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Qualitative SMI based Cloud Service Selection using Intuitionistic Fuzzy TOPSIS

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Abstract: ***Cloud Computing allows access to a public resource pool on demand and easy network connection for the same. Due to the popularity and profits of using Cloud Services, many organizations are moving to Cloud .So selecting a suitable and best Cloud Provider is a challenge for all the users. Many ranking approaches had been proposed for solving this multicriteria decision making problem like AHP, TOPSIS etc. But many of the works focused on quantitative QoS attributes .But qualitative attributes are also important in the case of many application scenarios where the user may be more concerned about the qualitative attributes. CSMIC has released Service Measurement Index attributes for effectively comparing the Cloud services. The comparison of Cloud Service providers based on SMI attributes which are qualitative in nature by using a ranking approach that handles fuzziness in the dataset is the objective of this paper. The proposed approach uses the MCDM algorithm called Technique for Order Preference by Similarity to ideal Solution and uncertainty is handled by Intuitionistic fuzzy values. The qualitative SMI attributes are used as criteria for ranking the Cloud Services.***

Keywords **:** ***MCDM, fuzzy, Intuitionistic, SMI, Cloud Service.***

I. INTRODUCTION

Cloud computing is emerging and is known as the next gener ation of computing architectures. It is indeed a confluence of computing resources widely available via internet. The prominent commercial and individual cloud computing services are Amazon, Google, Sales force and Microsoft etc. Examples of shared resources that can be configured are infrastructure, platform, and software. Services based on internet cloud computing focus on the computing, software and data of consumers. Consumers who want to use cloud services should get them over the network. Cloud Service clients can purchase the services or use the services available at no cost in the cloud. Several forms of services, such as Platform- As -a -Service, and Software- As- a- Service, Infrastructure- As- a -Service are available in the cloud. For the most part, cloud offers various facilities, such as the consumer can enable bandwidth to access the cloud, or the consumer can gain computing power over the cloud, or the consumer can store any of his data without thinking about its privacy, or the consumer can use or use the application for his own purpose, or the consumer can access the database via the cloud. The user can scale the application in the cloud to any point on the internet, as there is a vast pool of resources. Based on your submission, it becomes much easier to acquire the data from anywhere through the cloud. As cloud data is accessible on the internet, accessibility requirements are expelled at a specific location. The cloud provider can provide the hardware and software via the internet, either for running home .Application or business application. There are many cloud providers that are almost the same based on their utility. A major challenge is choosing the most appropriate cloud provider. Different Cloud services ranking strategies are proposed by different authors. Some of the most effective techniques are MCDM methods such as AHP, TOPSIS etc. This is because it is important to accurately choose an acceptable cloud service provider to improve the degree of trust between customers and service providers. The Cloud Service Measurement Initiative Consortium (CSMIC) developed Service Measurement - Index (SMI) offers a set of key performance Indicators (KPIs) for cloud services evaluation[35]. Selection of cloud services is a multi-criteria decisionma king (MCDM) issue where multiple QoS considerations play a key role, especially for deciding the best cloud service among the choices. So for dealing with user or client's requirements and rate the services offered by the cloud provider according to their capabilities, a Multicriteria Decision Making approach may be appropriate. In this paper, authors suggest a TOPSIS based finding the best cloud service between a numbers of comparable alternatives which depends on the qualitative Quality of Service attributes of the services offered by the cloud. In recent works, for egg, different MCDM based ranking approaches like AHP [4], Fuzzy AHP with Delphi [10], Fuzzy ELECTRE (Elimination and Option Expressing Reality)–Fuzzy TOPSIS [11] can be found in the literature. For the evaluation and selection of Cloud Computing service ,authors propose a new approach which concentrates on SMI qualitative attributes like Usability, Agility and Security and Privacy by using Technique-for-Order -Preference by Similarity to ideal Solution and uncertainty is handled by Intuitionistic fuzzy values. The qualitative SMI attributes are used as criteria for ranking the Cloud Services. This approach was not used yet in the literature.

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The subsequent portion of this paper in the following way. Section number two gives a brief overview of the cloud service collection related works. Section number three defines the evaluation criteria required for the calculation of cloud services. Section 4 describes with its key elements the proposed structure. Section 5 introduces some basic concepts and fundamentals important to our work.

II. RELATED WORK

Rehman et al. [13] have presented Multicriteria Decision Making techniques for choosing the right cloud service in IaaS, but those Multi-criteria Decision Making strategies are any way not appropriate for fuzzy data. In [14], the researchers described a Multi Criteria Decision Making process called [15] Elimination and Selection Expressing Reality (ELECTRE), to explain question of cloud service availability, which used user preferences. Garg et al. [4] developed a system using the AHP method to rank cloud service providers ' confidence in attribute we lights measurement. The authors calculated the QoS requirements of the Cloud- Service- Measurement- Initiative -Consortium (CSMIC) and used key indicators of performance (KPIs) to assess the service of the cloud. Nonetheless, selection of the service and rating of the same are based solely on CSMIC's quantifiable criteria and does not recognize the attributes which are not quantifiable for QoS trustworthiness CSP selection. The researcher did not take into account in this paper, the incoherence with the evaluation criteria in the issue of selection of cloud service. R. Ranjan Kumar et al [15] explains about the importance and importance of best service among the available services in the cloud and showed the previous approaches and limitations of those methods and he proposed a new Computational Framework by combining the TOPSIS and AHP approach to select the best Service for the Customer. The authors had used 5 parameters to identify the best cloud services amongst the many cloud services that would suit. The following are five criteria: Performance rate of the Central Processing Unit (A1), the Consistency of the Disk Input/output (A2), Performance factor of the disk (A3), Efficiency of the memory (A4) and the Cost factor (A5). The 3 criteria A1, A3 and A4 are the parameters of benefit-type and the other criteria C2 and C5 are the criteria of cost. Eleven actual providers named as GoGrid , Century Link, Joynet, Softlayer, HP,Linode, Amazon, Rackspace, City-CloudGoogle, and Azure were used in the process of selection . In this proposed framework, the weights of criteria are assigned by using AHP and also the cloud services are rated using TOPSIS. The weights extracted by AHP methodology are also given in the selection process of the TOPSIS calculations to determine the cloud alternatives order of ranking. Vagueness with evaluation criteria was not considered in this paper also. In [16], the problem of cloud service selection has been done by Fuzzy AHP method to solve the ambiguity or inconsistency inherent in this field. Using 4 business viewpoints, that is customer, financial, internal business process, learning and development, the authors in [17] combines idea fuzziness with the AHP and the Delphi approaches for tackling problem of selecting a suitable service among the alternatives. In fact those techniques did not reflect the original requirements for selecting the best service among the alternatives. In [18] , Houssine Tliga and Abdelwaheb Rebaib developed fuzzy based TOPSIS approach based on intuitive fuzzy- values to address multiple-criteria- decision-making issues in which the output rating of alternative values and criteria weights are based on linguistic terms. The Arithmetic operations, which are between intuitionistic Fuzzy standards are used to standardize imprecise scores and parameters weights. For demonstrating how effective the suggested method is, here proposes a case study to evaluate and differentiate the quality of service of some Cloud Providers. At last, using the sensitivity analysis, the results of this study verified the efficacy and discourse of the suggested methodology. In this way, this paper states and proves the consistency of the estimated results. As per the literature survey done in the domain of selection of best cloud service among the alternatives, this is the first study that contains both TOPSIS method and Interval valued fuzzy Intuitionistic values for differentiating numerous cloud services in real world. Because of this, this model is different from other works. In [19] Yuhang BAO had drawn the conclusion that Multi Attribute Decision Making problem and fuzzy concept are both elusive and ambiguous, which has attracted growing researchers ' concentration to using fuzzy concepts as appropriate methods to resolve Multi Attribute Decision Making problems. MADM's approach plays a good role that researchers are evaluating a range of choices and selecting the suitable one. That paper introduces an approach that uses intuitional reluctant fuzzy collection. That unique technique will facilitate the users to compare the right cloud service provider and choose it.

III. EVALUATION CRITERIA

CSMIC developed SMI attributes according to requirements of the International Organization for Standardization (ISO) [2]. Key Performance Indicators (KPI's) that are business significant that offer an institutionalized technique to esti mate and look at a market benefit. Customer will be capable of selecting suitable cloud provider that meets the QoS criteria based on SMI attributes such as Agility, Service Assurance, Pri ce, Quality, Protection, Privacy, Usability and Accountabili ty.

A. Agility

In Cloud registering's, the most imperative favourable position is, that adds to that readiness of an association. The above association can extend and change quickly. Based on the requirements given by the business, new features will be incorporated into IT. Agility, which is in SMI is estimated as the progress metric rate demonstrating the same. The organization wants to check whether the service provided by the Cloud provider is adaptable and flexible and will check whether it is portable from one provider to another by considering the Agility factor. Agility attribute was also used by Saurabh Garg [4] to compute the RSRV using the above method to rank the cloud service providers.

B. Security and Privacy

Information privacy and protection are the critical worries of almost every association.

Facilitating information in different associations control is dependably a basic problem that needs stringent security strategies utilized by the Cloud suppliers. For example, financial offerings/services for the most part require high consistence controls including information trustworthiness and security. Privacy and security is additionally multidimensional in nature also and incorporate numerous qualities, for example, protection, and respectability and information misfortune.

C. Usability

The convenience of using a cloud service is very important while accessing any cloud service. The easiness and convenience will attract more client Organization to move to that Cloud provider. The ease of use of a Cloud administration can rely upon numerous variables, for example, Accessibility, Installability, Learnability, Operability, Essentially a cloud provider that offers various services should meet the QoS requirements specified by the CSMIC Hence it increases the confidence of the users on a particular cloud provider. For running any business in a cloud provider, user requires an assurance about the SMI attributes. And at the same time if there is a mechanism to rank all the available cloud providers that will help the user to find a relevant cloud service utilizing the SLA of the service.

IV. CLASSICAL TOPSIS

Step. 1. Build the matrix(decision matrix) and establish the criteria weights.

Consider B = (b_{ij}) as the decision matrix and Z =[z1, z2,… zn] as the vector of weights, and bij ∈ R , zj ∈ R and z1 + z2 +…….. + zn =1. Benefit functions (can be more) or cost functions (can be less) are the criteria of the functions.

Step 2. Calculate the NDM (normalized –decision-matrix).

This phase converts different dimensions of the metrics into non-dimensional metrics that require comparisons among criteria. Since different criteria are usually calculated in different units, all results in the assessment matrix B need to be converted to a standardized scale. One of the several known standard formulas will be used for the normalization of values. The steps for calculating the normalized value t_{ij} are given below:

$$t_{ij} = \frac{b_{ij}}{\sqrt{\sum_{i=1}^{m} b_{ij}^2}}$$

$$t_{ij} = \frac{b_{ij}}{\max_i b_{ij}}$$

$$t_{ij} = \begin{cases} \dfrac{b_{ij} - \min_i b_{ij}}{\max_i b_{ij} - \min_i b_{ij}} & \textit{if Ci is a benefit criterion} \\ \dfrac{\max_i b_{ij} - b_{ij}}{\max_i b_{ij} - \min_i b_{ij}} & \textit{if Ci is a cost criterion} \end{cases}$$

for I = 1, … , m ; j = 1, … , n

Step 3. Compute decision matrix after weighted normalization. The weighted normalized value y_{ij} is computed as follows,

$y_{ij} = z_j . t_{ij}$, for . i = 1 . , … , m; , j = 1 . , … , n where z_j is nothing but the weight of the jth criterion , $\sum_{j=1}^{n} z_j = 1$

Step. 4. To calculate the + ideal and - ideal solutions.

Define the ideal + alternatives(extreme performance of criterion) and define the ideal - solution. The optimal + solution is to optimize the profit criteria and minimize the costs criteria while the - ideal solution enhances the cost criteria and diminishes the profit criteria. + ideal solution P^+ has the form:

$$P^+ = (a^+_1, a^+_2, a^+_3, \ldots . a^+_n)$$
$$= \left(\left(\max_i a_{ij} \middle| j \in I \right), \left(\min_i a_{ij} \middle| j \in J \right) \right)$$

The - ideal solution P^- has the form:

$$P^- = (a^-_1, a^-_2, a^-_3, \ldots . a^-_n)$$
$$= \left(\left(\min_i a_{ij} \middle| j \in I \right), \left(\max_i a_{ij} \middle| j \in J \right) \right)$$

Where I have the gain criteria and the expense criteria J, i = .1, … , m; j. = .1, … , n

Step 5 .

Compute the distinguishing steps from the ideal + solution and the ideal negative solution. A variety of distance metrics can be implemented in the TOPSIS system. The distance of each alternative is given as,

$$k_i^+ = \left(\sum_{j=1}^{n} (a_{ij} - a_j^+)^p \right)^{1/p} \quad , i=1, 2, .m$$

The distance of each alternative from the ideal - solution is given as,

$$k_i^- = \left(\sum_{j=1}^{n} (a_{ij} - a_j^-)^p \right)^{1/p} \quad , i=1, 2, .m$$

Where p ≥1. The usual Euclidean n-dimensional metric most used for p= 2,

$$k_i^+ = \sqrt{\sum_{j=1}^{n} (a_{ij} - a_j^+)^2} \quad , i=1, 2, .m$$

$$k_i^- = \sqrt{\sum_{j=1}^{n} (a_{ij} - a_j^-)^2} \quad , i=1,2,\ldots.m$$

Step 6. Computing the relative closeness

It is defined as,

$$C_i = \frac{de_i^-}{de_i^- + de_i^+}$$

where $0 \le C_i \le 1$, i = .1.,2., … , m

Step 7. Rating the order of preference, or choose the nearest alternative to 1.

The descending order of the value of Ci can now rank a set of alternatives

V. INTUITIONISTIC- FUZZY -SETS

Authors are reviewing the basic concepts relating to intuiti ve fuzzy sets in this section.

An intuitionistic-fuzzy set A in X1 = { x. } is given as (Atanassov (1986).

$$X1 = \{ (x, \mu_{1A}(x), v_{1A}(x)), x \in X1 \}$$

And $\mu_{1A}(x)$: X 1 → [0,1] , $v_{1A}(x)$: X 1 → [0,1] and 0 ≤ $\mu_{1A}(x) + v_{1A}(x) \le 1$, $\forall x \in X1$

$v_{1A}(x)$, $\mu_{1A}(x)$ be the degree at which non-membership and membership function of x to A .

VI. INTERVAL-VALUED FUZZY TOPSIS

The weights of the parameters and ratings based on performance are evaluated in terms of language, defined by intuitionis t fuzzy values. The suggested IFV-TOPSIS technique is given below.

Step 1: Aggregate the performance ratings and perform normalization

Let $x_{ijk} = \left(t_{x_{ijs}}, 1 - f_{x_{ijs}} \right), x_{ijk} \geq 0$, $i = 1,2,\ldots n,\ j = 1,2,\ldots.m,\ s = 1,2,\ldots\ldots k$ is the performance rating given to alternative A_i by decision maker D_k for criterion C_j..

The aggregated performance rating , $x_{ij} = \left(t_{x_{ij}}, f_{x_{ij}} \right)$ of alternative A_i under criterion C_j can be evaluated as :

$$x_{ij} = \left(\frac{1}{k}\right) \otimes \left(x_{ij1} + x_{ij2} + x_{ij3} + \cdots x_{ijk} \right) \quad 1$$

The aggregated, i.e. $x_{ij} = \left(t_{ij}, 1 - f_{ij} \right)$, can be normalized as follows ,

$$r_{ij} = \left(\frac{t_{x_{ij}}}{t^{+}_{x_{ij}}}, \frac{(1 - f_{x_{ij}})}{(1 - f_{x_{ij}})^{+}} \right), \quad 2$$

$$t^{+}_{ij} = \max_i t_{ij} \ and \ (1 - f_{x_{ij}})^{+} = \max_i (1 - f_{x_{ij}}) \text{ for } j \in B$$

$$r_{ij} = \left(\frac{t^{-}_{ij}}{t_{x_{ij}}}, \frac{(1 - f_{x_{ij}})^{-}}{(1 - f_{x_{ij}})} \right), \quad 3$$

$$t^{-}_{ij} = \min_i t_{ij} \ and \ (1 - f_{x_{ij}})^{-} = \min_i (1 - f_{x_{ij}}) \text{ for } j \in C$$

Step 2 Perform normalization by aggregating the importance weights

Let $w_{jk} = \left(t_{w_{js}}, 1 - f_{w_{js}} \right), x_{ijs} \geq 0$, $j = 1,2,\ldots.m,\quad s = 1,2,\ldots.k$ the weight that decision makers give D_k to criterion C_j .

The aggregated importance weight, $w_j = \left(t_{w_j}, 1 - f_{w_j} \right)$ of criterion C_j can be calculated as :

$$w_j = \left(\frac{1}{k}\right) \otimes \left(w_{j1} + w_{j2} + w_{j3} + \cdots w_{jk} \right) \quad 4$$

The aggregated weights can be normalized as follows,

$$w'_j = \frac{w_j}{\sum_{j=1}^{m} w_j} = \left(\frac{t_{w_j}}{\sum_{j=1}^{m} t_{w_j}}, \frac{(1 - f_{w_j})}{m - \sum_{j=1}^{m} (1 - f_{x_{ij}})^{+}} \right) \quad 5$$

where w'_j denotes the normalized w_j

Step 3 . To construct the NDM(Normalized Decision Matrix)

Fuzzy decision matrix (the weighted -normalized one) is given by $V_{ij} = [\, v_{ij} \,]_{nxm}$ where $v_{ij} = r_{ij} \otimes w'_j$. The multiplication operator is applied as:

$$v_{ij} = \left[t_{\left(r_{ij \times w'_j}\right)}, (1 - f)_{\left(r_{ij \times w'_j}\right)} \right]$$

$$= \left[t_{r_{ij}} \times t_{w'_j} \ , \ \left(1 - f_{r_{ij}}\right) \times \left(1 - f_{w'_j}\right) \right] \quad 6$$

Step 4 . Determinate ideal and ideal negative solutions

One can describe + ideal and - ideal solutions as:

$A^{+} = (1,1)$, $j \in \Omega_b$

$A^{-} = (0,0)$, $j \in \Omega_c$

The distance between each alternative A^{+} and A^{-} can be obtained as:

$$d_i^{+} = \sqrt{\frac{1}{2m} \sum_{j=1}^{m} \left[\left(t_{v_{ij}} - 1 \right)^2 + (f_{v_{ij}})^2 \right]} \text{ , i= 1,2,\ldots n} \quad 7$$

$$d_i^{-} = \sqrt{\frac{1}{2m} \sum_{j=1}^{m} \left[\left(f_{v_{ij}} - 1 \right)^2 + (t_{v_{ij}})^2 \right]} \text{, j =1,2 \ldots.n} \quad 8$$

where ed_i^{+} denotes the separation between each alternative and A^{+} and d_i^{-} denotes the separation between each alternative and A^{-}.

Step 5 . Calculate the closeness coefficient

Compute the coefficient of closeness The coefficient of closeness of each alternative may be obtained as:

$$C_i = \frac{ed_i^{-}}{ed_i^{-} + ed_i^{+}}, \text{ i =1,2\ldots\ldots.n} \quad 9$$

Authors will determine the rating of all alternatives as per the closeness coefficient, and choose the best one from them.

VII. PROPOSED RANKING APPROACH AND RESULTS

The quality in service is a basic performance indicator for the cloud service providers. High service quality may have a significant impact in promoting the various services offered by the CSPs. Thus, the evaluation of the quality of services has become an important issue for service selection. Thus, the customers like business organizations of these Cloud Providers have recently become interested in evaluating the service quality of the available Providers for selecting the best CSP.Cloud Service Measurement Index Consortium (CSMIC) [21] proposes the system dependent with regular qualities of services provided by the cloud . The important point of the consortium was to characterize each one of QoS properties that have been given in structure and give a strategy to registering a relative file for contrasting diverse services provided by cloud. CSMIC has built up Service Measurement Index (SMI) that comprises of Key Performance Indicators (KPI) which institutionalizes the estimation of business offerings or services. CSMIC has developed the attributes of SMI by depending on International Organization for Standardization (ISO)standards [20]. Key Performance Indicators (KPI's) which are business significant that give an institutionalized technique to estimating and looking at a business benefit. The client will be capable of selecting an appropriate cloud provider that satisfies his QoS requirements based on the SMI criterias such as Usability, Security, and Agility which are shown in figure 7.1.

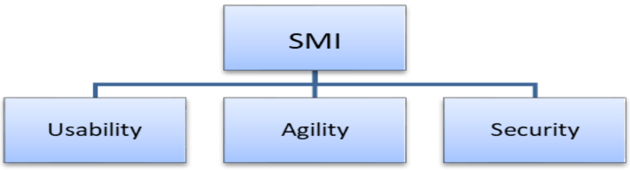

Fig 7.1: The Qualitative SMI Attributes

From the above SMI attributes ,the qualitative attributes like usability , agility and security are used as the selection criteria in this proposed work. TOPSIS is a multicriteria decision making approach. But the fuzziness in the problem should be taken care for selecting the best possible services for the customer. The concept of linguistic TOPSIS combined with intuitionistic fuzzy concept is used for ranking the services for the users. As per the literature, this is the first work that uses the TOPSIS method and Interval valued fuzzy Intuitionistic values for comparing several actual services on cloud based on SMI qualitative attributes.In our work, Intuitionistic Fuzzy Value based on Technique for Order Preference by Similarity to ideal Solution is used for ranking the Cloud Service Providers. The criteria used for ranking and choosing the best Cloud Service used in this paper is SMI attributes. The quality of the service is compared with respect to the qualitative attributes like usability, security and privacy agility. This is the first work in the literature which performs the ranking of services only based on the qualitative attributes of SMI. The steps involved in the ranking and selection of the services is shown in the figure 7.1 shown below. The steps in the ranking process is implemented using Matlab 2018b version and visualization of the results have been done using the Microsoft Excel.

A. Steps in the proposed ranking approach

The ranking and selection of the service based on the three SMI criterias using the TOPSIS and intuitionistic fuzzy concept is shown using the schematic diagram in figure 7.2

As mentioned above , Intuitionistic Fuzzy Value based Technique for Order Preference by Similarity to ideal Solution is used for ranking the Cloud Service Providers. The criteria used for ranking and selection of suitable Cloud Service used in this paper is Service Measurement Index attributes.

The quality of the service is compared with respect to the qualitative attributes like usability, security and privacy agility. This is the first work in the literature which performs the ranking of services only based on the qualitative attributes of SMI like usability, agility and security.

The dataset which is provided in Mendeley [1] is used in this paper. But that dataset includes both the quantitative and qualitative attributes of a Software as a Service. But in this case study only the qualitative attributes of services are considered for ranking. The qualitative attributes like Agility, Security and Privacy and Usability are considered. These three attributes are benefit criteria only.

The linguistic variable for rating performance and importance of each criterion by a linguistic variable is shown in the table given below. An intuitionistic value is assigned for each linguistic variable. Table 1 and table 2 are having these values.

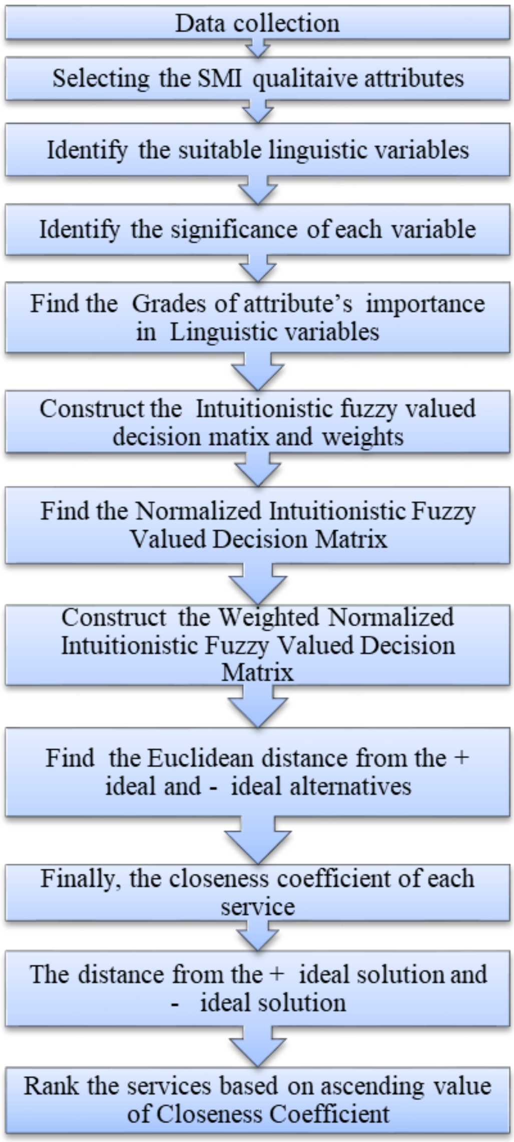

Fig 7.2 . The step by step processes involved in the proposed ranking approach

Table 1
Definitions of Linguistic Variables for the ratings

Poor	(0.1; 0.8)
Fair	(0.3; 0.66)
Good	(0.5; 0.44)

Table 2
Definitions of the linguistic variables for each criterion's significance

Low	(0.11; 0.78)
Medium	(0.22; 0.56)
High	(0.5; 0.34)

After obtaining the users' perception, using first equations (1) and (4) the rating of alternatives with respect to each criterion and the importance of the criteria is evaluated. The grades of attribute's importance is given as Linguistic Variable in table 3.

Table 3Grades of attribute's importance in Linguistic variables

Candidates	A_1	A_2	A_3
SRV_1	F	G	P
SRV_2	P	F	P
SRV_3	P	F	F
SRV_4	F	P	P
SRV_5	G	F	G
SRV_6	G	G	F
SRV_7	F	G	G
SRV_8	G	P	P
SRV_9	F	G	G
SRV_{10}	P	G	G
Weight	M	H	H

Software services like service1(SRV_1),service 2(SRV_2) etc upto 10 services are selected for ranking. SMI attributes like Usability (A_1), Security (A_2) and Agility (A_3) are the benefit criterias used for the ranking and selection of services. The intuitionistic fuzzy valued decision matrix is given in Table 4.

Table 4
Intuitionistic fuzzy valued decision matrix and weights

Candidates	Usability	Security	Agility
SRV 1	(0.3; 0.66)	(0.5; 0.44)	(0.1; 0.8)
SRV 2	(0.1; 0.8)	(0.3; 0.66)	(0.1; 0.8)
SRV 3	(0.1; 0.8)	(0.3; 0.66)	(0.3; 0.66)
SRV 4	(0.3; 0.66)	(0.1; 0.8)	(0.1; 0.8)
SRV 5	(0.5; 0.44)	(0.3; 0.66)	(0.5; 0.44)
SRV 6	(0.5; 0.44)	(0.5; 0.44)	(0.3; 0.66)
SRV 7	(0.3; 0.66)	(0.5; 0.44)	(0.5; 0.44)
SRV 8	(0.5; 0.44)	(0.1; 0.8)	(0.1; 0.8)
SRV 9	(0.3; 0.66)	(0.5; 0.44)	(0.5; 0.44)
SRV 10	(0.1; 0.8)	(0.5; 0.44)	(0.5; 0.44)
Weight	(0.22; 0.56)	(0.5; 0.34)	(0.5; 0.34)

Equation (2) and Equation (3) were used to normalize the decision matrix. Table 5 shows the normalized decision matrix

Table 5
Normalized Intuitionistic Fuzzy Valued Decision Matrix

Candidates	Usability	Security	Agility
SRV 1	(0.6;0.825)	(1;0.55)	(0.2;1)
SRV 2	(0.2;1)	(0.6;0.825)	(0.2;1)
SRV 3	(0.2;1)	(0.6;0.825)	(0.6;0.825)
SRV 4	(0.6;0.825)	(0.2;1)	(0.2;1)
SRV 5	(1;0.55)	(0.6;0.825)	(1;0.55)
SRV 6	(1;0.55)	(1;0.55)	(0.6;0.825)
SRV 7	(0.6;0.825)	(1;0.55)	(1;0.55)
SRV 8	(1;0.55)	(0.2;1)	(0.2;1)
SRV 9	(0.6;0.825)	(1;0.55)	(1;0.55)
SRV 10	(0.2;1)	(1;0.55)	(1;0.55)

The weighted normalized intuitionistic fuzzy valued matrix can be obtained by considering the different importance of each criterion. This matrix is given in Table 6.

Table 6
Weighted Normalized Intuitionistic Fuzzy Valued Decision Matrix

	Usability	Security	Agility
SRV 1	(0.10;0.14)	(0.40;0.22)	(0.08;0.40)
SRV 2	(0.03;0.18)	(0.24;0.33)	(0.08;0.40)
SRV 3	(0.03;0.18)	(0.24;0.33)	(0.24;0.33)
SRV 4	(0.10;0.14)	(0.08;0.40)	(0.08;0.40)
SRV 5	(0.18;0.09)	(0.24;0.33)	(0.40;0.22)
SRV 6	(0.18;0.09)	(0.40;0.22)	(0.24;0.33)
SRV 7	(0.10;0.14)	(0.40;0.22)	(0.40;0.22)
SRV 8	(0.18;0.09)	(0.08;0.40)	(0.08;0.40)
SRV 9	(0.10;0.14)	(0.40;0.22)	(0.40;0.22)
SRV 10	(0.03;0.18)	(0.40;0.22)	(0.40;0.22)

Authors can obtain the Euclidean distance from the positive- ideal and negative- ideal alternatives using Eq. (7) and Eq. (8) formulas, respectively. The results are shown in Table 7.

Table 7
The distance from the + ideal solution and - ideal solution

Candidates	A+	A-
SRV 1	0.609910651	0.556678229
SRV 2	0.633175056	0.504455207
SRV 3	0.602457549	0.527633916
SRV 4	0.650373449	0.490992311
SRV 5	0.573099487	0.593093152
SRV 6	0.573099487	0.593093152
SRV 7	0.569447853	0.615392438
SRV 8	0.644279792	0.50893987
SRV 9	0.569447853	0.615392438
SRV 10	0.582966966	0.606784118

The separation of each service from + and - ideal solution is shown in the figure 7.3.

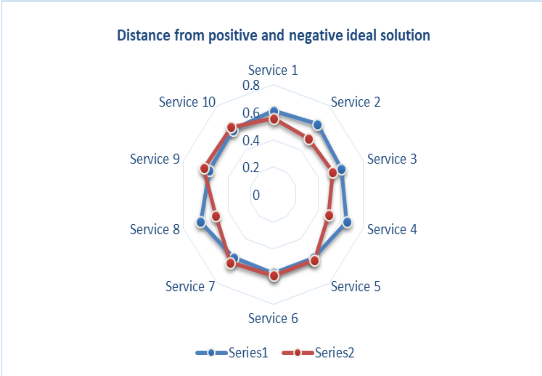

Fig 7.3 : Separation from + and - ideal solutions

Finally, the closeness coefficient of each service is obtained by applying Eq. (9). The results are shown in Table 8.

Table 8
Closeness Coefficient and rank

Candidates	Closeness Coefficient	Rank
SRV 1	0.477184584	4
SRV 2	0.443426325	7
SRV 3	0.466894877	5
SRV 4	0.430179639	8
SRV 5	0.508572197	3
SRV 6	0.508572197	3

SRV 7	0.519388514	1
SRV 8	0.44132084	6
SRV 9	0.519388514	1
SRV 10	0.5100093	2

As per the result shown above ,the graphical representation of the comparison of the closeness coefficients is shown in the figure 7.4.From the graph and table it is clear that the closeness coefficient of service 7 and 9 are high and it is followed by the service 10 and subsequently service 6 and so on.

Fig 7.4 : Closeness coefficients of each service

The final results are shown in the table 8 .The results shows that the services 7 and 10 are the best services among all the available services with respect to the SMI qualitative attributes like Agility, Security and Usability.

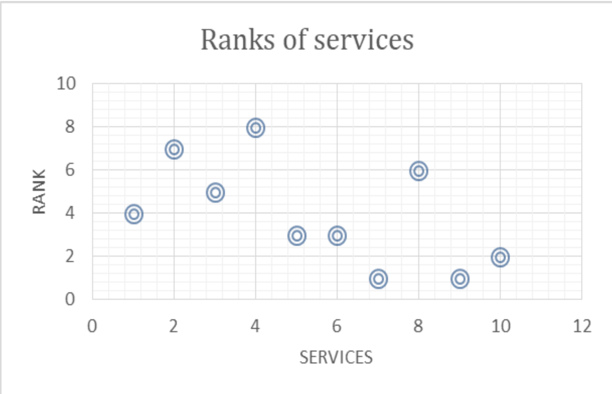

Fig 7.5 : Ranks of services

It is clear from the figure 7.5 , the service which is having the highest closeness coefficient is having the first rank and the best service suitable for the customer is service 7 and service 9 . The service 4 is having the least rank.

VIII. CONCLUSION

The selection of best Cloud Service among the available services is a challenging task for the users who wants to perform selection based on QoS attributes. The criteria for the selection comes under qualitative and quantitative varieties. So selection of the Cloud Services based on the qualitative SMI attributes like Agility, Usability and Security is proposed in this paper. The selection is done through the ranking of available services based on the above three criteria using the Technique for order preference approach using the intuitionistic fuzzy values. The ratings are represented using the respective linguistic variables and are converted to intuitionistic fuzzy values which efficiently ranked the cloud services. This work may be extended in future for ranking the cloud services based on both qualitative and quantitative SMI attributes. Fuzziness in selection will be handled efficiently by using new approaches. The users requirements will be captured much more efficiently using new approaches

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