SERVICE SELECTION IN CLOUD BASED ON MULTI-OBJECTIVE AND MULTI- CRITERIA SELECTION

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Abstract

Cloud computing technology provides on-demand services at low cost to the consumer. The customer request the cloud services that can fulfill their requirement while meeting the quality standards which are offered at low cost. The cloud user focuses on various parameters such as cost, security and performance while opting for the cloud services. The increase in number of services offered every year by the cloud provider is a challenge for the cloud user in identifying the relevant and best services from the list of available services. Multi criteria decision making (MCDM) techniques are designed for helping cloud user for selecting service in cloud. Quality of Service (QoS) in service selection also plays an important role in choosing the best suited service from the cloud provider list. In this paper, we present a basic concept of cloud computing and various techniques for service selection in cloud.

Keywords: Quality of Service (QoS); Cloud Computing

I. INTRODUCTION

Cloud Computing is an on-demand pay-as-you-go distributed technology for providing computational services and resources such as hardware and data storage space as a general utility which can be taken and released by the user through an internet communication. Cloud computing model increases the prospects of the cloud users by accessing leased infrastructure and software applications from any location and at time of the day [1]. The emergence of cloud technology impacted significantly on IT industry, several companies like IBM, Google, Amazon, HP, and Microsoft are providing trustworthy and cost-effective computing platforms to its users for facilitating the transition of their traditional business plans to the cloud environment in order to gain benefit [2]. Cloud technology helps in reducing the up-front cost of setting up a complete infrastructure, the cloud user can simply rent the resources required from the service provider and pay according to their usage. In cloud environment the services can be taken used and returned back as per the requirement of the cloud user and therefore the operational cost can be reduced to great extent while increasing the scalability. Cloud technology increases the accessibility to the services hosted in cloud environment which can be accessed through desktop, laptops, PDAs etc with the internet connections [3]. Nowadays many organizations are moving their business on the cloud environment in order to reduce their operating cost and to get the best service from the cloud provider. The increasing number of cloud services available in the market makes a challenge for the cloud consumer to decide most suitable cloud service provider for meeting all the requirements of the customer while maintain QoS parameters.

The Cloud Service Measurement Index Consortium (CSMIC) identified various attributes and integrates them to form Service Measurement Index (SMI), these attributes helps in evaluating and comparing different cloud services. [4]. SMI depends on the measurement of Key performance Indicators (KPI) which helps the customers in selecting the suitable cloud services. There are various attributes defined in SMI such as Throughput, Reliability, Availability, Accountability, Agility, Assurance of Service, Cost, Privacy,

Performance, Security and Usability [5] Table 1 below discussed various attributes and sub-attributes which improve QoS performance.

Table1: Attributes and Sub-Attributes for Service Selection

Attribute	Sub-Attributes
Agility	Adaptability Elasticity Extensibility
Assurance Of Service	Availability Maintainability Reliability
Performance	Accuracy Interoperability Service Response Time
Security and Privacy	Data Privacy Data Integrity Security
Usability	Transparency Accessibility Learn ability

Few attributes and their related sub-attributes which is used for service selection in cloud are discussed below:

Accountability: This attributes if fulfilled by the service provider helps in building trust of the customer. Organizations usually want to take services from those service providers which take accountability in case of data loss and security issues.

Agility: The organizations these days keep on expanding their business, cloud technology provides the feature of agility and it helps the customer to expand their business without worrying about the expenditure. Customer always focus on elastic , flexible and portable nature of cloud.

Performance: The organization moving to the cloud is concerned about how the services taken will be performing. Response time, Interoperability etc are some of the attributes which are considered for evaluating performance of any service.

Availability: The Cloud customer wants their resources to be Up and available all the time. There might be some times when the services are down the customer expect that the cloud provider should have the backup of the services in order to cover the down time.

Security: The organizations have sensitive data related to its business and the customer. Cloud customer would like to ensure that the cloud provider is taking necessary steps related to the security of the customers data. Authentication and Encryption techniques should be used to make sure that there will be no leakage of the sensitive information.

Service Response Time: The response time of any service depends upon how fast the services are made available to the customer. Service response time is the maximum response time in which service requested reaches to its customer.

Usability: The customer would like to go the services which are easy to learn and operate. The organizations would like to take the cloud services which are easy to install, operate and learn.

The remaining part of the paper is organized as follows. Section II discusses the characteristics of Cloud Computing, Section III gives an insight on various service models in cloud. Section 4 explores the Multicriteria (MCDM) Techniques and Multi-Objective decision making. Conclusion and the future research directions are discussed in Section V.

II.   CLOUD COMPUTING CHARACTERISTICS

Cloud computing provides various features which make it different from traditional service computing, the features are summarized below:

On-demand self service. The user can demand and release the services as per the requirement. The services can be requested dynamically from the control panel and the payment for the services can be done by using "pay-and-go" method [6].

Multi-tenancy: Cloud computing is known for its multi-tenancy approach i.e the services taken by multiple consumers can be co-located in the

single data centre. Multi-tenancy models should have policies for isolation, security and separation [7].

Shared resource pooling: In cloud computing the cloud provider offers sharing of resources to its consumers. The dynamic resource allocation is the flexibility offered by the cloud providers to grant or release the services of the consumer during peak demand [8].

Ubiquitous network access: The service in cloud environment is accessible through internet. The devices which have internet connection can easily access the services of cloud. Also there are number of data centers across the globe facilitating the cloud service provider to take advantage by achieving maximum service utility [9].

Service oriented: Cloud computing has service oriented architecture where Service Level Agreement plays an important role. IaaS, PaaS and SaaS provide its services according to SLA agreed between the provider and the consumers [10].

Scalability: Cloud consumer can be allocated and de-allocated resources according to the demand. The dynamic resource management features of cloud technology differentiate it from traditional computing models. The elasticity of cloud technology allows user to request the services and resources whenever they are required [11].

Utility-based pricing: Cloud computing is based on pay per- use pricing model. Different services have different pricing scheme. Utility-based pricing reduces the total service cost by charging customers on a per-use basis. Various cloud providers reduce the unnecessary cost on the resource consumption [12].

III. CLOUD COMPUTING SERVICE MODELS

In cloud computing environment, the resources such as infrastructure, hardware, platform and software are provisioned as services on-demand basis and are offered to the cloud consumer[13].These services offered by cloud are grouped into three categories: **software as a service (SaaS)** which refers to providing on demand software applications over the Internet , **platform as a service (PaaS)** which facilitates to providing platform such as operating system support and software development frameworks for building applications and **Infrastructure as a Service (IaaS)** refers to on-demand provisioning of infrastructural resources [14]**.**
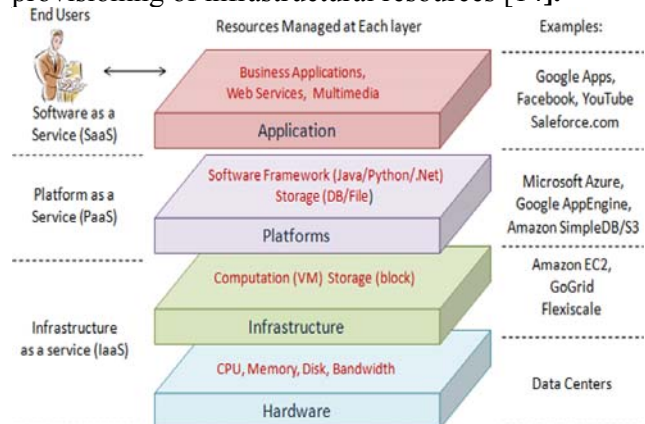

Fig 1   Service Models and Deployment Models [2]

Example of the taxonomy of cloud computing services

This section explores the taxonomy of four different cloud service provider Amazon EC2[36], Microsoft Azure[37], Google Apps [38], IBM Blue Mix[39].

Taxonomy in cloud environment	Amazon	Microsoft Azure	Google Apps	IBM Blue Mix
Virtualization	Xen	VMware		Alpha 7
Payment Option	Pay as you go	Pay as you go	Free to use	Pay as you go
Types of Service	SaaS	PaaS IaaS	Saas	PaaS
Security	Availability Zones, PKI	Not Mentioned	SSL	Authentication , Security Compliance
Operating System	Microsoft Windows, Linux	Microsoft Windows, Linux	Cloud Shell	Cloud Foundry
Standards	API	SOAP	API	Ticketing System

Cloud Services provisioning is considered an important feature of cloud computing, the services selection approach is based on choosing the best service from the available list of services and the optimal composition of those service. With the growth of cloud computing it becomes increasing difficult for the cloud consumer to decide which provider can fulfill their QoS requirement because it is an important attribute which is used in doing cloud service selection [15]. Each cloud provider nowadays are offering similar services with the variation in the cost and the level of performance. Therefore it becomes very challenging for the customer to decide which cloud provider will offer him the best services and at lowest price. The QoS helps in identifying and evaluating the best suited parameter that fits into the customer requirement of service selection, the criteria (both Qualitative and Quantitative attributes) for the service selection need to be identified. The service selection of cloud depends upon many criteria and can not be evaluated effectively by using single criteria and therefore Multi-Criteria decision making (MCDM) techniques [16] which is used in evaluating multiple cloud services but also the services which are most suitable according to the customer requirements.

IV. MCDM METHODS

Multi-Attribute Decision Making is the branch of operations research which deals with decision problem, it is tool for selecting the best alternative among the number of alternatives. MCDM is used to consider multiple and conflicting criteria in decision making. Hwang and Yoon in 198**1** categorized the MCDM methods into two different categories: multi-objective decision making (MODM) [17] and multi-attribute decision making (MADM) [18].

4.1 Multi-Objective Decision Making

In Multi-Objective two or more objectives are defined for service selection and these objectives can be evaluated by using mathematical and theoretical frameworks for solving real life decision problems that involves multiple conflicting criteria. Objectives includes maximizing performance, minimizing response time, minimizing cost of the services taken from the service provider. The objective of MODM is to optimize the multiple objective and to find the best solutions among the available solutions. The limitations of MODM approach is associated identification of Pareto-optimal set which measure the efficiency in multi-objective optimization [19]. MODM methods can be calculated by using Multi-objective mathematical programming (MOPM), Goal Programming (GP), Evolutionary Algorithms(EP), Genetic Algorithms (GA) etc.

4.1.1 Multi-objective mathematical programming (MOMP)

MOMP methods are classified as a priori methods, interactive methods, and a posteriori methods. In a priori methods, the Decision maker expresses the preferences before the solution process (e.g., setting goals or weights for the objective functions). The decision maker in the interactive methods interchanges the phases of dialogue with the phases of calculation and after some repetitions the best solution is evaluated. In the a posteriori methods the optimal solutions of the problem are generated, the decision maker selects the most preferred solution from the list of optimal solution [23].

Yongqiang et al in [24] proposed a multi-objective ant colony system algorithm for the virtual machine placement problem. The objective of the algorithm is to obtain set of non dominated solution that reduces the resource wastage and power consumption.

4.1.2 Goal Programming (GP)

Goal Programming is an expansion to Linear Programming for handling multiple conflicting objectives. Goal programming is an analytical method used to determine if the required resources are sufficient to achieve the desired set of objectives and if the goal can be achieved with the available resources. It is also used for portfolio selection and analysis problem. GP can handle various issues related to risk measurement, multi-period etc [25]

Manoj Kumar et al in [26] used GP technique for solving vendor selection problem. The proposed approach has few objectives including cost minimization, reducing failures in delivery, vendors capacity and improving flexibility. The approach also has the capability to handle real time issues in the fuzzy environment by

providing a good decision tool for vendor selection in supply chain.

4.1.3 Genetic Algorithm (GA)
The GA is the most popular heuristic algorithm and optimization technique which is based on Evolutionary Algorithm [27] of natural selection and genetics. GA is based on several parameters like Selection, Crossover and Mutation. GA is considered better when compared with traditional Artificial Intelligence algorithms and is found to be more strategic when adopted to find best individuals to add to their mating pool in a GA framework [28]

In [29], Zhen Ye et. al, the author proposes QoS model for calculating QoS values for service selection in cloud environment and in order to find the appropriate composition of services, the genetic based algorithm is proposed.

4.2 Multi-Attribute Decision Making
MADM methods is concerned with the planning and solving problems which are having involving multiple criteria. There is no single optimal solution for the above problems and therefore it is mandatory for the decision maker to select the best possible solution. The MADM process begins with the selection of criteria, selection of alternatives, Selection of the weighing methods to represent importance. There are various techniques which uses a different approach for selecting the best among several pre-selected alternatives [20]. MADM provides a platform to the decision maker for considering the preferences and judgments based on a set of attribute-aggregation methodologies [21]. MADM technique or the model should be carefully selected in accordance to the type of problem, objectives and attributes selected. Both quantitative and qualitative attributes should be considered to make the decision maker judgment easier [22]. MADM techniques are Analytical Hierarchy Process (AHP), Preference ranking organization method for enrichment evaluation (PROMTHEE), Multiple attribute utility theory (MAUT) etc.

4.2.1 Analytical Hierarchical Process (AHP)
AHP is a structured MADM technique which simplify complex decision by organizing unstructured decision attributes and their alternatives in a hierarchical structure, doing pair wise comparisons among the attributes and finding the best solution from the available criteria. The paired comparison produces the weighting scores which help decision makers to optimize the solution when there are various quantitative and qualitative parameters [30].

In [31] ,Gengiz kahraman proposed a Fuzzy AHP approach to select the best supplier firm which will fulfill all the requirement of the customer. The approach for the supplier selection is based on the questionnaire filled in respect to the criteria including cost, service performance, product performance etc.

4.2.2 Preference ranking organization method for enrichment evaluation (PROMTHEE)
PROMETHEE method is used for ranking of alternatives and can be classified into PROMTHEE I which is a partial ranking to PROMTHEE II as a full ranking approach. PROMETHEE II is most popular method based on the pair wise comparison of the alternatives and also by finding the preference degree which range from 0 to 1. This amplitude of deviation between the alternatives in each attribute reduces the scaling effect and provides information related to the conflicting attributes assisting the decision maker to rank the alternatives [32].

The author V. Balali [33], used PROMTHEE which is a multi-criteria decision making approach for selecting most appropriate structural system for multi-housing projects. The approach is executed with the involvement of expert opinion which includes engineers, managers and contractors who have a vast experience on working of such projects. The team of these experts can make a decision about PROMTHEE parameters such as weights of different criteria.

4.2.3 The technique for order preference by similarity to ideal solutions (TOPSIS)
TOPSIS method is known to be one of the best MADM methods in the rank reversal issue. The fundamental theory behind TOPSIS is that there should be shortest distance in between the selected alternatives from the ideal solution and the longest distance from the solutions which are not ideal. TOPSIS method has the ability to select in less time the best alternative and is also

found performing better than AHP technique in matching a base prediction model. Simple additive weight result calculation in TOPSIS varies when there is variation in the number of attributes [34].

In [35]Chi-Chun Lo et al uses TOPSIS approach which can help service providers and consumers to identify the available web services. The author divided the approach in three parts. Firstly the pre-defined linguistic variables are parameterized by triangular fuzzy numbers. Secondly evaluation of the weights of various criteria is done and finally ranking is given to each web service and they are arranged in order of the group preference .

V. CONCLUSION AND FUTURE SCOPE

The paper presents a comprehensive review on the service selection in cloud environment. The service selection approach is classified into two parts which are multi-objective decision making and multi criteria decision making. Various techniques related to multi-objective decision making and multi criteria decision making were discussed. QoS based selection when used with any of the technique will give better result for increasing the efficiency for service evaluation and selection.   For future work, the service selection in cloud computing can be focused on the algorithm to enhance the performance and function of service selecting.

VI. REFERENCES

[1] Buyya, Rajkumar, et al. "Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility." *Future Generation computer systems* 25.6 (2009): 599-616.

[2] Zhang, Qi, Lu Cheng, and Raouf Boutaba. "Cloud computing: state-of-the-art and research challenges." *Journal of internet services and applications* 1.1 (2010): 7-18.

[3] Zissis, Dimitrios, and Dimitrios Lekkas. "Securing e-Government and e-Voting with an open cloud computing architecture." *Government Information Quarterly* 28.2 (2011): 239-251.

[4] Garg, Saurabh Kumar, Steve Versteeg, and Rajkumar Buyya. "Smicloud: A framework for comparing and ranking cloud services." *Utility and Cloud Computing (UCC), 2011 Fourth IEEE International Conference on*. IEEE, 2011.

[5] Liu, Yongwen, Moez Esseghir, and Leila Merghem Boulahia. "Evaluation of Parameters Importance in Cloud Service Selection Using Rough Sets."*Applied Mathematics* 7.06 (2016): 527.

[6] Jula, Amin, Elankovan Sundararajan, and Zalinda Othman. "Cloud computing service composition: A systematic literature review." *Expert Systems with Applications* 41.8 (2014): 3809-3824.

[7] Espadas, Javier, et al. "A tenant-based resource allocation model for scaling Software-as-a-Service applications over cloud computing infrastructures."*Future Generation Computer Systems* 29.1 (2013): 273-286.

[8] Wischik, Damon, Mark Handley, and Marcelo Bagnulo Braun. "The resource pooling principle." *ACM SIGCOMM Computer Communication Review* 38.5 (2008): 47-52.).

[9] Hamdaqa, Mohammad, and Ladan Tahvildari. "Cloud computing uncovered: a research landscape." *Advances in Computers* 86 (2012): 41-85.

[10] Patel, Pankesh, Ajith H. Ranabahu, and Amit P. Sheth. "Service level agreement in cloud computing." (2009).

[11] Gong,Chunye, et al. "The characteristics of cloud computing." *Parallel Processing Workshops (ICPPW), 2010 39th International Conference on*. IEEE, 2010.

[12] Buyya, Rajkumar, et al. "Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility." *Future*

Generation computer systems 25.6 (2009): 599-616.

[13] Ellinger, R. S. (2013). Governance in SOA Patterns (white paper). In The Northrop Grumman Corporation for Consideration by OASIS SOA Reference Architecture

[14] B. P. Rimal, E. Choi, and I. Lumb, "A Taxonomy and Survey of Cloud Computing Systems," 2009 Fifth International Joint Conference on INC, IMS and IDC, pp. 44–51, Aug. 2009.

[15] Khowfa, Wachana, Onsiri Silasai, and Chatchada Kaewpruksapimon. "QoS Based Service Selection in Cloud Environment: A Review." *Int. J. Advance Soft Compu. Appl* 7.3 (2015).

[16] Ur Rehman, Zia, Farookh K. Hussain, and Omar K. Hussain. "Towards multi-criteria cloud service selection." *Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS), 2011 Fifth International Conference on*. IEEE

[17] Roijers, Diederik Marijn, et al. A survey of multi-objective sequential decision-making." *Journal of Artificial Intelligence Research* (2013).

[18] Hwang, Ching-Lai, and Kwangsun Yoon. "Methods for multiple attribute decision making." *Multiple attribute decision making*. Springer Berlin Heidelberg, 1981. 58-191

[19] Ehrgott, Matthias, and Margaret M. Wiecek, "Mutiobjective programming."*Multiple criteria decision analysis: State of the art surveys*. Springer New York, 2005. 667-708

[20] Asghar, Sohail. "A survey on multi-criteria decision making approaches."*Emerging Technologies, 2009. ICET 2009. International Conference on*. IEEE, 2009.

[21] Zopounidis, Constantin, and Michael Doumpos. "Multicriteria classification and sorting methods: A literature review." *European Journal of Operational Research* 138.2 (2002): 229-246.

[22] Velasquez, Mark, and Patrick T. Hester. "An analysis of multi-criteria decision making methods." *International Journal of Operations Research* 10.2 (2013): 56-66.

[23] Mavrotas, George. "Effective implementation of the ε-constraint method in multi-objective mathematical programming problems." *Applied mathematics and computation* 213.2 (2009): 455-465.

[24] Gao, Yongqiang, et al. "A multi-objective ant colony system algorithm for virtual machine placement in cloud computing." *Journal of Computer and System Sciences* 79.8 (2013): 1230-1242.

[25] Azmi, Rania, and Mehrdad Tamiz. "A review of goal programming for portfolio selection." *New Developments in Multiple Objective and Goal Programming*. Springer Berlin Heidelberg, 2010. 15-33.

[26] Kumar, Manoj, Prem Vrat, and Ravi Shankar. "A fuzzy goal programming approach for vendor selection problem in a supply chain." *Computers & industrial engineering* 46.1 (2004): 69-85

[27] Haupt, Randy L., and Sue Ellen Haupt. "The binary genetic algorithm."*Practical Genetic Algorithms, Second Edition* (2004): 27-50

[28] Oreski, Stjepan, and Goran Oreski. "Genetic algorithm-based heuristic for feature selection in credit risk assessment." *Expert systems with applications*41.4 (2014):2052-2064

[29]   Ye, Zhen, Xiaofang Zhou, and Athman Bouguettaya. "Genetic algorithm based QoS-aware service compositions in cloud computing." *International Conference on Database Systems for Advanced Applications*. Springer Berlin Heidelberg, 2011.

[30]   lexander, Melvin. "Decision-making using the analytic hierarchy process (AHP) and SAS/IML." *Available from (Last checked 28th July 2014)* (2012).

[31]   Kahraman, Cengiz, Ufuk Cebeci, and Ziya Ulukan. "Multi-criteria supplier selection using fuzzy AHP." *Logistics information management* 16.6 (2003): 382-394.

[32]   Behzadian, Majid, et al. "PROMETHEE: A comprehensive literature review on methodologies and applications." *European journal of Operational research*200.1. (2010): 198-215

[33]   Balali, V., et al. "Selecting appropriate structural system: Application of PROMETHEE decision making method." *Engineering Systems Management and Its Applications (ICESMA), 2010 Second International Conference on*. IEEE, 2010.

[34]   Behzadian, Majid, et al. "A state-of the-art survey of TOPSIS applications."*Expert Systems with Applications* 39.17 (2012): 13051-13069.

[35]   Lo, Chi-Chun, et al. "Service selection based on fuzzy TOPSIS method."*Advanced Information Networking and Applications Workshops (WAINA), 2010 IEEE 24th International Conference on*. IEEE, 2010.

[36]   Amazon, E. C. "Amazon web services." *Available in: http://aws. amazon. com/es/ec2/(November 2012)* (2015).

[37]   Copeland, Marshall, et al. "Overview of Microsoft Azure Services." *Microsoft Azure*. Apress, 2015. 27-69.

[38]   Zahariev, Alexander. "Google app engine." *Helsinki University of Technology* (2009): 1-5.

[39]   Gheith, Ahmed, et al. "IBM bluemix mobile cloud services." *IBM Journal of Research and Development* 60.2-3 (2016): 7-1.