Quality Based Cloud Service Broker for Optimal Cloud Service Provider Selection

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Abstract

Cloud consumers (CC) are confounded while taking the choice of selecting Cloud service provider (CSP) to accomplish Cloud services. Large number of CSPs are present in the market, which provide diverse cloud administrations viz Platform-as-a-Service PaaS, Infrastructure-as-a-Service IaaS and Software-as-a-Service SaaS. CSPs are conveying their Cloud services to CC in light of Service Level Agreement (SLA). In this archive, every one of the transactions have been obviously characterized, what nature of administration will CSP give and what the consumer should pay have been dispassionately characterized. Unfortunately, SLA is not strictly pursued; quality of service is not accomplished. In several events, availability of administration is not up to the mark, reliability is traded off. Cloud service broker (CSB) is an entity which can resolve all these issues. The problem which we will take up in the present research paper is the selection of Quality based Cloud service provider. This procedure will be accomplished by Cloud service broker. Optimal CSP is one which fulfills all the quality requirements of user. In section – I, we will give an introduction of CSB and its categorizations. In section – II, we will figure out motivation behind the research and contribution made. Section – III, IV and V will discuss Research Methodology, Quality Metrics and present status of CSB for CSPs selection. In next section, Quality Based Cloud Service Broker framework QCSB will be proposed. This framework will not only help CC to select optimal CSP but also rank candidate CSPs according to user preferences mentioned in SLA. Subsequent sections will discuss its components, algorithm and implementation issues. Case study on three CSPs with three Quality metrics will be executed using CloudSim simulator. We envision the present research will benefit all those users who are interested in SLA based selection and ranking of CSPs.

Keywords: Cloud consumer, CSB, CSP, SLA.

INTRODUCTION

Role of CSB is very crucial in today’s scenario of service and provider selection. Thousands of providers are present in the market and more are added daily in the service catalog. All these providers are claiming their offered services are unique and hassle free. To test their claim, CSB checks service quality of CSPs and requirements level of user. According to the need of CC, CSB assigns a CSP to it. In the coming text, we are going to define a CSB and its categorization.

A. Cloud Service Broker (CSB)

CSB [1] is a delegate which is situated between user and atleast one CSP. It frames a layer of deliberation between user and CSPs with the end goal that users see a solitary strong perspective of all offered services. According to NIST (National Institute of Standards and Technology) [2] “Cloud service broker as an entity that manages the use, performance, and delivery of cloud services and negotiates relationships between cloud providers and cloud consumers.” According to Forrester [3] “Cloud broker is a business model that leverages skills and capabilities from all three of the traditional business models of software, consulting, and infrastructure to offer a wide value contribution in the emerging cloud space.”

Figure 1: Architecture of Cloud Service Broker [4]
A.1 Categorization of CSB

There are several factors based on which CSB can be categorized [2].

- **Service Aggregation** [2]: CSB consolidates and coordinates various administrations into at least one new administration. The broker will give information mix and guarantee the safe information flow between cloud purchaser and various cloud suppliers.

- **Service Intermediation** [2]: CSB upgrades a given administration by enhancing some particular capacity and gives the esteem added administration to cloud customers. Cases incorporate identity and access management, execution announcing, and security upgrades.

- **Service Arbitrage** [2]: It is like administration collection, with the distinction that the administrations being aggregated are not settled. Benefit arbitrage permits adaptable and shrewd decisions for the service broker. For instance, the cloud benefit representative can utilize a credit-scoring administration and select the best score from different scoring offices.

Motivation and Contribution

Institutions are shifting their data onto the cloud. Cloud services are provided by CSPs. Users need to contact CSPs to get their job done. Thousands of providers are available in the market. They all claim that they are providing best cloud services to users. To select the appropriate CSP for the user is a skillful job. This selection procedure is assisted by CSB. CSB is responsible for coordinating with CSPs and to provide SLA based service provisioning to the CC. Present research paper has following contributions:

- Identify and define Quality standards pertaining to cloud services.
- Study Major CSB frameworks for selection of CSP from existing literature.
- Propose Quality Based Cloud Service Broker framework QCSB for selection of optimal CSP and ranking of candidate CSPs.
- Implement proposed framework and analyse results.

RESEARCH METHODOLOGY

Scientific approach has been followed for literature survey of existing CSBs. Here we employ descriptive review method. We collect significant materials of research domain mainly from online sources. Renowned online databases like IEEE Xplore, Springer, ScienceDirect (Elsevier) have been searched. We use different keywords for searching like Cloud Broker, Cloud Service Broker, Quality issues of Cloud Service Brokers, Cloud Service Broker for Cloud Service Provider selections etc. To filter the searched papers, we used Mendeley Desktop utility (it can be downloaded from https://www.mendeley.com/). It removed duplicate papers, papers without author name or anonymous author from collection. Next, manual scanning of titles for obviously irrelevant articles was carried out. It removed articles who did not address Cloud Service Brokers. At last, abstracts were manually scanned and reading complete articles were performed. This round was comprehensive and time-consuming. Next step in research paper is to propose a framework for CSB. After careful survey of existing CSB, we have introduced a quality based CSB for optimal CSP selection. Pseudo code using Multi Criteria Decision Making (MCDM) technique has been written. Code has been implemented using CloudSim Cloud simulator. Separate JAVA classes have been developed to implement each module of framework. Classes are part of DataCenterBroker class which is further a part of org.Cloudbus.Cloudsim package. Sequence diagram has been drawn to show implementation flow. At the end, case study on three CSPs using three quality metrics has been carried out. This study verifies and validates the QCSB framework.

Quality Metrics

Following quality metrics are relevant to service selection. These are the part of service level agreement document. This document is settled before the start of any service. CC registers his/her service level requirements with broker which form the part of SLA; CSPs also entitled their service offering to broker which also constitute to SLA document.

- **Availability** [5][6]: It is uptime of cloud service during a specified time interval.
  \[ \alpha = \frac{t}{t_s} \]
  where 0≤α≤1, t and t_s represent uptime and total time of service. As value of α approaches to 1, availability increases.

- **Reliability** [6]: It calculates assertion level (free from any software or hardware fault) of cloud service.
  \[ \rho = 1 - \frac{n}{n_s}; 0 \leq \rho \leq 1 \]
  where n and n_s represent number of failed and total operations in particular time interval. As value of \rho approaches to 1, reliability increases.

- **Security** [7]: It calculates data security in cloud. To measure it main factors are:
Confidentiality: It measures data kept in the cloud is secure from any unauthorized access, and secrecy of data is maintained.

Confidentiality = \[
\frac{\text{Total number of access to service} - \text{number of unauthorized access to service}}{\text{Total number of access to service}}
\]

Data Integrity: It measures that data kept in the cloud could only be modified by authorized user only. Data integrity maintains accuracy and consistency of data.

Data Integrity = \[
\frac{\text{Percentage of accuracy after modification}}{\text{Percentage of accuracy before modification}}
\]

Cost [7]: It includes any type of expenditure incurred during cloud services. Mainly two types of cost involved:

- On demand cost: It includes the cost of hiring VMs, data cost and storage cost.
- Reservation cost: It includes onetime fee and usage fee

Service Response time [7]: It is waiting time for a user to get a response of his/her request.

Response time = \[\sum \frac{T_i}{n}, T_i \text{ is the time elapsed between sending a request and getting a response.}\]

Throughput [8]: It calculates number of tasks accomplished by cloud services per unit of time.

Throughput = \[\frac{n}{T_e(n,m)+T_o}; \text{ Where } T_e(m,n) \text{ is the execution time of running } n \text{ tasks on } m \text{ machines. } T_o \text{ is the time overhead delay.}\]

Cloud Service Brokers for Cloud Service Provider Selection

In this section, we shall carry out a literature survey on cloud service brokers. Primary objective of these CSBs is CSP selection.

SMICloud [8], this broker model was developed by Cloud Service Measurement Index Consortium. Core motive of this model was to compare and rank CSPs. Seven attributes had been proposed in this framework namely accountability, agility, cost, performance, assurance, security and usability. Core components of broker were SLA Management, SMI Calculator and Ranking system. Popular MCDM technique AHP (Analytic Hierarchy Process) was employed. Model mainly handled quantitative measures of IaaS services. Providers played a vital role in providing inputs to framework.

A Cloud Broker Architecture for Multicloud Environments [9], Cloud broker architecture introduced for handling operations in multcloud environment. Cloud service broker and user were two main role players in this model. Administrator prepared a cloud provider list and user prepared a service description file for cloud services. Broker was supported by a central database and three other components viz the scheduler, VM manager and cloud manager.

Towards Cooperative Cloud Service Brokerage for SLA-driven Selection of Cloud Services [10]

Author stressed upon forming a Cloud Brokers’ Federation for selection of cloud services. This would increase accuracy
precision. KPI for various cloud services viz IaaS, PaaS and SaaS were discussed. These KPIs were further divided into different subheadings.

Figure 4: Cloud Broker Modules

The proposed architecture of cloud broker had different components. Identity and access management components authenticate the service consumer. SLA management would take care of SLA between user and cloud service provider. Service provisioning assisted in selecting the appropriate cloud service for the user. Monitoring infrastructure had a check on overall procedure of cloud service selection.

CloudCmp [11], this framework compared various cloud service providers. To take up a case study Amazon AWS, Google AppEngine, Google AppEngine and RackSpace Cloud servers providers were compared. Intra-Cloud network, Elastic Compute Cluster, Wide-area network and Persistent storage quality parameters were employed for comparison. Results showed that fast storage service was provided by Amazon AWS, Cost effective virtual machine instances was delivered by Microsoft Azure and smallest wide area latency was provided by Google AppEngine.

Towards Multi-Criteria Cloud Service Selection [12], Paper discussed methodology of Cloud service selection procedure in a generalized and abstract way. To formulate a selection problem certain things were pinpointed like services set, Performance Criteria Set, Performance measurement functions Set, Service Descriptor vector, Decision matrix, User req criteria vector, User priority weights vector.

A Cloud Service Broker for SLA-based SaaS Provisioning [13], Author introduced a Broker based framework for SaaS provisioning. Framework had various components like service consumers, the Cloud Service Broker, the Monitoring Infrastructure, and SaaS Providers. Various management modules under the control of coordinator component were also there like SLA Management, Identity and Access Management, Service Provisioning and Policies Management. The Selection Manager helped in selecting suitable SaaS providers depending on user requirements. SLA manager carried out SLA negotiation between user and cloud service provider. The Policy Manager handled various policies including authorization policies. Monitoring infrastructure helped in observing the activities of system through monitoring adapters and measurement services. SaaS provider offered various software related services. SLA manager of SaaS managed SLA templates, negotiate SLA with CSB.

An efficient QoS framework for Cloud Brokerages Services [14], QoS framework was introduced for brokerage services. Multi criteria optimization technique was employed to study non dominant sets. Pareto optimization technique was used to search non dominated set from given n number of cloud service providers. Here two different methods were employed for resource allocations. First approach was homogeneous algorithm; this gave uniform quality to all the users. Next was non-homogeneous algorithm, they employed different sets of quality to different users. Throughput and response time metrics were used here.

SLA based Service Brokering in Intercloud Environments [15], Generic architecture of cloud service broker was proposed to manage intercloud environment. It helped in locating optimal cloud service provider which satisfied users’ functional and non-functional requirements.

Figure 5: Cloud service broker architecture
CSB architecture had following components:

- SLA Manager: It negotiated SLA creation and provisioning.
- Monitoring and Discovery Manager: It observed SLA metrics of services.
- Match Maker: It assisted in locating optimal CSP for user.
- Deployment Manager: It deployed the cloud service of CSP.
- Identity Manager: It authenticated the cloud user.
- Persistence: It stored CSB related data like SLA template and resource data.
- Abstract cloud API: It was used to provide API to cloud user to interact with the system.
- InterCloud Gateway: It provided an interface to CSB to interact with different CSPs.
- Vendor Cloud platform: It was the platform for Cloud service providers.

To validate the work simulation testbed was created.

An End to End QoS Mapping Approach for Cloud Service Selection [16], in this framework first users’ QoS requirements were assigned to right QoS specifications of SaaS and then these specifications further mapped to optimal IaaS service. Certain rules were studied for mapping. AHP (Analytic Hierarchy Process) technique was used to hierarchically map QoS specifications of cloud services. The AHP based model helped to aid mapping process across various layers of cloud and to rank applicant cloud services for end users. Case study was also proposed to validate the process. Ranking of cloud services was also carried out. Different quality parameters had been proposed.

Fuzzy Cloud Service Selection Framework [17], research proposed a novel fuzzy framework for cloud service selection. Fuzzy concepts were used during the process. Different quality metrics were considered. To validate a framework case study was carried out at the end. Framework had different components namely QoS modeling, calculating metrics and AHP algorithm. Only few quality attributes were considered during the study.

QoS Ranking Prediction for Cloud Services, CloudRank [18], this model considered past experience of users to measure QoS ranking prediction of cloud services. CloudRank1 and CloudRank2 were two QoS ranking predictions proposed by it.

Above framework consisted of various components like Similarity Computation, Find Similar Users, Training Data. Similarity computation unit was used to compare users’ QoS rankings on the commonly invoked services. Various methods like smoothing, random walk, matrix factorization, utilizing content information could be added to this framework to get better results. Throughput, response time and failure probability client side quality metrics were considered by it.
Cloud Brokerage Architecture for Efficient Cloud Service Selection [19]

Research presented cloud broker architecture for selecting a optimal cloud service. A novel data structure B-cloud-tree was used to maintain CSPs information. User submitted its service request to cloud broker. Through Service selection query module request was passed to B-cloud-tree, further it contacted a CSPs store where all the information related to CSPs were stored.

![Figure 8: Cloud Brokerage Model](image)

B-cloud-tree was constructed using property encoding (Service Type, Properties with continuous values, Properties with categorical values and Relationship property) and Indexing Key Generation. Cloud service selection procedure was divided into Query normalization, Query encoding, search in the B-cloud-tree and refinement steps.

CompatibleOne: The Open Source Cloud Broker [20]. The open source cloud broker CompatibleOne was based on open standards CDMI and OCCI. It used a object oriented description model CORDS. This model managed various cloud resources of ACCORDS. ACCORDS handled service provisioning in several steps a) Handling the User's Requirements b) Validation and Provisioning Plan c) Execution of the Provisioning Plan d) Delivering the Cloud Services. CompatibleOne offered various services like Security, Monitoring, Placement, Energy Efficiency, Ordering, Billing & Accounting, Network, Image Production and Elasticity.

Design of Cloud Service Brokerage System Intermediating Integrated Services in Multiple Cloud Environment [21]. Research introduced Anybroker, a cloud service brokerage system. It addressed mainly IaaS services. Broker supported integrated service provisioning and SLA based service lifecycle management. Architecture of broker was divided into various sections Anybroker portal, Anybroker core engine and Anybroker proxy. Anybroker portal was further divided into different portals CSP, CSC and CSB portals. CSP portal handled cloud resource and service catalog management, CSB portal managed cloud services, user related services, billing, accounting, CSC portal handled create, update, delete and monitoring services.

PulSaR: Preference-based cloud service selection for cloud service brokers [22]. User preference based cloud service broker PulSaR (Preference-based Cloud Service Recommender) was introduced for cloud service selection. Broker used MCDM technique for optimizing its services. Broker evaluated multi-objective assessment of Cloud Services in a unified way by considering precise and imprecise parameters and fuzziness of system. Fuzziness of imprecise parameters was deal with linguistically expressed preferences. Number of experiments were carried out to check the performance and scalability of broker.

Cloudle: A Multi-criteria Cloud Service Search Engine [23] Authors proposed a multi criteria cloud service search engine Cloudle. It assisted cloud consumer to select optimal cloud services according to their requirements. Research distinguished requirements set into three categories viz functional requirements, technical requirements and cost requirements. Cloud ontology increased accuracy of derived results. Cloud ontology is a study of cloud objects and their associations. Its use is to determine similarity among cloud services. Three Similarity reasoning methods were proposed namely concept similarity reasoning, object property similarity reasoning and datatype property similarity reasoning. Empirical study was carried out at the end to show that Cloudle with cloud ontology gave far better results than with using Cloudle without cloud ontology.


Number of Cloud service providers are increasing day by day. Now, to select optimal Cloud service provider is a tactful job. Paper discussed this issue, to get rid of this situation, paper introduced the concept of cloud broker. Broker helped cloud consumer in discovering, considering and comparing services of different Cloud service providers. Vendor lock-in was also discussed here. It is a common problem for a user when it is not easy for him to leave the provider because of so much expansion of work. It is generally observed when deploying small and homogeneous applications, it is easy to search best provider for services, but when it comes with application of large complexity, it is bit difficult to locate appropriate provider. QoS based genetic approach of cloud brokering QBROKAGE focusing on Infrastructure-as-a-Service (IaaS) was introduced in the paper. Here quality requirements of user were taken care of. Number of experiments were performed to validate the model and it was observed that model located a near optimal solution. Problems to deal with hundreds of providers and vendor lock-in were also reduced.
Towards a unified customer aware figure of merit for CSP selection [25]

Paper proposed a framework that assisted users to select appropriate Cloud service providers according to their need. Benchmarks were set to test the performance of VMs with four different sizes namely Small, Medium, Large and XLarge. Eight CSPs were selected for study viz Rackspace, Amazon, Microsoft Azure, Softlayer, Google, Joyent, Aruba and Digital Ocean. Seven quality metrics Memory performance, CPU performance, Mean Response time, Disk I/O performance, Provisioning time, Variability and Availability were selected for making the comparison between Cloud service providers. Price factor was also included to have a comparison between performance and price. A new method was proposed that asked user to specify the importance of performance and price metric to categories the CSPs. Evaluation procedure were fragmented into different steps:

a) Selection of CSPs and VMs.

b) Recognize standards and other features.

c) Execute performance tests to assessed defined features.

d) Process results of above tests.

e) Develop performance and value figures.

f) Evaluate obtained information and put into practice customer aware figure of merits for CSP’s choice.

Cloud Broker for Reputation-Enhanced and QoS based IaaS Service Selection [26]

Role of cloud broker was highlighted in the paper. It helps to select appropriate Cloud service providers for cloud user based on quality parameters. Reputation of provider was also considered during the selection procedure of CSPs. A cloud broker framework was proposed that assisted dynamic selection of IaaS service providers based on QoS requirements, cost and reputation of provider. It also ranked the providers based on Service Measurement Index metrics, which were proposed by Cloud Service Measurement Index Consortium.

Cloud Broker Based Trust Assessment of Cloud service providers [29]

Present research focused on mechanism to evaluate trustworthiness of the providers. Trust framework was proposed which considered real-time cloud transactions to model the trustworthiness of providers. The Trustworthiness of a Cloud service provider was modeled by employing opinion derived from following:

(i) Conforming of SLA attributes

(ii) Satisfaction rating of provider

(iii) Behaviour of the provider

Trust model was further enhanced to include necessary Cloud features, credibility for measuring responses and methods to sort out uncertain feedback providers. Different Cloud service broker models viz recommendation, intermediation, aggregation and arbitration had been employed to study the performance of trust model. Robustness against malicious feedback providers was shown during simulation.
In the above figure model has been shown which depicts service providers are contacting the broker and broker in turn contacts infrastructure providers.

**Trustworthy Cloud service provider Selection using Multi Criteria Decision Making Methods [30]**

Research discussed the trust issue while selecting any cloud service from open and anonymous environments; this built the confidence and provided a reliable service to Cloud user. Here trust based model assisted the user to select optimal services according to requirements. MCDM techniques had been utilized to arrange providers in view of their infrastructure attributes. A blend of Analytic and Fuzzy methods gave a superior trust evaluate when contrasted with an Analytic method alone. Here ranking of CSPs were based on attributes recommended by CSMIC called SMI. The attributes considered in the trust estimation of CSPs are Assurance, Accountability, Performance, Agility, Financial, Usability and Security & Privacy. Evaluations for five attributes were gotten from infrastructure properties like Agility (Number of VM, DC and storage room), Financial (VM, Storage and Transfer Costs), Performance (Number of Processor, RAM), Security (Physical, Internal and Network securities) and Usability (Understandability, Easability and Flexibility). The non-quantifiable subjective appraisals like Security and Usability could be acquired and united from a survey. For the correlation of services, four infrastructure CSPs were viewed: Gogrid, Rackspace, Amazon EC2 and Cloudflare.

**MMBcloud-tree: Authenticated Index for Verifiable Cloud Service Selection [31]**

CSBs have been offered additional layer of computation to assist cloud service choice and administration for CC. Nonetheless existing Cloud brokerage services for Cloud service provider selection are assumed to be completely trusted. It is then feasible for a bargained or untrustworthy broker to effectively exploit the constrained capacities of the customers and give erroneous or inadequate reactions. To address this issue, authors proposed an inventive Cloud Service Selection Verification (CSSV) architecture and index structures MMBcloud-tree to empower cloud customers to distinguish trouble making of the Cloud service brokers amid the service determination process. Rightness and productivity of methodologies were checked both theoretically and empirically.

**Multi-Criteria IaaS Service Selection based on QoS History [32]**

Growth in number of Cloud services make selection difficult for users. One has to form formal decision making strategies to assist decision maker in selecting optimal Cloud service that satisfies the client's necessities. In this study, authors exhibited a Cloud service selection strategy which used QoS history of Cloud services over various eras and performed parallel Multi-Criteria Decision Analysis to position Cloud services in each time slot. This system helped the cloud service user to choose the most ideal accessible service as per the prerequisites. The MCDM forms utilized for each era are autonomous of the other eras and are executed in parallel.
CloudEval: A Cloud Service Selection Model based on User-Specified Quality of Service Level [33]

Research proposed a framework which chose cloud services on the basis of nonfunctional parameters and user mentioned QoS objectives. Model employed a Grey Relational Analysis method which was a well known MCDM technique for cloud service selection. Empiric studies carried at the end established that proposed model was effective in case of large number of CSPs and this number would be difficult to handle manually.

A Brokerage-Based Approach for Cloud Service Selection [34]

Research introduced brokerage based architecture to select appropriate Cloud service for cloud consumer. Unique indexing scheme was devised to manage large number of Cloud service providers. An algorithm was developed which ranked the potential providers and aggregate them if necessary. Real as well as synthetic cloud data were used to carry out different experiments.

![Brokerage Architecture](image)

In this architecture, mainly three types of actors are there:

- **Cloud broker**: It contacts Cloud service providers and stores their properties like cost, response time, service type etc. Further users contact broker for fulfilling their requirements.
- **Cloud service provider**: Entity that offers Cloud services to consumers.
- **End user**: Consumer of the cloud services.

There were two broad issues in this architecture first was the construction of index for managing Cloud service providers and another was algorithm for Cloud service selection. B+ data structure was used as a basis for creating CSP-Index.

Cloud Services Selection Based on Rough Set Theory [36]

Research presented an application of Rough set theory in Cloud services selection. Many experiments were carried out with huge amount of dataset and the experimental results verified the efficiency of proposal. With the development of Cloud computing technique, users enjoy various benefits that high technology services bring. However, with the technique maturity, there are more and more cloud service programs emerging. So it is important for users to choose the right cloud service. For Cloud service providers, it is important to make a progress for the cloud services they provided, thus to win more customers and expand the scale of the cloud services. Rough set theory is a good data processing tool to deal with uncertain information. Authors proposed a method using the Rough set theory in Cloud service selection and an example to illustrate the practice and analyze the feasibility of it. The main contributions of this work were: To perform the program experiments with large scale dataset to verify the feasibility and practicality; Next, Cloud services selection approach was proposed to evaluate parameters importance based on the users’ preferences using Rough set theory. The performance of program code was by Java language. They were executed sequentially on a processor Intel Core2 Duo CPUs x64. The total main memory was 8 Gigabyte and the operating system was Windows 8. Results collected during the experiments on a number of small datasets and lots of huge datasets for selecting a classified attributes show that the proposed application was an efficient approach with good practical value.
Proposed Quality Cloud Service Broker Framework

QCSB

CC/Organisations will submit his/her Quality of Service (QoS) requirements for CSP selection to the QCSB through Broker’s GUI. This GUI will form Abstract Cloud API. When CSP selection process will be over, derived results will be returned through this API. All the requests made to QCSB will be stored in Request Buffer (RB). Once a certain request will be fulfilled, next request will be taken from this buffer.

QCSB will have certain core modules:

- **Authentication Module**: It will validate the CC credentials.
- **SLA Module**: This module will decide and negotiate quality constraints mentioned in the service level agreement between CC and CSP.
- **Match Maker Module**: It will search for CSP which will fulfill user quality requirements. It will also contact a Ranking Module (RM). RM will assist in ranking CSPs according to ranking algorithm.
- **Selection and Deployment Modules**: These modules will select and employ required CSP for CC.
- **Publish Module**: It will maintain list of cloud services of CSPs. CSP will contact this module if there will be any change in its services.

QCSB will also manage a central database. This database will be a repository of all the publish cloud services of CSPs with CSB. Selecting appropriate CSP is a MCDM problem. There are number of algorithms under this category viz Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Multi-Attribute Utility Theory (MAUT) etc. AHP/ANP techniques could be applied in this framework. AHP algorithm divides goal, available criteria and alternatives into hierarchy structure. Then it performs pairwise comparisons between alternatives and criteria to achieve the required objective. It is worth noting here proposed broker will handle IaaS services. To monitor the above process, Monitoring Manager (MoM) will be deployed. Responsibility of MoM will be to watch whole process. Framework will be built using layered approach.

In the following section, we will write pseudo code for QCSB. Here we will consider three quality criteria viz. Reliability, Cost and Availability. Algorithm will suggest optimal CSP and will also rank list of candidate CSPs.

**Algorithm (QCSB)**

**Input:** Maximum value of Reliability $\text{Rel}_{\text{max}}$, Minimum value of Cost $\text{Cost}_{\text{min}}$, Maximum value of Availability $\text{Avl}_{\text{max}}$. These values of quality criteria are the threshold values provided by CC.

1. For all Cloud Service Providers $P$ Do
2. If ($\text{CSP}_{\text{Rel}}(P) \geq \text{Rel}_{\text{max}} \&\& \text{CSP}_{\text{Cost}}(P) \leq \text{Cost}_{\text{min}} \&\& \text{CSP}_{\text{Avl}}(P) \geq \text{Avl}_{\text{max}}$)
3. Select $P$ for Candidate list of CSPs ‘L’.
4. Else
5. Discard $P$.
6. Endif
7. Endfor
8. If Sizeof (L) > 0 then
9. Let $L = \{P_1, P_2, P_3, \ldots, P_k\}$ be candidates CSPs.
10. Apply $\text{AHP}(P_1, P_2, P_3, \ldots, P_k)$ technique on Candidate CSPs. // AHP (Analytical Hierarchical //Process) technique is for match making
11. Perform pairwise comparison between CSPs based on quality criteria (Reliability, Cost and Availability).
12. Perform comparison between quality criteria based on objective (here objective is to locate optimal CSP).
13. Finally calculate priorities of CSPs w.r.t. objective.
14. Let $L_{\text{pri}} = \{\text{Pri}_1, \text{Pri}_2, \text{Pri}_3, \ldots, \text{Pri}_k\}$ be a list of priorities of CSPs.
15. Sort $L_{\text{pri}}$ in descending order.
16. Select CSP $P_i$ corresponding to the first priority item of list $L_{\text{pri}}$.
17. Let $L_{\text{ranking}}$ be a list of CSPs derived from $L_{\text{pri}}$.
18. Return $P_i$ and $L_{\text{ranking}}$.
19. Else
20. Return Null
21. Endif
**Output:** Optimal CSP and Ranking of Candidate CSPs.

**IMPLEMENTATION**

QCSB can be implemented using CloudSim, popular JAVA based cloud simulator. Eclipse IDE could be used to work on CloudSim environment. Different modules viz Authentication, SLA, Match Maker, Selection, Deployment and Publish could be implemented using JAVA classes. These classes will be a part of DataCentreBroker class of CloudSim which is further a part of org.Cloudbus.Cloudsim package. User will contact QCSB through abstract cloud API which will be a Graphical User Interface. User will submit his/her acceptable values of quality parameters to SLA module. In previous section, we had discussed quality metrics like Reliability, Availability, Cost, Service Response time, Throughput etc. For instance Q1, Q2 and Q3 are three quality metrics. CSP1, CSP2 and CSP3 are three candidate CSPs. To calculate value of any quality metric user will give inputs; further SLA module will calculate the value of that quality parameter e.g. to calculate availability, user will enter uptime and total uptime of cloud service, SLA module will calculate availability of that cloud service. SLA module will also contact central database to get already stored values of quality metrics of providers and user preferences of quality metrics. All these values will be passed to Match Maker Module, which will further use ranking algorithm to rank given CSPs. Match Maker Module could use any MCDM technique (AHP, ANP, MAUT etc) to perform its match making task. After processing, Match Maker Module will pass the result to selection and deployment modules which will select and deploy optimal CSP and also will rank given cloud service providers CSP1, CSP2 and CSP3.

**DISCUSSION**

At the outset, we mentioned the need of CSB. It could impose the quality restrictions on services provided by CSPs to users. After literature survey, we enlisted quality metrics Availability, Reliability, Security, Cost, Service Response time and Throughput. Further, we discussed cloud service broker frameworks for cloud service selection. Next, we proposed a quality based Cloud Service Broker framework QCSB. It had various modules viz Authentication, SLA, Match Maker, Selection and Deployment modules, these modules were explained. Algorithm was also presented, which depicted working of QCSB. Implementation detail and flow were given, that showed how proposed framework was applied.
deployed and information progressed between various modules of framework.

To conclude the discussion, we would articulate that studied broker frameworks during literature survey discussed various aspects of cloud service selection. They enlisted variety of quality metrics which could affect the selection of services. Here we would like to mention that none of the above frameworks discussed all core quality metrics (Availability, Reliability, Security, Cost, Service Response Time and Throughput) for service selection. So, we introduced in this research paper Quality based cloud service broker framework QCSB. This broker would take care of quality aspects of CSP and would provide cloud services to CC according to SLA.

CONCLUSION

Cloud computing is upcoming trend of today’s computing scenario. Vast number of organizations are now dependent on this computing. They are shifting their sensitive data on the cloud. To get a cloud service, they have to contact cloud service provider. Now, huge number of providers are available in the market. To locate a perfect provider who can fulfill their need is a skillful job. This job can be accomplished by cloud service broker. Present research focused on these issues. Quality metrics and detailed survey on present cloud service broker frameworks were given. These quality metrics helped in enforcing standards on cloud service providers. Next, we have proposed a Quality based Cloud Service Broker framework QCSB. Algorithm and implementation of QCSB have been given. At last, we would like to conclude that proposed framework QCSB not only assist CC to locate optimal CSP for cloud services but also rank candidate CSPs according to user quality preferences.

REFERENCES


Appendix

Let us apply pseudo code of QCSB on 3 CSPs using 3 quality metrics viz Reliability, Cost ($/hr) and Availability. Amazon, Microsoft Azure and Rackspace are CSPs. Table 1 shows values of quality metrics corresponding to CSPs. These values are obtained by applying various formulae mentioned in this research paper.

Table 1: Quality Values of CSPs

<table>
<thead>
<tr>
<th>CSP</th>
<th>Reliability</th>
<th>Cost</th>
<th>Availability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amazon</td>
<td>0.5</td>
<td>2.5</td>
<td>99.99</td>
</tr>
<tr>
<td>Microsoft Azure</td>
<td>0.7</td>
<td>2.7</td>
<td>99.95</td>
</tr>
<tr>
<td>Rackspace</td>
<td>0.4</td>
<td>2.1</td>
<td>99.90</td>
</tr>
</tbody>
</table>

Following graphs show comparison of Quality values of CSPs.

Figure 15: Reliability.

Figure 16: Cost

Figure 17: Availability.

Figure 18: Ranking of CSPs.

From above we conclude that Ranking of CSPs is as follows:

1. Microsoft Azure
2. Amazon
3. Rackspace

Optimal CSP: Microsoft Azure.