Fuzzy Cloud Service Selection Framework

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Abstract— Cloud computing is the latest computing paradigm that delivers hardware and software resources as virtualization enabled services. Recently, cloud service selection has emerged as an important research problem due to large number of cloud providers and their diverse service configurations, multiple selection criteria, and customer's fuzzy perception of Quality of Service (QoS). In this paper, we propose a novel fuzzy logic framework for cloud service selection based on the individual QoS criteria of customers. In this model, the necessary service configuration and run-time QoS data is collected from reliable sources such as monitoring services, customers' feedbacks, and certified cloud providers' information. The obtained results from conducted case study shows validity and applicability of the proposed framework.

Keywords — Fuzzy Logic; Cloud Service Selection; Cloud Provider; Multi-Criteria Decision Process; Monitoring tools; User feedback.

I. INTRODUCTION

Cloud computing paradigm [1], [2] provides users a wide range of services based on a flexible pay-as-you-go pricing model. The flexibility of dynamically acquiring (based on application workload demands) cloud services have encouraged many enterprises to migrate their IT applications to cloud-based virtualized services (e.g. CPU, storage, network, databases, application server, and web server). Fuelled by such demands leading IT vendors including Google, Microsoft, and Amazon has started offering variety of cloud services. Naturally, it is challenging [3] for customers to select the right mix of cloud services that meet their QoS criteria at different stages of application lifecycle orchestration (e.g. selection, deployment, and run-time management).

The first step in migrating application to the cloud is to select the best mix of cloud services that can deliver the QoS agreed as part of Service Level Agreement (SLA). However, selecting QoS optimized cloud services is not a trivial task due the heterogeneities of service configuration naming [4] and diverse QoS features. For instance, a low-end CPU service of Microsoft Azure is 30% more expensive than the comparable Amazon EC2 CPU resource, but it can process application workload twice as quickly. One of the available approaches for choosing cloud services is to manually read the configuration information from provider's websites. However, such an approach does not support streamline and easy-to-understand comparison of cloud service configurations, specially based on mix of often conflicting QoS criteria. Further the information published by providers is not 100% reliable, as the providers may exaggerate the claims about their services' capabilities in order to overthrow other competitors [5],[6]. Moreover, it is extremely daunting task for customers to directly map their application QoS needs (e.g. maximize web server throughput) to the service configuration (e.g. available RAM on a CPU resource or available processing power of CPU resource) published by providers.

The importance of service selection issue returns to the fact that migrating from one cloud provider to another is not only costly but also a risky process. If the selection process is not optimally executed it could lead to vendor lock-in issues such as dependency of application stack on particular virtualization format (e.g., Hyper-V, Xen, KVM, etc.) or programming platforms (Amazon SimpleDB, Microsoft SQL Server, etc.). Even though the cloud federation has been coined to solve some of the issues mentioned above, and the technical issues involved with establishing such a federation are numerous. Hence, cloud federation is not likely to become reality in near future. It is clear that cloud service selection should be carefully undertaken while considering customer's QoS needs and available services' configuration.

In order to assist customers with the selection process and enable them to select the most appropriate (as per QoS needs) service, a reliable cloud service selection framework is required. To this end, we propose a novel fuzzy logic framework that undertakes service selection based on the individual QoS criteria of customers. Although many research proposed models and frameworks for ranking cloud services exist, to the best of our knowledge, most of the existing approaches neglect configuration and QoS information capture and validation phase. So the existing approaches are biased with uncertain information of could service providers, consumer's vague conception of the requirement, and also unrealistic measurement of QoS which depends on real time measurement and past QoS history of the services [4]. The main contributions of this framework can be described as follows:

- Ability to validate the captured configuration service information via a third party validator
- Ability to obtain realistic run-time measurement of QoS attributes from monitoring tools
- Ability to include customers feedback information (about past performance of services) in the selection process
- Ability to simplify the customer's fuzzy perception of QoS by modeling the problem as a fuzzy multi criterion decision-making process. The proposed approach can

handle the imprecise customer's preferences related to the QoS attributes.

The rest of the paper is organized as follows. In Section II, the related works are briefly discussed. In Sections III and IV, the proposed approach and the main components of the framework are defined. Section V details the empirical case study for experimental justification of the proposed fuzzy model. In Section VI, analysis of results against the state-of-the-art is presented. The paper ends with the brief summative analysis and conclusions in section VII.

II. LITERATURE REVIEW

Cloud computing encompasses different area of research including virtualization, datacentre hardware design, datacentre assembling, software defined networks, software platform development, and resource orchestration. However, the focus of this paper is propose a novel approach to improve the existing state of the art in cloud service selection process [9],[10],[11],[12],[30] which in broader sense is part of resource orchestration research.

Cloud providers are compared and classified and a provider independent classification model is proposed for infrastructure as a Service (IaaS) level in this paper [7]. The main criteria for selecting the IaaS providers from the customer's perspective are defined based on expert's point of view, an international literature review, and a cloud provider market analysis.

Li et al. in [8] developed a systematic comparator of the performance and cost of cloud providers (CloudCmp). The authors have introduced specialized cloud service metrics. The case study of this paper shows the high impact of proper selection of the services based on the overall service cost on the performance of customers' applications.

A set of broad service QoS measurement index (SMI) has been devised in [22] which proposes a set of business-relevant Key Performance Indicators (KPI) as a standard method of measuring and comparing cloud computing providers. Garg et al. [3] defined a SMICloud framework for the comparison of the cloud services based of the SMI criteria. In the proposed model, the ranges of the selected QoS attributes are expressed in SMI values and, based on such measures, the cloud services are ordered based on *Analytical Hierarchical Process* (AHP).

III. FUZZY CLOUD SERVICE SELECTION FRAMEWORK

Service selection is not a new problem [14] and has been addressed in many research works on Service-Oriented and Grid Computing, hence there are many approaches [15] for resolving this problem in other fields. A survey of web services research in [13], presents a general service selection model that includes two modules: i) QoS Management and ii) Service Selector. We have customized and extended this general model for cloud services selection as illustrated in Figure1.

The proposed framework is consist of four main modules, namely i) Interface, ii) QoS Management module, iii) Service Selection Process component, and iv) Cloud Service repository Module. The user interface module captures the required criteria and their related importance weights directly from the customers. Due to the complexity and the consumer's vague perception of QoS, this data is not crisp. Therefore, a separate module (Fuzzy Control Module) is defined in the QoS management phase [13]. This module is responsible for capturing the linguistic weight of criteria, based on fuzzy logic; then it converts the triangular fuzzy numbers into precise numbers. These numbers will later be used in the ranking algorithm, located in the service selection process module. This module has two components, calculating the metrics and ranking. The input of calculating the metric component is the data gathered from different sources, i.e. cloud providers' published information which certified by a third party component, user feedback, monitoring tool information, as well as user claimed priority and requirement. The output of this component feeds the ranking algorithm. Finally, the result will be shown to user through the user interface layer.

For solving the selection problem, some basic questions need to be answered: i) which service attributes should be compared? ii) how to express those attributes? iii) how to make them comparable in order to make a proper selection?

A. QoS Modeling

Selection of the proper service attributes is a key issue in the cloud service selection. QoS Modeling layer is responsible for modeling the most important criteria, their relationships and mapping for QoS needs to available service configurations [13]. Modeling the QoS is an important step in decision making processes, therefore we use one of the most suitable models [16], for cloud service selection and comparison, i.e. Service Measurement Index (SMI) [4]. SMI model provides hierarchy structural view of the characteristics that customer care about in selecting process [17].

B. Calculating The Metrics

For most of the services, no SMI measurement methodology is available for defining and capturing run-time QoS attributes. Cloud providers are the main source of service configuration information (excluding run-time QoS attributes), but due to competitive market, they might exaggerate about the capability of their services. Hence this could lead to uncertainty in decision making. For tackling this issue, it is assumed that there is a cloud repository in which the data published on cloud provider's website will be gathered in a standard format (i.e. XML). This repository is supported by a Cloud Service Broker, whose role is to verify the service provider's QoS claims (see [18] for similar solution). It allows keeping the data reliable.

Another important issue to consider during selection process is the run-time QoS measurements (e.g., response time, throughput, reliability, etc.) as well as historical QoS performance (for example how did a cloud service performed in last few months). As mentioned above such information is not published by cloud providers. To deal with this, one of the best means to collect information is monitoring services such as Amazon CloudWatch or Microsoft Fabric Controller. Apart from these cloud vendors specific monitoring service, there are numerous third-party services as well such as Montis, Gangalia, etc. In this framework a third-party monitoring tool is considered as a source of data gathering. Vendor-provided monitoring tools usually only rely on cloud performance benchmarks, which cannot represent the state of the application performance [8]. Therefore, we define another component, User Feedback, by which cloud users share their real experiences with each other. This component is designed based on [21]. The information provided by real cloud service users

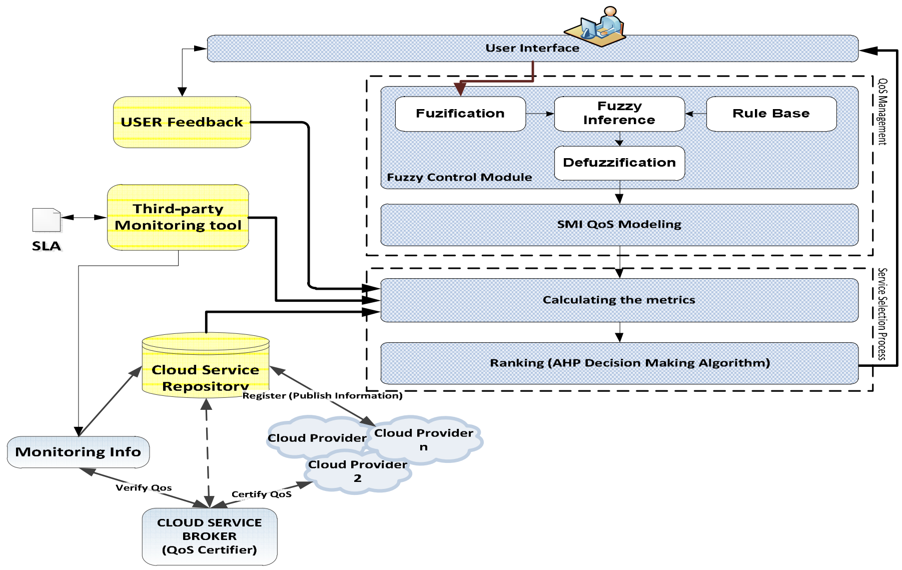

Fig. 1. Fuzzy Cloud Service Selection Framework

are more reliable, compared with the monitoring tools of both third-party and cloud venders. Therefore, the data is collected from three reliable sources: cloud service repository, user feedback, and monitoring tools.

A. AHP Algorithm

The main step in the selection process is the transformation of the various specifications into a unified standard in order to make data comparable. This step will make it available as the input data for the ranking algorithm. We have selected the *Analytic Hierarchy Process (AHP)[13]* as the most suitable ranking method for cloud services. AHP is a multi-criteria decision making algorithm, which could be easily extended and modified due to its hierarchical structure and simple implementation. Another reason is that our QoS model (SMI) is also hierarchical model. Therefore, there is no need for an extra adaptation (modification of the algorithm general structure, re-writing the code) of AHP to our service selection problem. Moreover, some cloud service characteristics cannot be expressed with numbers and they also need to be considered in selecting approach, which could easily be handled with AHP, since it is based on pair-wise comparison.

In this paper the main concern is tackling the consumer's vague conception by a fuzzy model. For this aim, we benefit from fuzzy AHP approach to include vagueness of user claims about the importance of required QoS. The linguistic variables for criteria's weigh are represented by triangular numbers 0. In this study, we use Buckley's methods[25], which is implemented to determine the relative importance weights for criteria. While this is the main concern of this paper, its detail and the main steps are described in next sections.

IV. CLOUD SERVICE SELECTION

For our proposed AHP-based ranking approach, one of the important inputs is the comparative weight of the criteria which is modeled by fuzzy logic in this paper. In this section, first we describe fuzzy approach for capturing the criteria's weight, and then explain the overall process of AHP algorithm, used in this paper.

A. Fuzzy-based Weightening Process

For taking the attribute relative importance, we need to assign weights to each criterion, based on the customer preferences. Cloud customers assign their weights by linguistic terms. Then these terms will be converted to crisp numbers by fuzzy Sets.

Step1. Triangular weight matrix: In this step, cloud users are supposed to claim their requirements and constraints, also to set weight for each criterion by linguistic terms, as shown in Table I. Since these linguistic terms cannot be used in AHP algorithm, we need to implement the *Defuzzification* procedure, in order to achieve the crisp numbers. Therefore, as in the first step, the triangular fuzzy numbers will allocate to each term, e.g. if customer considers an criterion definitely important, its fuzzy set is (3,5,7), as shown in Table I.

TABLE I. LINGUISTIC TERMS AND TRAINGULAR FUZZY NUMBERS

Linguistic terms	Triangular Fuzzy number
Unimportant	(1,1,1)
Weakly important	(1,3,5)
Definitely important	(3,5,7)
Strongly important	(5,7,9)
Extremely important	(7,9,9)

Weight matrix for available criteria is defined in (1), where 'tilde' denotes the triangular numbers.

$$\widetilde{A_i} = \begin{bmatrix} \tilde{d}_{11} & \dots & \tilde{d}_{13} \\ \dots & \dots & \dots \\ \tilde{d}_{n1} & \dots & \tilde{d}_{n3} \end{bmatrix} \quad (1)$$

Each row of the matrix in (1) represents triangular numbers of all sub-criteria, i.e. $\tilde{d}_{ij}$ indicates the importance of i^{th} criterion and j^{th} fuzzy triangular number (j=1, 2, or 3).

Step2. Geometric mean calculation: according to [25] the geometric mean of sub criteria fuzzy value is calculated as the defined in (2).

$$\tilde{r}_i = \left(\prod_{i=1}^{n} \tilde{d}_{ij}\right)^{1/n},\ i=1,2,..n\ (n=3) \quad (2)$$

Step3. Determining the final fuzzy weight of each criterion: The fuzzy weight of each criterion is defined as (3).

$$\widetilde{W}_i = \tilde{r}_i \times (\tilde{r}_1 + \tilde{r}_2 + \ldots + \tilde{r}_n)^{-1} = (lW_i, mW_i, uW_i) \quad (3)$$

Where, vector summation of each row of matrix r should be calculated, and then the reverse of this value will be calculated. Finally to find the fuzzy weight of each criterion, we multiply each r with the reverse vector.

Step4. Defuzzification and Normalization: Since W is still a set of fuzzy triangular numbers, we need to *defuzzify* it by using *Center of Area* method [26] , in the following way:

$$M_i = \frac{lW_i + mW_i + uW_i}{3} \quad (4)$$

Even though, at this stage, the result is a non fuzzy number, it still needs to be normalized by (5).

$$N_i = \frac{M_i}{\sum_{i=1}^{n} M_i}\ (= w_q) \quad (5)$$

The generated fuzzy numbers N_i are defined as the input data for the AHP algorithm.

B. AHP Ranking Process

For starting the AHP algorithm, cloud end-users define their requirements and constraints, and AHP only analyzes and selects the services which meet such requirements. The AHP additionally orders those selected services according to the ranking procedure defined in the following three steps.

Step1. Definition of the solution of service selection problem as the hierarchical procedure: the hierarchy is defined by the ranking objective definition (level 1), ordering of QoSs based on the SMI model (level 2), and available cloud services (i.e. IBM, Amazon EC2, and GoGrid)- (level 3).

Step2. Pair wise comparison: In this step the relative importance of one criterion over another can be expressed. Let vi and vj be the value of criterion q for cloud service i and j respectively. Let si and sj be the cloud services. Then si/ sj indicates the relative rank of si over sj [3].

The proposed relative ranking model for each type of attributes, Numeric, Boolean, and Unordered set is calculated differently.

The numeric value has two types, the higher value is better (e.g. performance) or the lower is better (e.g. cost). This value for a specific QoS is vi/ vj, in case that the higher value is considered better, otherwise the reverse is the result, i.e. vj/ vi.

The Boolean values, for example "the existence of firewall security" attribute in which 1 stand for firewall availability and 0 stands for no firewall protection, can be calculated as follows:

$$\frac{s_i}{s_j} = 1 \text{ if } vi = v_j,$$
$$\frac{s_i}{s_j} = w_q \text{ if } v_i = 1 \text{ and } v_j = 0, \quad (6)$$
$$\frac{s_i}{s_j} = \frac{1}{w_q} \text{ if } v_i = 0 \text{ and } v_j = 1$$

Where w is the related weight of each criterion which obtained in the fuzzy weigh process.

For unordered sets (such as "usability" that is defined by number of programming languages it is supported), the size of unordered set is considered and the calculation is shown in (7).

$$s_i / s_j = \frac{\text{size }(v_i)}{\text{size }(v_j)} \quad (7)$$

The pair wise comparison matrix obtained by using above comparison metrics for each criterion.

Step3. Aggregating the relative importance of the criteria: The related matrix of each criterion is aggregated with the weigh value obtained from the previous sub section by multiplying the result matrix from step 2 with the weight of the attributes matrix.

V. CASE STUDY

To clarify fuzzy AHP approach, we use a simple case study example in this section. For this aim, three real cloud services, i.e. Amazon EC2 [27], IBM [28], and GoGrid [29], are selected. For the sake of simplicity, in this example we only consider three criteria, as follow: (i) Finance SMI, (ii) Security SMI (iii) Performance SMI.

Table II illustrates the information gathered from cloud providers' official websites. Here we explain the process of proposed fuzzy weighting method and AHP service ranking approach, step by step in a real example.

A. Fuzzy-based Weightening Process

Step1. Triangular weight matrix: let's assume that the input is as Table III, with no constraint limitation introduced. Weight matrix of each criterion is calculated based on (1). For Finance attribute, it is calculated as matrix $\widetilde{A_1}$, in which rows demonstrate the sub-criteria triangular numbers (inbound bandwidth price, outbound bandwidth price, and base plan price respectively). Subsequently, the related matrix will be:

$$\widetilde{A_1} = \begin{bmatrix} 5 & 7 & 9 \\ 3 & 5 & 7 \\ 7 & 9 & 9 \end{bmatrix} \quad (8)$$

And so forth for other criteria (where matrix $\widetilde{A_2}$ and $\widetilde{A_3}$ belong to Security and Performance attributes, respectively):

$$\widetilde{A_2} = \begin{bmatrix} 1 & 3 & 5 \\ 1 & 1 & 1 \\ 1 & 3 & 5 \end{bmatrix} \quad (9) \qquad , \widetilde{A_3} = \begin{bmatrix} 7 & 9 & 1 \\ 1 & 3 & 5 \end{bmatrix} \quad (10)$$

Step2. Geometric mean calculation: calculating the geometric mean of each matrix as (2), for each criterion will result in:

$$\tilde{r}_1 = [\ (5*3*7)^{1/3};\ (7*5*9)^{1/3};\ (9*7*)^{1/3}] \quad (11)$$
$$\tilde{r}_2 = (1, 2, 2.9) \quad (12)$$
$$\tilde{r}_3 = (2.6, 5.1, 6.7) \quad (13)$$

In Table IV, the geometric means of available criteria fuzzy values are shown. Also the total value and the reverse value are represented. In the last row, the fuzzy triangular numbers are in an increasing order.

Step3. Determining the final fuzzy weight of each criterion: considering the total value, reverse of total and the last row of Table IV, the fuzzy weight of Finance criterion is calculated based on (3).

$$W_1 = (4.7*0.12); (6.8*0.07); (8.3*0.05)$$
$$= (0.564, 0.476, 0.415) \quad (14)$$

Other relative fuzzy weights are calculated and shown in Table V.

TABLE II. FINANCIAL, SECURITY AND PERFORMANCE ATTRIBUTES FOR IBM, EC2 AND GOGRID CLOUD SERVICES

Criterion	Sub criterion	Data type	Service1: IBM	Service2: EC2	Service1: GoGrid
Finance SMI	Outbound Bandwidth Price	Int($)	0.15	0.12	0.29
	Inbound Bandwidth Price	Int($)	0.15	0.01	0.01
	BasePlan	Int($)	0.01	0.08	0.01
Security SMI	SecurePermission	Boolean	0	1	0
	AdvancesFirewall	Boolean	0	1	0
	Persistency	Boolean	0	1	0
Performance SMI	NetworkAvailability	Int(%)	99	99.999	100
	UrgentResponce	Boolean	0	1	0

TABLE III. CUSTOMER'S LINGUISTIC INPUT AND CORRESPONDING TRIANGULAR FUZZY NUMBER

Criterion	Sub-criterion	The importance	Triangular number	Geometric Mean
Finance	Inbound Bandwidth Price	Strongly important	(5,7,9)	(4.7.6.8, 8.3)
	Outbound Bandwidth Price	Definitely important	(3,5,7)	
	BasePlan	Extremely important	(7,9,9)	
Security	SecurePermission	Weakly important	(1,3,5)	(1, 2, 2.9)
	AdvancesFirewall	Unimportant	(1,1,1)	
	Persistency	Weakly important	(1,3,5)	
Performance	NetworkAvailability	Extremely important	(7,9,9)	(2.6,5.1, 0.7)
	UrgentResponce	Weakly important	(1,3,5)	

Step4. Defuzzification and Normalization: this step is realized by center of area method (4) and normalization via (5). The result of the calculations is shown in Table V.

N_i is the final value of each attributes that will be illustrated by w_q from now on, since it is the final weight matrix.

For AHP algorithm we need attribute weights, which captured here. Now we launch the AHP process by knowing the weight of each attributes as the matrix below:

$$W_q = \begin{matrix} \text{Finance} \\ \text{Security} \\ \text{Performance} \end{matrix} \begin{bmatrix} 0.5 \\ 0.14 \\ 0.35 \end{bmatrix} \quad (15)$$

B. AHP Ranking Process

Step1.Decomposing the problem into a hierarchy structure: the hierarchy structure has three main criteria and eight sub-criteria, as shown in Table II.

Step2. Pair wise comparison: Based on the data gathered in Table I, the pair wise comparison matrix (CM) for Finance attribute, which has three sub-criteria, will be calculated as follows. Note that for finance matrix, since smaller values are more desirable, the reverse equation should be calculated.

$$sCM_{Outbound} = \begin{matrix} s1 \\ s2 \\ s3 \end{matrix} \begin{bmatrix} 1 & \frac{0.12}{0.15} & \frac{0.29}{0.15} \\ \frac{0.15}{0.12} & 1 & \frac{0.29}{0.12} \\ \frac{0.15}{0.29} & \frac{0.12}{0.29} & 1 \end{bmatrix} \quad (16)$$

Then the normalized vectors are as follow:

$$CM_{Outbound} = \begin{bmatrix} 0.38 \\ 0.48 \\ 0.19 \end{bmatrix} \quad (17)$$

For two other sub criteria the final vectors are:

$$CM_{Inbound} = \begin{bmatrix} 0.03 \\ 0.48 \\ 0.48 \end{bmatrix}, \; CM_{Baseplan} = \begin{bmatrix} 0.47 \\ 0.05 \\ 0.47 \end{bmatrix} \quad (18), (19)$$

Combining three above vectors, we get the comparison matrix for Finance attribute:

$$CM_{Finance} = \begin{bmatrix} 0.38 & 0.03 & 0.47 \\ 0.48 & 0.48 & 0.05 \\ 0.19 & 0.48 & 0.77 \end{bmatrix} \quad (20)$$

Computing the normalized vector of this matrix, we will have:

$$CM_{Finance} = \begin{bmatrix} 0.26 \\ 0.3 \\ 0.43 \end{bmatrix} \quad (21)$$

The same process for other attributes, security and performance, will result:

$$CM_{Security} = \begin{bmatrix} 0.1 \\ 0.79 \\ 0.1 \end{bmatrix}, \; CM_{Performance} = \begin{bmatrix} 0.26 \\ 0.46 \\ 0.26 \end{bmatrix} \quad (22), (23)$$

Step3. Aggregating the relative importance of the criteria: Now, we need to aggregate all the related matrixes to conclude one matrix: $\begin{bmatrix} 0.26 & 0.1 & 0.26 \\ 0.3 & 0.79 & 0.46 \\ 0.43 & 0.1 & 0.26 \end{bmatrix}$.

Then by multiplying the above matrix with the weight of the attributes as calculated in the Fuzzy-based weighting process, (15), the result is:

$$\begin{bmatrix} 0.26 & 0.1 & 0.26 \\ 0.3 & 0.79 & 0.46 \\ 0.43 & 0.1 & 0.26 \end{bmatrix} \begin{bmatrix} 0.5 \\ 0.14 \\ 0.35 \end{bmatrix} = \begin{bmatrix} 0.23 \\ 0.42 \\ 0.32 \end{bmatrix} \quad (24)$$

As expected, the cloud services are ranked as S2 > S3> S1. Amazon EC2 (i.e. S2) ranked higher than other services, while IBM (i.e. S1) ranked as the lowest preferable service among three available cloud services in this case study.

VI. DISCUSSION

This work complements previous works by proposing new components for validating the input data. Even though previous works were good and applicable, they neglected collecting reliable data. For example a research by Li Ang et al. [8] proposed an approach for comparing cloud services while measuring cost and performance by benchmarking. Benchmark tools cannot produce precise data since they only rely on benchmarking test and not on real data. As another example, Ruiz-Alvarez et al. [12] collected data from provider's websites that is not completely reliable due to the fact that they might not be honest about their services and exaggerate about their service attributes. In our proposed framework, this problem is addressed by introducing a broker as a third party certifier. The SMICloud framework [3] involves customers in the decision making process. They are supposed to announce their essential requirement and also the preferences. But in this work, customer fuzzy perception of the requirement has not been considered.

To put it in a nutshell, our proposed framework is the first to introduce essential components for capturing reliable data while its main concern is handling the vague conception of QoS by costumer.

VII. CONCLUSION

In this paper, we propose a cloud service selection framework that uses valid data as an input for selection process. To the best of our knowledge, the existing approaches are biased with uncertain data published by could service providers, customers' vague conception of the requirement, and also unrealistic measurement of QoS which need real time measurement and history of the service usage. In this research, we focus on taking care of customer fuzzy perception of QoS, to deliver more certain information into the ranking algorithm. For this aim, a fuzzy logic module is introduced in the framework to convert linguistic terms of customer's perception into some precise numbers.

TABLE IV. GEOMETRIC MEANS OF FUZZY VALUES

Criterion	$\tilde{r}_i$		
Finance	4.7	6.8	8.3
Security	1	2	2.9
Performance	2.6	5.1	6.7
Total	8.3	13.9	17.9
Reverse (power of -1)	0.12	0.07	0.05
Increasing order	0.12	0.07	0.05

TABLE V. FINAL FUZZY, AVERAGED AND NORMALIZED RELATIVE WEIGHT OF EACH CRITERION

Criterion	W			M_i	N_i (w_q)
Finance	0.564	0.485	0.5	0.485	0.5
Security	0.12	0.135	0.14	0.135	0.14
Performance	0.312	0.334	0.35	0.334	0.35

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