

AN IMPROVED ACCURACY OF WEB SERVICE  
SELECTION BASED ON MULTI-CRITERIA DECISION  
MAKING AND WEB SERVICE MODELING ONTOLOGY

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AN IMPROVED ACCURACY OF WEB SERVICE SELECTION BASED ON  
MULTI-CRITERIA DECISION MAKING AND  
WEB SERVICE MODELING ONTOLOGY

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To Mahdi, the promised saviour,  
looking forward to his arrival....

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## ABSTRACT

The subject of web services has become a popular topic in the area of computer science, as it provides the ability to collect capabilities and components in a unique interface to meet user requirements. One of the significant issues in this area is the development of an accurate service selection approach. In the existing approaches, accuracy refers to the accuracy of the selection method; the accuracy of the input data are neglected. There are many approaches in service selection for managing modelling or algorithmic issues. This research proposes an Accurate approach based on multi-criteria decision making (MCDM) and web service modelling ontology (WSMO), which is called AMW. The accuracy of the selection method is improved compared to existing methods, and the accuracy of the input data are considered. For this purpose, first, a comparative evaluation of state-of-the-art approaches for web service selection approaches has been performed, and the strengths and weaknesses of those approaches have been discussed. Second, the weaknesses of the existing approaches have been identified by applying the analytical hierarchy process (AHP) method to define default criteria weights and enhanced VIšekriterijumsko KOmpromisno Rangiranje (VIKOR) for the selection of services. Moreover, to improve the accuracy of input data, the confidence level of the service provider and the power of the decision maker are considered. Finally, the AMW approach has been validated by applying two case studies with various situations. The results of the experimental validation demonstrate that AMW provides an accurate and feasible solution. The results of this research can assist service consumers in attaining a more accurate decision when selecting the appropriate service.

## ABSTRAK

Perkhidmatan web telah menjadi satu topik yang popular dalam bidang sains komputer, kerana ia menyediakan kebolehan untuk mengumpul keupayaan dan komponen dalam antara muka yang unik untuk memenuhi keperluan pengguna. Salah satu isu penting dalam bidang ini adalah pembangunan pendekatan pemilihan perkhidmatan yang tepat. Dalam pendekatan yang sedia ada, ketepatan merujuk kepada ketepatan kaedah pemilihan; ketepatan data input adalah diabaikan. Terdapat banyak pendekatan dalam pemilihan perkhidmatan untuk menguruskan isu-isu model atau algoritma. Kajian ini mencadangkan satu pendekatan yang tepat berdasarkan penghasilan keputusan multi-kriteria (MCDM) dan permodelan ontologi perkhidmatan web (WSMO) yang dipanggil AMW. Ketepatan kaedah pemilihan adalah lebih baik berbanding dengan kaedah yang sedia ada, dan ketepatan data input telah dipertimbangkan. Bagi tujuan ini, penilaian perbandingan terhadap pendekatan terkini dalam pemilihan perkhidmatan web telah dilaksanakan, dan kekuatan dan kelemahan pendekatan tersebut telah dibincangkan. Kemudian, kelemahan pendekatan sedia ada telah dikenal pasti dengan menggunakan kaedah proses hierarki analisis (AHP) untuk menentukan pemberat kriteria lalai dan VIšekriterijumsko KOMPromisno Rangiranje (VIKOR) yang dipertingkatkan untuk pemilihan perkhidmatan. Selain itu, untuk meningkatkan ketepatan data input, tahap keyakinan pembekal perkhidmatan dan kuasa pembuat keputusan akan dipertimbangkan. Akhirnya, pendekatan AMW telah disahkan dengan melaksanakan AMW terhadap dua kajian kes dengan pelbagai situasi berbeza. Keputusan pengesahan melalui eksperimen menunjukkan bahawa AMW menyediakan penyelesaian yang tepat dan boleh dilaksanakan. Hasil kajian ini boleh membantu pengguna perkhidmatan dalam mencapai keputusan yang lebih tepat dalam memilih perkhidmatan yang sesuai.

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**LIST OF ABBREVIATIONS**

AMW	-	Accurate Approach based on MCDM and WSMO
CL	-	Confidence Level
DM	-	Decision Maker
MCDM	-	Multi Criteria Decision Making
OWL	-	Web Ontology Language
OWL-S	-	Web Ontology Language for Web Services
QoS	-	Quality of Service
SOA	-	Service Oriented Architecture
SOAP	-	Simple Object Access Protocol
SP	-	Service Provider
SWS	-	Semantic Web Service
UDDI	-	Universal Description, Discovery, and Integration
WSDL	-	Web Services Description Language
WSML	-	Web Service Modelling Language
WSMO	-	Web Service Modelling Ontology
WSMX	-	Web Service Modelling execution environment
WSS	-	Web Service Selection

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## **CHAPTER 1**

### **INTRODUCTION**

In this chapter, the introduction of research is discussed in detail. First, background of the problem is described. Then, to clarify the problem, the statement of the problem is provided. Moreover, the objectives and scope of the study are defined, and the significance of the study is discussed.

#### **1.1 Background of the Problem**

Researchers have recently shown increased interest in web services, which are among the most widely used groups in service-oriented architecture (SOA) and service computing. According to the World Wide Web Consortium (W3C), “A web service is a software system designed to support interoperable machine-to-machine interaction over a network” [1].

Many organisations and companies develop applications that are accessible via the Internet. Therefore, the capability of correctly selecting and combining inter-organisational and various services at runtime on the web is a significant issue in the development of web service applications [2].

The components of the traditional web service architecture are web service definition language (WSDL), simple object access protocol (SOAP) and universal description discovery and integration (UDDI), which are used to describe services, transfer messages and store services, respectively [3].

As described in recent research, web service mechanisms can be separated into discovery, selection and composition [4-7]. Web service discovery enables providers to publish service descriptions and profile information regarding businesses, services and other related details in UDDI repositories. However, there are instances in which non-functional properties need to be utilised and the most appropriate service needs to be selected to cater to user requirements, apart from functional properties. The selection component is used for this purpose. Finally, web service composition composes the selected services together within the time frame required. A set of services can be composed as a composite service to provide requisite functions [8]. This research concerns web service selection (WSS).

WSS appears when there is a set of discovered web services that can fulfil user requirements [9] and one of these services should be selected to be returned to the service consumer [10]. This selection must be tailored to user preferences because one user may require high quality, whereas another may require low prices [11].

At the present time, there are some approaches for sustaining semantic WSS, such as web service modelling ontology (WSMO) [4], web ontology language for web services (OWL-S) [12] and semantic annotations for WSDL (SAWSDL) [13]. The infrastructure of the proposed approach is WSMO, which is a suitable modelling ontology for supporting semantic web services in this research because it supports user preferences and can include non-functional properties in a straightforward manner.

## **1.2 Statement of the Problem**

There are several approaches for WSS; these approaches use different methods for selecting the services that sustain the user requirements. The existing approaches attempt to improve the accuracy of WSS by improving the selection method. Although the method must be accurate, the accuracy of input data are more

important, as accurate results cannot be obtained without accurate data. Existing approaches also attempt to propose a solution for the weighting of criteria. These approaches do not consider default criteria weights. However, default weights are very important when the service consumer is not familiar with the weighting system.

This research intends to provide an approach to select the most appropriate web service that fulfils the descriptions by WSMO. This research proposes a new service selection approach called AMW (Accurate approach based on multi-criteria decision making (MCDM) and WSMO) and posits that utilising AMW for service selection resolves the aforementioned issues. The hypothesis responds to the general research question:

*How can MCDM and WSMO be used to achieve an accurate approach for selecting appropriate web services to respond to user requirements?*

To answer this question, the following research questions must be addressed:

- (i) Why are the existing approaches unable to answer the present problem in WSS?
- (ii) How can accurate data be prepared, using extra QoS, and achieve the best results, particularly in terms of the accuracy of supporting WSS?
- (iii) What are the main elements of the accurate approach for selecting web services?
- (iv) How to select best service via the accurate approach?
- (v) How to validate and evaluate the effectiveness of the proposed approach to support WSS?

### **1.3 Objectives of the Study**

Based on the described problem statements, the research objectives are as follows.

- (i) To investigate and evaluate the state of the art in web service selection approaches.
- (ii) To develop a new approach for web service selection in which the accuracy of both the input data and selection method are considered.
- (iii) To propose default criteria weights using the AHP method to help users express their preferences.
- (iv) To design and formulate algorithms to support the proposed approach.
- (v) To evaluate the accuracy of the proposed approach by developing a selector tool and comparing it with other approaches.

### **1.4 Scope of the Study**

The three areas related to this subject are: semantic web services, MCDM and trust and reputation. These areas are described below.

First, this research is related to semantic web services. Web services are described semantically in semantic web services, and the discovery, composition and selection of services are completed via semantic web services. To describe a service, the capability and the required inputs, semantic-rich languages are used. For example, in making concept ontology service descriptions, the resource description framework (RDF) and OWL are used. The basis of the semantic web service of this research is WSMO. In Section 2.2.3, semantic web services are described in detail.

The second direction of this research is MCDM. The problem of service selection is similar to the MCDM problem. Therefore, one of the topics of this research is MCDM. There are some MCDM methods that can be applied in service selection problem, such as AHP, TOPSIS and VIKOR. This research employs VIKOR, which is absent in the service selection literature but is well known in other research areas. This subject is discussed in detail in Section 2.3.

Finally, trust and reputation are the other areas that are related to the proposed approach. Trust and reputation rely on feedback from other users who have used the service previously. In this situation, each service can be popular after it is used. In fact, it is the reputation of services that is gained by trusting service providers (SPs). Trust and reputation are described further in Section 2.5.2

## **1.5 Significance of the Study**

Whereas some topics, such as discovery and composition for semantic web services, have been addressed by numerous studies, WSS as one of the final stages is essential. However, WSS has not been given sufficient attention; thus, additional research is necessary.

Although discovery and composition are important issues in web service studies, WSS is more important because if discovery and composition fulfil their tasks, one step still remains to fulfil the web service process; this step is the selection of the best discovered services that have functionalities similar to the user preferences. Therefore, the selection mechanism should perform this essential task. Consequently, successful discovery and composition stages would not yield a good result without an adequate selection mechanism.

WSS is one of the most significant discussions in SOA. WSS is the identification of the best candidate services among a group of services with similar functions but different Qualities of Service (QoS) [10]. QoS is important when

quality metrics need to be accomplished through service stipulation. These metrics are measurable and include what service is being offered [14].

There are approaches available for supporting semantic WSS, such as WSMO [4], OWL-S [12, 15] and SAWSDL [13, 16]. However, these approaches attempt to improve the selection methods; the accuracy of data are not considered. In this research, the WSMO is used as the basis of the research to improve the accuracy of both the input data and selection method.

## **1.6 Thesis Organization**

The organization of thesis is as follow: Literature Review (Chapter 2), Comparative Evaluation of WSS Approaches (Chapter 3), Research Methodology (Chapter 4), THE AMW Approach to Support WSS (Chapter 5), Evaluation of the Proposed Approach (Chapter 6) and Conclusion (Chapter 7).

In Chapter 2, the concepts of web services, semantic web and semantic web services are described. In addition, the WSS and related approaches are discussed. Moreover, MCDM and some related methods are described. Finally, the classification of WSS approaches is proposed, and each approach is described in detail.

Chapter 3 describes a comparative evaluation of the state-the-art approaches that are discussed in Chapter 2. First, the WSS criteria are described. Second, the comparison in the first level of classification is discussed. Third, the comparison of the second level, which is divided into the semantic level and MCDM level, is discussed. Finally, the approaches are evaluated.

Chapter 4 describes the methodology of this research, including the research design, research procedure, operational framework, instrumentation, assumptions and limitations.



In Chapter 5, the proposed approach, called AMW, is described. This approach fixes the issues discussed in Chapter 3. The proposed solution for providing flexible and automated service selection involves the application of a flexible framework and proficient MCDM method. The AMW approach involves a framework as an architectural aspect and a formula as an algorithmic aspect.

Chapter 6 describes the evaluation of the AMW approach. The aim of this section is to identify the types of problems that AMW can solve that cannot be solved by the existing approaches. The proposed approach must be validated analytically. Specifically, the conditions in which each of the existing approaches fails must be explained and specified, and the reasons for which AMW worked correctly also must be explained. The explanations are validated by demonstrations of each approach applied to specific examples that illustrate each of the conditions identified in the analysis. The results demonstrate how the features of AMW can affect the accuracy of WSS.

Chapter 7 presents the conclusions of this research. The achievements and contributions of the proposed approach, AMW, are summarised, and unresolved issues and future work are described.

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