analytical Hierarchy Process (AHP) and Technique for Order Performance by Similarity Ideal Solution (TOPSIS) are usually applied in decision activities. In most complex decision problems, the two frameworks have been integrated in a fuzzy environment to form a model due to the uncertainties in data collection. The integrated AHP and TOPSIS is complex in data collection which is performed in two phases with no inconsistency measures in the second phase; this leads to unreliable and inaccurate results. To make the results more accurate and reliable, this study has reviewed, analysed the integration of AHP and TOPSIS, investigated how the deficiencies therein can be mitigated and proposed an appropriate model named Hybrid Fuzzy Based Decision Model (HFBDM). In this model, data can be collected in either crisp or fuzzy formats and is able to determine inconsistencies in the data. This feature validates and eases data collection thereby solving the complexity and hence increasing reliability and accuracy which is the novelty and the contribution of HFBDM. The model has been evaluated and applied in a case study where data were collected in crisp format and the results demonstrate that HFBDM has more accurate and reliable outcomes compared to evaluated existing frameworks

ABSTRAK

Industri perisian kini menggunakan platform sesawang kerana keupayaannya menyedia capaian kepada fail dan maklumat secara setempat, terpencil dan melalui peranti mudah alih tanpa pra-syarat perisian. Justeru itu, lahir pelbagai pembekal perisian yang seterusnya menghasilkan pelbagai platform pembangunan sesawang. Ini membawa kepada perkembangan platform web, dengan banyak merit yang bertentangan antara platform. Masalah ini diklasifikasi sebagai antara masalah membuat keputusan yang kompleks. Teknik membuat keputusan telah berjaya diaplikasi untuk pelbagai permasalahan membuat keputusan dan menghasilkan penyelesaian yang boleh dipercayai. Rangka kerja keputusan pelbagai kriteria seperti *Analytical Hierarchy Process* (AHP) dan *Technique for Order Performance by Similarity Ideal Solution* (TOPSIS) lazim diguna dalam aktiviti membuat keputusan. Dalam kebanyakan permasalahan kompleks, dua rangka kerja ini telah disepadukan dalam persekitaran kabur kerana ketidak-pastian dalam pengumpulan data. Penyepaduan AHP dan TOPSIS adalah kompleks dalam pengumpulan data dan ianya dilaksanakan dalam dua fasa. Oleh kerana tiada pengukuran tidak konsisten dalam fasa kedua, keputusan yang terhasil tidak boleh dipercayai dan tidak tepat. Untuk meningkatkan kebolehpercayaan dan ketepatan keputusan, penyelidikan ini telah mengkaji, menganalisa penyepaduan AHP dan TOPSIS serta menyiasat bagaimana kelemahan yang ada boleh diatasi. Hasil dari itu satu model baru dicadangkan iaitu *Hybrid Fuzzy Based Decision Model* (HFBDM) bertujuan untuk memenuhi kekurangan yang ditemui. Model ini boleh mengumpul data sama ada dalam format yang jelas atau kabur dan mempunyai kebolehan untuk menentukan ketidakseragaman dalam data. Ciri yang dibangunkan dapat mengesahkan dan memudahkan pengumpulan data dan seterusnya menyelesaikan masalah kekompleksan serta dapat meningkatkan ketepatan dan keboleh percayaan yang mana ini merupakan keunikan dan sumbangan HFBDM. Model ini telah diuji dan diaplikasikan dalam satu kajian kes yang mana data dikumpul dalam format jelas dan hasil menunjukkan HFBDM lebih tepat dan boleh dipercayai berbanding kerangka sedia ada yang dinilai bagi masalah membuat keputusan yang kompleks.

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LIST OF ABBREVIATIONS

DM	-	Decision Making
SCDM	-	Single-Criteria Decision Making
MCDM	-	Multi-Criteria Decision Making
AHP	-	Analytical Hierarchy Process
TOPSIS	-	Technique for Order Preference by Similarity to Ideal Solution
SC	-	Soft Computing
FAHP	-	Fuzzy Analytical Hierarchy Process
FTOPSIS	-	Fuzzy Technique for Order Preference by Similarity to Ideal Solution
WWW	-	World Wide Web
HTTP	-	Hypertext Transfer protocol
HFBDM	-	Hybrid Fuzzy Based Decision Model

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CHAPTER 1

INTRODUCTION

1.1 Overview

Web applications emerged as a medium to render hypertext documents on users' computers using intermediary software called web browser and a protocol called Hype Text Transfer protocol (HTTP). This grew up rapidly as a new medium of information communication technology where static content could be published by sharing of files and information saved on web servers. The content is published using Hyper Text Markup Language (HTML) that uses different types of tags to publish contents on Web pages. WWW (W3) has been transformed from just static content supplier to an interactive dynamic content supplier where information, files, graphics, data in databases are transmitted both locally within an organization and remotely without necessary installation of any specific software but instead a web browser which will operate for all applications. W3 is now used as the presentation layer and hosts all online applications and services, ranging from e-banking, e-mail, e-shopping, to highly Decision Making Applications (DMA) and further more online expert systems (ES) (Al-Salem and Abu Samaha, 2007; Baker *et al.*, 1994; Byrne *et al.*, 2010; Fraternali, 1998; Sefton, 2009; Tantam, 2006; Trent *et al.*, 2008). These factors have pushed web applications to dominant in software industry. Companies, organizations and institutions are transforming their systems running as desktop applications to web applications. Intranets and extranets are playing a major role in transforming businesses to different level of operations. They provide services like online shopping, online applications, mobile application and so many other services.

Due to the large number of software vendors and the need of web development platforms, so many developing platforms have been invented. To achieve both long term and shot term success of the system (project), selecting of an appropriate tool is considered to be a very crucial stage before developing stage of applications start (Byrne *et al.*, 2010; Fraternali, 1998; Ravi *et al.*, 2009; Tantam, 2006).

Selection process is carried out by decision making (DM) mechanisms and therefore the process of selection and evaluation involves decision making, DM has been defined as the science of identifying and choosing alternatives/choices based on the values and preferences of the decision maker. Making a decision implies that there are alternatives/choices to be considered, and in such a case we want not only to identify as many of these alternatives as possible but to choose the one that best fits with decision makers goals, objectives, desires, values, and so on (Aczél and Saaty, 1983; Basak and Saaty, 1993; Tuzkaya *et al.*, 2010; Wang and Li, 2011). The differences in conflicting merits of web development platforms practically and in the real world is so close and hence ranking this problem a complex one. This makes this problem difficult to humans or any other decision making techniques incapable of handling complex problems this makes. On top of being a complex problem, it is also embroiled with uncertainties due to human biasness and imprecision. This study therefore will mainly put much emphasis on decision techniques capable of handling complex problem appropriately paving way for web development platforms selection and evaluation (Ahmad *et al.*, 2012; Ertuğrul and Karakaşoğlu, 2008).

Decision making is known to be a human behavior. Humans use the natural gifted intelligence to think deeply, reason and analyze choices available and come out with the best choice. The accuracy may differ from one human to another depending on the reasoning capacity and most of the times time taken to come up with a conclusion is usually long. Human decisions are full of biasness and uncertainties therefore intelligent algorithms are preferred for accurate results. Making machines think deeply, reason and analyze to make decision like human free from biasness and uncertainties is not an easy task, this process is termed as Artificial Intelligence (AI) where Soft Computing (SC) techniques are employed (Lin and Hsu, 2007).

1.2 Problem Background

The increase of software vendors and continual advancement and improvements in software products and information technology in general has generated a need of Decision Making (DM) process. In addition to that, the tremendous number of software in the market today becomes the other factor requiring DM process. Online systems have dominated software development industry in the recent years, because of this there have been so many platforms for support and development of web applications. Hence selecting and evaluating the platforms that developers will use to develop online systems has taken a very strong stand before the development stage. With the help of DM mechanism mechanisms this problem of selection and evaluation has been curbed down. DM processes include comparing the alternatives of the existing problem with both tangible and intangible criteria. The conflicting merits (criteria) are assessed and results to optimum alternatives (Basak and Saaty, 1993; Berk, 2006; Bohanec, 2008; Carlsson and Fullér, 1996; Chang and Chen, 1994; Dong, 2011; Fülöp, 2005).

DM problems are categorized into Single Criteria Decision Problem (SCDP) and Multi-Criteria Decision Problems (MCDP). SCDP are decision problems where a single conflicting merit is considered and in this case there is no decision process. In addition MCDP are decision problems with two or more conflicting merits, comparing these conflicting merits basing on the alternative is all that takes place in DM.(Aczél and Saaty, 1983; Basak and Saaty, 1993; Carlsson and Fullér, 1996; Wang and Li, 2011).

Solving decision problems is done by converting the problem into numbers that will fully represent the problem. A good number of MCDM mechanisms have been used in solving decision problems, most of them are Arithmetic based which ignore qualitative and some subjective considerations, because of this weakness a combination of MCDM and soft computing (SC) decision mechanism is employed to cater for the it. Fuzzy set theory proposed by Zadeh (1970) that can be used to rates every alternative with the criteria by linguistic terms which are easier for decision

makers and catering for uncertainties. This has been tested and found useful when combined by MCDM mechanism in handling qualitative and some subjective considerations (Awasthi and Chauhan, 2012; Bellman and Zadeh, 1970; Büyüközkan and Çifçi, 2012; Çakır, 2008; Wang *et al.*, 2010).

Among the most used MCDM mechanism is Analytical Hierarchy process (AHP) that was proposed by Saaty (1973) and has been successfully used in so many decision making problems for especially problems which are not embedded with uncertainties. Data used in decision making is collected from humans (Decision makers), humans are known to be biased especially is carrying out decision this gives birth to uncertainties in the decision problem and needs to be catered for if we are to have an accurate and reliable decision process. To make AHP more accurate and free from biasness, AHP is further fuzzified using the fuzzy operations by scaling each rank provided in crisp value to fuzzy sets by employing different forms of fuzzy sets for this matter triangular scale has been proved to be the ideal (Ahmad *et al.*, 2012; Ayağ and Özdemir, 2006; Çakır, 2008; Huo *et al.*, 2009; Ishizaka and Labib, 2011; Lai *et al.*, 2002; Lin and Hsu, 2007; Önüt and Soner, 2008; Vaidya and Kumar, 2006; Wang *et al.*, 2010). This process of utilization of the fuzzified AHP called Fuzzy Analytical Hierarchy process (FAHP) is good for small and medium decision problems and not good for complex problems (Ballı and Korukoğlu, 2012). Despite the complexity of web development platforms evaluation and selection, FAHP was used (Ahmad *et al.*, 2012), this problem requires a solution capable of dealing with complex problems embedded with uncertainties and therefore more analysis is needed for more accurate results.

The Decision making mechanisms that can handle different complex problems have been proposed in different literatures available but none has proposed the one capable to handle problems like that of web platform selection and evaluation. There has been a combination of different mechanisms to try to solve complex problems including integration of mechanism (Awasthi and Chauhan, 2012; Büyüközkan and Çifçi, 2012; Büyüközkan *et al.*, 2011; Çakır, 2008; Dağdeviren *et al.*, 2009; Ertuğrul and Karakaşoğlu, 2008; Huo *et al.*, 2009; Önüt and Soner, 2008; Shyur, 2006; Singh and Benyoucef, 2011; Wang *et al.*, 2010) but clarity of integration was not mentioned

in the text, they combined the results rather than hybridizing, there is a need therefore for a clear hybrid model that will answer the an answered questions regarding hybridization of decision making techniques that will be able and capable of handling complex decision problems.

1.3 Statement of Problem

Sarfaraza *et al.*, (2012) in the study; Using fuzzy analytical hierarchy process (AHP) to evaluate web development platform, did some work in as regards evaluating web platforms. The criteria used in this literature were security, compatibility, performance and licensing cost only which were to be at the same level of functionality in the evaluation process and there was no alternatives optimization, the results here are expected to be inaccurate. (Ballı and Korukoğlu, 2012; Gao *et al.*, 2008).

Above all the mentioned drawbacks, selection and Evaluation of web-based development platforms is a complex decision problem with biasness, uncertainty due to imprecision, vagueness and ambiguity (Ahmad *et al.*, 2012). This gives a clear indicator that there is unfinished work in as far as this study is concerned.

The problem of web development platform evaluation requires techniques capable of handling complex decision problems by integration decision models(Ahmad *et al.*, 2012). The existing models than integrate integrated AHP and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) is a fuzzy environment are collecting data in two forms, the pairwise criteria comparison matrix to obtain the weight suitable for FAHP that will be multiplied by the alternative optimization matrix suitable for TOPSIS whose data is also collected separately (Hwang and Yoon 1981; Chen 2000; Ertuğrul and Karakaşoğlu 2008; Dağdeviren, Yavuz *et al.* 2009; Amiri 2010; Wang, Fan *et al.* 2010; Demirtaş, Alp *et al.*, 2011; Büyüközkan and Çifçi ,2012). This not only causes confusion among the experts but

also complexity in the work done by the experts who most of the times don't have much time to concetrate and give much time to understand complex questionaires, above that the inconsistencies and validaton of the data collected are not taken care of and therefore a big risk to end up with inconsitence data and hence innacurate. Generally the statement of the problem to this study is:-

The present decision models that can handle complex decision problems are complex, makes data collection a tiresome job to the experts, and ontop of that there is no measure of inconsistencies in the data collected which makes results unreliable and less accurate.

The discussion above in the statement of problem gives a clear indication that there is a problem that is yet to be solved and questions that are yet to be answered. These questions are:-

i. Data collection is a very important phase in any decision process because it determines the results of the decision processes. The existing models that are capable of handling complex problems tend to be complex in data collection in. Data is collected in two phases, the phase that favours AHP and that of TOPSIS techniques. Is there any way that data can be collected in just one single phase to solve this problem?
ii. Which decision techniques will clearly be capable of find the consistencies in the data collected as done in AHP and at the same time optimization of alternatives as done in TOPSIS?
iii. Is there a reliable way that will not make experts work difficult in collecting data as well as simplifying decision makers' work?

1.4 Purpose of the Study

The main purpose of this study is to propose a model basing on the existing models that will be capable of handling complex decision problems more accurately

will minimize errors. The model proposed should be able to ease the decision process, simplify the process of data collection, measurement of inconsistencies in the data collected, find ways of collecting data in only one phase and less effort to decision makers (experts) role. The decision model proposed will be evaluated to prove its accuracy by published work. The other purpose of this study is the selection and evaluation of web development platforms. The problem of web development platform is categorized as a complex decision problem by Ahmad, 2012 with elements of ambiguity, uncertainties caused by imprecision and vagueness. It is therefore to the model to be used for evaluation to be capable of handling all the side backs mentioned. This model will be of a great importance to the decision makers mostly dealing with complex problems. In web development, the results are expected to be accurate and so important to web development in software engineering industries for both large and small software projects.

1.5 Research Objectives

The objectives of this study are:-

i. To propose a hybrid fuzzy based model that will be capable of data validation and alternative optimization.
ii. To evaluate the model proposed with the already published related work and use to use the model in a case study of evaluating and selection of web development platforms.

1.6 Research Scope

This study has mainly circulated around proposing the model for complex problems which will be evaluated and utilized in a case study. The proposed

evaluation will be using relevant published data and with case study of evaluation and selection of web development platforms. In general this study has:-

i. A discussion on DM and DM techniques available in use today in software evaluation and selection.
ii. A highlight on multi-criteria decision making (MCDM) mechanism, Artificial intelligence (AI) in soft computing (SC) Decision making mechanisms and an integration of both MCDM and SC decision making techniques.
iii. Discussion on conventional and complex decision problems.
iv. A study on web development platforms in the software industry, consider specification like those collected in requirements as conflicting merits (criteria).
v. A study of available decision models capable of solving complex problems.
vi. Proposed a reliable decision model for complex decision problems, evaluate the model.
vii. Carry out surveys, collect data from web experts using the questionnaire approach for web development platforms. Use the data collected in the model, this will be considered the case study of this study.

1.7 Research Contribution

The dominance of web technology and the increase in the number of web development platforms has created a decision problem that should have an accurate solution. Software engineering emphasizes choosing the right platform before beginning the development phase. This will greatly affect positively and negatively the success of the project. If the right decision is made then the project will be successful and the opposite is true (Larman, 2004).

The models available for complex decision problems are themselves complex especially when it comes to data collection, many experts have no time to sit for hours trying to understand the questionnaire, on top of this there is no specified measure of

measuring inconsistencies and validation of the data collected. Contributions of this research are therefore:-

i. The proposed hybrid fuzzy based decision model (HFBDM) that is capable of solving complex problems and at the same time simple to understand by the experts and on top of that able to measure the inconsistencies and validate the collected data.
ii. To help web developers in selecting the best alternative platform to develop certain web project basing on the needs and requirements available which this study calls criteria.

1.8 Research Significance

Software developing industries are deploying web applications every minute and have got unfinished and untouched web projects. These projects carry different functional and non-functional requirements required by the clients. Therefore finding an appropriate platform to develop such projects has been a tiresome process for so many industries due to lack of reliable mechanism free from biasness and uncertainties to carry out this task. Selection and evaluation of alternatives from so many platforms available is a very crucial step after requirement gathering in software engineering analysis (Larman, 2004), this is because it greatly determines whether the project will be successful or not. Selection of appropriate platforms will determine whether the project will be successor not. Poor selection will result in a poor the project and will not survive this world of competition. This may result into big loses to the industry especially if the project is big.

Humans take long time in decision making and the outcome is always biased leaning towards desires and other factors causing uncertainties. The significance of this study therefore is to come up with a model that will be used in decision making of complex problems like web development platforms selection. Some literature have been done in as regards tools selection like Performance Comparison of Dynamic Web

Platforms (Gellersen and Gaedke, 1999), Exploring the Relationship Between Web Application Development Tools and Security (Finifter and Wagner, 2011), Using fuzzy analytical hierarchy process (AHP) to evaluate web development platform (Ahmad *et al.*, 2012; Awasthi and Chauhan, 2012) mention but a few, but none has addressed the problem of complexity in the decision problem as well as in the decision process. Therefore the significance of this study is to help decision makers that deal with complex decision.

1.9 Organization of the Thesis

This research is organized into 6 chapters. This Chapter introduces what the research will be all about by introducing the background of the study, highlighting the problem that this study strived to solve, the scope contribution and significance of the study, from chapter one, it is clearly indicated that there are research questions that are yet to be answered in as regards decision models for complex problem, it has also indicated that although there are some efforts in inventing these mechanisms, there is still work needed to be done and this is the reason to this research.

Chapter 2 is the literature review that highlights on issues concerning decision making mechanisms, with types of decision problems and how these problems can be solved. It also introduces the methods and Models available for both Multi-Criteria Decision Making and soft-computing mechanisms discussing most of the methodologies available. How the two can be integrated for more accurate results. It also gives a critical highlight on the available hybrid mechanisms the drawbacks of these mechanisms are the reasons for this study.

Chapter 3 discusses in details the methodology proposed starting from AHP to TOPSIS and then when the two methodologies are fuzzified, gives clear reasons as to why these mechanisms should be fuzzified and explains further the importance of

fuzzy and not other SC mechanism. All the processes of evaluation and selection will be discussed in this chapter.

Chapter 4 illustrates the real hybrid fuzzy based decision model (HFBDM) in details, discusses on the criteria and alternatives that have been proposed in this study and why in particular these were selected from a variety. Evaluation of this model is also part of this chapter; evaluation is by testing the model by using the data published that is friendly to the model.

Chapter 5 discusses the case study chosen for this research. Web development platform was selected to be the case study of this model due to its complexity in nature. This case study involved data that collected from web experts with a minimum of five years experience in web development. The data collected was fed into the model and the results indicated a stiff competition for the first rank and the last rank, an indication of complex decision problem. Furthermore the results are discussed in this same chapter.

Chapter 6 discusses the summary of the entire thesis where the conclusion of the thesis resides. It mainly focuses on the objectives achieved from the thesis, the contribution and the impact this thesis is printing. The other factors covered here are the limitations of the proposed model and proposed future work where the use of other intelligent techniques have been proposed as the solution to the limits observed in the proposed model.

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