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Cloud Service Selection Using Integrated Approach Of Fuzzy AHP And Fuzzy Topsis

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Abstract— Cloud computing has emerged as a new computing platform for providing fast and low cost services to the individual ,organizations ,government etc. over the internet and is a future generation technology. Cloud computing model means to increase the opportunities for cloud user by accessing leased infrastructure and software application from anywhere and anytime manner. Cloud computing mainly consist there service model as Software as a Service (Saas), Platform as a Service (PaaS) and Infra structure as a Service (IaaS). These service models are being provided by many cloud services provider and a user can choose any one of them based on various parameters .which many differ from one service provider to another service provider and is a challenging and tedious task for an end user to select the best one. This paper provides an approach to select cloud services among the available alternatives to the IT users using two popular Multi Criteria Decision Making (MCDM) Techniques: Fuzzy Analytical Hierarchy Process (FAHP) and Fuzzy Technique for Order Preference by Similarity to Ideal Solution(FTOPSIS) with special reference to triangular fuzzy membership function for experimental hypothetical alternatives as and services are considered with identified criteria. Selection process MCDM techniques are enough capable to find out the best alternatives as cloud service, a hypothetical cloud services as alternatives, used on identified criteria where ranked and found satisfactory.

Keywords— Cloud services, Fuzzy analytic hierarchy process (FAHP), Fuzzy technique for order preference by similarity to ideal solution.

I. INTRODUCTION

Cloud computing is a new buzzword in IT companies and entire companies is being shifted towards cloud computing technology. Cloud computing means that instead of all the computer hardware and software you're using sitting on your desktop, or somewhere inside your company's network, it's provided for you as a service by another company and accessed over the internet. Cloud computing is a buzzword that means different things to different people and it is environmentally friendly because it uses fewer resources (servers, cooling systems, and all the rest) and less energy if 10 people share an efficiently run, centralized, cloud-based system. The aim of cloud computing model is to increase the opportunities for cloud user by accessing leased infrastructure and software applications from anywhere any time manner. Cloud computing offers a new kind of information and service to users for new vision of information technology (IT) services [1] [2].

Cloud computing environment, service provider is divided into two parts: The infrastructure provider who manages cloud platforms and another was service provider, who rent resources from one or many infrastructure provider to server the end users. The emergence of cloud computing has made a fantastic impact on the Information Technology(IT) industry [6]over the past few years, where large companies such as Google, Amazon and Microsoft strive to provide more powerful, reliable and cost-efficient cloud platforms. Cloud computing [10] providers several compelling feature that make it attractive to consumers which offers hug opportunities to the IT industry and understanding and design of the challenges in different area discussed [12] cloud computing architecture according to the needs of IT customers and to arrive as a prototype to come across with on-demand resource(e.g. infrastructure, platform, software, etc.)[4].cloud computing mechanism which is explained by a case study.

Decision making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker. Making a decision implies that there are alternative choices to be considered, and in such a case we want not only to identify as many of these alternatives as possible but to choose the one that best fits with our goals, objectives, desires, values, and so on. Multi MCDM [3] refers to making decisions in the presence of multiple, usually conflicting, criteria. MCDM is concerned with

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structuring and solving decision and planning problems involving multiple criteria.

Due to hugs utilizations of cloud services by the individual, government, enterprise, IT companies etc. it became a challenging task to select a suitable cloud service and this is the reason why this area has attracted many researchers. However very few research articles is available on this domain. The following are the summary of research article's considered in this research work to review the work done till date, Researchers have made their contribution to find out best cloud services among the available alternatives using popular MCDM techniques which is a widely accepted techniques for ranking the alternatives specially in case conflicting criteria as shown in Table 1.

Table 1. Related work for cloud computing services

Objective	Approach	Author and year
Architecture for market-oriented allocation of resources within clouds.	Negotiation of QoS between user and provider to establish SLAs;	R. Buyya et al. (2008)
Presented a vision for the creation of global cloud exchange for trading services.	Mechanisms and algorithms for allocation of VM resources to meet SLAs; and manage risks associated with the violation of SLAs.	R. Buyya et al. (2008)
Survey of cloud computing, highlighting its key concepts, architectural principles, state –of-the –art implementation as well as research challenges.	Surveyed the state-of-the-art of cloud computing, covering its essential concepts	Qi Zhang et al. (2010)
Customer to evaluate cloud offerings and rank them based on their ability to meet the user's Quality of Service(QoS)	Service level Agreement(SLA), Measure all the QoSattibutes proposed by CSMIC and rank the cloud services based on AHP method	S.K. Garg et al.(2013)
Analyse the application of MCDA to service selection in CC	Describe the MCDA types and summarize several of the advantages and disadvantages applications of MCDA methods	MdWhaiduzzaman et al.(2014)
Ranking and selecting the most suitable cloud computing to accommodate and access big data.	Fuzzy AHP and PROMETHEE for comparing and deciding the ranking	Omar Boutkoum et al.(2016)
Emphasized the importance of cloud computing to full fill computing needs of today's complex business scenarios	SaaS, PaaS and IaaS, have their own performance challenges as well as inter-dependencies	Shailesh Paliwal

II. PROPOSED APPROACH

The entire process of research work is deputed in Figure 1 in three different phases as below:

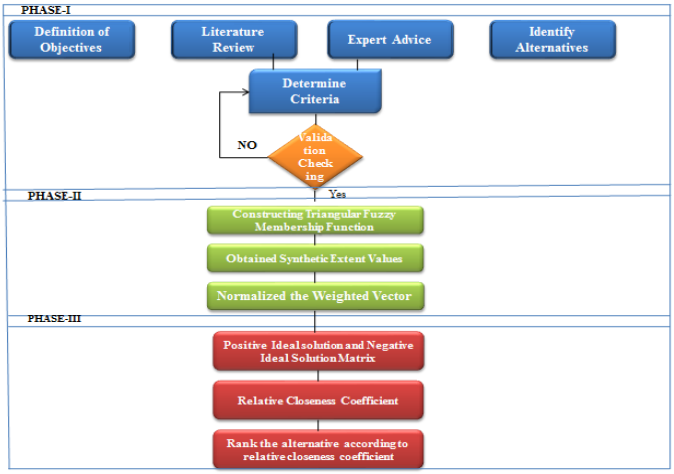

Figure 1.Praposed structure for ranking of cloud services

A. Defining Objective, Identifying criteria and alternatives: Before applying MCDM method it is necessary to define objective in the precise manner. The objective of the research work is to rank the available alternatives as cloud services based on conflicting criteria which clearly help the MCDM methods to select best alternative is important.

The criteria which have been identified for selection process are as follows:

(I) Server Management: Server Management services cover installations, upgrades, troubleshooting, maintenance,

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monitoring, OS updates, and much more. You get complete peace of mind for a predefined reasonable cost.

(II) Portability: Cloud portability enables the migration of cloud service from one cloud provider to another or between public cloud and a private cloud. Cloud portability requires interoperability among cloud providers, which means that one cloud provider, must be able to replicate the application environment that the previous cloud provider had established for the service.

(III) User Friendly: Cloud Services- User friendly Web Infrastructure helping IT companies cut cost sales related Query. Cloud services enable individuals and companies to use software applications and hardware that are administered by third parties at remote locations.

(IV) Performance: Cloud can help improve performance because it addresses an expected range of availability and performance. It is also critical to convert application performance to set parameters that can be measured on the cloud provider's infrastructure.

(V) Security and Compliance: Security stands as one of the main concerns for most firms with regard to cloud computing services. Cloud-based software provider worth its salt will utilize compliance controls and which allows service organizations, including cloud computing providers, to disclose control activities and processes to their customers and their customers' auditors.

Alternatives

Based on the objective alternatives are identified from the well-known and reputed cloud service providers which provides cloud services to the users.name of the cloud service providers and their corresponding cloud services are listed below in Table2.This cloud services are considered hypothetically CS1,CS2,CS3,CS4 and CS5.

Table 2. Cloud service providers and their corresponding cloud services

Cloud Service providers	**Cloud services**
Google: Google cloud platform and infrastructure for business and IT user used because Highly secure, global, high-performance, and cost effective and constantly improving. Google cloud platform has been built for the long haul.	iweb, Bluehost
Microsoft: Microsoft cloud provider sole vender to be named a leader for its platform and infrastructure service offerings, it also earned top marks for its ability to easily with company's and IT users.	Azure
Amazon: Amazon's AWS continuous to innovate and dominate the cloud services market. its grown so much that its become a key component of Amazon's wall street mechanics and materialize profit from its low- margin e-commerce roots.	AWS (Amazon Web Services)
HP: Cloud is the set of cloud solutions that offers many cloud services all available from Hewlett Packard organization. HP offers compute, storage and platform services that were accessible via the public internet to developers.	HPE (Helion Cloud System)
IBM: Cloud resources make it possible to bring together multiple data sources, scale systems, and incorporate cognitive services to drive business value quickly and inexpensively. Integrate high-performance cloud infrastructure and cutting-edge services into your IT environment with the IBM Blue mix cloud platform.	IBM blue mix

In order to rank of cloud services, before applying any MCDM methods an hierarchy, showing objective criteria and alternatives is need to be constructed as shown in Figure 2.

Hierarchy of cloud services ranking process is shown in Figure 2 as there are three layer where upper layer represents goal and second layer represents COCOMO's five criteria of cloud services. Whereas last layer (leaf) represent alternatives i.e. cloud service to be ranked.

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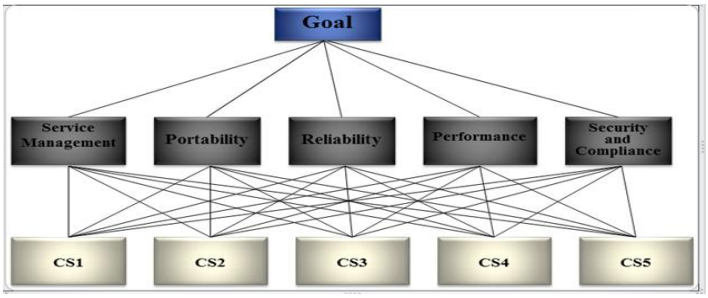

Figure2. Hierarchy of selecting cloud services

B. Appling MCDM method

Multi criteria decision making (MCDM) method is the best optimization method for deals with the process of making decisions in the presence of multiple criteria or objectives. A expert is required to choose among quantifiable or non-quantifiable and multiple criteria. The DM's evaluations on qualitative criteria are often subjective and imprecise. The objectives are usually conflicting and therefore the solution is highly dependent on the preferences of the DM (Kaur et al.,2012). Besides, it is very difficult to develop a selection criterion that can precisely describe the preference of one alternative over another. The evaluation data of subject alternatives suitability for various subjective criteria, and the weights of the criteria are generally expressed in linguistic terms. MCDM has been successfully applied in various knowledge domains; it still imperfectly matched with imprecise, vague and incomplete information. The flexibility, dynamic and receptive nature of MCDM opens a new multitude in leveraging the decision theory.

Many literatures are available on applying MCDM methods in the wide domain like civil engineering, software development process, information technology and mechanical engineering etc. Fuzzy AHP and fuzzy TOPSIS are the very popular MCDM methods suggested by Satty (1980) and Hwang and Yoon (1981). In order to incorporate fuzziness, implicit and ambiguity name of alternative, we need to think Fuzzy logic then to be integrated with MCDM, known as a fuzzy MCDM method. In this research paper we have used two fuzzy MCDM methods, namely Fuzzy AHP and Fuzzy TOPSIS to obtain ranks.

AHP is the one of the most popular analytical techniques for complex decision making problems. T.L.Saaty (1980, 2000)[9], developed AHP, which decomposes a decision-making problem in to a system of hierarchies of objectives, attributes and alternatives. The AHP helps decision makers find one that best suits their goal and their understanding of the problem. So the AHP is most highly regarded and widely used decision making method. It can efficiently deal with tangible (i.e. objective) as well as non-tangible (i.e. subjective) attributes. FAHP is an extension of classical AHP method, in which uncertainty can be resolved and allows more accurate description of the decision making process. The goal of these methods is to decide the ranking among the various available alternatives where the human intelligence is very difficult to apply due to conflicting nature of criteria. TOPSIS thus gives a solution that is not only closest to the hypothetically best, that is also the farthest from the hypothetically worst. The steps for implementing the FAHP and FTOPSIS process[7] are illustrated as follows in Table 3:-

Table 3. Steps for FAHP and FTOPSIS

Fuzzy Analytic Hierarchy Process			
Steps	Purpose	Formula	Eq. No
1	Construct Fuzzy triangular membership	$\mu_A(x) = \begin{cases} 0 \text{ for } x \le 1 \\ \frac{x-l}{m-l} \text{ for } l \le x \le m \\ \frac{u-x}{u-m} \text{ for } m \le x \le u \\ 0 \text{ for } x \ge n \end{cases}$	(1)
2	Construct Triangular Fuzzy Number (TFN) and corresponding triangular fuzzy equivalent 5-point scale is provided in Table 4	a*ij*= (l*ij*, m*ij*, u*ij*) Here l is the lower limit value, m is the most promising value and u is the upper limit value.	(2)
3	Obtained synthetic extent values	$S_i = \sum_{j=1}^{m} N_{ci}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} N_{ci}^{j}\right]^{-1}$ Where N_{ci}^{j} , j = 1, 2, 3….n are TFN values and ⊗ is fuzzy multiplication operation.	(3)
4	Computed ordinate of D	$V(N_2 \ge N_1) = hgt\,(N_1 \cap N_2) = (l_1 - u_2)/(m_2 - u_2) - (m_1 - l_1)$	(4)
5	The degree possibility for a convex fuzzy number	$V(N \ge N_1, N_2, \ldots, N_k) = V[(N \ge N_1), \ldots, (N \ge N_k)] = \min V(N \ge N_i)$	(5)
6	Normalized the weight vector W_A	$W_A = W^T / (\Sigma W^T)$	(6)
FTOPSIS			
7	Determine the objective, and to identify the pertinent evaluation attributes.	--	--

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8	Obtain the normalized decision matrix, $\boldsymbol{R_{ij}}$.This can be represented as :	$r_{ij} = \frac{x_{ij}}{\left[\sum_i x_{ij}^2\right]^{\frac{1}{2}}}$ For i=1,….., m; j=1,……., n	(7)
9	Obtain the weighted normalized matrix v_{ij}	$v_{ij} = w_j.r_{ij}$	(8)
10	Obtain the ideal (best) and negative ideal (worst) solutions in this step:- Ideal solution:-	A* = {v_1*, …….. , v_n*},where $v_j^* = \left\{\max_i(v_{ij}) if j \in J; \min_i(v_{ij}) if j \in J'\right\}$ Negative ideal solution :- A' = {v_1',……., v_n'},where $v_j' = \left\{\min_i(v_{ij}) if j \in J; \max_i(v_{ij}) if j \in J'\right\}$	(9)
11	Obtain the separation measure for each alternative. The separation from the ideal alternative is:	$S_i^* = \left[\sum_j (v_j^* - v_{ij})^2\right]^{\frac{1}{2}}; i = 1, \ldots, m$ Similarly, the separation from the negative ideal alternative is : $S_i' = \left[\sum_j (v_j' - v_{ij})^2\right]^{\frac{1}{2}}; i = 1, \ldots, m$	(10)
12	The relative closeness to the ideal solution Ci* and the corresponding rank of the candidate.	$C_i^* = \frac{S_i'}{S_i^* + S_i'}$	(11)

Table 4:- Fuzzy Scale

Linguistic Expressions	**Equivalent Fuzzy Numbers**	**Triangular Fuzzy Scale (l,m,u)**	**Equivalent Reciprocal Fuzzy Numbers**	**Triangular Reciprocal Fuzzy Scale (l,m,u)**
Equal Importance (EI)	1	(1,1,1)	1	(1,1,1)
Moderate Importance (MI)	3	(1,3,5)	1/3	(1/5,1/3,1)
Strong Importance (SI)	5	(3,5,7)	1/5	(1/7,1/5,1/3)
Very Strong Importance (VSI)	7	(5,7,9)	1/7	(1/9,1/7,1/5)
Extreme Importance (EI)	9	(7,9,9)	1/9	(1/9,1/9,1/7)

III. EVALUTION OF CLOUD SERVICES

As per the explain mathematical formulation of MCDM methods ranking of cloud services was performed using self-develop software for AHP ,FAHP and simple integrated Fuzzy AHP and FUZZY TOPSIS methods. However and improve version of integrated Fuzzy AHP and Fuzzy TOPSIS, using triangular membership function was stimulated using ms excel software. The experimental detailed of the above are elaborated as below,

Based on criteria a fuzzy TOPSIS method is applied which consist AHP method to find out weight. In first step FAHP is used for calculating the weights of the programmer. In second step these weights are used in fuzzy TOPSIS process. In order to apply this method for cloud services selection, let us follow the following steps:-

Step 1

Matrix with triangular fuzzy numbers for comparison between cloud services is shown below in Table 5. As mentioned earlier, we have identified five criteria for detection, viz. Service Management (SM), Portability (P), User Friendly (UF), Performance (P), Security and Compliance (SC).

Table 5. Fuzzy matrix of the criteria with respect to goal

	SM	**P**	**R**	**P**	**SC**
SM	[1,1,1]	[1/5,1/3,1]	[1/7,1/5, 1/3]	[1/9,1/7, 1/5]	[1/5,1/3, 1]
P	[1,3,5]	[1,1,1]	[1/5,1/3, 1]	[1/7,1/5, 1/3]	[1/9,1/7, 1/5]
R	[3,5,7]	[1,3,5]	[1,1,1]	[1,3,5]	[1/7,1/5, 1/3]
P	[5,7,9]	[3,5,7]	[1,3,5]	[1,1,1]	[1,3,5]
SC	[1,3,5]	[5,7,9]	[3,5,7]	[1,3,5]	[1,1,1]

Step2

Fuzzy AHP for the criteria of the Factors:

Table 6. Sum of rows and columns based on different criteria

	Rows Sum	**Column Sum**
SM	[1.65, 2.01,	[11,19,

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	3.53]	27]
P	[2.45,4.67, 7.53]	[10.20,16.33, 23]
R	[6.14,12.20, 18.33]	[5.34,9.53, 14.33]
P	[11,19, 27]	[3.25,7.34, 11.53]
SC	[11,19, 27]	[2.45,4.68, 7.53]
Sum of Column Sums		[32.25,56.88, 83.39]

Table 7. Fuzzy synthetic extent for cloud services

	l	m	u
S_1	0.0198	0.0353	0.1094
S_2	0.0294	0.0821	0.2334
S_3	0.0736	0.2144	0.5683
S_4	0.1319	0.3340	0.8371
S_5	0.1319	0.3340	0.8371

Using equations (4) and (5), raw weights are calculated using synthetic extent calculated above given in Table 8.

Table 8. Raw weights based on different criteria

	Synthetic Index					Raw Weights
	S_1	S_2	S_3	S_4	S_5	
$V(S_1 \geq S_2, S_3, S_4, S_5)$	-	1.5567	1.6642	1.7802	1.7802	1.5567
$V(S_2 \geq S_1, S_3, S_4, S_6)$	1	-	1.6270	1.7430	1.7430	1
$V(S_3 \geq S_1, S_2, S_4, S_5)$	1	1	-	1.6549	1.6549	1
$V(S_4 \geq S_1, S_2, S_3, S_5)$	1	1	1	-	1	1
$V(S_5 \geq S_1, S_2, S_3, S_4)$	1	1	1	1	-	1

After normalization of the weights using equation (6), the weights of C1, C2, C3, C4 and C5 are as W = (0.2801, 0.1799, 0.1799, 0.1799, 0.1799).

Step 3

FTOPSIS of the cloud services with respect to the criteria using equation (9),(10) and (11) shown in Table 9 and final rank is shown in Table 10.

Table 9. Overall weights of alternatives

Weights	**0.2801**	**0.1799**	**0.1799**	**0.1799**	**0.1799**
Cloud Service	**CS1**	**CS2**	**CS3**	**CS4**	**CS5**
CS1	0.1059	0.0690	0.1117	0.0644	0.0799
CS2	0.0698	0.0976	0.1117	0.0977	0.0799
CS3	0.0988	0.0793	0.0072	0.0740	0.0799
CS4	0.1059	0.0976	0.0846	0.1122	0.0918
CS5	0.0860	0.0911	0.0972	0.0977	0.0918

Table 10. Relative Closeness and Rank of triangular cloud services

Cloud Service	Weight	Rank
CS1	0.6688	4
CS2	0.7279	3
CS3	0.5690	5
CS4	0.8731	1
CS5	0.8150	2

IV. CONCLUSION

Cloud computing helps IT user to access cloud service from anywhere any time mode over the internet with low cost; this is the reason why this technique is popular among the IT users. Availability of various cloud service providers in the market, it is difficult to find out the best one. This research work focuses on selection of cloud service with identified criteria. The proposed approach is enough capable to find out the best alternative among the hypothetically considered alternatives. The proposed approach may be reflected in real sense to choose best cloud service.

REFERENCES

[1] R. Buyya, C.S. Yeo, S. Venugopal, J. Broberg, and I.B. Randic, "*Cloud computing and emerging IT platform: vision, hype, and reality for delivering computing as the 5th utility*",Future Generation Computing system,Vol.25,No. 6,pp.599-616,2009.

[2] R. Buyya, C.S. Yeo, S. Venugopal, "*Market-Oriented Cloud Computing: Vision, Hope, and Reality for Delivering IT services as computing Utilities*", IEEE,2008

[3] O. Boutkhoum, M. Hanine and T. Agouti, "*Selection problem of cloud solution for big data accessing: fuzzy AHP-PROMETHEE as a proposed methodology"*, JDIM,2016.

[4] S. K. Garg, S. Versteeg and R. Buyya,*"A framework for ranking of cloud computing services"*, Elsevier,2013.

[5] A.C. Kutlu, M. Ekmekcioglu, "*Fuzzy failure modes and effects analysis by using fuzzy TOPSIS-based fuzzy AHP"*, Expert Systems with Applications, Elsevier, Vol.39, pp. 61–67,2012.

[6] S. Pearson, *"Taking Account of privacy when Designing Cloud computing Services"*, HP Laboratories,2009.

[7] R.V. Rao, *"Decision making in the manufacturing environment"*, Springer-Verlag London Limited,2007.

[8] S.S. Kaur, Y. Brar And K.N. Singhand, *"Multi Criteria Decision Making Approach for Selecting Effort Estimation Model"*,International Journal of Computer Applications (0975 – 8887),Volume 39– No.1,pp.10-17,2012

[9] T.L. Satty, "*The Analytical Hierarchy Process*", McGraw Hill, New York ,1980.

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[10] G. Wei, A.V. Vasilakos, Y. Zheng And N. Xiong, "*A game – theoretical method of fair resource allocation for cloud computing services"*, Springers ,2009.
[11] M. Whaiduzzaman, A. Gani, N.B. Anuar, M. Shiraz, M.N. Haque and I.T. Haque, "*Cloud services selection using multicriteria decision analysis"*, The Scientific world Journal volume, article ID pp.459-3375,2014.
[12] Qi. Zhang, Lu. Cheng, R. Boutaba, "*Cloud computing: state- of-the- art and research challenges*", Springers,2010.

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