2020 IEEE International Conference for Innovation in Technology (INOCON)
Bengaluru, India. Nov 6-8, 2020

Cloud Service Provider Selection Using Fuzzy TOPSIS

Thasni T
Assistant Professor (IEEE member)
Computer Science Department
Presidency University
Bangalore
thasniumer@gmail.com

C Kalaiarasan
Associate Dean
School of Engineering
Presidency University
Bangalore

K A Venkatesh
Professor of Math and Computer Science
Myanmar Institute of Information Technology,Myanmar

***Abstract*— Cloud Providers allows on-demand access and simple network connections to a shared resource pool. Because of the success and benefits of the use of Cloud Services, a range of business organizations are heading towards Cloud. The selection of the best Cloud Provider is a research topic, and this article addressing the same. Several other methods for addressing this problem and researchers suggested deploying Multi Criteria Decision-Making Models. Nevertheless, a significant number of works focused on quantitative QoS attributes and also the fuzziness involved in the QoS data was not handled in the existing works. So a framework for ranking and selection of Cloud Providers is proposed in this work. SMI attributes that are proposed by CSMIC and approved by ISO is used as the criteria for the ranking of the cloud providers in this research work. Fuzzy TOPSIS is the MCDM approach used to rank and select the best Cloud Provider in this proposed work.**

Keywords—MCDM, Fuzzy, TOPSIS, SMI, Cloud Provider

I. INTRODUCTION

The rise of cloud computing is regarded as the next generation of computer architectures. In reality, it is an intersection of computer resources widely accessible via the Internet. The cloud itself is a set of hardware, networks, storage, services, and interfaces that enable the delivery of computing as a service. Cloud services include the delivery of software, infrastructure, and storage over the Internet (either as separate components or a complete platform) based on user demand. Amazon, Google, the sales force and Microsoft are valuable commercial and individual cloud computing services. Examples of popular resources that can be managed are Infrastructure, Platform and Software Services. In cloud services companies are finding some significant new interest. The cloud can remove many of the complex constraints, including space, time, power and expense, from the conventional computing world. . As the popularity of the cloud services are increasing, there is a necessity of comparing and selecting the best Cloud Provider from the available Providers in the market. The SMI Cloud Service Measurement (CSMIC) Consortium offers a collection of main performance indicators (KPIs) for the assessment of cloud services. [1]. This work proposes a framework for and selection of the Cloud Providers based on the SMI criteria proposed by CSMIC and by using an MCDM technique called Fuzzy TOPSIS. Following sections of this paper is structured as follows section 2 is the related works followed by section 3 explains TOPSIS and Fuzzy TOPSIS followed by section 4 that explains the proposed framework followed by results and conclusions.

II. RELATED WORK

The selection of a Cloud Provider is a Multi criteria Decision Making (MCDM) problem. So the literature is reviewed to find out the existing frameworks for the ranking and the selection of Cloud Providers and also the available MCDM techniques. The related works and contributions are summarized in this section. The authors in [2] had proposed a framework to select an ideal cloud provider from the available ones. The Framework is called as SelCSP. The cloud providers were ranked based on the risk of interaction. The risk of interaction was computed using trustworthiness and competency. A hybrid DANP (DEMATEL and ANP) method was proposed by R.C Zoie et al in [3]. The proposed framework is used to find the criteria weights and rank the Cloud Providers. In paper [4], author of the paper proposed an MCDM approach called fuzzy AHP for the ranking and selection of the cloud provider . N.Tanoumand [5] had used Fuzzy AHP approach for the ranking and selection of the Cloud Providers. A Cloud Brokerage Architecture was introduced in [6] for the cloud service selection .B+ tree was used for the indexing of the information. They developed a service selection algorithm for selecting the best cloud service . In [7] ,the authors had introduced a hybrid approach using TOPSIS and (Best Worst Method) for the Cloud Service Selection . Several MCDM methods like AHP,ANP,TOPSIS ,DEMATEL etc are present in the literature .As we need to address the fuzziness of the data ,Fuzzy TOPSIS is the MCDM technique used in this work. The evaluation criteria is an important factor in the ranking and selection of any Cloud Provider Problem. So the SMI criteria used in the proposed approach are explained in section 3. The MCDM method used in this work is Fuzzy TOPSIS which will be explained in section 4.

III. EVALUATION CRITERIA

One has to use the MCDM techniques for any decision-making problem that requires a significant evaluation criteria based on the domain. The Service Measurement Index attributes like Accountability, Agility, Security, Performance, Usability, Billing and Assurance are used as the criteria of evaluation in this work. The SMI attributes are proposed by CSMIC approved by ISO[1].

A. Agility

One of the most immediate benefits of cloud-based infrastructure services is the ability to add new infrastructure capacity quickly and at lower costs. Therefore, cloud services allow the business to gain IT resources in a self-service manager, thus saving time and money. By being able

978-1-7281-9744-9/20/$31.00 ©2020 IEEE

to move more quickly, the business can adapt to changes in the market without complex procurement processes. A typical cloud service provider has economies of scale (cost advantages resulting in the ability to spread fixed costs over more customers) that the typical corporation lacks. As mentioned earlier, the cloud's self-service capability means it's easier for IT to add more compute cycles (more CPU resources added on an incremental basis) or storage to meet an immediate or intermittent needs. With the advent of the cloud, an organization can try out a new application or develop a new application without first investing in hardware, software and networking.

B. *Assurance*

It is degree of assurance given by any Cloud Provider to the customers .Cloud Service Providers should promote the understanding between users and providers of cloud computing regarding security requirements .Cloud Providers should give the assurance of best practices for cloud security also.

C. *Security and Privacy*

Cloud providers must ensure the security and privacy of your data, but you are ultimately responsible for your company's data. This means that industry and government regulations created to protect personal and business information still apply even if the data is managed or stored by an outside vendor.

D. *Usability*

The ease of use is an important factor considered by any Cloud Customer . Usability is the degree of ease with which cloud can be used to achieve required goals effectively and efficiently. Usability assesses the level of difficulty involved in using a user interface. Although usability can only be quantified through indirect measures and is therefore a nonfunctional requirement, it is closely related to a cloud provider's functionality.

E. *Accountability*

Accountability is a way forward in resolving data security problems resulting from cloud-based handling of personal data, but these problems surpass the handling of personal data and generalize it to other forms of data, including privacy concerns.

F. *Performance*

Quality aspects are critical to cloud computing 's ultimate performance, including the optimal cost of cloud infrastructure, reliability , and scalability. The cloud computing providers, integrators and service consumers require a lot of attention and effort.

G. *Billing*

One of the most important tasks when preparing for the cloud: Assessing your cost structure (for example, how much you're spending on supporting existing hardware, software, networking services). How can you determine the cost savings if you don't know what you're spending today? Also take potential future costs into account. Things may get fuzzy. You may sometimes want to use business services offered by cloud application vendors. You may want to build some internal service oriented architecture-based services that can live inside a cloud environment. In some situations, it may save money to move a service such as email, software testing, or storage to a cloud, because the costs of performing the service internally are so much higher. In other situations, the costs for implementing a key application in the cloud may be much more expensive than running it internally.

IV. TOPSIS

Step. 1. Construct matrix (decision matrix) and assign weights for the parameters.

Consider C = (cij) as the matrix of decision and M = [m1, m2, mn] as the weight vector, and cij ∈ R, mj ∈ R and m1 + m2 +……. + mn =1.

Step 2. Calculation of normalized DM (Decision matrix)

The process of converting the different dimensions of the metrics into non-dimensional metrics which requires comparisons between parameters. And different criteria are usually calculated in different units so all the results of the assessment matrix B should be changed to a standardized scale. Normalization of the dataset is done using a standard formula and the same is given below,

$$\text{tij} = \frac{c_{ij}}{\sqrt{\sum_{i=1}^{m} c_{ij}^{2}}}$$

$$\text{tij} = \frac{c_{ij}}{\max_i c_{ij}}$$

$$\text{tij} = \begin{cases} \dfrac{c_{ij}-\min_i c_{ij}}{\max_i c_{ij}-\min_i c_{ij}} & \text{if } Ci \text{ is a benefit criterion} \\ \dfrac{\max_i c_{ij}-c_{ij}}{\max_i c_{ij}-\min_i c_{ij}} & \text{if } Ci \text{ is a cost criterion} \end{cases}$$

for i = 1, …, m; j = 1, …, n

After weighted normalization, determine decision matrix. The normalized weighted value hij shall be determined as follows,

hij = mj.tij, for . i = 1 . , … , m; , j = 1. , … , n

where m_j is called as weight of the jth criterion , $\sum_{j=1}^{n} m_j = 1$

Step. 3. Determination of positive and negative ideal solutions.

The - ideal approach will increase the cost criteria and will lower profit criteria and the optimal + approach is to maximize benefit criteria and lower cost criteria. + Ideal solution P+ is in the form of:

$$P+ = (b^{+}{}_{1}, b^{+}{}_{2}, b^{+}{}_{3}, \ldots \ldots b^{+}{}_{n})$$

$$= \left(\left(\max_i b_{ij} \,\middle|\, j \in I \right), \left(\min_i b_{ij} \,\middle|\, j \in J \right) \right)$$

$$P- = (b^{-}{}_{1}, b^{-}{}_{2}, b^{-}{}_{3}, \ldots \ldots b^{-}{}_{n})$$

$$= \left(\left(\min_i b_{ij} \,\middle|\, j \in I \right), \left(\max_i b_{ij} \,\middle|\, j \in J \right) \right)$$

And j = 1, … , n ; i = 1, … , m;

Step 4. Separation from + and – ideal solution

Calculate the separation steps from the ideal + solution, and the ideal negative solution. TOPSIS framework deploy a variety of distance metrics, each alternative distances are given by,

$$kl_i^- = \left(\sum_{j=1}^{n}\left(b_{ij} - b_j^-\right)^p\right)^{1/p} \quad ; i=1,2,\ldots.m$$

$$kl_i^+ = \left(\sum_{j=1}^{n}\left(b_{ij} - b_j^+\right)^p\right)^{1/p} \quad ; i=1,2,\ldots.m$$

And $p \geq 1$. The Euclidean n-dimensional metric which is used for p= 2,

$$kl_i^+ = \sqrt{\sum_{j=1}^{n}\left(b_{ij} - b_j^+\right)^2} \quad , i=1,2,\ldots.m$$

$$kl_i^- = \sqrt{\sum_{j=1}^{n}\left(b_{ij} - b_j^-\right)^2} \quad , i=1,2,\ldots.m$$

Step 5. Determination of the relative closeness

$$rCl_i = \frac{kl_i^-}{kl_i^- + kl_i^+}$$

And $0 \leq rCli \leq 1$, i = 1.,2., … , m

Step 6. Ranking based on the Closeness coefficient value

The descending order of Cli 's value can now rank a series of alternatives [8] .

In this work Fuzzy TOPSIS MCDM approach is used for the ranking and selection of the Cloud Providers. The weights of the performance-based parameters and ratings are assessed in terms of language as described by fuzzy values.

V. PROPOSED RANKING APPROACH

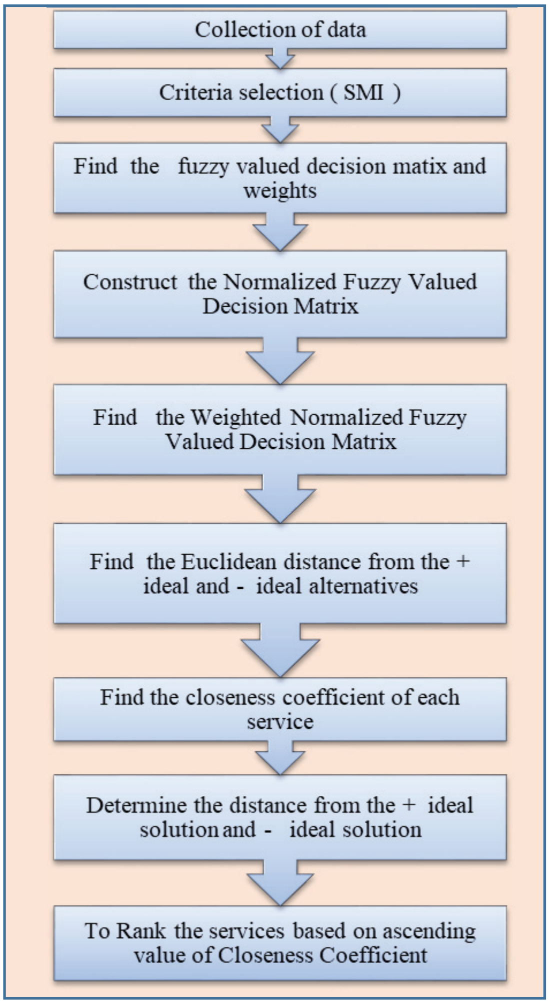

Fig. 1. The step by step processes involved in the proposed ranking approach

High quality of service may have a significant impact on the promotion of the various services offered by CSPs. As a result, the quality assessment of services has become an important issue for the selection of services. Quality of service is a basic performance indicator for cloud service providers. As a result, customers like the business organizations of these Cloud Providers have recently become interested in assessing the quality of service of the providers available to select the best CSPs. In our research, Cloud service providers are ranked with the intuitionist Fuzzy Value based on Technique for Order Choice by Similarity to Ideal Solution. TOPSIS is a multi-criteria decision-making approach. However, the fuzziness of the problem should be taken care of in selecting the best possible services for the customer. According to the literature, this is the first work that uses the fuzzy intuitionist values of the TOPSIS system to compare multiple actual cloud services based on SMI attributes.

The Cloud Provider ranking and selection based on the SMI criteria using the Fuzzy TOPSIS approach using the schematic diagram is shown in Figure 1 below.

The data collected from review sites and documentations of the cloud providers are used to perform the decision making of selecting the best cloud provider based on the SMI criteria certified by ISO.

VI. RESULTS

The ranking and selection of the best Cloud Providers after applying the fuzzy TOPSIS method are explained in this section . The criteria of ranking is selected based on the SMI framework approved by ISO .The SMI attributes considered for ranking are accountability, security, performance ,usability and billing .The SMI attribute values of 16 Cloud Providers such as Amazon Web services, Kamatera, Cloud Sigma, access Alto, M5,HYVE, e24Cloud, Google, CLOUDWARE, Windows Azure, eApps, elastic hosts, Storm, dimension data, zettagrid , EXOSCALE are collected from the review sites and documentations of the Cloud Providers. The values of the SMI attributes considered for the ranking and evaluation of the cloud providers are Accountability , Usability, Security, Billing and Performance. It is possible to obtain the weighted normalized fuzzy valued matrix. Using the formulas, we can obtain the Euclidean distance from the positive-ideal and negative-ideal alternatives. Finally, the coefficient of closeness is obtained for every provider. The findings are shown in Table 1. After ranking, anonymous names such as CP1, CP2 etc have been allocated to the cloud providers.

TABLE I. THE DISTANCE FROM THE + IDEAL SOLUTION AND THE - IDEAL SOLUTION

Cloud Provider	d+	d-	CCi	Rank
CP1	31.71	26.32612	0.488519	1
CP2	27.66	25.39281	0.478669	2
CP3	27.54	20.12446	0.474583	3
CP4	29.02	27.719	0.462265	4
CP5	28.71	15.35937	0.453635	5
CP6	32.13	29.02004	0.452948	6
CP7	27.65	19.77702	0.442752	7

CP8	33.13	27.43295	0.422252	8
CP9	28.46	22.61273	0.417016	9
CP10	30.69	26.38347	0.368654	10
CP11	32.81	14.83042	0.34852	11
CP12	31.88	16.83634	0.345604	12
CP13	30.30	17.69429	0.312107	13
CP14	33.14	15.03387	0.311282	14
CP15	33.10	14.26362	0.301141	15
CP16	30.03	8.349415	0.217556	16

The Cloud Providers are named as CP1 ,CP2 etc after ranking the Cloud providers to show the results .d+ and d- are the distance from the ideal + and ideal – solution.CCi denotes the closeness coefficient and the CSPs are ranked based on the value of the CCi.The higher the value of CCi ,then the provider will be having the best performance. So all the CSPs are ranked based on the decreasing order of the CCi.So the CP1 is the provider which has highest CCi and so is ranked as the best provider with rank 1.

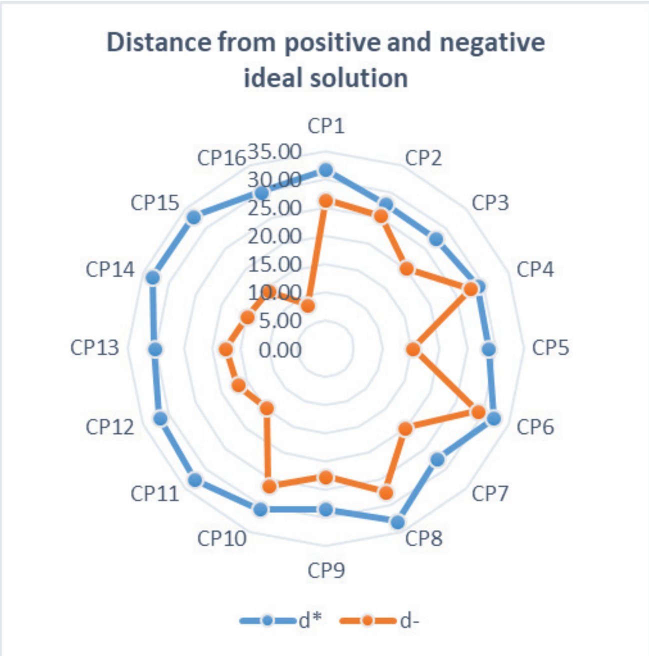

Fig. 2. Distance from positive and negative ideal solution

The graphical representation of the distance from positive and negative ideal solution is shown in figure 2. As per the result shown in table 1. Figure 3 shows a graphical representation of the closeness coefficients compared. From the graph it is obvious that the coefficient of closeness of CP1 is strong, followed by the CP2 and then the CP3 and so on.

Final results are shown in table 1. Results show provider 1 is the best provider with rank 1. The provider with least CCi is the poor performing provider with rank 16.

Table 1 shows that providers with the highest closeness coefficient are ranked first and that provider CP1 is the best cloud provider suitable for the customer and provider CP16 has the lowest rank. So the ranks of all the Cloud Providers are shown in figure 4.Cloud provider with highest closeness coefficient value is ranked as best performing provider with rank 1 and subsequently all the 16 providers have been ranked as shown in figure 4.

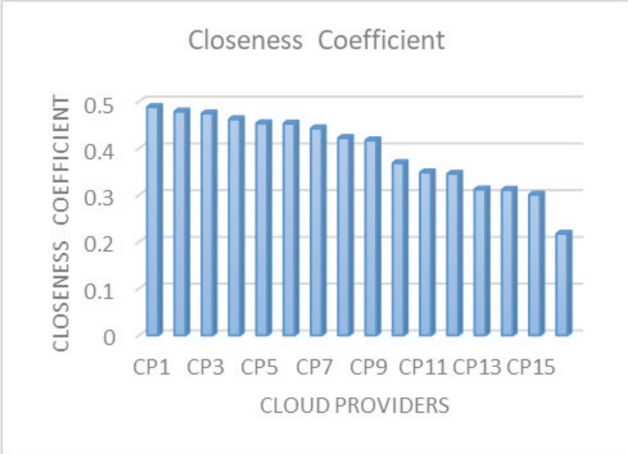

Fig. 3. Cloud provider and the Closeness coefficient values

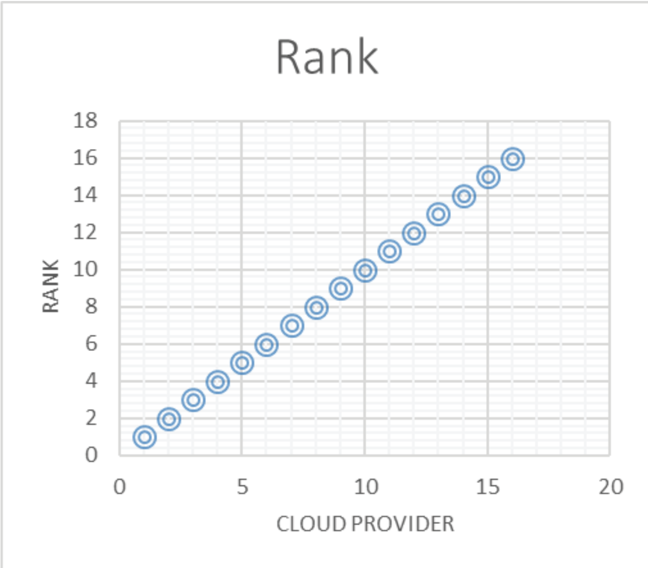

Fig. 4. Cloud Providers and the ranks

VII. Conclusion

Selecting the best cloud provider among the available providers is a difficult task for users who want to select Cloud Provider based on QoS attributes. The criteria for selection fall on both qualitative and quantitative varieties. Therefore, this paper proposed the selection of cloud services based on SMI attributes such as transparency, billing, usability of service, protection and the performance The scores are defined using the respective linguistic variables and are translated into fuzzy values which effectively rate the cloud services. The selection is made using the Fuzzy Technique for Order Preference Approach to rank the available providers based on the above parameters. This research can be expanded in future to rate the cloud services based on other approaches to MCDM. Fuzziness in the data collection can be handled successfully by using different approaches. The needs of the consumers can be defined even more easily using modern MCDM approaches.

REFERENCES

[1] C. S. M. I. C. (CSMIC), SMI FRAMEWORK, URL HTTP://BETAWWW.CLOUDCOMMONS.COM/SERVICEMEASUREMENTINDEX, 2014

[2] N. Ghosh, S. K. Ghosh and S. K. Das, "SelCSP: A Framework to Facilitate Selection of Cloud Service Providers," in IEEE Transactions on Cloud Computing, vol. 3, no. 1, pp. 66-79, 1 Jan.-March 2015, doi: 10.1109/TCC.2014.2328578.

[3] R. C. Zoie, B. Alexandru, R. Delia Mihaela and D. Mihail, "A decision making framework for weighting and ranking criteria for Cloud provider selection," 2016 20th International Conference on System Theory, Control and Computing (ICSTCC), Sinaia, 2016, pp. 590-595, doi: 10.1109/ICSTCC.2016.7790730.

[4] R. R. Kumar and C. Kumar, "An evaluation system for cloud service selection using fuzzy AHP," 2016 11th International Conference on Industrial and Information Systems (ICIIS), Roorkee, 2016, pp. 821-826, doi: 10.1109/ICIINFS.2016.8263052.

[5] N. Tanoumand, D. Y. Ozdemir, K. Kilic and F. Ahmed, "Selecting cloud computing service provider with fuzzy AHP," 2017 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE), Naples, 2017, pp. 1-5, doi: 10.1109/FUZZ-IEEE.2017.8015681.

[6] D. Lin, A. C. Squicciarini, V. N. Dondapati and S. Sundareswaran, "A Cloud Brokerage Architecture for Efficient Cloud Service Selection," in IEEE Transactions on Services Computing, vol. 12, no. 1, pp. 144-157, 1 Jan.-Feb. 2019, doi: 10.1109/TSC.2016.2592903.

[7] A. E. Youssef, "An Integrated MCDM Approach for Cloud Service Selection Based on TOPSIS and BWM," in IEEE Access, vol. 8, pp. 71851-71865, 2020, doi: 10.1109/ACCESS.2020.2987111.

[8] S. Kaur, S. K. Sehra and S. S. Sehra, "A framework for software quality model selection using TOPSIS," 2016 IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology (RTEICT), Bangalore, 2016, pp. 736-739, doi: 10.1109/RTEICT.2016.7807922.