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Quality Standards for Selecting Optimal Cloud Service Provider for Higher Educational Institutions

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ABSTRACT

Cloud computing (CC) is Internet based pay per use technology of 21st century. From last couple of years, higher educational institutions are shifting to this paradigm because of its enormous benefits. Educational institutions have restricted budget to spend on software and hardware technologies, because grants from government are inadequate, mostly in India, institutions have to generate their own revenue to deploy these resources. Because of this very reason Cloud Computing would be better choice for them. There are n-number of providers exist to provide cloud services. In the cloud terminology, they are termed as Cloud Service Providers (CSPs). CSPs are providing various levels of cloud services viz. Infrastructure-as-a-Software (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS) and many more. Presence of colossal number of CSPs obviously confuses cloud consumers. CSPs are distributing their range of services to the consumer on the basis of Service Level Agreement (SLA). In this document, all the terms and conditions are clearly mentioned in a structured manner. Quality of service consumer requires from CSP and what CSP will deliver have been defined objectively. Unfortunately, service level agreement is generally violated by CSPs; cloud service quality is not upto the expectation. On many occasions, service is not available, and user has to compromise on reliability, the cloud service takes more time than expected, the desired standards of throughput is not achieved and fluctuating cost becomes a major factor. Due to above mentioned reason there is desperate need of some quality standards which CSPs should follow to avoid non-SLA compliance. In the present research paper, our main focus is on setting up quality standards for cloud service providers. These standards will help educational institutions for ranking CSPs and selecting optimal CSP. Optimal CSP will provide quality services to the institution with affordable cost.

Keywords: CSP, SaaS, PaaS, IaaS, SLA.

1. INTRODUCTION

There is a strong relationship between Cloud Computing and Education. Cloud is a repository of those resources through which education can be spread in an effective way for instance costly software (SaaS) can be put on the cloud, so that the user can take advantage of that software. There are numerous cloud based applications like Google Apps, Dropbox, Gmail, Microsoft Office365 etc which any higher educational institution can use to spread quality based education to their students (Jose et. al., 2014). Institutions are always looking for hardware and software upgradation to attract more students in their campuses. These changes involve a huge budget which normally an institution cannot afford, so in these situations the Cloud Computing model can help them achieve these ambitions at prices they can afford. Moreover, by outsourcing the responsibilities to external providers (cloud service providers) for hardware and software infrastructures, cost and labor can be saved. Following are some benefits of using cloud computing in education (Jose et. al., 2014). These benefits actually reflect how cloud computing changes the shape of education.

- Easy availability of online applications.
- Flexible learning environment can be created.
- There is a huge support for mobile learning.
- Computing and simulation supports are available.
- Infrastructure (hardware as well as software) can be scaled.
- Cost savings in both hardware and software.

Beside above rewards of cloud computing, there are some issues which hinder the deployment of cloud computing applications in educational institutions. Some of issues are security, quality of service of applications. In the present research paper, we are concerned with standards of service provided by CSPs.

CSP is an association that provides cloud services to its users. As there is large number of CSPs in the market users get confused. Although these CSPs provide similar type of computation and storage services yet they claim to be unique and best, which is not a real picture. Most of the CSPs are specialized for particular type of service and not effective in case of other issues e.g. a quick storage service is provided by Amazon AWS, virtual instances are more economically handled by Microsoft Azure and smallest wide area latency is the highlight of Google App Engine. Quality standards like efficiency, availability, reliability, usability etc. are not strictly followed by CSPs which affect the service quality given to the users.

In the present research paper, we will discuss these issues. Paper has been divided into different sections. In section II, brief introduction of cloud computing and its related issues have been given. Next, in the section III, objectives of study are listed. In sections IV and V, CSP selection techniques and frameworks have been discussed. Quality standards for optimal selection of CSP have been discussed in section VI. At the end, results of findings and conclusion of study have been mentioned.

2. OBJECTIVES OF STUDY

1. To study major techniques and paradigms for CSP selection from existing literature.
2. To identify and define quality standards for optimal CSP selection for educational institution.

3. To analyse finding to locate most prevalent quality standards, cloud service and CSP selection technique.

3. CLOUD COMPUTING & RELATED ISSUES

According to National Institute of Standards & Technology, NIST (NIST SP 500-291 version 2 2013)

"Cloud computing is a pay per use model. It provides a pool of computing resources like memories, servers and other services. These services are rapidly provided and released with least management efforts and intervention of cloud service provider."

According to Buyya (Buyya et. al., 2009)

"Cloud computing is a parallel and distributed system consisting of set of joined and virtualized nodes that are dynamically provided and presented as one or more integrated computing resources based on agreements established through negotiation between the cloud service provider and cloud consumers."

Services related to Cloud computing:

- Software-as-a-Service (SaaS): Users pay for software services as per usage.
- Platform-as-a-Service (PaaS): It facilitates environment for development. Middleman's equipment can be used to develop code and deliver it to consumers.
- Infrastructure-as-a-Service (IaaS): Platform virtualization is assisted rather than buying costly network devices which include servers, software and data center space. In this case, the user just has to pay for these services as per usage.

Cloud Computing Models:

- Public Cloud: In this model, more than one user can share the resources. Here some hidden dangers are involved like regulatory compliance, security and QoS (Quality of Service).
- Private Cloud: Here some private enterprises control the cloud resources. Advantage of this model is that the dangers of public clouds are less.
- Hybrid Cloud: Fusion of public and private clouds.

Characteristics:

- Pay per use model
- Wide network access
- Resource sharing
- Scaled and measured service

Selection Techniques for Cloud Services

MCDM (Multi criteria Decision Making) (Triantaphyllou 2000) and MCOT (Multi Criteria Optimization Techniques) (Turskis et. al., 2009) are employed for selection of cloud services. Main aim of these techniques is to structure a mathematical model for selecting a best option out of given possibilities. Methods that

come under MCDM are AHP (Analytic Hierarchy Process), ANP (Analytic Network Process), SAW (Simple Additive Weighing), ELECTRE (Elimination and Choice Expressing REality), MAUT (Multi Attribute Utility Theory). MCOT finds optimal solution of a problem that either maximizes profit or minimizes cost within given constraints (Dastjerdi et. al., 2011). Methods that fall under MCOT are Greedy Method, Integer Programming, Dynamic Programming, Backtracking etc. MCDM and MCOT are heavily used by Cloud service selection paradigms for cloud service selection procedure. Users can also employ them to find optimal CSP and to rank list of CSPs according to given quality standard.

Paradigms for Cloud Service Selection

SMICloud (Garg et. al., 2011)

SMICloud model was developed by CSMIC (Cloud Service Measurement Index Consortium). Selection and ranking of CSPs are the core objectives of the framework. Seven attributes have been proposed by this model: accountability, cost, assurance, performance, agility, usability and security. These attributes help in measuring the services offered by CSPs. This model was mainly developed for IaaS services. Figure 1 shows the overall architecture of SMICloud model.

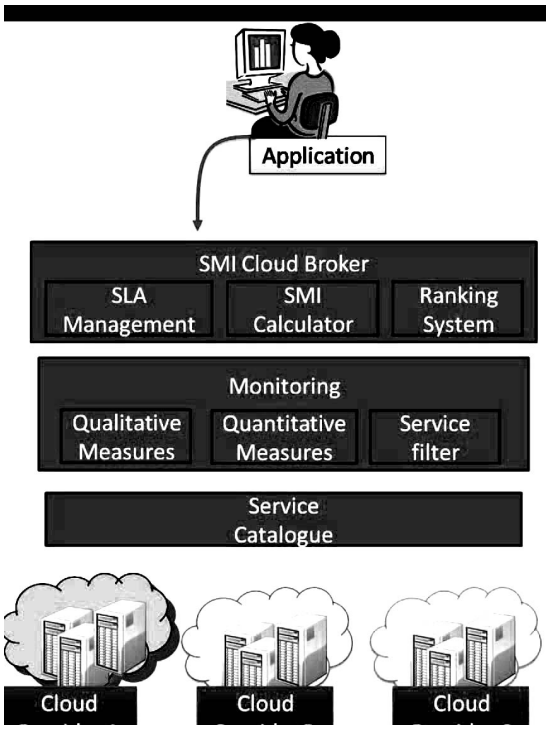

Figure 1: SMICloud framework

CloudCmp (Ang et. al., 2010)

CloudCmp (Ang et. al., 2010) model helped to compare CSPs systematically. Four famous providers viz. Google App Engine, Microsoft Azure, Rackspace cloud servers and Amazon AWS were compared. Wide area network, Intra cloud network, persistent storage and elastic compute cluster parameters were used for comparison. Fast storage services were given by Amazon AWS, economical virtual instances were provided by Microsoft Azure and smallest wide area latency was given by Google App Engine.

CloudQual (Zheng et. al., 2014)

CloudQual (Zheng et. al., 2014) quality framework addressed six quality standards namely elasticity, security, responsiveness, reliability, usability and availability. Expect usability which is a subjective standard rest of standards are objective in nature. Case studies were carried out on three popular CSPs namely Aliyun OSS (Open Storage Service), Microsoft Azure Blob storage and Amazon S3 (Simple Storage Service). Consistency, Discriminative Power and Correlation techniques were used to validate the results.

C-Meter (Yigitbasi et. al., 2009)

C-Meter **(**Yigitbasi et. al., 2009) model was employed to produce test workloads for computing Clouds. It had different features like extensibility and portability. It considered various overheads like getting and leaving virtual resources and other network related issues while carrying out the study.

CloudProphet (Li et. al., 2010)

CloudProhpet (Li et. al., 2010) model assisted to obtain response time of web applications if they were shifted to the Cloud. It also traced resource usages. Different quality standards were discussed like throughput and response time of cloud services.

CloudRank (Zheng et. al., 2012)

CloudRank (Zheng et. al., 2012) was a QoS ranking estimation framework which used past experience of users to deliver cloud services. Two QoS ranking predictions CloudRank1 and CloudRank2 were proposed by the framework as shown in figure 2. Other components of this framework were similarity computation, find similar users and training data. Various cloud users interact with this framework through cloud networking infrastructure. Failure probability, throughput and response time quality metrics were discussed by the framework.

QoS - Aware Clouds (Ferretti et. al., 2010)

QoS aware clouds (Ferretti et. al., 2010) used middleware architecture to optimize cloud resources. They possessed the feature to proactively alter the demanded Cloud resources. By providing sufficient number of Cloud resources to the hosted applications, optimal utilization of resources was achieved. Variety of quality parameters had been considered by it to enhance cloud services.

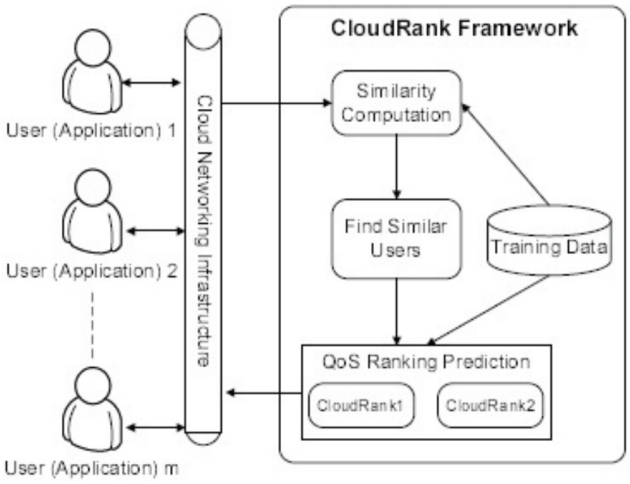

Figure 2: CloudRank model

Fuzzy Cloud Service Selection (Tajvidi et. al., 2014)

In this research for the selection of Cloud service provider fuzzy theory was employed. Different quality standards had been discussed. Proposed framework was validated by performing case study.

A Quality Model for Evaluating SaaS in Cloud Computing (Lee et. al., 2009)

Quality model was proposed for evaluating SaaS. Empirical approach was employed for evaluation of service. IEEE 1061 standards had been used for assessment. Various quality standards like availability, efficiency, reusability, scalability and reliability were elaborated. Various methods like Discriminative power, Correlation and Consistency were used to validate the quality model.

Quantifying Manageability of Cloud Platforms (Maiya et. al., 2012)

In this IaaS providers, vCloud, OpenStack, OpenNebula and Eucalyptus and PaaS providers Microsoft Azure, Google App Engine and Amazon Elastic Beanstalk were evaluated. Use cases and user roles were basis for comparison. Quality standards discussed by this model were time to learn, documentation, interfaces, number of steps, ease of use and time taken.

An End to End Qos Mapping Approach (Karim et. al., 2013)

Dual steps were performed in this approach, firstly quality requirements of Cloud consumer for Cloud services were mapped to correct quality pattern of SaaS and thereafter they were assigned to IaaS services. Different quality standards had been put forwarded like cost, security, reputation, usability, response time, Defects per million, reliability, data control (IaaS) and availability (IaaS).

QoS Architecture for Ranking of Cloud Services (Saravanan et. al., 2013)

Federated cloud environment had been proposed. In this setup, coordinator was assigned to each Cloud; this coordinator controlled and managed working of cloud. Different quality standards had been discussed like availability, assurance, suitability, interoperability, accuracy, stability, response time, performance, reservation cost and on demand cost.

Ranked Voting Method for Selecting Best Cloud Service Provider (Gaurav et. al., 2014)

This framework employed a Ranked Voting technique to select best CSP. SMI parameters along with few other parameters were proposed here. Mainly parameters were fragmented into two different sections: user dependent and application dependent. User dependent parameters were user experience, elasticity, scalability, sustainability, certification, API, free trial, monitoring, client interface and reputation. Furthermore, application dependent parameters were capacity, throughput, efficiency, response time, customer support, virtualization, platforms supported, operating systems, cost, data centers, security, availability and reliability.

Qos History for Parallel Cloud Service Selection and Ranking (Zia et. al., 2013)

For parallel Cloud service selection and ranking of services, research proposed a QoS history model corresponding to different time slots. After collecting history at different time intervals, final result was prepared by aggregating them. Along with user criteria weights, two other well known MCDM techniques were used here namely ELECTRE or TOPSIS.

CloudEval (Hsu 2014)

CloudEval[21] (Hsu 2014) framework used user specified service goals and non functional standards for cloud service selection. MCDM method Grey Relational Analysis was used for selection procedure. Empirical study revealed that, the proposed model was more effective in instance of colossal number of Cloud services.

Uncertain User Preference in Cloud Service Selection (Mu et. al., 2014)

This model considered uncertainty in specifying user subjective and objective requirements for Cloud service selection. For considering subjective preferences, Intuitionistic fuzzy set was used; furthermore, attribute significance of rough set was employed to consider objective preferences. User preferences were mapped into multiple attribute decision making problems. To find the ideal solution corresponding to a problem TOPSIS technique was employed.

Quality Standards

Availability (Lee et. al., 2009) (Zheng et. al., 2014)**:** It is the time during which cloud service is accessible for the user in a particular time interval.

Reliability (Zheng et. al., 2014)**:** Assurance level of cloud services is measured by this standard. It assures error free software and hardware services.

Reliability can be measured by the following:

***Mean Time To Failure, MTTF*:** It is the time during which provider is active in operation. MTTF is directly proportional to reliability.

***Mean Time Between Failure, MTBF*:** It calculates the time slot between the two successive service failures.

***Mean Time To Recover, MTTR*:** It calculates the time to rectify the failure and set the system into its normal mode.

***Mean Time To Discovery, MTTD*:** It calculates the time interval between the two successive discoveries of unknown vulnerability.

***Mean Time To Exploit, MTTE*:** It calculates the time interval between the two successive discoveries of known vulnerability.

Scalability: It is the feature by virtue of which Cloud services work in accordance with pre-assigned order despite of change in size or volume of user's demand.

Usability (Zheng et. al., 2014): It is measured by the degree of easiness to use Cloud services. GUI of Cloud services should be simplified in order to get best Cloud services.

Reusability (Lee et. al., 2009): Commonality of functional features can be measured by it. Following parameters are there to measure reusability:

***Functional Commonality*:** It measures the commonality in functional features of cloud service.

***Non-Functional Commonality*:** It measures the commonality in non-functional features of cloud service.

***Coverage of variability*:** It calculates the points where variation occurred in the Cloud service.

Elasticity (Saravanan et. al., 2013) **(**Herbst 2013): It measures how any system can balance workload alteration by provisioning and deprovisioning resources, with the objective that available resources match the current demand of the user.

Adaptability (Saravanan et. al., 2013): It is measured by how the Cloud service provider changes in Cloud services according to the request of user.

Security (Saravanan et. al., 2013): It calculates the extent of security provided to the data in the cloud. Security is always a major concern for any organization. Data needs to be kept in a secured manner so as to avoid huge losses to a company.

Cost (Saravanan et. al., 2013): The reduction of cost of infrastructure and hardware is a primary objective of any cloud service.

Efficiency (Lee et. al., 2009): Time behaviour and resource utilization are the factors employed to know the efficiency of Cloud service.

Service Response time (Saravanan et. al., 2013): Time lapse between request sending and receiving response is service response time. Minimizing this response time is an important objective of cloud services.

Throughput (Garg et. al., 2011): It is measured by counting the number of tasks completed per unit time by Cloud service.

Easiness (Saravanan et. al., 2013): It is the measure of comfort provided to the cloud service users by cloud service providers.

4. DISCUSSION & RESULTS

As mentioned earlier, educational institutions are shifting their infrastructure onto the cloud due to various advantages. Quality standards really help them to adopt optimal cloud service provider. Optimal CSP provides quality service at low cost. In this research paper, different quality parameters are mentioned namely Usability, Reliability, Availability, Cost, Security, Service Response time, Agility, Performance and Throughput. Results obtained from the present research are: quality parameter Service Response Time is an important parameter which is taken care of by majority of frameworks; its percentage is 14%. Percentages of other quality parameters are Security (10%), Availability (10%), Performance (10%), Cost (10%), Usability (8%), Reliability (8%), Assurance (5%) and Throughput (5%). Parameters Agility, Accountability, Elasticity, Scalability and Efficiency are referred least by frameworks with percentage 4% each. Infrastructure-as-a-Service with 47% is the most referred service by the frameworks. General services with 35% are next to follow and least are Software-as-a-Service and Platform-as-a-Service with 12% and 6% each. Analytic Hierarchy Process and its variant are mostly employed during the selection of Cloud services.

5. CONCLUSION

Cloud Computing is an advancement of previous computing technologies viz cluster, grid technologies. It changes the way education is delivered in institutions. Educational institutions are now heavily dependent on this technology. Large number of CSPs is available in the market. Selecting appropriate cloud service

provider is the challenging task. In the present research paper, we focused on the issue of selecting optimal CSP for educational institutions. From the existing literature, we studied cloud service provider selection techniques and frameworks. During study of frameworks we highlighted quality parameters, techniques and service contexts they were using. Next, we listed quality standards to be followed for selection of optimal CSP. These quality standards are the part of SLA (Service Level Agreement). In the discussion and result section, usage patterns of quality standards by the cloud service selection frameworks were mentioned. Service response time parameter was used by most the frameworks. Cloud service IaaS and cloud service selection technique AHP were widely employed by frameworks.

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