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Selection of e-learning Web service based on QoS and user profile

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Abstract: With the increasing number of e-learning Web services, the selection process has become increasingly difficult. To remedy to this problem, we propose a new decision approach for Web Service selection based on QoS, allowing to choose the best service from a group of similar e-learning Web services.

Keywords: Web Service, e-learning, QoS (Quality of service), uncertainty, MADM.

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I. Introduction

The evolution of Internet and of Service Oriented Architecture (SOA) has favored the emergence and the development of Web services. In recent years, companies from different domains in particular education, electronic commerce, travel and tourism, have widely adopted the technology of Web services. The Web service is a technology proposed by the World Wide Web Consortium (W3C), it implements the Service Oriented Architecture (SOA).

The major idea of SOA is that every element of the information system must become a documented, independent and accessible service.

Service Oriented Architecture is based on three basic concepts: Service Provider, Service Requester and Registry (Duvanel, 2004):

- *Provider*: publishes services in the registry.
- *Service Requester*: accesses to the registry to discover services available through the use of descriptions already published by providers.
- *Registry:* is a directory that contains the description of all available services. This register acts as an intermediary between the provider and the service requester, each provider publishes its contracts in the registry and the client accesses to these contracts for the search and the discovery of available services.

Internet provides a distributed infrastructure for sharing and publishing of information which bring fundamental changes to our society in knowledge acquisition. Nowadays, e-learning is a current trend of e-society. Web services are perfectly feasible for implementing e-learning systems since it guarantees interoperability and facility of evolution.

Web service technology is widely adopted by a large number of companies, which has led the increasing numbers of Web services. Following this increase, a new problem appeared.

It concerns the choice of the best Web service that satisfies user requirements from the set of candidate services that provide the same functionality (similar services).

Several works have been proposed in order to help the user during the selection process and satisfy his requests. In this paper, we propose a new selection approach of elementary e-learning Web services based on QoS and user profile.

Our approach allows the representation of uncertain attribute values of e-learning Web service and user profile that reflects his preference about e-learning systems.

The rest of this paper is organized as follows. In the second section, we present the Web service technology. Then some related work are discussed in section 3. In section 4, we develop our selection algorithm. Finally, some conclusions and future work are drawn.

II. The Web Service Technology

A. Web service definition

The Web services technology is considered as the most popular technology of distributed computing. As defined by the W3C « A Web service is a software designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL)» (Berbner et al., 2006).

Indeed, a Web service is an autonomous application that works independently and without external assistance. It is self-describing, through a public XML interface. Service Oriented Architecture is based on three elements; Service Provider, Service Requester and Service Registry :

- The service provider publishes his services in the registry (UDDI: Universal Description Discovery and Integration) (T. Rogers, 2004) through their specifications using WSDL (Web Services Description Language) (Christensen et al., 2001).
- The service requester (client) accesses to the UDDI directory to search and discover available services. The goal is to select the best service that satisfies their requirements.

During the discovery process, the service requester can find a set of similar Web services and he should select at most one service. Hence, he uses a Web service selection algorithm to select the most appropriate one.

B. Quality of service

At the beginning of the emergence of Web services technology, the selection was based on the functionality provided by the service (Peng et al., 2005; Ernst et al., 2006). Different companies provide Web services which increase the number of similar services and complicate the selection approach. In order to deal with this problem, new selection criteria were adopted such as the concept of Quality attributes (QoS). The QoS attributes describe the non-functional aspects of the Web service. They evaluate the quality of a Web service.

QoS is used essentially to help the customer to choose the best Web service that satisfies their requirements from a large number of similar ones. During the selection process, the customer selects the service having the highest quality from a set of candidate services.

C. e-learning Web service

An e- learning system originates from distance learning. On the web, there are about one million courses. Many e-learning content and applications have been developed by different vendors. e-learning is a system made up of multiple technologies. In an e-learning system, there are three principal actors (users):

- Tutor (instructor)
- Learner (student)
- Administration

In the past, each educational organization builds its own e-learning application which is developed independently with different technologies and tools. This diversity causes interconnect and heterogeneous e-learning systems which complicates interchange of content.

Several solutions have been proposed in order to develop e-learning environment such as Learning Managment System (LMS) and Learning Content Management System (LCMS).

The growth in the field of e-learning has been very fast is last few decades which require the use of appropriate technologies like ontologies (Verma, 2003), web service (Ivan, 2005 ; Westerkamp, 2003), and semantic web service (Chris, 2005) for the development of e-learning systems.

In fact, several researches have proposed to use Web service technologies in the development of e-learning systems such as (Ivan, 2005), (Vossen and Westerkarp, 2003) and (Xiaohong and Anumit, 2005).

Today, most famous e-learning applications provide several functions such as list of courses, skills assessment, discussion forums and evaluation, etc. (Xiaolin, 2009). In addition, e-learning systems evolve continually and having an adaptable application over time is a challenge in education domain. Web services provide a standard means of communication among different software applications.

Therefore, an e-learning system can be seen like a set of specific Web services in the educational domain (Ivan, 2005; Vossen and WesterKamp, 2003).

An e-learning Web service has some constraints such as the pedagogic, the ergonomic, the financial and the technological one's. Financial and technological constraints can be represented as quality attributes (QoS) of the Web service.

III. Related work

The Web service selection is a very active research area. In the literature, several techniques and algorithms have been proposed. For example the use of the optimization algorithm (Baldon et al., 2007), linear programming (Ardagna et Pernici, 2007; Talantikite et al., 2008), genetic algorithms (Lécué, 2009; Chang, 2012), heuristics (Yu et al., 2007), multi attribute decision making approach (Tong and Zhang, 2006; Zeng et al., 2003), etc.

During the selection phase, Web services can be combined to satisfy customer request, when a single Web service cannot do it. In this case, we talk about the composition of Web services (Rusli et al., 2011; Rao and Su, 2004; Khadka and Sapkota, 2010).

Selecting a Web service based on its functional aspect is usually the access to its functional description stored in the UDDI directory and makes a comparison between the functionality offered by the service and what is required in the client's request.

(Ernst et al., 2006) propose a syntactic description Web services approach by finding syntactic similarities between the inputs and outputs of different Web services.

In addition, (Balke et al, 2003) propose a semantic discovery selection approach.
With the continued increase of the number of services, the need to add other selection criteria with the functional aspect is becoming a necessity; hence the emergence of quality attributes (QoS). In the literature there are several approaches for selecting Web services based on QoS.

(Chaari et al, 2008) propose a selection Web services approach based on QoS.

In the same context, (Ran, 2003) proposes the extension of the UDDI registry as well as adding a new component. The new proposed UDDI allows the registration of functional and quality attributes.

Moreover, (DAD'Mello et al., 2008) present a semantic mechanism to discover and select Web services based on the functionality and QoS.

In addition, the Web services selection can be considered as a decision making problem, so we must choose the most appropriate service that satisfies the customer's requirements. Some works have used the Multi-Attribute Decision Making approaches (MADM) to resolve this problem of choice. MADM approach is a branch of decision-making; it treats decision problems in the presence of a number of decision criteria (Berbner et al., 2006).

(Zeng et al., 2003) have used the multi attributes decision making method 'SAW' (Simple Additive Weightings) in their selection approach. Indeed, this selection algorithm has been adopted by several authors as a basic algorithm for their selection Web service approaches. This algorithm is composed by two sequential phases; normalization and weighting.

However, in their work, (H.Tong et al., 2006), have adopted the 'modified TOPSIS' (The Technique for Order Preference by Similarity to Ideal Solution) method proposed by H.Deng et al (Deng et al., 2000) in 1998.

(Boudali et al., 2009) have proposed an e-learning Web service selection method based on ontologies. They developed some new classes to enrich the description of Web services in order to consider user's profile.

IV. The proposed Approach

In this paper, we propose a new Multi Attributes Decision Making approach for e-learning Web service selection based on QoS and user profile. Our approach is based on the approach proposed by H.Tong et al, in which they have adopted the modified TOPSIS (Tong et zhang, 2006).

This method used two basic concepts, the positive ideal solution and the negative one. The principle of this method is the selection of the alternative having the shortest distance to the positive ideal solution and the largest distance to the negative ideal solution.

Main objectives of our approach are:

- Treatment of uncertainty concerning attribute values of e-learning Web service.
- Consideration of user preferences concerning quality attributes.

A. The Quality Model

In this sub-section, we detail our e-learning Web service selection model under uncertainty. Firstly, we define the different quality attributes adopted in our model. Then, we present the structure of this selection model.

1. Quality attributes

QoS represent the non-functional aspect of e-learning Web services. We consider in our work five principal quality attributes: Cost, Response Time, Reliability, Availability and Reputation defined as follows:

- Cost: denoted by $(A_{Cost}(S_i))$ is the amount of money paid by the user for consuming the service S_i.
- Response Time: denoted by $(A_T(S_i))$ can be calculated as follows:
  $A_T(S_i)= A_{Tex}(S_i) + A_{Tat}(S_i)$
  Where $A_{Tex}(S_i)$ is the time used by an instance of a web service in its execution, and $A_{Tat}(S_i)$ is the waiting time needed by the request to be processed.
- Reliability: denoted by $(A_F(S_i))$, it is the probability that the service S_i proceed correctly and consistently. It can be computed as follows: $\frac{Inv(S_i)}{T_{Invoc}(S_i)}$. Where $Inv(S_i)$ is the number of times that the service S_i has been successfully delivered, and $T_{Invoc}(S_i)$ is the total number of invocations.
- Availability: denoted by $(A_D(S_i))$ is the probability that the service S_i is available during a γ time interval.
  Availability can be computed as follows $A_D(S_i) = \frac{T(S_i)}{\gamma}$ Where $T(S_i)$ is the total time that the service S_i is available in the last γ seconds.
- Reputation: denoted by $(A_R(S_i))$ is a measure of the trustworthiness of the service S_i. This reputation is computed from the ranks R_j assigned to the service by their end users. Reputation can be computed using the expression $A_R(S_i) = \frac{\sum_1^L R_j}{L}$. Where $R_j$is the rank assigned to the service by their end users, and L is the total number of users.

Note that these quality attributes are appropriate to e-learning Web service since its interest different users in education domain (learner, tutor and administration).

We can distinguish two classes of attributes :

- Negative attributes: if values of these attributes increase the quality of the Web service decreases, such as Response Time and Cost.
- Positive attributes: the quality of the Web service improves when values of these attributes increase, such as Reliability, Availability and Reputation.

Our quality model is based on the model proposed by (H.Tong et al., 2006) The quality attributes adopted in our approach are presented as a quadruplet ***(Z, V, G, T):***

- *Z*: the name of the quality attribute.
- *V*: the quantification of attributes represented by the couple (V_i,P_i), where:
  - $V_i=\{v_{i1},...,v_{ik}\}$: possible values of the attribute A_i.
  - $P_i=\{P_{i1},...,P_{ik}\}$: probability distribution associated to each possible value of the attribute A_i.
- *G*: the unit of measurement.
- *T*: type of attribute n or p (negative or positive).

B. Customer preferences

Our approach gives to e-learning Web service user (Tutor, learner or administration) the possibility to express their preferences about quality attributes without obliging them to give real values. These preferences depend especially on the user profile.

For example, some learner prefer e-learning Web service with lowest cost while other one's prefer more available services.

The user gives an order of preference about different quality attributes. In our work, preferences introduced by the user are transformed in weights (numerical values between 0 and 1).

The user can select at most all attributes and at least no attributes. The number of selected attributes is denoted by *(ns)* where $0 \leq ns \leq n$. Where *n* is the total number of Web service.

The transformation is done by two steps:

- We assign for each attribute A_i a position denoted by (pos_{Ai}). The most favorite attribute will have the position *1* and the least preferred attribute will have the position *ns,* etc.
- We compute the weight of each attribute from its position using the following proposition:

Proposition:

The weight $p(A_i)$ of each attribute A_i is computed as follows:

1) **Case 1**: No selected attribute (ns = 0):

$$p_{A_i} = \frac{1}{n} \quad \forall i \qquad (1)$$

We suppose in this case that the customer is indifferent for all attributes (total ignorance).

2) **Case 2**: One attribute is selected (ns = 1):

$$\begin{cases} p_{Ai} = 1 \\ p_{Aj} = 0 \quad \forall j \neq i \end{cases} \qquad (2)$$

3) **Case 3:** Many attributes are selected $(1 < ns \leq n)$

- If *(np = ns):*

$$p_{Ai} = \frac{1}{np} \quad \forall i \qquad (3)$$

Where np is the number of attributes having the position 1.

- If $(ns \neq np)$:
  - For $i = pos_{Max}$ (with pos_{Max} is the maximal position and A_i is the least preferred attribute) then:

$$p_{Ai} = 10^{-n} \qquad (4)$$

  - For i = 1 (A_i: the most preferred attribute)

$$p_{Ai} = \frac{pos_{Max} - 1}{\sum_{j=1}^{ns} pos_{Aj}} + \frac{1 - \sum_{j=1}^{pos_{Max}-1} p_{Aj} - (R_{K^*} 10^{-n})}{np} \qquad (5)$$

Where R_k: the number of attributes having the position equal to pos_{Max}.

- For $1 < i < pos_{Max}$:

$$p_{Ai} = \frac{pos_{Max} - pos_{Ai}}{\sum_{j=1}^{ns} pos_{Aj}} \quad (6)$$

All non-selected attributes will have a null weight.

Proof

We should prove that the transformation of clients' preferences into weight suggested in the previous proposition guarantees four principal conditions:

a) The weights normalization $(\sum_{i=1}^{ns} p_{Ai} = 1)$

- Case 1 $(ns = 0)$:

$$\sum_{i=1}^{n} p_{Ai} = n * p_{Ai} = n * \frac{1}{n} = 1$$

- Case 2 $(ns = 1)$:

$$\sum_{i=1}^{pos_{Max}} p_{Ai} = p_{Ai} + (n-1) * p_{Aj} \qquad \forall\, j \neq i$$

- Case 3 $(1 < ns \leq n)$:

$$\sum_{i=1}^{pos_{Max}} (p_{Ai}) = p_{AposMax} + p_{A1} + p_{Ai} = 1$$

This equality is ensured by adding

$\frac{1 - \sum_{j=1}^{pos_{Max-1}} p_{Aj} - (R_K * 10^{-n})}{np}$ to p_{A1}.

b) The weight of the most preferred attribute is greater than all other weights :

$p_{AposMax} = 10^{-n} \cong 0$ and

$$p_{Ai} = \frac{pos_{Max} - pos_{Ai}}{\sum_{i=1}^{pos_{Max}} pos_{Ai}} < p_{A_1}$$

So p_{A_1} is the maximal weight.

c) The weight of the less preferred attribute is lower than all other weights :

$p_{A_{posMax}} = 10^{-n} \cong 0$

d) The weight of the attribute A_i is greater than the one of the attribute A_{i+1}:

$$p_{A_i} = \frac{pos_{Max} - pos_{A_i}}{\sum_{j=1}^{ns} pos_{Aj}} \text{ and } p_{A_{i+1}} = \frac{pos_{Max} - pos_{A_{i+1}}}{\sum_{j=1}^{ns} pos_{Aj}}$$

Or $p_{Ai} - p_{A_{i+1}} = \frac{pos_{A_i} - pos_{A_{i+1}}}{\sum_{j=1}^{ns} pos_{A_j}} > 0$

So $p_{A_i} > p_{A_{i+1}}$

C. Uncertainty about attributes values

In our approach, we consider that attributes values are uncertain. Indeed, the values of quality attributes can be influenced by several factors such as hosting platform, network performance, etc. (Serhani, 2005). Moreover, these values can be fixed by a non-objective manner and can be based on incorrect information or missing data.

Hence, our approach proposes a flexible way to treat uncertainty concerning attributes values. In our model the quantification of each attribute is no longer represented by a fixed value but by a couple (values, probabilities) fixed by experts where each attribute is quantified by several possible values characterized by probabilities.

For the presentation of our problem we use the decision matrix (see Table I), where the columns represent attributes and rows represents services. Each cell c_{ij} (the intersection between the line i and column j represents the quantification of the attribute A_i for the service S_j.

Let $S=\{S_1, \ldots, S_m\}$ be a set of similar e-learning Web services and $A=\{A_1, \ldots, A_n\}$ be a set of quality attributes.

The decision matrix is presented as follows:

Table I. GENERAL REPRESENTATION OF THE DECISION MATRIX

	A_1	…	A_i	…	A_n
S_1	V_{11}, Pr_{11}		V_{i1}, Pr_{i1}		V_{n1}, Pr_{n1}
S_j	V_{1j}, Pr_{1j}		V_{ij}, Pr_{ij}		V_{nj}, Pr_{nj}
S_m	V_{1m}, Pr_{1m}		V_{im}, Pr_{im}		V_{nm}, Pr_{nm}

- $V_{ij} = \{v_{ij1}, \ldots, v_{ijk}\}$: the set of attribute value's A_i for the service S_j.
- $Pr_{ij} = \{pr_{ij1}, \ldots, pr_{ijk}\}$: the probability pr_{ijk} that the attribute A_i has the value v_{ij} such that

$$\sum_{i=1,m=1}^{n,k}(pr_{ijm}) = 1$$

At the end of this process each attribute A_i of the service S_i should have one and only one expected value EV_{ij} using the following function:

$$EV_{ij}(A_i) = \sum_{m=1}^{k} pr_{ijm} * \ v_{ijm}$$

In this step, our decision matrix is presented as follows:

Table II: DECISION MATRIX

	A_1	…	A_i	…	A_n
S_1	EV_{11}		EV_{i1}		EV_{n1}
S_j	EV_{1j}		EV_{ij}		EV_{nj}
S_m	EV_{1m}		EV_{im}		EV_{nm}

D. Selection process

As we have mentioned, we propose in this paper a new e-learning Web services selection approach based on user preferences and quality attributes. Our selection approach implements the TOPSIS algorithm. The main idea of this method is the selection of the candidate with the highest degree of membership belonging to the positive ideal solution.

However, the major modification of our new TOPSIS algorithm for Web services selection is its input. The input of our new algorithm is the decision matrix preprocessed (the decision matrix obtained after computing the expected value of each quality attribute).

Our selection approach is as follows:

- **Step 1**: Computing the positive ideal solution I^+ and the negative ideal solution I^-.

Definition 1:

Let I^+ be the positive ideal solution defined as: $I^+ = (I_1^+, I_2^+, I_3^+, I_4^+, I_5^+)$
$=(EV_{1j}^{max}, EV_{2j}^{max}, EV_{3j}^{max}, EV_{4j}^{max}, EV_{5j}^{max})$
where EV_{ij}^{max} is the highest expected value of the attribute A_i (in the column i with $1 \le i \le n$ and $1 \le j \le m$).

Definition 2:

Let I^- be the negative ideal solution defined as:
$I^- = (I_1^-, I_2^-, I_3^-, I_4^-, I_5^-)$
$=(EV_{1j}^{min}, EV_{2j}^{min}, EV_{3j}^{min}, EV_{4j}^{min}, EV_{5j}^{min})$
where EV_{ij}^{min} is the lowest expected value of the attribute A_i (in the column i with $1 \le i \le n$ and $1 \le j \le m$).

- **Step 2**: Computing weighted Euclidean distance to the positive ideal solution and to the negative ideal solution for each service.

Definition 3:

Let D_j^+ be the weighted Euclidean distance between the service j and the positive ideal solution:

$$D^+_j = \sqrt{\sum_{i=1}^{5}[p_{A_i}(I_i^+ - EV_{ij})]2} \quad (8)$$

Definition 4:

Let D_j^- be the weighted Euclidean distance between the service j and the negative ideal solution:

$$D^-_j = \sqrt{\sum_{i=1}^{5}[p_{A_i}(EV_{ij} - I_i^-)]2} \quad (9)$$

- **Step 3**: Computing the degree of membership of each service to the positive ideal solution.

Definition 5:

Let $\mu(D_i)$ be the degree of membership of D_j to the positive ideal solution:

$$\mu(D_j) = \frac{1}{1+\left[\frac{D_j^+}{D_j^-}\right]^2} \quad (10)$$

- **Step 4**: The step of the final decision. From the different values $\mu(D_j)$ we select the best service which has the highest value $\mu(D_j)$.

V. Case study

In this section, we will detail an example of selection of the best e-learning Web service among three similar ones $S = \{S_1, S_2, S_3\}$ characterized by four attributes:

$A = \{A_1\ (Cost),$
A_2(Response Time),
A_3(Availability),
A_4 (Reliability)}

The user in our case study is the e-learning administration which has the following preference relation about the four quality attributes:
$A_2 \geq A_4 \geq A_3 \geq A_1$

This preference relation is transformed into weights using Equation (1) to (6) as follows:

- P(A1) = 0.699
- P(A2) = 0.2
- P(A3) = 0.1
- P(A4) = 0 = 0.0001

The initial decision matrix is represented in Table III:

Table III: Decision Matrix

	A_1	A_2	A_3	A_4
S_1	V_{11}={7,6} Pr_{11}={0.2, 0.8}	V_{21}={5,6} Pr_{21}={0.3, 0.7}	V_{31}={60,70} Pr_{31}={0.9, 0.1}	V_{41}={90,65} Pr_{41}={0.4, 0.6}
S_2	V_{12}={5} Pr_{12}={1}	V_{22}={8} Pr_{22}={1}	V_{32}={20} Pr_{32}={1}	V_{42}={80} Pr_{42}={1}
S_3	V_{13}={8,5} Pr_{13}={0.5, 0.5}	V_{23}={5} Pr_{23}={1}	V_{33}={7,6} Pr_{33}={0.2, 0.8}	V_{43}={7,6} Pr_{43}={0.2, 0.8}

In our decision matrix the cell C_{11} represents the intersection between the Web service S_i and the attribute Cost. This cell contains the couple $\{V_{11}, Pr_{11}\}$ which represents the set of the different possible values and their respective probabilities of the attribute Cost for the service S_1 where: pr(cost(S_1)=7) = 0.2 and pr(cost(S_1)=6) = 0.8.

In the next step, we will compute the expected value of each attribute using Equation (7). The cell c_{11} in the Table IV represents the expected value of the attribute cost.

Table IV: Expected Values

	A_1	A_2	A_3	A_4
S_1	6.2	5.7	61	75
S_2	5	8	20	80
S_3	6.5	5	59.5	73

Positive ideal solution and negative ideal solution are represented in Table V.

Table V: The positive and negative ideal solutions

	A_1	A_2	A_3	A_4
Positive idSol	6.5	8	61	80
Negative idSol	5	5	20	73

In Table VI, we compute weighted Euclidean distance using ideal solutions represented in Table V and Equation (8) and (9).

Table VI: Weighted Euclidean distance

	Positive idSol	Negative idSol
S_1	5.179	7.84
S_2	0.6	2
S_3	50.059	9.7

The degree of membership (Table VII) of each service to the positive ideal solution is computed using Equation (10).

Table VII: The degree of membership to positive solution

	$\mu(D_j)$
S_1	0.696
S_2	0.9174
S_3	0.0361

VI. Conclusion

Our approach is based on the MADM method. The principle of this approach is the selection of the most appropriate e-learning Web service with the highest degree of membership belonging to the positive ideal solution.

Our approach allows to users i.e. learner, tutors and administration to express their preferences concerning quality attributes by transforming preference relation between quality attributes into weights. It allows the treatment of uncertainty concerning quality attributes' values expressed by probability theory. Then, expected values of each e-learning Web service are computed from the attribute values expressed by experts in the domain of education.

As future work, we will extend our approach by integrating semantic aspect through the use of ontologies and policy languages.

A second perspective of our work is the use of graphical decision models to represent the problem of e-learning Web services selection.

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