A NEW MODEL FOR WEB SERVICES SELECTION BASED ON FUZZY LOGIC

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ABSTRACT

With the growing popularity of using web services, the qualities of services characterizing web services have become important qualifying the services of customers and consumers. However the current technologies do not respond best because the information of the customers towards the qualities of the web services is imprecise and sometimes uncertain ambiguous. In this paper we will present a new model based on fuzzy logic that can help consumers of Web services better select the best service in terms of quality.

KEYWORDS: Web service, quality of Service (QoS), fuzzy logic, Fuzzy ranking, selection, Matlab.

1 INTRODUCTION

The number of web services offering the same functionality is constantly growing, hence the task of selecting a web service among several similar services is a very delicate task for the service consumer because generally, the services providing the functionality in question will be returned in the order of their registration in the UDDI register in question [1] and the selection approaches consider the consumer need in the selection of Web Services but they do not consider other constraints such as functional and non-functional qualities [2]. To remedy this kind of problem, it was proposed to take into account the quality of service criteria and more precisely during the selection process [3],[4].

Here again, the consumer's assessment of the web service is not always precise and sometimes unclear and ambiguous, hence the need to translate this evaluation into a logic analogous to human logic and adopt quality of service criteria to assist the consumer in choosing his own services. Therefore, fuzzy logic can be applied to support imprecise representation of QoS constraints [5] and present user preferences as QoS properties with a fuzzy presentation as they are better suited to the interpretation of linguistic terms [6].

In this article, we use fuzzy logic to represent vague or inaccurate data. This technique allows the representation of data with linguistic variables and fuzzy values.

The remainder of the paper is structured as follows: Section 2 illustrates some related works. Section 3 describes some preliminary notions about fuzzy. Section 4 displays our proposed model. Section 5 presents a numerical illustration. Section 6 shows the results by comparing our proposal with a conventional method. Section 7 concludes with a conclusion and future scope.

2 RELATED WORKS

In [7], the authors proposed an architecture in which the UDDI registry supports the integration of QoS parameters with Web services information, which can be summarized as follows: Once the Web service is published, the quality information services are stored in the UDDI registry via the tModel data structure. A service negotiator added to this model, this negotiator helps the customer to choose the appropriate web service based on QoS settings. The service provider is responsible for registering, deleting, and updating web services. The publisher service publishes service feature information in the UDDI registry after the QoS authentication process. The consumer can search the Web Service Registry through the Web Services Negotiator. It sends its request which includes its functional needs as well as its preferences in terms of QoS. It chooses the web service that satisfies the user preferences and QoS constraints of the registry. The approach presented in this article does not include fuzzy logic, so it does not take into account inaccurate and uncertain consumer information. To test this model, the authors used the following quality criteria: response time, security, reliability and cost. Thus, to classify similar Web services, they opted for the AHP and TOPSIS ranking methods. The purpose of the AHP method is to assign weights for each criterion while TOPSIS is used to classify the web services to be sent to the consumer. In [8] the authors propose an architecture that allows representing the QoS in fuzzy terms, the description of the QoS and the functionalities of the Web services is made with the use of ontology for each Web Service. The proposed model makes it possible to present the properties of QoS in fuzzy terms. To test this model, the authors used the following quality criteria: Cost, reputation and security, they used the criteria that depend directly on the client, which can be called preferences. In [9] the author proposes an algorithm on 7 steps based on fuzzy logic to deal with the problem (MADM multi attribute decision making). Its goal is to find the best alternative among several existing alternatives. The data relating to the criteria is based on uncertainty, for this the author used the representation Triangular Fuzzy numbers to represent the linguistic data. The author tested his algorithm by three alternatives or each is characterized by 4 criteria. In [10], responding to the following spread: classical classification approaches are difficult to apply in practice because of incomplete and non-quantifiable information and imprecise human judgment. The author proposes a multi-criteria group decision making approach using fuzzy logic and the Entropy method for the calculation of weights relative to the criteria which have a great influence on the final result of selection. It uses the TOPSIS algorithm to support consumer linguistic data. The proposed algorithm consists of 6 steps of the decision matrix formed by linguistics passing through normalization, construction of Positive Ideal Solution and Negative Ideal Solution and arriving at the closeness coefficient inducing the weight of each alternative. In [11], the author proposes a fuzzy multicriteria approach to evaluate the environmental performance of suppliers. This approach is summarized in three main steps: The first step is to identify the criteria for evaluating the environmental performance of suppliers. In Step 2, the experts evaluate the selected criteria and the different alternatives (providers) against each of the criteria. Language assessments are used to evaluate criteria and alternatives. These linguistic notes are then combined by TOPSIS for an overall performance score for each alternative. In step 3, a sensitivity analysis is performed to assess the influence of the criteria on the assessment of suppliers' environmental performance. The author has experimented with four alternatives that are evaluated by a panel of three experts. Decision-makers provide linguistic evaluations for criteria that are twelve in number and also for alternatives.

3 PRELIMINARY NOTIONS OF FUZZY LOGIC

In this section, we examine definitions of fuzzy numbers to represent the proposed algorithm

Definition1: A fuzzy set $\tilde{A}$ is a subset of a universe of discourse X, which is characterized by membership function $u_{\tilde{N}}(x)$ representing a mapping $u_{\tilde{A}} \to [0,1]$. The function value $u_{\tilde{A}}(x)$ of $\tilde{A}$ is called the membership value, which represents the degree of truth that x is an element of fuzzy set. It is assumed that $u_{\tilde{A}}(x) \in [0,1]$, where $u_{\tilde{A}}(x) = 0$ reveals that x belongs completely to $\tilde{A}$, while indicates that x does not belong to the fuzzy set $\tilde{A}$ [12].

Definition 2: A triangular fuzzy number $\tilde{N}$ can be defined as a triplet (l,m,u) and the membership function $u_{\tilde{N}}(x)$ is defined as[15]:

$$\tilde{N} = \begin{cases} 0; & x < a \\ \frac{x-a}{b-a}; & a \leq x \leq b \\ \frac{c-x}{c-b}; & b \leq x \leq c \\ 0; & x > c \end{cases}$$

Where a,b and c are real numbers and $(a \leq b \leq c)$ (Fig.1.)

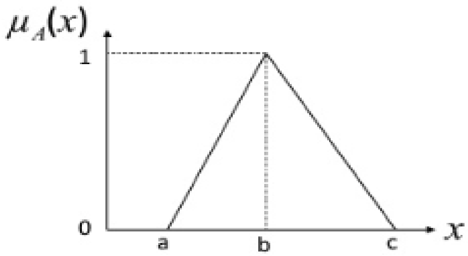

Figure 01: Triangular fuzzy number $\tilde{N}$ [12]

Definition 3: A trapezoidal fuzzy number $\tilde{N}$ can be defined by a quadruple (a,b,c,d) and the membership function $u_{\tilde{N}}(x)$ is defined as[5]:

$$\tilde{N} = \begin{cases} \frac{x-b}{b-a}; a < x \leq b \\ 1; b \leq x \leq c \\ \frac{d-x}{d-b}; c \leq x \leq d \\ 0; & otherwise \end{cases}$$

Where a,b,c and d are real numbers and $(a \leq b \leq c \leq d)$ (Fig.2.

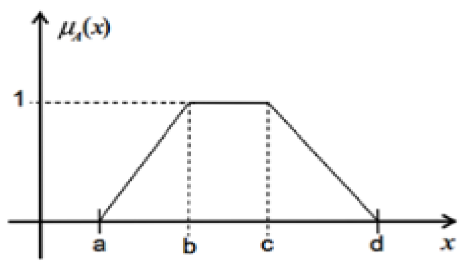

Figure 02: Trapezoidal Fuzzy number [5]

Definition4: let $\tilde{N}_1 = (l_1, m_1, u_1)$ and

$\tilde{N}_2 = (l_2, m_2, u_2)$ be two triangular fuzzy numbers. Then, the aggregation and multiplication operation of $\tilde{N}_1$ and $\tilde{N}_2$ produce another triangular fuzzy numbers [5]:

$$\tilde{N}_1 \oplus \tilde{N}_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$$

$$\tilde{N}_1 \otimes \tilde{N}_2 = (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2)$$

Definition 5: let $\tilde{N}_1 = (l_1, m_1, u_1)$ and $\tilde{N}_2 = (l_2, m_2, u_2)$ be two triangular fuzzy numbers. Then, the distance between them applying the vertex method is as follows [11]:

$$d(\tilde{N}_1, \tilde{N}_2) = \sqrt{\frac{(l_1 - l_2)^2 + (m_1 - m_2)^2 + (u_1 - u_2)^2}{3}}$$

4 PROPOSED MODEL

The proposed model is described as follows:

Initially, the user sends his functional request to the UDDI registry that contains the names Web Services lists and their QoS parameters. In response to this request, a list of similar services is produced. QoS extraction is performed for each web service to produce a fuzzy web services matrix and their corresponding QoS. Once the fuzzy matrix is ready, it is passed to fuzzy inference engine which use the fuzzy rule base to produce a weight for each web service. In the end, these score values are ranked to provide the best service to recommend to the client.

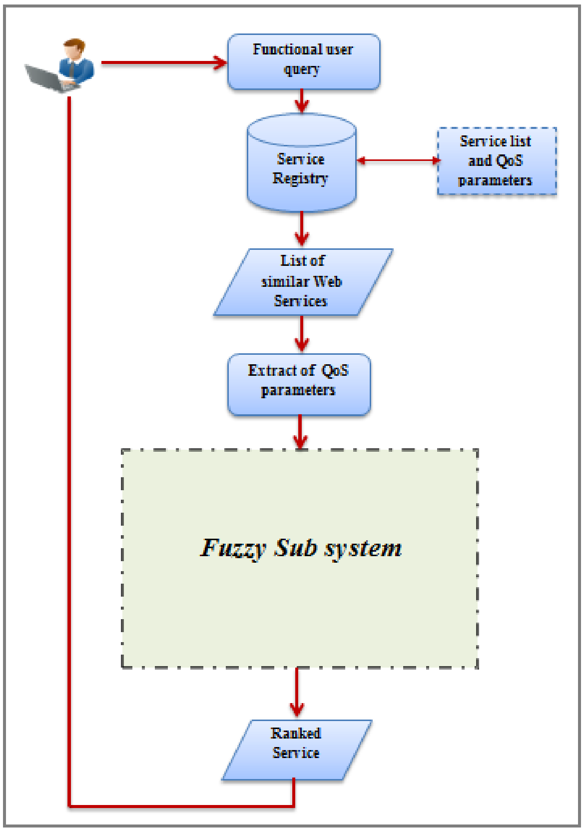

Figure 3: Proposed model

4.1 Fuzzy selection algorithm

The algorithm for selecting similar web services is represented as follows:

Input: Query contains functionally parameters

Output: Ranked Web Services

1: Get the query from the user

2: Find the list for the search of similar services from the UDDI registry.

3: Extract the non-functional proprieties (QoS) of the service.

4: Pass each QoS to the Fuzzy sub module

5: By choosing a type of membership function (for example Triangular, trapezoidal or Gaussian membership method, translate the QoS parameters crisp values into fuzzy values.

6: For each web service, the fuzzy engine calculates the QoS weights using the inference fuzzy rules base.

7: Defuzzify the values of each Web service using the average of the maxima or center of gravity method to obtain crisp values of each Web Service

8: Rank the obtain services

4.2 Fuzzy sub system

This sub system is described as follows (fig.4):

It has as input the quantitative values of the quality parameters. it builds a matrix that has online web services and columns the appropriate quality criteria. These crisp values are passed to Fuzzification module which with the help of human experts and with the choice of a given membership function, proceeds to fuzzification to give as result a fuzzy matrix.

Then, this matrix is received by the fuzzy inference engine which, with the exploitation of the fuzzy rules database produced for each web service, a result in fuzzy term named weight.

This weight is redirected to the defuzzification module which with the use of a defuzzification method produces a quantitative value characterizing the web service in question.

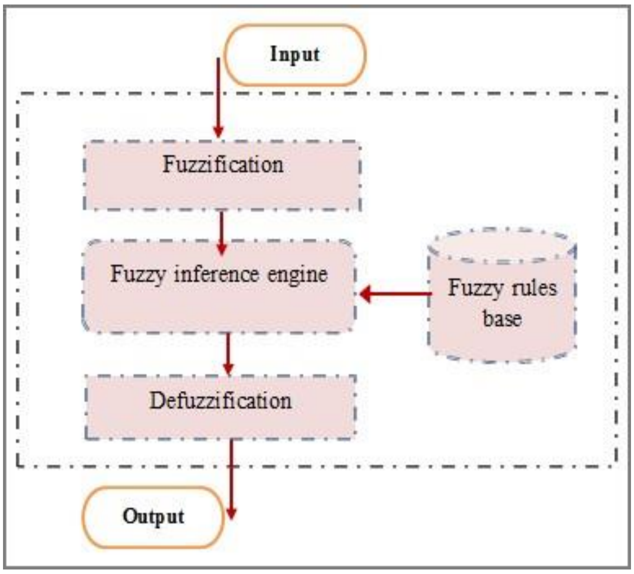

Figure 04: Fuzzy engine architecture

4.3 Fuzzification

The purpose of the fuzzification stage is to transform a numeric data into a linguistic variable. For this, we need to create membership functions that define the degree of membership of a numeric data to a linguistic variable. The inputs to fuzzification are the quality of service (QoS) parameters in quantitative values. For each criterion, we can create several membership functions depending on the criterion we have. If the web services which we want to test meet the criteria: reliability, availability and Response time: each of these data will have several membership functions. For example: If we want to transform reliability into linguistic variable. We can find several linguistic variables qualifying this numerical data: low, medium and high. The same principle for the two other criteria: availability can be presented by the linguistic variables: low, medium and high and the criterion response time can be presented by the linguistic variables: cheap, average and expensive.

Since we chose the triangular membership function to present our linguistic data, the following table presents the values assigned to each quality criterion:

Table 01: Criteria linguistic term (example)

Linguistic term	Triangular fuzzy number
Reliability	
Low	(0,0,3)
medium	(2,5,8)
high	(6,9,10)
Availability	
Low	(0,0,4)
medium	(2,5,7)
high	(5,8,10)
Response time	
Cheap	(0,0,4)
average	(2,5,7)
expensive	(5,8,10)

4.4 Fuzzy inference engine

The fuzzy inference engine input is a fuzzy matrix resulting from the fuzzification of which the linguistic values corresponding to each web service.

$$\widetilde{M} = \begin{array}{c} \\ s_1 \\ s_2 \\ .. \\ s_m \end{array} \begin{array}{c} \begin{array}{cccc} c_1 & c_2 & \dots & c_n \end{array} \\ \begin{pmatrix} \widetilde{x}_{11} & \widetilde{x}_{12} & \dots & \widetilde{x}_{1n} \\ \widetilde{x}_{21} & \widetilde{x}_{22} & \dots & \widetilde{x}_{2n} \\ \dots & \dots & \dots & \dots \\ \widetilde{x}_{m1} & \widetilde{x}_{m2} & \dots & \widetilde{x}_{mn} \end{pmatrix} \end{array}$$

Where s_1 , s_2 , ..., s_m are the web services, c_1 , c_2 , ..., c_n are the quality of service parameters and x_{ij} is a fuzzy value presenting the quality value cj for the service si for each web service, its data is passed to the fuzzy inference engine that uses the inference rule base for its reasoning. Each rule is described according to the knowledge it has. For its operation, it applies each rule to the linguistic variables calculated in the Fuzzification step and the result of this step is a fuzzy value characterizing each web service.

4.4.1 Fuzzy rules base

These rules have the form (if X then Y), they are created by the designer and will be exploited by the fuzzy inference engine to produce a fuzzy result that will be translated later to give a quantitative value. The most used operators in rule evaluation are the union that is translated by MAX and the intersection that is translated by MIN.

4.5 Defuzzfication

Unlike fuzzification, defuzzification allows to associate with each fuzzy value, which corresponds to the desired output, a real and concrete value. This step can be done in several ways depending on the chosen mathematical concept. We report that there are multiple methods for deffuzification:

- Center of Sums Method (COS)
- Center of gravity (COG)
- Centroid of Area (COA) method
- Bisector of Area Method (BOA)
- Weighted Average Method
- Mean of Maxima Method (MOM)

Center of gravity method (COG): this method is similar to the gravity center used in physics. It is the most used despite its exponential order of complexity. The expression of the output is written as [13]:

$$x_{COG} = \frac{\int u(x)\,x\,dx}{\int u(x)\,dx}$$

Where x_{COG} is the crisp output and $u(x)$ is the aggregate membership function and x is the output variable.

Mean of Maxima Method: The principle of the method is to calculate the arithmetic mean of all the maximums obtained on the surface of the output element. This method is characterized essentially by a low degree of complexity, and therefore relatively easy to implement. In the present work, we will test our outputs center of gravity method because it is the most used in defuzzification.

5 NUMERICAL ILLUSTRATION

In this section, we propose an experiment whose implementation has been realized with MATLAB to demonstrate the feasibility of our proposal. These data (web services and their qualities) are based on the test in [13].

The example is described as follows (table2): We have six Web Services (ABC, BTC, WS1, WS2, WS3 and WS4). These web services are examined according to 7 criteria: Price (Pe), availability (Av), timeout (To), Compensation rate(Cr), Penalty rate (Pr), Execution duration (Ed), reputation (Re).

Table 02: QoS information in Service Provider

	Pe	Av	To	Ed	Re	Cr	Pr
ABT	25	0.7	75	100	3	0.5	0.5
BTC	40	0.8	200	40	2.5	0.8	0.1
WS_1	46	0	65	60	1	0.7	0.4
WS_2	38	0.8	120	25	4	0.85	0.3
WS_3	27	0.9	95	30	3	0	0.1
WS_4	30	0.75	180	85	3	0.95	0.2

The request issued by the user is given by: (Price≤ 50, availability≥ 0.75, timeout≥ 70, Compensation rate≥ 0.7, Penalty rate≤ 0.45, Execution duration≤ 100, reputation≥ 2.5)

The two web services ABT and WS1 are eliminated from the selection because they do not meet the user requirements.

The first step in our approach is to present each variable (quality criterion) in fuzzy values which essential to perform the fuzzification. In the following table we will present the linguistic terms corresponding to the membership functions each variable. Let us note here that we chose the triangular fuzzy model to present our data.

Table 03: Criteria linguistic term

Linguistic term	Triangular fuzzy number
Price	
cheap	[0 15 30]
acceptable	[20 40 60]
expensive	[50 70 100]
Availability	
low	[0 0 0.3]
medium	[0.2 0.35 0.5]
high	[0.4 0.6 0.8]
excellent	[0.7 0.9 1]
Time Out	
low	[0 50 80]
medium	[50 120 170]
great	[130 200 250]
Execution duration	
small	[0 0 80]
medium	[50 100 160]
long	[120 160 200]
Reputation	
bad	[0 0 2]
good	[1.5 2.5 3.8]
very good	[2.8 4 5]
Compensation rate	
bad	[0 0 0.3]
good	[0.1 0.5 0.9]
very good	[0.6 1 1]
Penalty rate	
bad	[0 0 0.3]
good	[0.1 0.4 0.7]
very good	[0.5 0.8 1]

For example, reputation and availability are represented as follows:

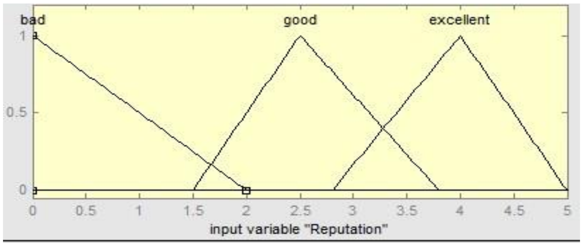

Figure 05: Reputation variable

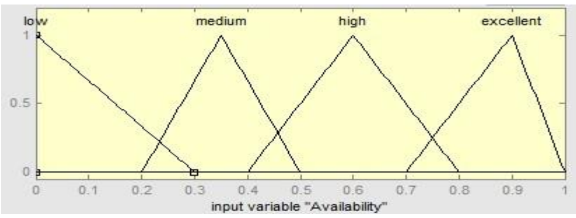

Figure 06: Availability variable

The result that present the fuzzy engine weight assigned to each service is presented as follows:

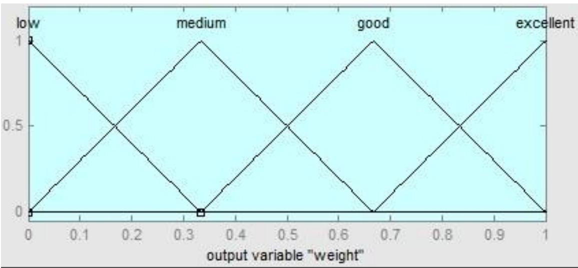

Figure 07: weight variable

By using fuzzy logic, the user requirements can be rep- resented as follows:(Price=cheap, availability=excellent, timeout=low or medium, Compensation rate=very good, Penalty rate= cheap or acceptable, Execution duration= small or medium, reputation= good or excellent)

In this experiment, we wrote a set of rules that will be used by the fuzzy inference engine. In the following, we present some rules:

1. If (Price is cheap) and (Availability is excellent) and (TimeO is low) and (Execution is small) and (Reputa- tion is good) and (Rate is good) and (Penalty is bad) then (weight is excellent)
2. If (Price is acceptable) and (Availability is medium) and (TimeO is medium) and (Execution is medium) and (Reputation is good) and (Rate is good) and (Penalty is good) then (weight is medium)
3. If (Price is expensive) and (Availability is low) and (TimeO is great) and (Execution is long) and (Repu- tation is bad) and (Rate is good) and (Penalty is bad) then (weight is low)
4. If (Price is cheap) and (Availability is excellent) and (TimeO is low) and (Execution is small) and (Reputa- tion is excellent) and (Rate is bad) and (Penalty is bad) then (weight is excellent)
5. If (Price is cheap) and (Availability is excellent) and (TimeO is medium) and (Execution is small) and (Reputation is excellent) and (Rate is bad) and (Penalty is bad) then (weight is excellent)

By running the inference engine that applies all of the rules for each web service we get the real-valued weights of each web service.

Table 04: Web services weight

	Pe	Av	To	Ed	Re	Cr	Pr	weight
BT C	40	0.8	200	40	2.5	0.8	0.1	**0.5**
W S2	38	0.8	120	25	4	0.85	0.3	**0.6**
W S3	27	0.9	95	30	3	0	0.1	**0.849**
W S4	30	0.75	180	85	3	0.95	0.2	**0.5**

as, we see the last column of the previous table, the best service is the one that the greatest weight so the service WS3 is the ranked service then it will be returned to the user

6 RESULTS

We proposed a web service selection algorithm based on fuzzy logic. The ranking was mainly done by a fuzzy engine which uses as input a fuzzy matrix consisting of similar web services with their corresponding quality parameters and with the base of the rules that it holds, it applies it in this case of all the web services, each one apart to give to the end, a weight characterizing each entry (WS + QoS) that will be used for the ranking and actually sent back to the user. The model was evaluated by ranking a set of similar web services with the help of seven quality of service criteria described in linguistic values. They are classified by the use of fuzzy engine (table5).

6.1.1 Conventional approach and fuzzy approach

If we compare our results with [14], we can say that the two methods gave almost the same result (table 5) but with our proposal we favored the user to use the natural language by launching his request.

Table 05: Fuzzy and conventional rank

Web Service	Fuzzy rank	Conventional rank
BTC	0,4458	0,5
W S_2	0,5713	0,6
W S_3	0,8457	**0,849**
W S_4	0,568	0,5

This result can be represented by a chart as follows:

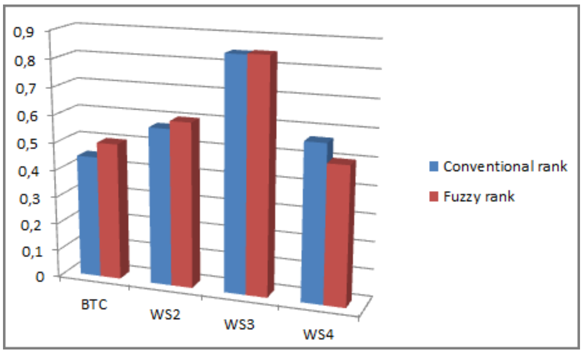

Figure 08: Services rank

The results obtained in the table above are graphically shown in Figure 8 and from this figure we also deduce the same results. Compared to conventional methods, the fuzzy method easily helps customers to select web services while proposing a query in linguistic terms. This especially encourages unskilled users of quality criteria parameters to choose the best services in terms of quality.

7 CONCLUSION

In this paper, we have presented a fuzzy logic-based Web service selection model that will consider the consumer's language data and then select the appropriate services and render the desired web services. This model was illustrated by an example of Web services selection consisting of six Web services and seven quality criteria (Price, availability, timeout, Compensation rate, Penalty rate, Execution duration, and reputation). This approach enables customers to get a dynamic ranking of the available web services with respect to various QoS criteria. In the future work, we will focus on the discovery and selection of services in multi-agent systems. The use of the notion of agent for web services is thus a major challenge to equip the web services with interesting capacities of the software agents which are in fact considered as one of the main elements constituting the Web infrastructure of the Next generation.

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