AN EVALUATION FRAMEWORK FOR OPTIMAL SELECTION OF CLOUD PROVIDER USING QUALITY OF SERVICE PARAMETERS

Dissertation submitted in partial fulfillment of the requirements for the Degree of

MASTER OF TECHNOLOGY

in

COMPUTER SCIENCE AND ENGINEERING

By

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Phagwara, Punjab (India)

April 2017

TOPIC APPROVAL PERFORMA

School of Computer Science and Engineering

Program : 1202D::B.Tech -M.Tech (Dual Degree) - CSE

COURSE CODE : CSE546 **REGULAR/BACKLOG :** Regular **GROUP NUMBER :** CSERGD0005

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Qualification : ________________________ **Research Experience :** ________________________

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SPECIALIZATION AREA : Software Engineering **Supervisor Signature:** ___________________

PROPOSED TOPIC : An Evaluation Framework for optimal selection of cloud provider using quality of service parameters.

Qualitative Assessment of Proposed Topic by PAC		
Sr.No.	**Parameter**	**Rating (out of 10)**
1	Project Novelty: Potential of the project to create new knowledge	6.83
2	Project Feasibility: Project can be timely carried out in-house with low-cost and available resources in the University by the students.	7.17
3	Project Academic Inputs: Project topic is relevant and makes extensive use of academic inputs in UG program and serves as a culminating effort for core study area of the degree program.	7.50
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5	Social Applicability: Project work intends to solve a practical problem.	7.00
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Final Topic Approved by PAC: **An Evaluation Framework for optimal selection of cloud provider using quality of service parameters.**

Overall Remarks: Approved

PAC CHAIRPERSON Name: 11011::Dr. Rajeev Sobti **Approval Date:** 26 Oct 2016

ABSTRACT

Cloud computing is an Internet-based computing paradigm based on sharing of resources, programs and processed data machines on-demand. It provides users to share the distributed resources and services associated to various other organization. Since cloud computing uses distributed resources in open environment, thus it is essential to provide security to share data in under processing cloud environments. It is the cloud providers earning their customer requirements through the ranking of services based on pair wise comparison of relative weights assigned according to the user requirements and business demands with the weights in the scale table. The ranking of services is done considering many QoS factors for the service that includes security, privacy, reliability and many other parameters for ranking of cloud service provider. Various models, technologies and framework are used to give these services and by providing the optimal cloud service provider to the users and business startups and various other organizations fulfilling their demands. The ranking of services firstly depends on the requirements of user and organizations, secondly the availability of the quality parameters and finally providing the best cloud service provider satisfying the customer demands. So, this paper provides the optimal service keeping all the requirements into consideration.

DECLARATION

I hereby declare that the research work reported in the dissertation entitled **"AN EVALUATION FRAMEWORK FOR OPTIMAL SELECTION OF CLOUD PROVIDER USING QUALITY OF SERVICE PARAMETERS"** in partial fulfillment of the requirement for the award of Degree for Master of Technology in Computer Science and Engineering at Lovely Professional University, Phagwara, Punjab is an authentic work carried out under supervision of my research supervisor **Mr. HARSHPREET SINGH**. I have not submitted this work elsewhere for any degree or diploma.

I understand that the work presented herewith is in direct compliance with Lovely Professional Universitys Policy on plagiarism, intellectual property rights, and highest standards of moral and ethical conduct. Therefore, to the best of my knowledge, the content of this dissertation represents authentic and honest research effort conducted, in its entirety, by me. I am fully responsible for the contents of my dissertation work.

Signature of Candidate

SAHIBA KALRA

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SUPERVISOR'S CERTIFICATE

This is to certify that the work reported in the M.Tech Dissertation entitled **"AN EVALUATION FRAMEWORK FOR OPTIMAL SELECTION OF CLOUD PROVIDER USING QUALITY OF SERVICE PARAMETERS "**, submitted by **SAHIBA KALRA** at Lovely Professional University, Phagwara, India is a bonafide record of her original work carried out under my supervision. This work has not been submitted elsewhere for any other degree.

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Date: ....

ACKNOWLEDGMENT

I humbly hold the opportunity thanking to all those guidepost who really acted as lightening pillars to enlighten our way throughout this project that has led to successful and satisfactory completion of this study.
I am really thankful to my mentor Mr. Harshpreet Singh for giving me an opportunity to undertake this research work under his guidance and providing me with all the bright and innovative ideas for making this research a really worthwhile for proposing something useful. I am highly thankful for the support, precious time and advice, whole-hearted guidance, sincere cooperation and thoroughgoing involvement during the literature review of the research.

SAHIBA KALRA

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Chapter 1

INTRODUCTION

1.1 Cloud Computing

To meet every changing business needs every organizations need to invest money and time to seek up own IT infrastructure in form of hardware and software. The tough question by every organization is, how to reach to maximum utilization of the IT infrastructure. Cloud Computing is a way to achieve that utilization in terms of hardware, where cloud helps to set up the infrastructure which is not real to store large amount of data whereas in terms of software, cloud helps to maintain the data in database and gives a relaxation in daily work by placing the data at storage area[1]. Also it provides data confidentiality and transmission of data easily. Now, Cloud computing means computation over Internet that consists of virtualized data centers in which software, hardware, information resources can be used when needed. Through cloud, organizations can use as many resources of computation as per their requirement. This is a great way to avoid extra expenditures and scale up their production on basis of business requirements and also infrastructure resources can also instantly scale up or scale down[2].

Man power in terms of operational and maintenance cost is required by organization to maintain the control over IaaS where the operational cost are the overheads related to the maintenance and applications of a company as per the requirements. The operating cost is a fundamental of performing earnings and is generally resembled on company's earning lines. Company that has million types of data related to the research stored in such a way that would be cheap and secured, then that solution is called cloud storage which is the best[2].

Now organizations require some analytical tool and some visualization tool to correlate the data to find out some business needed outcomes to achieve the company's goal[3]. Like the Windows Azure provides each kind of testing and analysis environment and Microsoft just focus on to reduce the time to make testing which reduces the project timeline. Now organization buying the virtual appliance for securing their network for example Virtual Cisco Abstractive Security Appliance, Cisco Abstractive Security Appliance(Cisco ASA) that can be deployed anywhere to secure remote network by cloud[4]. Cloud computing is a new thinking to reduce the hardware cost by utilizing at the optimal level and providing the services cheaply with minimum deployment time. Now cloud is growing as it is user friendly, reliable and provides maximum availability of service[5].

Cloud computing is an adoption to the way and style of the well-known technologies and concepts. The vision of the cloud is to allow customers to gain profit from all existing technologies, without being the expertise with these technologies. The cloud aims to reduce cost, and make users able to get benefits by using cloud service. It is simple to use and easy to deploy and less time consuming. Cloud does not mean by virtualization, it is above than that of virtualization[6].

Cloud computing is also possible to achieve the good performance and it is much more easily deployable, less time consuming and at affordable prices compared to traditional cloud computing techniques[7]. "Cloud Computing is a model for validating universal, suitable, network access to a shared pool of configurable computing resources (eg. data, server, space and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction..."[8] An Evaluation Framework for optimal selection of cloud provider using quality of service parameters has to be implemented for improving the performance of cloud service.

Trust and quality of service are adverse factors in cloud computing; presently it relies on factors of reputation and self examination through the cloud service providers[9].

The cloud provider service is better accepted if it is of low cost, reliable, scalable, available, globally interoperable, secure, optimized for service performance[10]. When all these features are fulfilled then the system is said to be a secure and trustworthy cloud provider service.

Cloud computing helps to enhance the business agility which gives an opportunity to the organizations reply instantly to the alterations in the exterior and interior domain that lacks in strength[11]. Adjustability, elasticity and stability are the essential parameters for maintaining business agility[12]. Keeping in mind

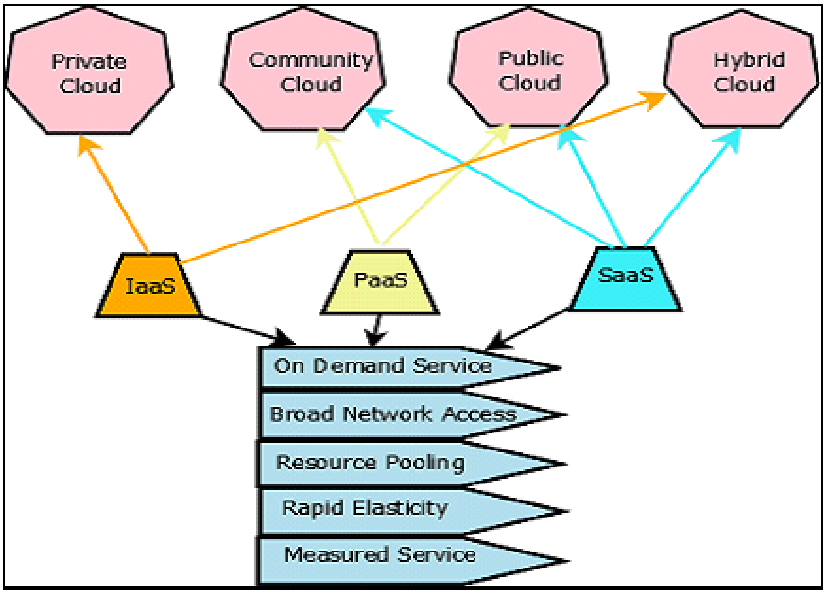

Figure 1.1: Cloud services, Models and Characteristics

of the business agility which is very important in terms of the growth of services provided by the cloud, the ranking of cloud services was considered for getting the optimum results using various QoS parameters and rank the cloud services[13]. Figure1.1 depicts the Cloud services, Models and Characteristics where the cloud services are of 3 types as:IaaS, PaaS, SaaS which are linked with the models that includes: Private, Community, Public and Hybrid cloud and also cloud computing has various characteristics as: On-demand self-service, Broad network access, Resource pooling, Rapid elasticity and Measured service.

1.1.1 Cloud Characteristics

- Agility enhances the capability of user in terms of technological resources.
- Cost decrements by using the cloud provider service.
- Device and location independence authorizes user to use computers using browser despite of their location and system.
- Maintenance of cloud computing applications is easier, as no installation on every computer is needed.
- Performance is examined through the analysis of the cloud services.

The National Institute of Standards and Technology's definition of cloud computing identifies “five essential characteristics”. The NIST invented these features in the promotion of permitted authorities under the Federal Information security Management act(FISMA) of 2002, Public Law 107-347. It is authorized for inventing degrees and instructions with minimum demands, for giving sufficient data certainty in all the businesses and methods implemented in that, but such degrees will not be applied to national certainty structure. The NIST explanation features main details of cloud computing and presents detailed contrasts of cloud services and deployment models. These services and models make a sole scheme of classification which does not compels other system of implementations, service distribution or business methods. The important features are as follows:[14]

- **On-demand self-service**- Its that service where the user can partially arrange the system abilities and its requirements like server time and web store, required with no user communication among every service supplier.
- **Broad network access**- Abilities and many features are present in the web and they run by accessible methods which uses different user devices like personal computer, mobile, ipad, etc.
- **Resource pooling**- The supplier's system resources are combined to provide various users with a multi-tenant system, alongwith various real and non real data instantly given and repeatedly given in favor of user requirement. A state is there where user has no constraint or any understanding about the right location of the data or resources but can extract the data at top level(like resource centers). Various types of resources can be files and network connections.
- **Rapid elasticity**- Abilities may be flexibly arranged and released accordingly, to adjust the external and internal proportion with requirements. For the user, the abilities present for planning seem to be infinite and can be prorated in whatever amount of time.
- **Measured service**- Cloud machines naturally regulate and build data work through calculating ability at few stage of consideration according to the

part of service like(web hosting, technical support). Data regulation can be measured, managed and recorded for both the supplier and user in terms of service utilization.

1.1.2 Cloud Deployment Models

A cloud deployment model depicts a particular kind of cloud domain, categorized by amount and approach. There are 4 general cloud deployment models which are as follows:

- **Private cloud**- The cloud framework is arranged for utilization through an individual corporation containing many users(like businesses). It can be acknowledged, controlled and regulated through a corporation, any other party or composition of both. Examples of private cloud can be own data center.

- **Community cloud**- The cloud framework is arranged for utilization through a particular group of users from companies which have involvements in response time, safety need, etc. It can be acknowledged, controlled and regulated through a single or many corporation in the company, other party or composition of both. Examples of Community cloud can be Google Applications for Government and Microsoft Government Community Cloud.

- **Public cloud**- The cloud framework is arranged for utilization of common community. It can be acknowledged, controlled and regulated through a company, educational, or executive company or composition of them. It is present through the existing cloud supplier. Examples of Public cloud can be IBM's Blue Cloud, Windows Azure Services Platform.

- **Hybrid cloud**- The cloud framework is a combination of two or more separate cloud models(private, community or public) which can exist individually organization but are tied jointly by non corporated company that makes resources movable. Examples of Hybrid cloud can be Amazon Simple Storage Service (Amazon S3).

1.1.3 Cloud Services Models

Service-oriented architecture promotes “everything as a service” (EaaS or XaaS), cloud provides services relating to different models as follows[15]:

- **Software as a service (SaaS)** -The ability given to the user is to utilize supplier’s services implemented on cloud platform. The services are available through many user tools such as Google chrome, Mozilla Firefox, or a system boundary. The user do not regulate web, database, drives, or implementation abilities alongwith the minimum consumer certain implementation layout.

- **Platform as a service (PaaS)**- The ability given to the user is to employ on the cloud boundary that user made by coding text, resources and machines given by the supplier. The user do not regulate web, database, drives, but has manage over the implementations and layout situations for the implementation-providing domain.

- **Infrastructure as a service (IaaS)**- The ability given to the user is to plan operations, store, web and different basic system measures in which the user is capable to employ and execute random set of programs that consists of various implementations.The user do not regulate the cloud boundary, but manages over the implementations and the selected web devices like security gateways.

- **Enterprise as a service(EaaS)**- Enterprise as a service is a proposed cloud computing service model which includes applications, program contribution alongwith extra business tasks and organization service layers. It determines problems related to maintenance in cloud by fulfilling each and every requirements in cloud computing services.

Figure1.2 depicts the cloud architecture system where the user first requests from the Internet for his/her requirement. Then there is a firewall which provides security to the cloud users like various vendors provide firewall for security so that any intruder entry or any other spam is restricted, like Cisco ASA firewall, Palo Alto firewall and Juniper firewall[16]. Now after that there is load balancer, that balances extra load in terms of power,data which the server is unable to manage,

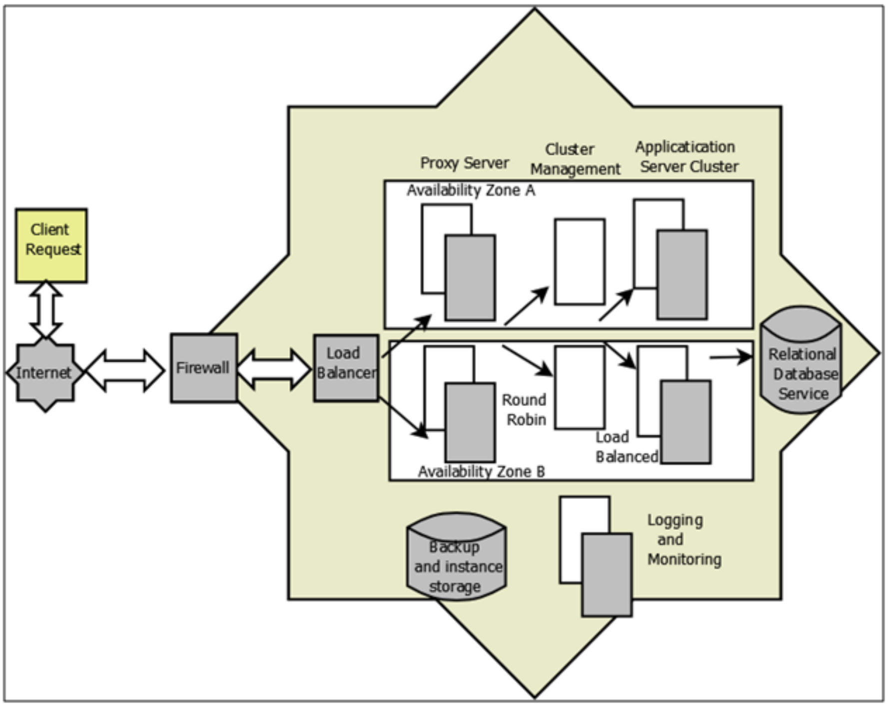

Figure 1.2: Cloud Architecture

after that there is management of data based on round robin scheduling algorithm where data is transferred to the relational database[17]. Also the backup of data and the log files are maintained in the storage device for further requirement.[18].

1.2 Cloud Provider Selection

Organizations require infrastructure and they do not know to invest in resources in terms of computation power, network bandwidth, CPU capacity, etc, This gives rise to the existing concept of cloud there in comes the concept of cloud. Due to this, maintenance is very less done in the systems[19]. The cost and various other parameters like computation power, service response time decreases and reverse happens for parameters like efficiency, adaptability that is, it increases[20]. The ranking of cloud service algorithm which is made in this paper is nearest to the optimum approach where running time is less and the important part is that it is simple and easy to understand and take care of most of the QoS parameters like computation power, service response time, cost, availability, security, efficiency, maintenance, adaptability[21].

The algorithm is nearest to better results. Furthermore, selecting the service which meets all the practical and non practical necessities is a selection issue. This makes compulsory to consider the multiple criteria of the parameters and ratings of the attributes. Here, every user rating to different attributes influences the service selection process, and its ranking results is dependent on the priority in the choosing process[22]. This process focuses on the issue of assigning weights[23]. This gives the results considering all the QoS parameters mentioned above one by one and gives the best cloud service for fulfilling the business , corporation , IT fields requirements. The user requirements are considered on a benchmark of the preferences. Sometimes there is a problem in the consideration of parameters like in some cases there is objective measurement parameter consideration but the subjective measurement parameter consideration is missing[24]. In this paper, both the measurements of the parameters for cloud service selection are considered. Both the quantitative and qualitative parameters are taken and weights are assigned to them on the basis of user requirement. Like the quantitative parameters are computation power, service response time, cost and availability whereas the qualitative parameters are security, efficiency, maintenance and adaptability.[25]

1.2.1 Need for Ranking

The problem arises through the data management in companies. They cant build the whole cloud in the start or purchase the whole cloud services at the beginning of setting infrastructure. So, there comes the need to use already made cloud storage services by the big companies on pay per use basis. Another need arises is to select the right service which can fulfill the user and company requirements[26]. Accordingly they choose the service, so to ease up these startup company requirements, for selecting the the service easily just by looking and analyzing some results, they can select their own choice cloud provider services. A ranking algorithm for the cloud provider services is made which calculates the optimal service based considering certain parameters. Its simple to calculate by maintaining matrices and tables[27]. The parameters affects quality in cloud service selection considered as follows: computation power, service response time, cost, availability, security, efficiency, maintenance, adaptability

Cloud Service ranking is one of the most necessary thing for the cloud service selection. Cloud Service selection here is based on Multiple Criteria Decision Making approach and comparison based on the QoS parameters taking computation power, service response time, performance, availability, security, efficiency, accuracy, adaptability[28]. It is based on the matrix multiplication criteria[21]. The ranking of cloud provider services based on various quality parameters like accountability, agility, cost , performance, assurance, security and usability has already been done. But further parameters like efficiency, adaptability, availability like parameters are not considered . So all these parameters are combined and respective weights are calculated and the results are analyzed for cloud service selection[5].

1.3 Challenges in cloud service selection:

- The biggest challenge is that we are taking all QoS parameters at same scale and we are converting them at same unit.
- Assigning the weights to the QoS parameters using the services, user and parameters consideration.
- To get the results close to the optimistic results.
- Collecting and analyzing the data for big companies like Amazon, Windows and prorating them according to the user and business requirements is also a challenge.
- Data processing is also a major challenge as the calculation based on different parameters is to be handled accurately because one value change in the calculation will affect the overall calculations and thus affects the final results in the selection of cloud service provider.
- Its important to maintain the security in the systems so that no any intruder or hacker attacks the system through the access in the system when used for storage of data[29].
- Its also important to take the user feedbacks and make them available for other users so that they can overview and know about the opinions related

to the services, from where they can decide what is lacking and what is not and even give their opinions regarding about the services according to their requirements and their benefits[30].

- Fulfilling the subjective as wall as objective parameter requirements according to the demands of customer and businesses is also a big challenge.[31]

The technique of ranking used is of the Multi criteria decision making approach. One of its method is Analytical Hierarchical Process that uses optimal approach with less running time and easy to understand in less time that does ranking of cloud services based on various QoS parameters[32]. The ranking of cloud services algorithm is contributed keeping the corporate world requirements and QoS parameters in mind[2].

1.4 Summary

This chapter discusses about cloud computing utilization, architecture, deployment models, services and characteristics. Also the approaches which will be used in this paper of selecting the optimal cloud service. According to the user requirements and priorities. This will help the cloud user to obtain the optimal service fulfilling the requirements of customer[5].

Chapter 2

REVIEW OF LITERATURE

This section introduces literature review in a framework for selection of cloud service provider. The different methodologies followed by the various authors in their work is mentioned in this section which generally includes rating of the parameters according to user as well as organization requirements and then finding out the optimal cloud provider service.

Garg et al(2011)[14] presented a consortium named Cloud Service Measurement Index Consortium(CSMIC) used for calculation of list of parameters which are binded in a kind of Service Calculation List(SCL) and based on Analytical Hierarchical process. SMICloud framework gives attributes including service selection dependent on Quality of service(QoS) needs and ranking of services. It is a conclusion building machine, planned to give judgment of cloud services in terminology of KPI's and customer needs in terms of QoS parameters. The main components of the framework include SCICloud Broker observing and service catalog where the SCICloud Broker includes SCI directorale, calculate and Ranking system observing includes Qualitative evaluation, Quantitative evaluation and Service Filter. This whole framework is controlled by cloud providers and used by applications and users. AHP dependent ranking technique concludes the service selection based on attributes, sub attributes on the premises of relative weights.

Zheng et al(2012)[33] propounded (Quality of Service)QoS ranking forecast framework for cloud services, that needs no extra service acknowledgments in making QoS ranking. Through the support of the previous learning of the customers, the ranking proposal associated and collected the priorities among the services to get their ranks. Two ranking forecast algorithms(CloudRank1 and CloudRank2) for calculating the service ranking are implemented.This paper used already implemented rating-dependent perspective and the old greedy methodology. This technique misses the calculation part for the QoS parameters using matrices which in the earlier papers of SMICloud and a framework for ranking of cloud computing services utilized for acquiring the optimum service provider. In this paper, authors concentrates on ranking forecast of user side QoS features, that contains distinct values for various customers(or customer implementations) of the similar cloud service. Under the CloudRank framework, it had various elements (i)On the basis of customer satisfied QoS rates, comparison among the alert customer and learning customer are measured. (ii)On the basis of likeness rates, a pair of similarity rates are recognized.The proposal of two algorithms(CloudRank1 and CloudRank2) was made to get an optimum service ranking through the benefits of previous service utilization practices of same kind of users. At the last, ranking forecast outcomes are made available to the present alert customer.The learning facts in the CloudRank framework are acquired through:(i) The Quality of Service(QoS) ratings by alternate customers; and (ii) The Quality of service(QoS) ratings gathered by examining cloud services.

Garg et al(2013)[2] presented a framework and a method that calculates the standard and determine the order. This type of framework makes a noteworthy effect creates a beneficial competitiveness for the cloud providers to suite to service level agreement and maintain their Qos. A consortium named Cloud Service Measurement Index Consortium(CSMIC) used for calculation of list of parameters which are binded in a kind of Service Calculation List(SCL) and based on Analytical Hierarchical process based ranking technique necessary for assessment of a Cloud Service. The SMICloud help users to contrast different cloud contributions relating to their preferences and choose which is suitable according to their requirements. It is a conclusion building machine, planned to give judgment of cloud services in terminology of KPI's and customer needs. The main components of the framework include SCICloud Broker observing and service catalog where the SCICloud Broker includes SCI director ale, calculate and Ranking system observing includes Qualitative evaluation, Quantitative evaluation and Service Filter. This whole framework is controlled by cloud providers and used by applications and users. AHP dependent ranking technique concludes the service selection based on attributes, sub-attributes on the premises of relative weights.

Kumar et all(2014)[34] presented a effectual and systematic way to get optimal cloud service provider dependent on quality of service attributes. The assessment cloud provider is done through a proposed Rank Cloud Framework Model where a cloud broker that would get out the optimum cloud service providers dependent on its capability. Broker ranks the supplier's dependent on few parameters(cost and performance). Now in the ranking cloud framework(i) the user gives the necessities to the broker. It can be infrastructure, platform or software necessity. (ii)After this ranking of cloud provider is done where all the recorded cloud service providers provide all the services cloud consists the backup of capability of cloud suppliers. Therefore, as the user provides the necessities to broker it examines the supplier's capability dependent on response time and cost of services.The Rank Cloud Framework operating a broker which gives an optimum cloud service supplier selection. They presented architecture which takes response time, suitability, interoperability and cost of services into consideration for ranking cloud service supplier.

J. Preethi et al(2014)[27] presented two ranking prediction algorithms for calculating the service ranking deployed on the cloud implementation taking author's choice. Innovative outcomes depicts that their approximations perform better than already implemented rating-deployed approximations and the old greedy method. QoS Ranking can be evaluated at the back end or at the front end, where the back end QoS features gives better signs of the cloud service volumes and front side Qos features gives more real calculations of the customer consumption involvement. The general utilized front side QoS features consists response time, throughput, loss probability,etc. There is also a cloud rank framework, that gives customized QoS ranking forecast for cloud services. The main customer's of the cloud rank framework are the cloud implementations which require customized cloud service ranking for building optimum cloud service choosing. There are various units in this framework (i)Deployed on customer QoS points (ii)Deployed on resemblance pair of customers are examined. Two more algorithms are identified which are Cloud Rank1 and Cloud Rank2 for getting service ranking using the previous work of same customers. Finally ranking outcomes are given to the customers.

Jahani et al(2014)[35] identified a W_SR(Weight Service Rank) proposal for cloud service ranking which utilized Qos attributes. The innovative outcomes depicted the result time of the proposal less than other proposal of ranking services based on front side analysis of the QoS features. In this paper, the W_SR proposal is more effective and expandable as compared to the others along with the increment in services or customers. This paper is dependent on satisfying customer needs and analyzed an agreement value for every service which can be utilized for ranking along with categorizing cloud services. The proposals chose candid services which assured customer requirements. Through this, customer is able to decide that particular W_SR is more efficient and expandable as compared to others. W_SR proposal utilized a filtering element and a ranking element. Filtering produced candid services and provided analyzed value to every service and then ranking of the services. This way the user gets the optimum cloud service.

kumar et al(2014)[21] proposed a framework for cloud service selection engine that reacts as a device to validate the users to choose the best suitable appropriate cloud service provider from the Web Depository. The framework utilized analytic hierarchy process for multi-criteria (Quality of Service)QoS that undergoes a method to choose the optimal service provider. Earlier customer's practices were utilized in a form of heuristic viewpoint which was used in the algorithm to connect with the further results in very less amount of time. It is similar to previous approach but it uses values from the earlier practices and does not provide appropriate results. The paper proposed a cloud service selection engine framework that used (Service Measurement Index)SMI features and a (Multiple-criteria decision-making)MCDM solving method to rate the obtainable service providers and choose that service that fulfills the Quality of service requirements appropriately. The Cloud Services Measurement Initiative Consortium(CSMIC) is also developed for providing a pair of key performance indicators (KPI) that is called as Service Measurement Index (SMI). It used seven QoS features that includes Accountability, Agility, Assurance, Financial, Performance, Security and Privacy and Usability.

Hsu et al(2014)[36] introduced a cloud service selection model, CloudEval, to assess the non practical premises and choose the optimum service that assures customer stated service stage and meet their objectives. CloudEval is applied on a recognized multi-attribute decision making technology and Grey Relational Analysis is applied on choice process. The ranking in past papers was based on benchmarks by a valid broker, called CloudHarmony. Though, in this paper particular things of cloud services, or need customers involvement in calculation task is done. The previous tasks can't calculate the non practical features and get the best service based on customer satisfaction and meeting the targets accordingly. Authors designed two class of tests:(i)First, its for the contrast among CloudEval alongwith acquiring weighted parameters and user evaluators alongwith acquiring weighted parameters.(ii)Second, its for the contrast among CloudEval not considering acquiring weighted parameters and user evaluators alongwith acquiring weighted parameters. Calculation of the outputs acquires the generally accepted signs, which included Pearson correlation coefficient (pronounced by rho) and Spearmans rank correlation coefficient(pronounced by ys) to assess and contrast the association among the rate file of cloud services chosen by the CloudEval. Then all the association coefficients were evaluated in for analysis for every test.

Wu et al(2014)[37] proposed an inventive approach to select the service dynamically on the basis of QoS parameters. This paper was based on selection of outline services dynamically on the basis of upcoming services and rejecting the old services. The selection of services was also based on QoS parameters for performance. Also an outline algorithm was invented for the selection of service dynamically. A learning approach is implemented so that the selection approach was done efficiently.

Kalloniatis et al(2014)[38] introduced threats, security, and privacy using a link in cloud areas. Many security and privacy provided threats to cloud. Various requirements makes possible for the development process. Through the requirements of trust, security and threats accomplishing thus, provided a greater cloud service trust model. Authors proposed secure troops which was the extension to troop methodology. Also they introduced trace security requirements starting from requirement gathering to design. A misuse case driven is used for fulfilling the security requirements. PriS requirements engineering which considers privacy requirements as their organizational goals adopting privacy process patterns.

Fan et al(2014)[39] introduced the theory of evaluation of objective trust and subjective trust. This was based on differencing trusted and untrusted Cloud Service Provider. This was an improved method of getting a cloud service which would help to reframe the cloud based on cloud service provider. There was also trust service providers used in paper for developing trust in cloud. This paper was based on a set of Trust service providers which were distributed to the cloud that extracted trust proof from various places in different forms. Through this they collect data related to cloud to service level and feedback sent by cloud user. Also trustworthy cloud service provider could be selected.

Burda et al(2014)[40] introduced a survey of data collected from 229 cloud service users. Trust and risk evaluation was done and through this cloud service was accepted using the rank of provider and contentment of the user. This made the end user adoption of cloud service. It uses a notable preclusive and provides the satisfaction. It uses personal file basis to reduce the risk factor. It used trustworthy method that provided satisfaction to the users and organization. It also used a theoretical framework and a research method for item development and pretesting, where theoretical and empirical literature review was done. Also data collection, data analysis, assessment of structural model was done.

J. Preethi et al(2015)[27] presented the dynamic ranking and choosing of cloud services taking quantifiable as well as non-quantifiable Quality of Service parameters(QoS) which resulted a suitable service that fulfills approximate total necessities of cloud service users with Linear Programming(LP). The system consisted of middleware, a cloud broker that clarified the ranking and choosing of cloud services. The operation that accompled static(offline) ranking that was performed at the back end and dynamic(online) ranking where the cloud service user identified the necessities. These tasks upgraded the capability of the system because the offline task was divided from the online task. Authors also attempted various compositions of taking quantifiable and non-quantifiable attributes. A series of repetitions adjusted with two attributes and got to know that the non-quantifiable attributes too have great influence in cloud service choosing. There was no straight- way association because cloud broker was deployed as intermediary between cloud service users and cloud service suppliers. Autonomous audation of service level agreement alongwith the broker can be taken into consideration.

Singh et al(2015)[5] proposed the output to get an ambitious goal, where the knowledge broke to the work stage. The attributes used in the work included reliability, bandwidth, completion time and cost level analysis for the software rating but some parameters were still left. The task could again be repeated using some other approach which was AHP(Analytical Hierarchical Process) approach that would be helpful for the decision builders that made changes in the ratings of parameter list for selecting the optimal cloud provider service. Also AHP technique was adjusted on multi criteria priorities analysis of different parameters that must be prorated by the customer for further analysis. This approach is superior than different multi-criteria methods. It calculates both quality and quantity parameters, mainly where the qualitative measurements are importantly concerned for the selection process of the cloud service.

Khowfa et al(2015)[23] proposed a method similar to the previous paper approach of AHP(Analytical Hierarchical process) technique to measure the quantitative parameters but also measured the qualitative parameters which was an additional feature in this paper. AHP approach focused on the Multi Criteria Decision Making AHP alongwith Hybrid methods. AHP approach is an outstanding process for calculation of quality parameters. It calculated both quality and quantity parameters, mainly where the qualitative measurements are importantly concerned for the selection process of the cloud service. The customer used contrast of data in for comparison. The Quality of Service (QoS) that is an important feature parameter was used as rating according to the customer satisfaction and fulfilling his/her requirements for making decision on service process. Then an optimal qualitative and quantitative service was selected on the basis of Multi Criteria Decision Making (MCDM) and Quality of Service (QoS) parameters ratings.

Rizvi et al(2015)[41] provided security controls of cloud that used a framework called novel security auditing which maintained trust and used conceptual mechanism validated security in cloud provided by the cloud service providers. They used a conceptual way to validate all the security issues and maintained a database of the cloud service providers giving responses of Consensus Assessments Initiative Questionnaire(CAIQ) alongwith the certificates. This maintained the trust among the cloud users.

Shaikh et al(2015)[42] measured the security and provided validity of trust in cloud services. It used the concept of CSA(Cloud Service Alliance) that evaluated the security and verification of trust and security in the cloud services. This concept used trust as a benchmark for all the cloud services provided with various other parameters. Data access control mechanism method was also introduced in this paper. It was good in terms of access but poor in security. Authors proposed evaluation of security based on service level agreement which selected best questionnaire that evaluated the security.

Tang et al(2015)[43]introduced a model named holistic including procedure, audit capability, maintainability and interoperability for the cloud service consumer with trusted cloud selected by third party that selects a monitored cloud with clarity. Authors proposed a FAGI model which was based on security best practices and it was a superset of most adopted standards such as ISO27001/2(ISO/ IEC, 2013), NIST SP800-53 (NIST SP800-53), CSA CCM (Cloud Security Alliance, CCM3.0, 2013a, b) and PCIDSS (PCISSC, 2013). It showed mapping of FAGI components to controls required by CSA CCM, ISO/IEC 27001, NIST SP800-53 and PCIDSS.

Haghighat et al(2015)[44] presented CloudID, which provided privacy with confidential information of customer and combined that information to the biometrics in an encrypted form. This was done to provide security so that the hackers dont use the private data and a new approach to protects the preserved data. It used a conjunctive range query over encrypted gallery samples which returned tree response only if all features fall under certain range using query sample. Due to this CloudID was secure against center search attack where intruder could find the biometric template. Authors also proposed k-d tree structure to quantize the biometric feature and define the ranges. which helped system to handle the variations in biometrics.

Bharathia et al(2015)[45] introduced a system using attributes of cloud generating trust. It used the location of user which avoided the malicious users in cloud. It also used cryptographic security keys that improved security and involved only the valid users to use the cloud. It used four things as Multi-Attribute Hashing function, Real-time service composition, Location Based service selection and extended trust management scheme. The multi attribute hashing system used many parameters to key for distant user. The cloud generates secret key for the valid user and provides to each user and validation of keys could be done at time of use. The signature verification was done which was just opposite to hashing system. The trust was computed differently for different users. The already registered customers were verified by public and private keys and the normal customers are verified by secret keys. After the request is received the identity will be verified using signature verification process and access history of user will be used for behavior analysis.

Liu et al(2016)[46] suggested an evaluation methodology of attributes necessary in cloud services using rough pair theory. This methodology proved to be an efficient in calculating the value of cloud services features. This could make cloud service providers to meet customer necessities and improve the customer learning. The customer requirements included according to the paper were availability, scalability, elasticity, security, renovation, cost, capability, outputs and brand impact. The rough pair assessment was a basic necessity in artificial intelligence particularly in the areas of tool learning. The basic benefit from rough pair theory was dependent on dataset instead of instinctive analysis. Authors presented a mathematical based framework that identified the components with the assumption of Software as a Service(SaaS) that utilized rough pair theory. Nevertheless, not only the output of component was considered but ranking of the services based on their weights were also taken into consideration. Moreover, a result was used to structure the assessment method. After reducing the components based on weights, the optimum service was chosen. It used rough pair theory in the structuring of the methodology for ranking the attributes of cloud services.

Ashraf et al(2016)[47] presented an organized cloud service named Recommender System Working based on userrequirements. The main objective for the paper was based on the evaluation of the cloud services for the customer requirements. The parameters which the customer required were chosen from the database and then cloud service was analyzed. The service chosen is based on customer needs and also the QoS quality parameters alongwith the user feedback. This way, the optimal cloud service was selected fulfilling the necessary requirements.

Dadhich et al(2016)[48] presented an ASMAN(Ap propriate Selection of SAAS Model According to Needs) framework based on SaaS technology with parameters of quality assurance like speed, performance, efficiency, etc. So, the framework helped to choose the optimal SaaS cloud service provider. In the framework, customer interacted with the business layer through the interface based on .net technology and then the business layer consisted the parameters, through which the customer could select according to his/her requirements and then from the database the service was extracted according to the customer.

Chiregi et al(2016) [49] presented the trust evaluation using five parameters considted of trust, composition, signature and maintenance. This all evaluated using judgment heads and dismissed the toll entities. It evaluated the trust by using the troll entities concept including input, output degrees and reputation which was used to evaluate trolls and judgment leaders. To measure trust, reliability, dependability, honesty, truthfulness, security, competence, and timeliness were considered. Availability means resources are always available data should be accessible easily and also services should be available even if the server is busy. Reliability is calculated mathematically. Data integrity included safe and accurate, was also calculated mathematically. Identity was divided into different levels Authorization level, Security level, Entity Protection level and Recovery level. Capability dependent on the computing speed and network parameters like bandwidth and latency. Trust values and reputation are calculated. Performance was measured on the basis of the above parameters.

Tanga et al(2016) [50] introduced a trust based framework called TRUSS for cloud service selection. This made a trust calculation bridge with subjective and objective trust calculation results. This was done to evaluate cloud based on quality of service in which objective and subjective trust was used to evaluate feedback ratings of user. So this was a perfect model for trust and reputation roles. It uses synthesized dataset to evaluate the performance. MATLAB 7.0 was used for experiments and implemented on HP desktop system with configuration as: Intel Core i3 3.20GHz CPU, 2GB RAM and windows 7 operating system.

Author	Computation Power	Performance	Adaptability	Security	User Feedback	Maintenance	Methodology
Garg et al(2011)	-	✓	✓	-	✓	-	Ranking process based on qualitative and quantitative analysis

Zheng et al(2012)	-	✓	-	-	-	✓	CloudRank1 and CloudRank2 algorithms for calculation of service ranking
Garg et al(2013)	✓	✓	✓	✓	✓	-	Service Calculation List(SCL) based on attributes and sub-attributes
Kumar et al(2014)	✓	✓	-	-	✓	-	Rank Cloud Framework to rank services
J. Preethi et al(2014)	✓	✓	-	-	✓	✓	Ranking forecast of front side QoS features
Jahani et al(2014)	✓	✓	-	-	✓	✓	W_SR(Weight Service Rank) proposal for cloud service ranking
Kumar et al(2014)	-	✓	-	✓	✓	✓	Cloud service selection engine framework
Hsu et al(2014)	-	✓	-	-	✓	✓	Cloud service selection model, CloudEval, that assessed the non practical premises
Chen et al(2014)	✓	✓	-	-	✓	-	Dynamic Skyline Service Algorithm
Kalloniatis et al(2014)	-	-	-	✓	-	-	List of security and privacy properties and design methodologies were developed
Fan et al(2014)	-	-	-	✓	✓	-	Theory of evaluation of objective trust and subjective trust

Burda et al(2014)	-	-	-	✓	-	-	Survey of data to evaluate trust and risk
J. Preethi et al(2015)	-	✓	✓	-	✓	-	Static(offline) ranking and dynamic(online) ranking for identification of user necessities
Singh et al(2015)	-	✓	✓	✓	✓	✓	Ratings of parameter list for selecting optimal cloud service.
Khowfa et al(2015)	-	✓	✓	✓	✓	✓	Calculated both quality and quantity parameters that used Analytical Hierarchical Process(AHP) method
Rizvi et al(2015)	-	-	-	✓	✓	-	Novel security auditing framework
Shaikh et al(2015)	-	-	-	✓	-	-	Trust model was used to evaluate security
Tang et al(2015)	-	-	-	✓	-	-	Model named holistic that included procedure, audit capability, maintainability and interoperability
Haghighat et al(2015)	-	✓	-	-	-	-	Privacy-preserving solution
Bharathia et al(2015)	-	✓	-	✓	-	-	An extended trust management scheme
Liu et al(2016)	✓	✓	-	-	✓	-	Rough pair theory for ranking of attributes of cloud services

Ashraf et al(2016)	-	✓	-	✓	✓	-	Recommender System Working
Dadhich et al(2016)	-	✓	✓	✓	✓	-	ASMAN(Appropriate Selection of SAAS Model According to Needs)
Chiregi et al(2016)	-	-	-	✓	-	-	Trust evaluation using five parameters included trust, composition, signature and capability
Tanga et al(2016)	-	✓	-	✓	✓	-	TRUSS(Trustworthy Selection Framework), Integrated Trust Evaluation Method, Other Trust Methods that developed an effective trust evaluation middleware

Table 2.1: Correlation Table depicting the different methodologies used by various authors

2.1 Summary

Authors talked about different methodologies adopted for selection of cloud provider service. Techniques used in the papers were based on multi criteria parameter rating, Analytical hierarchical process, subjective and objective parameter rating, focused framework rating, cloud broker architecture that provided the cloud service where the cloud broker acted as a mediator in some cases that indirectly provided the cloud service according to user requirements, customer parameter selection and many other methodologies. Among all of them, the method which was used in considering the quantitative as well as qualitative parameters rating for alternative cloud provider services considered for selecting an optimal cloud service provider.

Chapter 3

PRESENT WORK

3.1 Problem Formulation

After studying the literature review, it has been concluded that the work done on the ranking of alternate services in the cloud was not optimistic due to complexity. So, in this section implementation of the multi criteria decision making approach on ranking the services is considered using relative weights.[49].

3.1.1 Problem Definition

The proposed algorithm will be on the basis of providing quality of service to the customers in cloud services providing satisfaction to the user and acceptance in terms of budget. Thus, the research work will be done on quality of assurance parameter ratings according to the user requirements. The following parameters considered are:-

- **Computation power**:- Computation power refers to the speed in which the commands are planned out. This includes the bandwidth utilization, input output commands. It also include the memory utilization. The quantity of task finished by the organization or any system. The maximum work done and the maximum execution with quality is considered as the best computation power. It is related to minimum response time of the machine, maximum amount of task done, less use of stock, easy to obtain organization, fast increase and decrease in volume of facts, less time to transfer data. Computation Power can be calculated generally using frequency, capacitors and voltage. This can be calculated as:

$$P = CV^2 f \tag{3.1}$$

  Here in equation 3.1, P denotes power used by the system for calculating the overall service selection, C represents the capacitance depicting the energy flow when it is in charged mode, V represents the voltage consumption by the system and f represents the frequency where the computation power is directly proportional to the square of the voltage.

- **Service response time**:- The productivity of a service availability can be calculated in terms of response time. Suppose the user requests a virtual tool from cloud, then speed of response served is the service response time. It contributes furnishing the virtual tool, starting up the tool, allocating an ip address and beginning application formation. This also refers to many other aspects like average of service reply time which can be calculated as:

$$\sum_{i=0}^{n} \frac{T_i}{n} \tag{3.2}$$

Here in equation 3.2, T_i is the time where user request for some cloud service and n is the total number of cloud services provided, reply time and loss in reply time.

- **Cost**:- Asset and growth are the factors related to cost. In market, the services which company provides are of various types based on values and measures. The requirements services also give for virtual storage that fulfills the customer requirements. Suppose Windows provides a small virtual storage at a cheap rate than Cisco WebEx except the computation power, response time, data store, speed are different among them. This issue can be solved by a price of a single measure of computation power measure, response time measure, data store measure, speed measure. Likewise, suppose a virtual memory costs for 'p' consisting 'cp' computation power measure, 'rt' response time measure, 'ds' data store measure, 'sm' speed measure is:

$$\frac{p}{cp^a * rt^b * ds^c * sm^d} \tag{3.3}$$

in equation 3.3, a, b , c and d denotes the value for every feature measures and sum of all these equals to 1. The value may be different depending on different services. Like, in some service computation power is more vital than response time, so for that a >b. The varied values for every feature can be used on the basis of customer needs in terms of the QoS parameters. Normally, it can also acquire cost for sending out the data. So, the overall cost will be the sum of all feature values used[2].

- **Availability**:- This can be defined as the amount of time a user can able to use the facility. It can be calculated as:

$$\frac{\text{(total service time)-(total time for which service was not present)}}{\text{total service time}} \tag{3.4}$$

here in equation 3.4, total service time is the total amount of time taken by the server to process the request, total time for which service was not present related to the amount of time for which the server is busy while processing with some other service.

- **Security**:- Security concerns is related to the conservation of data in a secure manner, whether it can be any device or any service. Organizing maintenance when it is in the control of other corporation authority, then its a great problem that needs security management provided by cloud services. Likewise, every organization requires security management to control their data for security purpose so there should be data privacy and integration of data. This includes variety of parameters like using encryption of data, and the "cia" method which comprises of confidentiality, integrity and availability.

- **Efficiency**:- Efficiency is a necessary requirement to know the performance of cloud service. This is related to many factors like the response time that is the speed of time in which the request of customer is completed and accessed. Suppose a customer service has 'i' works and he/she worked to evaluate outcome on 'j' tools from cloud service provider. Then let T_e(i,j) be the evaluation time of i works on j machines and also T_o be the time raised because of different parameters like transfer delay and processing delay. So, the efficiency is the effectual use of the borrowed services. Then a maximum percentage of efficiency shows that the raised time should be minimum in service and its calculated as:

$$\frac{T_e(i,j)}{T_e(i,j)+T_o} \tag{3.5}$$

In equation 3.5, T_e(i,j) is the evaluation time of i works on j machines and also T_o is the time raised because of different parameters like transfer delay and processing delay.

- **Maintenance**:- Maintenance of service comprises of all the quantitative as well as qualitative parameters like the service response time, computation power, security, its infrastructure, cost, performance, adaptability and efficiency. The maintenance can be evaluated by the hourly estimation of the functioning of the cloud service.

- **Adaptability**:- This parameter is related to the capability of the service to balance the differences in services depending on user requirements. The time required in services according to the differences or modifications in an improved version(like modifying the Windows non genuine to genuine Windows) is adaptability of service.

  The parameters are prorated according to the equations 3.1-3.4 and then the weights are assigned according to the scale table. These are the general formula used in real time to calculate the parameters value mathematically used by the various organizations and the rating of the parameters is done using the scale table. The rating of the cloud provider services using the QoS parameters is also analyzed using the scale table and using multiple criteria approach.

3.1.2 Multiple Criteria Decision Making Approach

MCDM relates to constructing and evaluating the task and arranging issues considering the multiple criteria. The idea relates to giving the support to these issues.

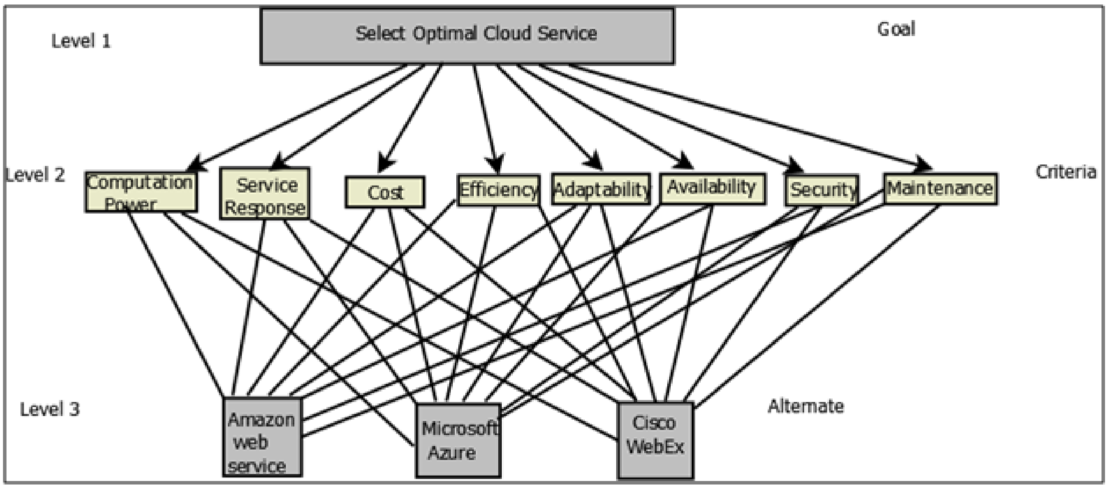

Figure 3.1: Analytical Hierarchy Process

This type of approach provides an optimistic result and makes the result appropriate through the multiple criteria rating under the user rating requirements.

3.1.3 Multiple Attribute Utility Theory

In MAUT theory, the weights of the parameters are assigned according to functioning of user requirements and on the basis of utility function. In the utility function, there is integration of the priority ratings of the parameters and the goal is achieved. Therefore, its a simple process to acquire the results based on the priority ratings of the parameters.

3.1.4 Analytic Hierarchy Process

Figure3.1 illustrates the AHP approach which is known to be the best approach for evaluating the issues related to the previous approaches, its a type of MCDM approach. This clarifies the composite design and disorganized selection forming criteria through organizing the parameters in a hierarchal design. Integrating with MAUT and MCDM approach, this depends on the pairwise relation according to the selection former to achieve the ratings among the services. This approach as compared to the MAUT is very efficient, in considering the ranking of services in account of (Quality of Services)QoS parameters. The assignment of weights of parameters is done through the scale table and the customer satisfaction for every parameter as compared to different parameters.

3.2 Scope of the Study

The cloud infrastructure is the base for performing various mechanisms in the system. The IaaS service of cloud fulfills for this requirement. The mechanism includes cloud storage, resource allocation, implementing a framework, ranking of services, etc. In the study of cloud computing, the basic requirements is fulfilling the demands of the business and organization which relates to the following tasks:

1. The ranking of cloud service provider.

2. The allotment of ratings to the Quality of Service parameters based on user and organization requirements.

3. The reallocation of multiple criteria approach to the Analytical Hierarchy Process.

All of the above aspects is examined in this report. The ranking of cloud service provider considers following tasks:

1. The allocation of the weights to the Quality of Service parameters.

2. The evaluation of the optimal service based on criteria priorities.

The main aspect of cloud service is to get the best service which satisfies the requirements of customer as well as the corporate world. For this, different matrices, tables are solved, algorithm and flowchart based on AHP method have been proposed. The optimum approach for the ranking of services which is implemented in this process is the AHP approach for ranking of the cloud service satisfying the quantitative and qualitative QoS parameters.
Taking into the account of previous approaches of Multiple Criteria Decision Making Approach(MCDM), Multiple Attribute Utility Theory(MAUT) and Analytic Hierarchy Process(AHP). The best approach of MCDM is AHP process which is based on assigning the weights to the QoS parameters and obtaining the ranks of the services on performance criteria.

3.3 Objectives of the Study

The Objectives could be attained by following tasks:

1. The ranking of cloud service provider based on QoS parameters(computation power, service response time, cost, availability, security, efficiency, maintenance, adaptability)is done which is based on assigning weights by using the scale table fulfilling user and businesses requirements.

2. The ranking of cloud service provider is done keeping in mind of the qualitative, quantitative parameters and also the present IT corporation basic necessities of handling of data.

3. Considering the above steps of both the rankings and necessities, it is evaluated based on the AHP methodology.

4. For the proper achievement of the task, many more methodologies have been taken into account like MCDM approach, MAUT approach and AHP approach. But among them, the more efficient approach is AHP.

5. The management of the weights and other data analysis requires many resources like computation power, memory, bandwidth, etc.
   The basic objective of this paper is to rank the cloud provider service based on weights and criteria priority. Thus, it would also enhance the stock of that service by getting the best ranked service.

3.4 Research Methodology

Figure 3.1 depicts the AHP process which consists of the QoS parameters where at the first level assignment of weights according to the user one by one is done then calculation of $n^{th} root$ and criteria priority is done. The second task is based on QoS parameters and analyzing them with every service alternatively, the weights of every parameter would vary, accordingly the assignment of weights are done based on scale table. This way an optimum cloud service provider is selected fulfilling the user requirements.

3.4.1 Cloud Service Selection

1. Calculation of weights for the criteria including QoS parameters

   The first process is the weights calculation by taking the values of rows and columns and dividing the weights assigned through the scale table. By this the weights for each block will be calculated. The Qos parameters taken into consideration include P1, P2 , P3, P4, P5, P6, P7, P8. For the calculation of weights for the parameters we will consider the values in the given scale table which is based on relative vital consideration.

Relative Vital Considerations	values
equally favored	1
more equally favored	2
more favored	3
more to mostly favored	4
mostly favored	5
mostly to much more mostly favored	6
much more mostly favored	7
much more to much much more mostly favored	8
much much more mostly favored	9

Table 3.1: Scale Table

   Let us consider a matrix with 8 parameters : P1, P2 , P3, P4, P5, P6, P7, P8 where i^{th} variable will be in row which denotes the 8 parameters and sum of j^{th} variable in column wise denotes the same 8 parameters. Then it calculates the relative weights for each parameters.

$$
= \begin{array}{c c}
 & \begin{array}{cccccccc} \text{P1} & \text{P2} & \text{P3} & \text{P4} & \text{P5} & \text{P6} & \text{P7} & \text{P8} \end{array} \\
\begin{array}{c} \text{P1} \\ \text{P2} \\ \text{P3} \\ \text{P4} \\ \text{P5} \\ \text{P6} \\ \text{P7} \\ \text{P8} \end{array} &
\begin{pmatrix}
i_1j_1 & i_1j_2 & i_1j_3 & i_1j_4 & i_1j_5 & i_1j_6 & i_1j_7 & i_1j_8 \\
i_2j_1 & i_2j_2 & i_2j_3 & i_2j_4 & i_2j_5 & i_2j_6 & i_2j_7 & i_2j_8 \\
i_3j_1 & i_3j_2 & i_3j_3 & i_3j_4 & i_3j_5 & i_3j_6 & i_3j_7 & i_3j_8 \\
i_4j_1 & i_4j_2 & i_4j_3 & i_4j_4 & i_4j_5 & i_4j_6 & i_4j_7 & i_4j_8 \\
i_5j_1 & i_5j_2 & i_5j_3 & i_5j_4 & i_5j_5 & i_5j_6 & i_5j_7 & i_5j_8 \\
i_6j_1 & i_6j_2 & i_6j_3 & i_6j_4 & i_6j_5 & i_6j_6 & i_6j_7 & i_6j_8 \\
i_7j_1 & i_7j_2 & i_7j_3 & i_7j_4 & i_7j_5 & i_7j_6 & i_7j_7 & i_7j_8 \\
i_8j_1 & i_8j_2 & i_8j_3 & i_8j_4 & i_8j_5 & i_8j_6 & i_8j_7 & i_8j_8
\end{pmatrix}
\end{array}
$$

$i_ij_j = \frac{value_i}{value_j}$

2. Calculation of sum and $n^{th}root$ of the parameter values

   This step includes calculation of sum of all QoS parameters for each column and then after this finding a new column which is the $n^{th}root$ column that is calculated by taking the product of all values in a row wise manner and then taking the $n^{th}root$ of that value. This will give the $n^{th}root$ for each parameter.

   Let us consider a matrix with 8 parameters : P1, P2 , P3, P4, P5, P6, P7, P8 where i^{th} variable will be in row which denotes the 8 parameters and sum of $n^{th}root$ and j^{th} variable in column wise denotes the same 8 parameters and $n^{th}root$. Then it calculates the relative weights for each parameter.

$$
= \begin{array}{c c}
 & \begin{array}{ccccccccc} \text{P1} & \text{P2} & \text{P3} & \text{P4} & \text{P5} & \text{P6} & \text{P7} & \text{P8} & n^{th}root \end{array} \\
\begin{array}{c} \text{P1} \\ \text{P2} \\ \text{P3} \\ \text{P4} \\ \text{P5} \\ \text{P6} \\ \text{P7} \\ \text{P8} \\ \text{sum} \end{array} &
\begin{pmatrix}
i_1j_1 & i_1j_2 & i_1j_3 & i_1j_4 & i_1j_5 & i_1j_6 & i_1j_7 & i_1j_8 & i_1j_9 \\
i_2j_1 & i_2j_2 & i_2j_3 & i_2j_4 & i_2j_5 & i_2j_6 & i_2j_7 & i_2j_8 & i_2j_9 \\
i_3j_1 & i_3j_2 & i_3j_3 & i_3j_4 & i_3j_5 & i_3j_6 & i_3j_7 & i_3j_8 & i_3j_9 \\
i_4j_1 & i_4j_2 & i_4j_3 & i_4j_4 & i_4j_5 & i_4j_6 & i_4j_7 & i_4j_8 & i_4j_9 \\
i_5j_1 & i_5j_2 & i_5j_3 & i_5j_4 & i_5j_5 & i_5j_6 & i_5j_7 & i_5j_8 & i_5j_9 \\
i_6j_1 & i_6j_2 & i_6j_3 & i_6j_4 & i_6j_5 & i_6j_6 & i_6j_7 & i_6j_8 & i_6j_9 \\
i_7j_1 & i_7j_2 & i_7j_3 & i_7j_4 & i_7j_5 & i_7j_6 & i_7j_7 & i_7j_8 & i_7j_9 \\
i_8j_1 & i_8j_2 & i_8j_3 & i_8j_4 & i_8j_5 & i_8j_6 & i_8j_7 & i_8j_8 & i_8j_9 \\
 & & & & & & & & i_9j_9
\end{pmatrix}
\end{array}
$$

3. Calculation of the criteria priority

   This step includes the sum of the $n^{th}root$ column, then finding a new column naming criteria priority for each parameter by dividing the $n^{th}root$ of each parameter with the sum of $n^{th}root$ of all parameters one by one. This will give the priority value for all the parameters taken into consideration, the sum of this criteria priority column will be 1.

   Let us consider a matrix with 8 parameters : P1, P2 , P3, P4, P5, P6, P7, P8 and the sum of all parameters where i^{th} variable will be in row which denotes the 8 parameters and sum of weights of these parameters and j^{th} variable in column wise denotes the same 8 parameters, $n^{th}root$ and criteria priority. Then it calculates the relative weights for each parameters.

$$= \begin{array}{c} \\ \text{P1} \\ \text{P2} \\ \text{P3} \\ \text{P4} \\ \text{P5} \\ \text{P6} \\ \text{P7} \\ \text{P8} \\ \text{sum} \end{array} \begin{array}{c} \begin{array}{cccccccccc} \text{P1} & \text{P2} & \text{P3} & \text{P4} & \text{P5} & \text{P6} & \text{P7} & \text{P8} & n^{th}root & \text{criteria priority} \end{array} \\ \begin{pmatrix} i_1j_1 & i_1j_2 & i_1j_3 & i_1j_4 & i_1j_5 & i_1j_6 & i_1j_7 & i_1j_8 & i_1j_9 & i_1j_{10} \\ i_2j_1 & i_2j_2 & i_2j_3 & i_2j_4 & i_2j_5 & i_2j_6 & i_2j_7 & i_2j_8 & i_2j_9 & i_2j_{10} \\ i_3j_1 & i_3j_2 & i_3j_3 & i_3j_4 & i_3j_5 & i_3j_6 & i_3j_7 & i_3j_8 & i_3j_9 & i_3j_{10} \\ i_4j_1 & i_4j_2 & i_4j_3 & i_4j_4 & i_4j_5 & i_4j_6 & i_4j_7 & i_4j_8 & i_4j_9 & i_4j_{10} \\ i_5j_1 & i_5j_2 & i_5j_3 & i_5j_4 & i_5j_5 & i_5j_6 & i_5j_7 & i_5j_8 & i_5j_9 & i_5j_{10} \\ i_6j_1 & i_6j_2 & i_6j_3 & i_6j_4 & i_6j_5 & i_6j_6 & i_6j_7 & i_6j_8 & i_6j_9 & i_6j_{10} \\ i_7j_1 & i_7j_2 & i_7j_3 & i_7j_4 & i_7j_5 & i_7j_6 & i_7j_7 & i_7j_8 & i_7j_9 & i_7j_{10} \\ i_8j_1 & i_8j_2 & i_8j_3 & i_8j_4 & i_8j_5 & i_8j_6 & i_8j_7 & i_8j_8 & i_8j_9 & i_8j_{10} \\ i_9j_1 & i_9j_2 & i_9j_3 & i_9j_4 & i_9j_5 & i_9j_6 & i_9j_7 & i_9j_8 & i_9j_9 & i_9j_{10} \end{pmatrix} \end{array}$$

4. Evaluation of the ratings taking each parameter for alternate services

   The previous steps will be repeated for calculation of the alternate cloud services for each parameter taking various services, sum, $n^{th}root$, priority will be calculated. This is based on the comparison of services and selection of cloud service for the utilization in fulfilling the business requirements.

   Let us consider a matrix with 3 alternate services : A1, A2 and A3 where i^{th} variable will be in row which denotes the 3 services ,sum of weights of these services and j^{th} variable in column wise denotes the same 3 services, $n^{th}root$ and criteria priority. Then it calculates the relative weights for each alternate services considering all the parameters one by one using the scale table. This way it will calculate relative weights for all the considered parameters.

5. Taking P1 as a quality of service parameter for the alternate services and solving for P1 parameter relative weights and finding the $n^{th}root$ and criteria priority. The $n^{th}root$ is calculated by multiplying all the parameter calculated values through analyzed scale table Table 3.1. After that criteria priority is evaluated by dividing with each value of $n^{th}root$ by the total sum of $n^{th}root$ considering all parameters one by one.

$$
= \begin{array}{c c} & \begin{array}{ccccc} \text{A1} & \text{A2} & \text{A3} & n^{th}root & \text{criteria priority} \end{array} \\ \begin{array}{c} \text{A1} \\ \text{A2} \\ \text{A3} \\ \text{Sum} \end{array} & \begin{pmatrix} i_1j_1 & i_1j_2 & i_1j_3 & i_1j_4 & i_1j_5 \\ i_2j_1 & i_2j_2 & i_2j_3 & i_2j_4 & i_2j_5 \\ i_3j_1 & i_3j_2 & i_3j_3 & i_3j_4 & i_3j_5 \\ i_4j_1 & i_4j_2 & i_4j_3 & i_4j_4 & i_4j_5 \end{pmatrix} \end{array}
$$

here $i_ij_j = \frac{value_i}{value_j}$

6. Taking P2 as a quality of service parameter for the alternate services and solving for P2 parameter relative weights and finding the $n^{th}root$ and criteria priority. The $n^{th}root$ is calculated by multiplying all the parameter calculated values through analyzed scale table Table 3.1. After that criteria priority is evaluated by dividing with each value of $n^{th}root$ by the total sum of $n^{th}root$ considering all parameters one by one.

$$
= \begin{array}{c c} & \begin{array}{ccccc} \text{A1} & \text{A2} & \text{A3} & n^{th}root & \text{criteria priority} \end{array} \\ \begin{array}{c} \text{A1} \\ \text{A2} \\ \text{A3} \\ \text{Sum} \end{array} & \begin{pmatrix} i_1j_1 & i_1j_2 & i_1j_3 & i_1j_4 & i_1j_5 \\ i_2j_1 & i_2j_2 & i_2j_3 & i_2j_4 & i_2j_5 \\ i_3j_1 & i_3j_2 & i_3j_3 & i_3j_4 & i_3j_5 \\ i_4j_1 & i_4j_2 & i_4j_3 & i_4j_4 & i_4j_5 \end{pmatrix} \end{array}
$$

here $i_ij_j = \frac{value_i}{value_j}$

7. Taking P3 as a quality of service parameter for the alternate services and solving for P2 parameter relative weights and finding the $n^{th}root$ and cri-

teria priority. The $n^{th}root$ is calculated by multiplying all the parameter calculated values through analyzed scale table Table 3.1. After that criteria priority is evaluated by dividing with each value of $n^{th}root$ by the total sum of $n^{th}root$ considering all parameters one by one.

$$= \begin{array}{c c} & \begin{array}{ccccc} \text{A1} & \text{A2} & \text{A3} & n^{th}root & \text{criteria priority} \end{array} \\ \begin{array}{c} \text{A1} \\ \text{A2} \\ \text{A3} \\ \text{Sum} \end{array} & \begin{pmatrix} i_1j_1 & i_1j_2 & i_1j_3 & i_1j_4 & i_1j_5 \\ i_2j_1 & i_2j_2 & i_2j_3 & i_2j_4 & i_2j_5 \\ i_3j_1 & i_3j_2 & i_3j_3 & i_3j_4 & i_3j_5 \\ i_4j_1 & i_4j_2 & i_4j_3 & i_4j_4 & i_4j_5 \end{pmatrix} \end{array}$$

here $i_ij_j = \frac{value_i}{value_j}$

8. Taking P4 as a quality of service parameter for the alternate services and solving for P2 parameter relative weights and finding the $n^{th}root$ and criteria priority. The $n^{th}root$ is calculated by multiplying all the parameter calculated values through analyzed scale table Table 3.1. After that criteria priority is evaluated by dividing with each value of $n^{th}root$ by the total sum of $n^{th}root$ considering all parameters one by one.

$$= \begin{array}{c c} & \begin{array}{ccccc} \text{A1} & \text{A2} & \text{A3} & n^{th}root & \text{criteria priority} \end{array} \\ \begin{array}{c} \text{A1} \\ \text{A2} \\ \text{A3} \\ \text{Sum} \end{array} & \begin{pmatrix} i_1j_1 & i_1j_2 & i_1j_3 & i_1j_4 & i_1j_5 \\ i_2j_1 & i_2j_2 & i_2j_3 & i_2j_4 & i_2j_5 \\ i_3j_1 & i_3j_2 & i_3j_3 & i_3j_4 & i_3j_5 \\ i_4j_1 & i_4j_2 & i_4j_3 & i_4j_4 & i_4j_5 \end{pmatrix} \end{array}$$

here $i_ij_j = \frac{value_i}{value_j}$

9. Taking P5 as a quality of service parameter for the alternate services and solving for P2 parameter relative weights and finding the $n^{th}root$ and criteria priority. The $n^{th}root$ is calculated by multiplying all the parameter calculated values through analyzed scale table Table 3.1. After that criteria priority is evaluated by dividing with each value of $n^{th}root$ by the total sum of $n^{th}root$ considering all parameters one by one.

$$
= \begin{array}{c} \\ \text{A1} \\ \text{A2} \\ \text{A3} \\ \text{Sum} \end{array}
\begin{array}{c}
\begin{array}{ccccc} \text{A1} & \text{A2} & \text{A3} & n^{th}root & \text{criteria priority} \end{array} \\
\begin{pmatrix}
i_1j_1 & i_1j_2 & i_1j_3 & i_1j_4 & i_1j_5 \\
i_2j_1 & i_2j_2 & i_2j_3 & i_2j_4 & i_2j_5 \\
i_3j_1 & i_3j_2 & i_3j_3 & i_3j_4 & i_3j_5 \\
i_4j_1 & i_4j_2 & i_4j_3 & i_4j_4 & i_4j_5
\end{pmatrix}
\end{array}
$$

here $i_ij_j = \frac{value_i}{value_j}$

10. Taking P6 as a quality of service parameter for the alternate services and solving for P2 parameter relative weights and finding the $n^{th}root$ and criteria priority. The $n^{th}root$ is calculated by multiplying all the parameter calculated values through analyzed scale table Table 3.1. After that criteria priority is evaluated by dividing with each value of $n^{th}root$ by the total sum of $n^{th}root$ considering all parameters one by one.

$$
= \begin{array}{c} \\ \text{A1} \\ \text{A2} \\ \text{A3} \\ \text{Sum} \end{array}
\begin{array}{c}
\begin{array}{ccccc} \text{A1} & \text{A2} & \text{A3} & n^{th}root & \text{criteria priority} \end{array} \\
\begin{pmatrix}
i_1j_1 & i_1j_2 & i_1j_3 & i_1j_4 & i_1j_5 \\
i_2j_1 & i_2j_2 & i_2j_3 & i_2j_4 & i_2j_5 \\
i_3j_1 & i_3j_2 & i_3j_3 & i_3j_4 & i_3j_5 \\
i_4j_1 & i_4j_2 & i_4j_3 & i_4j_4 & i_4j_5
\end{pmatrix}
\end{array}
$$

here $i_ij_j = \frac{value_i}{value_j}$

11. Taking P7 as a quality of service parameter for the alternate services and solving for P2 parameter relative weights and finding the $n^{th}root$ and criteria priority. The $n^{th}root$ is calculated by multiplying all the parameter calculated values through analyzed scale table Table 3.1. After that criteria priority is evaluated by dividing with each value of $n^{th}root$ by the total sum of $n^{th}root$ considering all parameters one by one.

$$
\begin{array}{c|c}
 & \begin{array}{ccccc} \text{A1} & \text{A2} & \text{A3} & n^{th}root & \text{criteria priority} \end{array} \\
= \begin{array}{c} \text{A1} \\ \text{A2} \\ \text{A3} \\ \text{Sum} \end{array} & \begin{pmatrix} i_1j_1 & i_1j_2 & i_1j_3 & i_1j_4 & i_1j_5 \\ i_2j_1 & i_2j_2 & i_2j_3 & i_2j_4 & i_2j_5 \\ i_3j_1 & i_3j_2 & i_3j_3 & i_3j_4 & i_3j_5 \\ i_4j_1 & i_4j_2 & i_4j_3 & i_4j_4 & i_4j_5 \end{pmatrix}
\end{array}
$$

here $i_ij_j = \frac{value_i}{value_j}$

12. Taking P8 as a quality of service parameter for the alternate services and solving for P2 parameter relative weights and finding the $n^{th}root$ and criteria priority. The $n^{th}root$ is calculated by multiplying all the parameter calculated values through analyzed scale table Table 3.1. After that criteria priority is evaluated by dividing with each value of $n^{th}root$ by the total sum of $n^{th}root$ considering all parameters one by one.

$$
\begin{array}{c|c}
 & \begin{array}{ccccc} \text{A1} & \text{A2} & \text{A3} & n^{th}root & \text{criteria priority} \end{array} \\
= \begin{array}{c} \text{A1} \\ \text{A2} \\ \text{A3} \\ \text{Sum} \end{array} & \begin{pmatrix} i_1j_1 & i_1j_2 & i_1j_3 & i_1j_4 & i_1j_5 \\ i_2j_1 & i_2j_2 & i_2j_3 & i_2j_4 & i_2j_5 \\ i_3j_1 & i_3j_2 & i_3j_3 & i_3j_4 & i_3j_5 \\ i_4j_1 & i_4j_2 & i_4j_3 & i_4j_4 & i_4j_5 \end{pmatrix}
\end{array}
$$

here $i_ij_j = \frac{value_i}{value_j}$

13. Calculation of final service weights

    This step is based on finding out the best cloud service with maximum rating from the final results column of all the parameters which includes the multiplication of the criteria priority and criteria priority among the parameters calculated in earlier matrices. After this sorting all the services based on values and getting the best cloud service based on maximum value.

    Let us consider a matrix with 3 alternate services : A1, A2 and A3 where i^{th} variable will be in row which denotes the 3 services and sum of weights of these services , and j^{th} variable in column wise denotes the earlier used 8 parameters and final results. Then it calculates the resultant values for each alternate services.

$$
= \begin{array}{cc}
 & \begin{array}{ccccccccc} \mathrm{P1} & \mathrm{P2} & \mathrm{P3} & \mathrm{P4} & \mathrm{P5} & \mathrm{P6} & \mathrm{P7} & \mathrm{P8} & \text{final results} \end{array} \\
\begin{array}{c} \\ \mathrm{A1} \\ \mathrm{A2} \\ \mathrm{A3} \end{array} & \begin{pmatrix}
i_1j_1 & i_1j_2 & i_1j_3 & i_1j_4 & i_1j_5 & i_1j_6 & i_1j_7 & i_1j_8 & i_1j_9 \\
i_2j_1 & i_2j_2 & i_2j_3 & i_2j_4 & i_2j_5 & i_2j_6 & i_2j_7 & i_2j_8 & i_2j_9 \\
i_3j_1 & i_3j_2 & i_3j_3 & i_3j_4 & i_3j_5 & i_3j_6 & i_3j_7 & i_3j_8 & i_3j_9 \\
i_4j_1 & i_4j_2 & i_4j_3 & i_4j_4 & i_4j_5 & i_4j_6 & i_4j_7 & i_4j_8 & i_4j_9
\end{pmatrix}
\end{array}
$$

3.4.2 Flowchart

3.2AHP flowchart is a basis to evaluate the problem in which the selection of cloud service provider. AHP is known as Analytical Hierarchy Process which is defined as assigning the weightsTable 3.1 according to the user as pair wise comparison then calculating the $n^{th}root$ and priority vector for the QoS parameters. The alternate services considering the weights assigned to the parameters one by one is done. Then $n^{th}root$ and priority vector is calculated and at last integrating the priority vectors of the parameters and the services priority vectors, the final weights in terms of priority vector is calculated. Finally according to the highest value of the priority vector, the optimistic cloud service provider is obtained.

3.4.3 AHP Algorithm

Figure3.1 illustrates the AHP approach which is known to be the best approach for evaluating the issues related to the previous approaches, its a type of MCDM approach. This clarifies the composite design and disorganized selection forming criteria through organizing the parameters in a hierarchal design. Integrating with MAUT and MCDM approach, this depends on the pairwise relation according to the selection former to achieve the ratings among the services. This approach as compared to the MAUT is very efficient, in considering the ranking of services in account of (Quality of Services)QoS parameters. The assignment of weights of parameters is done through the scale table and the customer satisfaction for every parameter as compared to different parameters.

3.2AHP flowchart is a basis to evaluate the problem in which the selection of

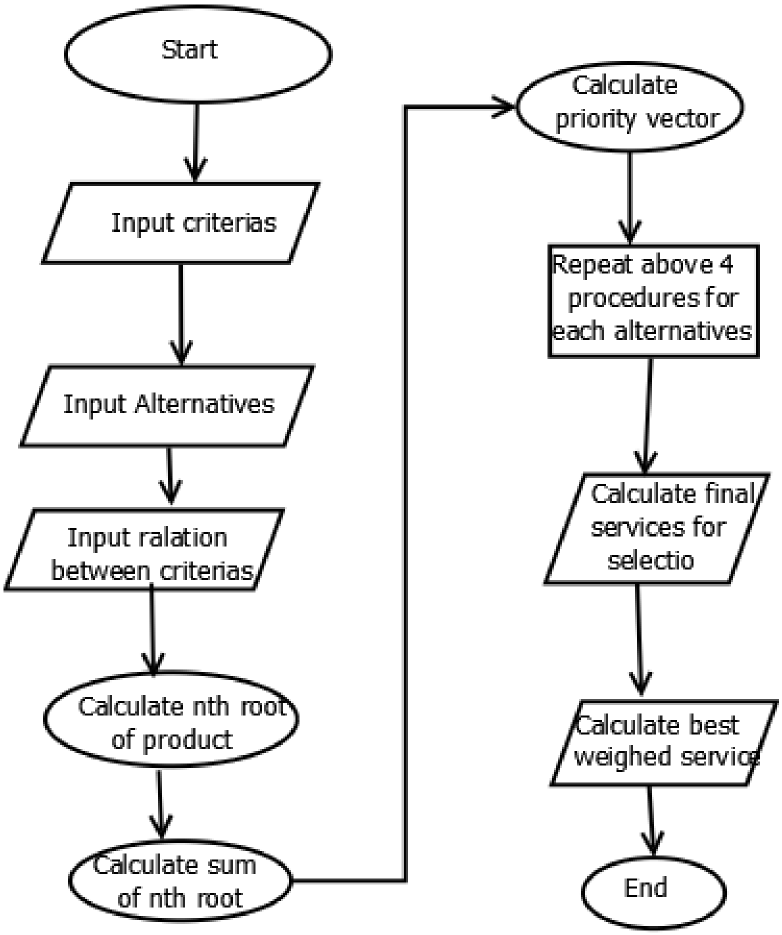

Figure 3.2: Flowchart for calculating the optimal cloud service provider

Algorithm 1 Cloud Service Selection algorithm

procedure RANKING OF CLOUD SERVICES(all QoS values)
  for `each pair of QoS values` **do**
    `computing(`QoS_i`,`QoS_j`)`
  for `each row of weight criteria matrix` **do**
    `compute(`$n^{th}root$`) by using row elements`
  for each $n^{th}root$ **do**
    `compute priority vector elements by calculating` $\frac{n^{th}root}{\sum n^{th}root}$
  for `each QoS parameters` **do**
    `Build alternates rating matrix by using rating vector`
  for `each alternates rating matrix` **do**
    for `each row of rating matrix` **do**
      `compute(`$n^{th}root$`) by using row elements and compute priority vector elements by using (`$n^{th}root$`)`
  for `each alternates service provider` **do**
    `compute final service weight by using weight criteria matrix priority vector and alternate rating priority vector`

cloud service provider. AHP is known as Analytical Hierarchy Process which is defined as assigning the weightsTable 3.1 according to the user as pair wise comparison then calculating the $n^{th}root$ and priority vector for the QoS parameters. The alternate services considering the weights assigned to the parameters one by one is done. Then $n^{th}root$ and priority vector is calculated and at last integrating the priority vectors of the parameters and the services priority vectors, the final weights in terms of priority vector is calculated. Finally according to the highest value of the priority vector, the optimistic cloud service provider is obtained.

Chapter 4

RESULTS AND DISCUSSION

In this chapter the implementation is examined deeply alongwith practical procedure. It also includes graphs, pie charts and tables of QoS parameters and alternate cloud services. The services considered are Amazon web service, Microsoft Azure, Cisco WebEx and parameters are computation power, service response time, cost, availability, security, efficiency, maintenance, adaptability respectively.

4.1 Data Analysis and Interpretation

The analysis of data consists of the relative weights, services and parameters which is solved using the AHP process according to the pair wise comparison of the parameters and weights.

Qos parameters:computation power, service response time, cost, availability, security, efficiency, maintenance, adaptability

Services:Amazon web service, Microsoft Azure, Cisco WebEx

1. Taking 8 parameters - computation power, service response time, cost, availability, security, efficiency, maintenance, adaptability , suppose it has analyzed from the above scale table Table 3.1.

    - Computation power is “mostly favored”(value 5).
    - Service response time is also “more equally favored” (value 2).
    - Cost is “mostly to much more mostly favored”(value 6).
    - Availability is “much more mostly favored”(value 7).
    - Security is “much much more mostly favored”(value 9).
    - Efficiency is “much more to much much more mostly favored”(value 8).
    - Maintenance is “more favored”(value 3).

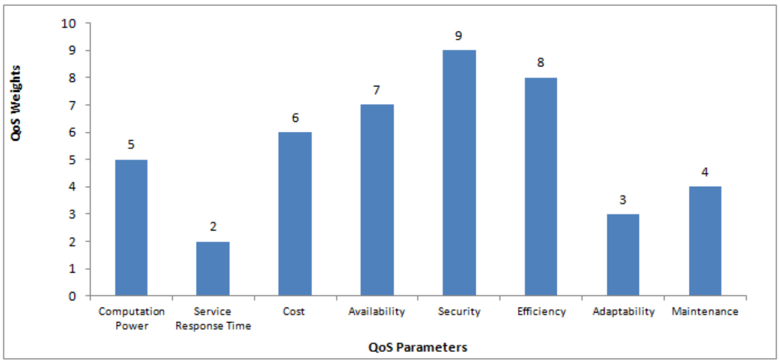

Figure 4.1: QoS ratings for all parameters

- Adaptability is "more to mostly favored"(value 4). The other values in the matrix shown in the diagonal must be equal to 1 as the values are divided by itself.

  The rest values in table depicts the division of pair-wise comparisons of the parameters

  The other values are automatically evaluated by dividing the pair wise comparisons of the QoS parameters as shown in table like computation power weight(5)/computation power weight(5),
  computation power weight(5)/service response time(2) and similarly the other values are calculated . The formula used is weight of parameter 1/weight of parameter 2

	Computation power	Service response time	Cost	Availability	Security	Efficiency	Maintenance	Adaptability
Computation power	1.000	2.500	0.833	0.714	0.555	0.625	1.667	1.250
Service response time	0.400	1.000	0.333	0.286	0.222	0.250	0.666	0.500
Cost	1.200	3.000	1.000	0.857	0.666	0.750	2.000	1.500
Availability	1.400	3.500	1.167	1.000	0.777	0.875	2.333	1.750
Security	1.800	4.500	1.500	1.286	1.000	1.125	3.000	2.250
Efficiency	1.600	4.000	1.333	1.143	0.888	1.000	2.667	2.000
Maintenance	0.600	1.500	0.500	0.429	0.333	0.375	1.000	0.750
Adaptability	0.800	2.000	0.666	0.571	0.444	0.500	1.333	1.000

Table 4.1: Relative weights for QoS parameters

4.1 shows the ratings of QoS parameters according to the customer requirements and needs which is considered through the scale table [Table 3.1]. The x-axis shows the QoS parameters[11] used for analyzing the optimal cloud service provider. Here the values of the Qos parameters are taken through dividing the weights of 1 parameter to the other parameter in each row. Likewise, if computation power is taken then the weight of computation power is divided by all the parameter's weight one by one to get the relative weight for each parameter in row wise. Similarly it is calculated for all other parameters. The Y-axis shows the QoS weights which is taken from the scale table.

2. The $n^{th}root$ and the sum: This step includes calculation of sum of all QoS parameters for each column and then after this finding a new column which is the $n^{th}root$ column which is calculated by taking the product of all values in a row wise manner and then taking the $n^{th}root$ of that value. This will give the $n^{th}root$ for each parameter.

   Let us consider a matrix with 8 parameters : Computation power, Service response time, Cost, Availability, Security, Efficiency, Maintenance and Adaptability where the values of the Qos parameters are taken through dividing the weights of 1 parameter to the other parameter in each row using [Table 3.1] and sum of $n^{th}root$.

	Computation power	Service response time	Cost	Availability	Security	Efficiency	Maintenance	Adaptability	8^{th}root with product
Computation power	1.000	2.500	0.833	0.714	0.555	0.625	1.667	1.250	1.009
Service response time	0.400	1.000	0.333	0.286	0.222	0.250	0.666	0.500	0.538
Cost	1.200	3.000	1.000	0.857	0.666	0.750	2.000	1.500	1.211
Availability	1.400	3.500	1.167	1.000	0.777	0.875	2.333	1.750	1.413
Security	1.800	4.500	1.500	1.286	1.000	1.125	3.000	2.250	1.817
Efficiency	1.600	4.000	1.333	1.143	0.888	1.000	2.667	2.000	1.615
Maintenance	0.600	1.500	0.500	0.429	0.333	0.375	1.000	0.750	0.605
Adaptability	0.800	2.000	0.666	0.571	0.444	0.500	1.333	1.000	0.807
Sum									9.015

Table 4.2: Calculation of $n^{th}root$ and the sum

3. Criteria Priority for parameters: This step includes the sum of the $8^{th}root$ column, then finding a new column naming criteria priority for each parameter by dividing the $8^{th}root$ of each parameter by the calculated sum of $8^{th}root$ for all parameters one by one. This will give the priority value for all the parameters taken into consideration, the sum of this criteria priority column will be 1.

   Let us consider a matrix with 8 parameters : Computation power, Service response time, Cost, Availability, Security, Efficiency, Maintenance and

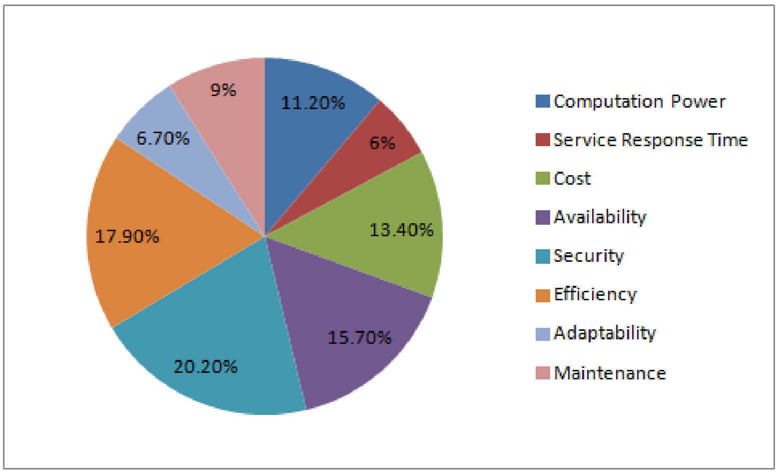

Figure 4.2: Criteria priority for all parameters

Adaptability and where the values of the Qos parameters are taken through dividing the weights of 1 parameter to the other parameter in each row using [Table 3.1] and sum of $n^{th} root$ and criteria priority.

	Computation power	Service response time	Cost	Availability	Security	Efficiency	Maintenance	Adaptability	8^{th}root with product	Criteria priority
Computation power	1.000	2.500	0.833	0.714	0.555	0.625	1.667	1.250	1.009	0.112
Service response time	0.400	1.000	0.333	0.286	0.222	0.250	0.666	0.500	0.538	0.060
Cost	1.200	3.000	1.000	0.857	0.666	0.750	2.000	1.500	1.211	0.134
Availability	1.400	3.500	1.167	1.000	0.777	0.875	2.333	1.750	1.413	0.157
Security	1.800	4.500	1.500	1.286	1.000	1.125	3.000	2.250	1.817	0.202
Efficiency	1.600	4.000	1.333	1.143	0.888	1.000	2.667	2.000	1.615	0.179
Maintenance	0.600	1.500	0.500	0.429	0.333	0.375	1.000	0.750	0.605	0.067
Adaptability	0.800	2.000	0.666	0.571	0.444	0.500	1.333	1.000	0.807	0.090
Sum	8.8	22	7.332	6.286	4.885	5.5	14.666	10	9.015	1.000

Table 4.3: Calculation of Criteria Priority for parameters

Figure 4.2 shows the criteria priority for all the QoS parameters where calculation of the sum of all the parameters in percentage is done, it will achieve 100%. The percentage value of the parameters shows that value for each parameter which is calculated by taking $8^{th} root$ of each parameter dividing by the sum of $8^{th} root$ of all parameters one by one and then converting into percentage with multiplying by 100.

4. Comparison among alternate services taking computation power:
As shown in table, Computation power as the parameter is taken and comparison among the alternate services are taken, three service as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table[Table 3.1], for the Amazon web service, computation power is

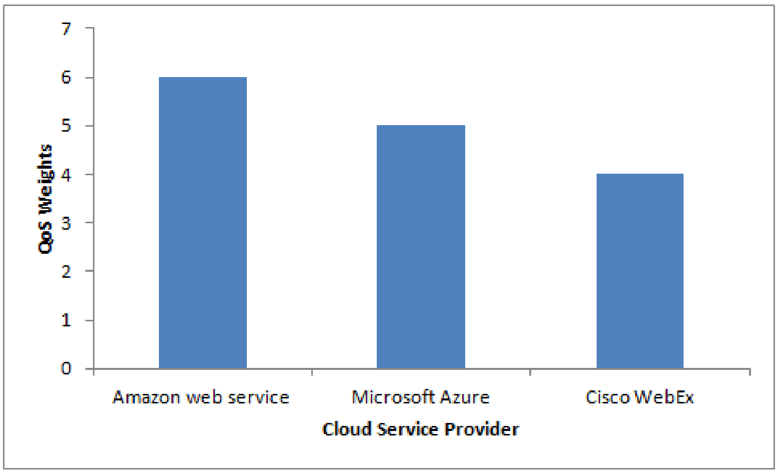

Figure 4.3: Comparison among alternate services taking computation power

"mostly to much more mostly favored"(value 6), for the Microsoft Azure, computation power is "mostly favored"(value 5) and for the Cisco WebEx, computation power is "more to mostly favored"(value 4). This way the value for Computation power for every service is calculated. This is done by dividing service 1 relative weight to other service relative weight and then the $3^{rd}root$ is calculated by dividing the service weight of Amazon to other services weight one by one for finding the values of first row and same for other rows as well.

Figure 4.3 depicts the ratings of QoS parameter taking computation power

	Amazon web service	Microsoft Azure	Cisco WebEx	$3^{rd}root$ with product	Criteria Priority
Amazon web service	1.000	1.200	1.500	1.216	0.404
Microsoft Azure	0.83	1.000	1.25	1.013	0.336
Cisco WebEx	0.600	0.800	1.000	0.783	0.260
Sum	2.430	3.000	3.750	3.012	1.000

Table 4.4: Relative weights of the alternate services taking computation power

according to the different cloud service provider requirements which is considered through the scale table Table 3.1. The x-axis shows the QoS parameters[11] and the Y-axis shows the QoS weights which is analyzed from the scale table. Computation power as the parameter is taken and comparison among the alternate services where three services are taken as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table Table 3.1, for the Amazon web service, computation power is "mostly to

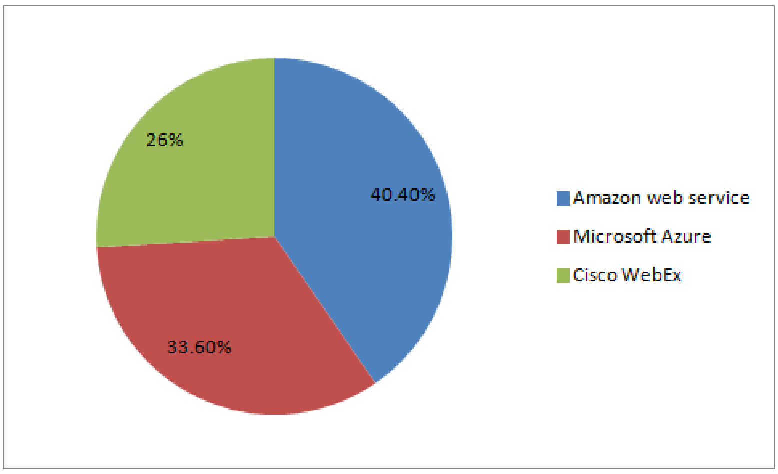

Figure 4.4: Percentage view taking computation power in services

much more mostly favored"(value 6), for the Microsoft Azure, computation power is "mostly favored" (value 5) and for the Cisco WebEx, computation power is "more to mostly favored"(value 4). This way the value for Computation power for every service is calculated.

Figure4.4 illustrates the criteria priority for the alternate service providers where calculation of the sum of all the services in percentage is done, it will achieve 100% taking computation power in consideration. The priorities calculated by dividing the $3^{rd} root$ of each parameter with the sum of all the values of $3^{rd} root$.

5. Comparison among alternate services taking service response time:
As depicted in the table, service response time is taken as the parameter and compare among the alternate services where it is taking three service as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table Table **??**, for the Amazon web service, service response time is "much much more mostly favored"(value 9), for the Microsoft Azure, service response time is "much more mostly favored"(value 7) and for the Cisco WebEx, service response time is "mostly favored"(value 5).

Figure 4.5 shows the ratings of QoS parameter taking service response time according to the different cloud service provider requirements which is considered through the scale table Table 3.1. The x-axis shows the QoS parameters[11] and the Y-axis shows the QoS weights which is analyzed

	Amazon web service	Microsoft Azure	Cisco WebEx	$3^{rd}root$ with product	Criteria Priority
Amazon web service	1.000	1.286	1.800	1.323	0.429
Microsoft Azure	0.778	1.000	1.400	1.029	0.333
Cisco WebEx	0.556	0.714	1.000	0.735	0.238
Sum	2.334	3.000	4.200	3.087	1.000

Table 4.5: Relative weights of the alternate services taking service response time

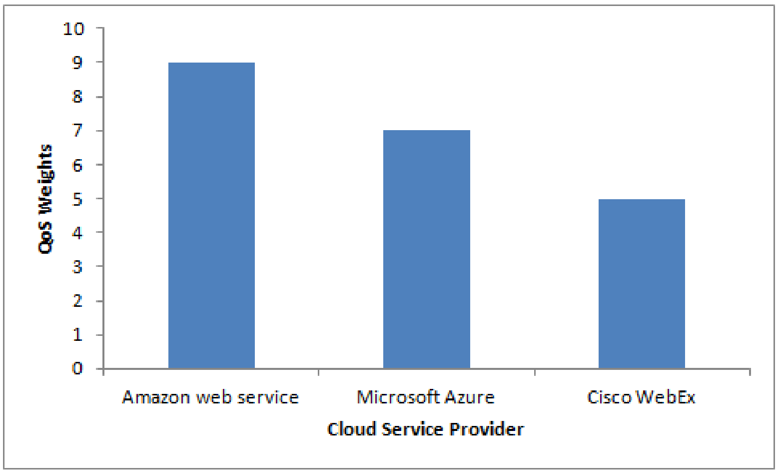

Figure 4.5: Comparison among alternate services taking service response time

from the scale table. Service response time is taken as the parameter and comparison among the alternate services where it is taking three service as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the scale table Table 3.1, for the Amazon web service, service response time is "much much more mostly favored"(value 9), for the Microsoft Azure, service response time is "much more mostly favored"(value 7) and for the Cisco WebEx, service response time is "mostly favored" (value 5).

Figure 4.6 illustrates the criteria priority for the alternate service providers where calculation of the sum of all the services in percentage is done, it will achieve 100% taking service response time in consideration. The priorities calculated by dividing the $3^{rd}root$ of each parameter with the sum of all the values of $3^{rd}root$.

6. Comparison among alternate services taking cost:

As given in the table, cost is taken as the parameter and comparison among the alternate services are taken, three services as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale ta-

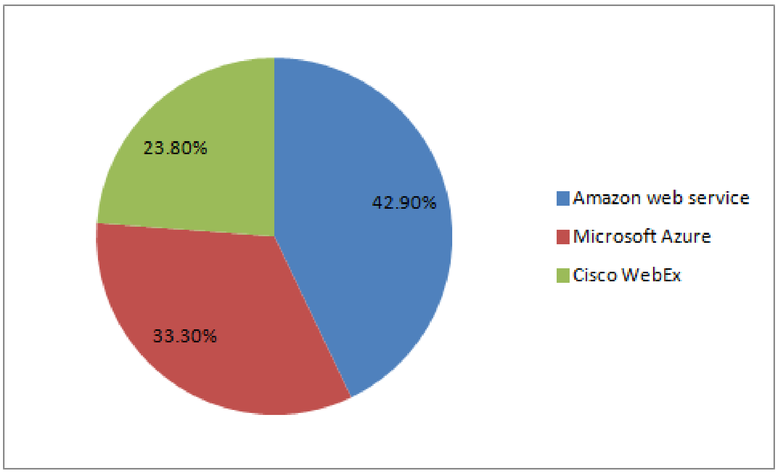

Figure 4.6: Percentage view taking service response time in services

ble, for the Amazon web service, cost is "much more to much much more mostly favored"(value 8), for the Microsoft Azure, cost is "mostly to much more mostly favored"(value 6) and for the Cisco WebEx, cost is "mostly favored"(value 5).

Figure 4.7 depicts the ratings of QoS parameter taking cost according to

	Amazon web service	Microsoft Azure	Cisco WebEx	$3^{rd} root$ with product	Criteria Priority
Amazon web service	1.000	1.333	1.600	1.287	0.421
Microsoft Azure	0.750	1.000	1.200	0.965	0.316
Cisco WebEx	0.625	0.833	1.000	0.805	0.263
Sum	2.375	3.166	3.800	3.057	1.000

Table 4.6: Relative weights of the alternate services taking cost

the different cloud service provider requirements which is considered through the scale table Table 3.1. The x-axis shows the QoS parameters[11] and the Y-axis shows the QoS weights which is analyzed from the scale table. Cost is taken as the parameter is taken and comparison among the alternate services are taken, three service as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table, for the Amazon web service, cost is "much more to much much more mostly favored"(value 8), for the Microsoft Azure, cost is "mostly to much more mostly favored"(value 6) and for the Cisco WebEx, cost is "mostly favored" (value 5).

Figure 4.8 shows the criteria priority for the alternate service providers where calculation of the sum of all the services in percentage is done, it

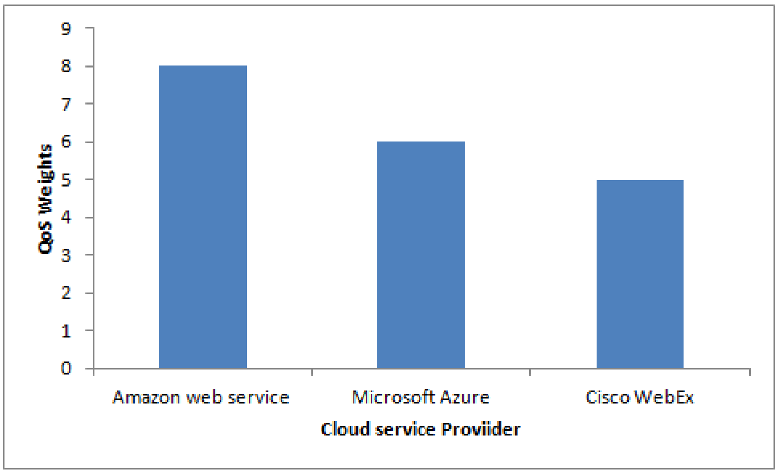

Figure 4.7: Comparison among alternate services taking cost

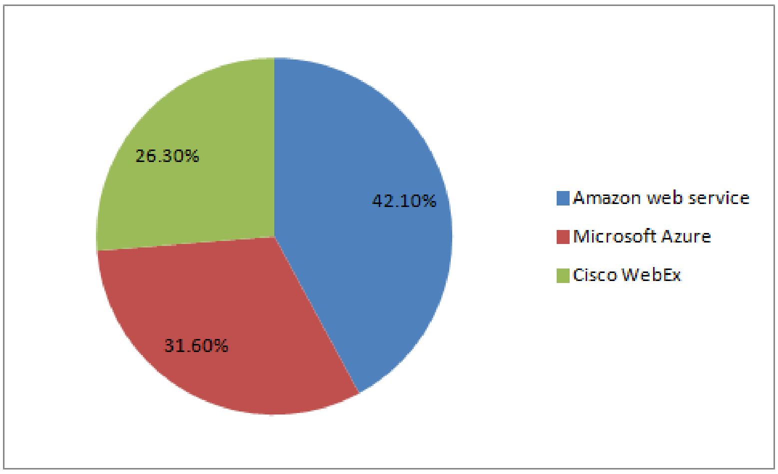

Figure 4.8: Percentage view taking cost in services

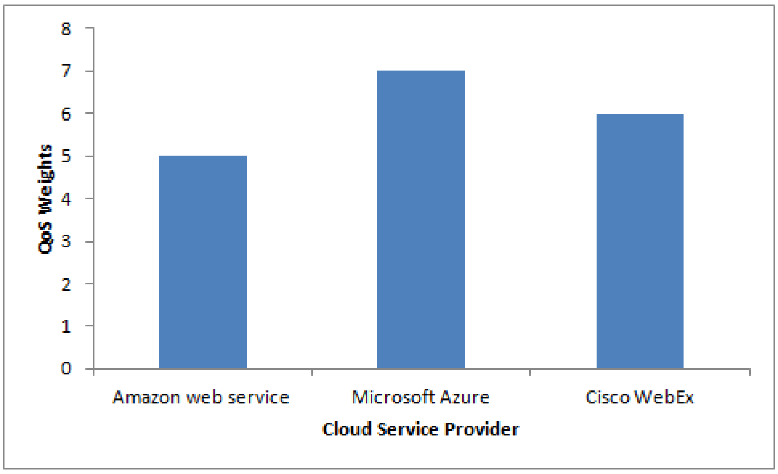

Figure 4.9: Comparison among alternate services taking availability

will achieve 100% taking cost in consideration. The priorities calculated by dividing the $3^{rd}root$ of each parameter with the sum of all the values of $3^{rd}root$.

7. Comparison among alternate services taking availability: As depicted in the table, availability is taken as the parameter and comparison among the alternate services are taken, three services as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table, for the Amazon web service, availability is "mostly favored"(value 5), for the Microsoft Azure, availability is "much more mostly favored"(value 7) and for the Cisco WebEx, availability is "mostly to much more mostly favored"(value 6).

   Figure 4.9 shows the ratings of QoS parameter taking availability accord-

	Amazon web service	Microsoft Azure	Cisco WebEx	$3^{rd}root$ with product	Criteria Priority
Amazon web service	1.000	0.714	0.833	0.841	0.278
Microsoft Azure	1.400	1.000	1.167	1.178	0.389
Cisco WebEx	1.200	0.857	1.000	1.009	0.333
Sum	3.600	2.571	3.000	3.028	1.000

Table 4.7: Relative weights of the alternate services taking availability

ing to the different cloud service provider requirements which is considered through the scale table Table 3.1. The x-axis shows the QoS parameters[11] and the Y-axis shows the QoS weights which is analyzed from the scale table.

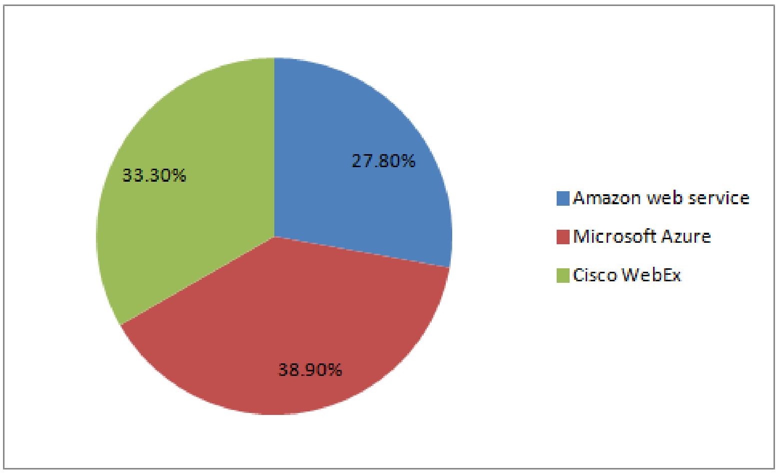

Figure 4.10: Percentage view taking availability in services

Availability is taken as the parameter and comparison among the alternate services are taken, three services as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table, for the Amazon web service, availability is "mostly favored" (value 5), for the Microsoft Azure, availability is "much more mostly favored"(value 7) and for the Cisco WebEx, availability is "mostly to much more mostly favored"(value 6).

Figure 4.10 illustrates the criteria priority for the alternate service providers where calculation of the sum of all the services in percentage is done, it will achieve 100% taking cost in consideration. The priorities calculated by dividing the $3^{rd} root$ of each parameter with the sum of all the values of $3^{rd} root$.

8. Comparison among alternate services taking security: As given in the table, security is taken as the parameter and comparison among the alternate services are taken, three service as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table, for the Amazon web service, security is "much more to much much more mostly favored"(value 8), for the Microsoft Azure, security is "mostly to much more mostly favored"(value 6) and for the Cisco WebEx, security is "more to mostly favored"(value 4).

Figure 4.11 depicts the ratings of QoS parameter taking security according to the different cloud service provider requirements which is considered

	Amazon web service	Microsoft Azure	Cisco WebEx	$3^{rd}root$ with product	Criteria Priority
Amazon web service	1.000	1.333	2.000	1.387	0.444
Microsoft Azure	0.750	1.000	1.500	1.040	0.333
Cisco WebEx	0.500	0.667	1.000	0.694	0.222
Sum	2.250	3.000	4.500	3.121	1.000

Table 4.8: Relative weights of the alternate services taking security

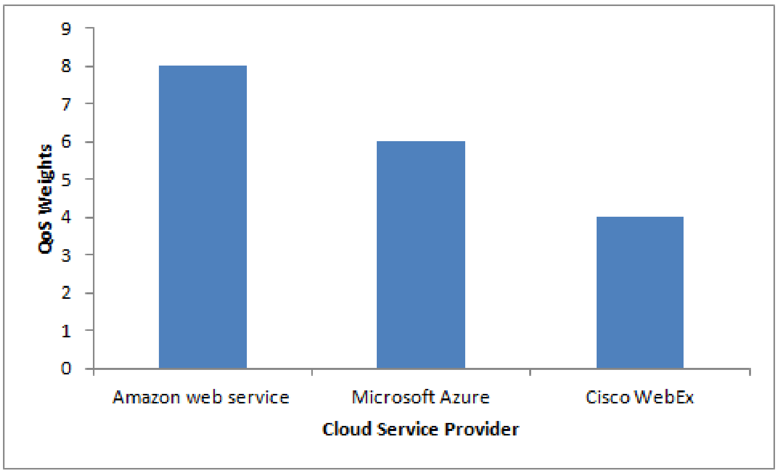

Figure 4.11: Comparison among alternate services taking security

through the scale table Table 3.1. The x-axis shows the QoS parameters[11] and the Y-axis shows the QoS weights which is analyzed from the scale table. Security is taken as the parameter and comparison among the alternate services are taken, three service as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table, for the Amazon web service, security is "much more to much much more mostly favored"(value 8), for the Microsoft Azure, security is "mostly to much more mostly favored"(value 6) and for the Cisco WebEx, security is "more to mostly favored"(value 4).

4.12 illustrates the criteria priority for the alternate service providers where calculation of the sum of all the services in percentage is done, it will achieve 100% taking security in consideration. The priorities calculated by dividing the $3^{rd}root$ of each parameter with the sum of all the values of $3^{rd}root$.

9. Comparison among alternate services taking efficiency: As shown In the table, efficiency is taken as the parameter and comparison among the alternate services are taken, three service as Amazon web service, Microsoft Azure and

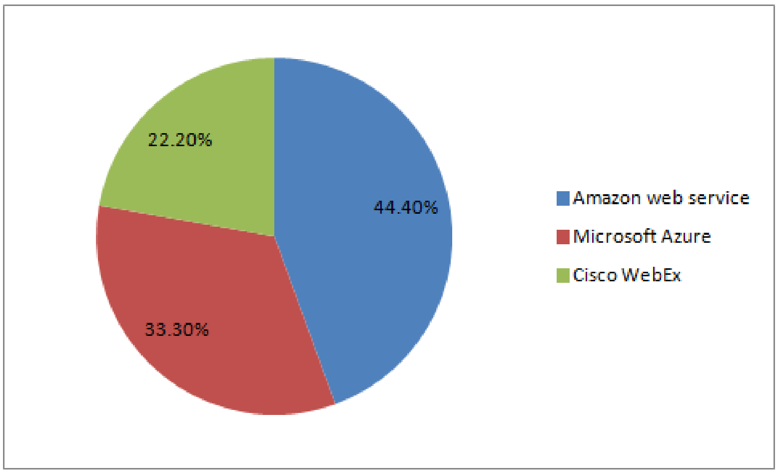

Figure 4.12: Percentage view taking security in services

Cisco WebEx. As compared with the above scale table, for the Amazon web service, efficiency is "much much more mostly favored"(value 9), for the Microsoft Azure, efficiency is "much more mostly favored"(value 7) and for the Cisco WebEx, efficiency is "mostly to much more mostly favored"(value 6).

Figure 4.13shows the ratings of QoS parameter taking efficiency accord-

	Amazon web service	Microsoft Azure	Cisco WebEx	$3^{rd}root$ with product	Criteria Priority
Amazon web service	1.000	1.286	1.500	1.245	0.409
Microsoft Azure	0.778	1.000	1.167	0.968	0.318
Cisco WebEx	0.667	0.857	1.000	0.830	0.273
Sum	2.445	3.143	3.667	3.043	1.000

Table 4.9: Relative weights of the alternate services taking efficiency

ing to the different cloud service provider requirements which is considered through the scale table Table 3.1. The x-axis shows the QoS parameters[11] and the Y-axis shows the QoS weights which is analyzed from the scale table. Efficiency is taken as the parameter and comparison among the alternate services are taken, three service as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table, for the Amazon web service, efficiency is "much much more mostly favored"(value 9), for the Microsoft Azure, efficiency is "much more mostly favored"(value 7) and for the Cisco WebEx, efficiency is "mostly to much more mostly favored"(value 6).

Figure 4.14 illustrates the criteria priority for the alternate service providers

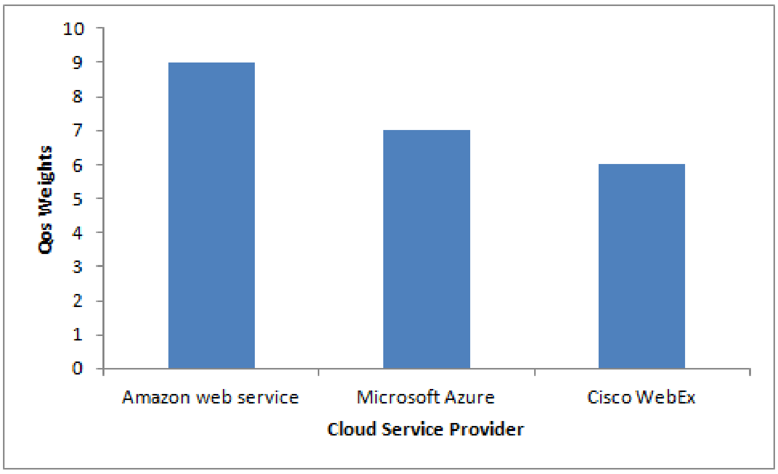

Figure 4.13: Comparison among alternate services taking efficiency

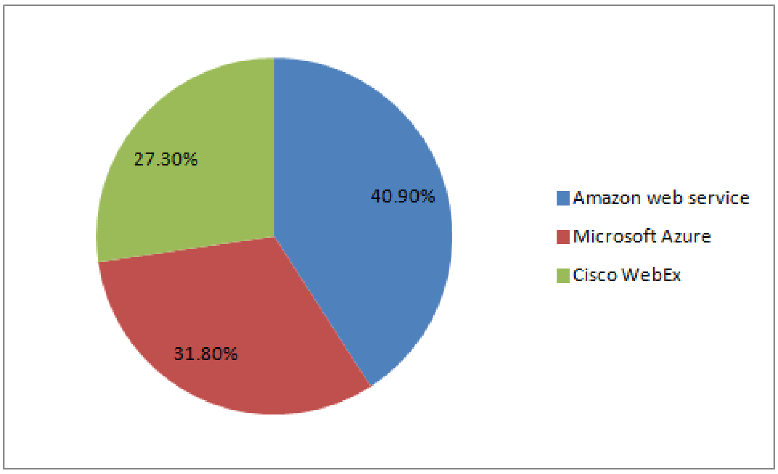

Figure 4.14: Percentage view taking efficiency in services

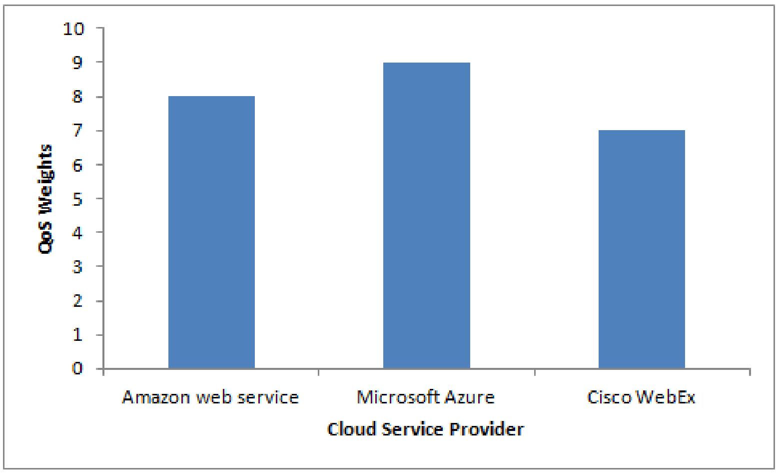

Figure 4.15: Comparison among alternate services taking maintenance

where calculation of the sum of all the services in percentage is done, it will achieve 100% taking efficiency in consideration. The priorities calculated by dividing the $3^{rd}root$ of each parameter with the sum of all the values of $3^{rd}root$.

10. Comparison among alternate services taking maintenance: A depicted In the table, maintenance is taken as the parameter and comparison among the alternate services are taken, three service as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table, for the Amazon web service, maintenance is "much more to much much more mostly favored"(value 8), for the Microsoft Azure, maintenance is "much much more mostly favored"(value 9) and for the Cisco WebEx, maintenance is "much more mostly favored"(value 7).

	Amazon web service	Microsoft Azure	Cisco WebEx	$3^{rd}root$ with product	Criteria Priority
Amazon web service	1.000	0.889	1.143	1.005	0.333
Microsoft Azure	1.125	1.000	1.286	1.131	0.375
Cisco WebEx	0.875	0.778	1.000	0.880	0.292
Sum	3.000	2.667	3.429	3.016	1.000

Table 4.10: Relative weights of the alternate services taking maintenance

Figure 4.15 depicts the ratings of QoS parameter taking maintenance according to the different cloud service provider requirements which is considered

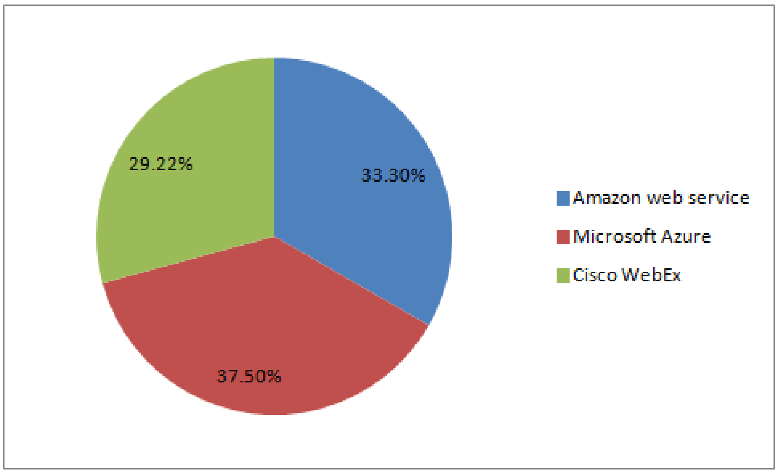

Figure 4.16: Percentage view taking maintenance in services

through the scale table Table 3.1. The x-axis shows the QoS parameters[11] and the Y-axis shows the QoS weights which is analyzed from the scale table. Maintenance is taken as the parameter and comparison among the alternate services are taken, three service as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table, for the Amazon web service, maintenance is "much more to much much more mostly favored"(value 8), for the Microsoft Azure, maintenance is "much much more mostly favored"(value 9) and for the Cisco WebEx, maintenance is "much more mostly favored"(value 7).

Figure 4.16 illustrates the criteria priority for the alternate service providers where calculation of the sum of all the services in percentage is done, it will achieve 100% taking maintenance in consideration. The priorities calculated by dividing the $3^{rd} root$ of each parameter with the sum of all the values of $3^{rd} root$.

11. Comparison among alternate services taking adaptability: As given In the table, adaptability is taken as the parameter and comparison among the alternate services are taken, three service as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table, for the Amazon web service, adaptability is "mostly to much more mostly favored"(value 6), for the Microsoft Azure, adaptability is "much much more mostly favored"(value 9) and for the Cisco WebEx, adaptability is "much

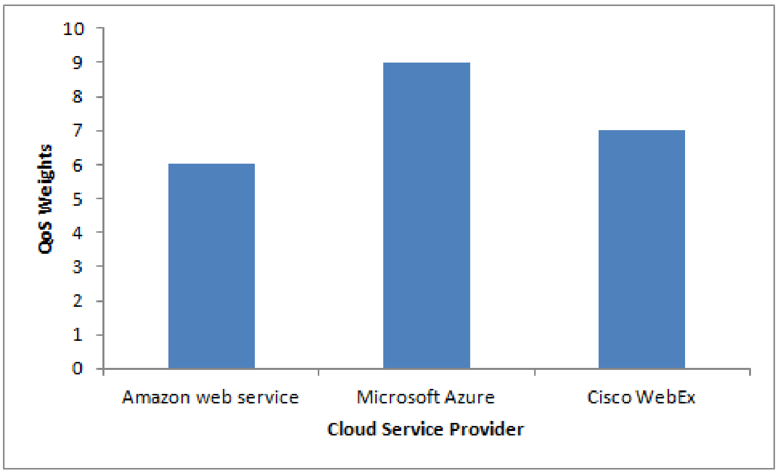

Figure 4.17: Comparison among alternate services taking adaptability

more mostly favored"(value 7).

	Amazon web service	Microsoft Azure	Cisco WebEx	$3^{rd}root$ with product	Criteria Priority
Amazon web service	1.000	0.667	0.857	0.830	0.273
Microsoft Azure	1.500	1.000	1.286	1.245	0.409
Cisco WebEx	1.167	0.778	1.000	0.968	0.318
Sum	3.667	2.445	3.143	3.043	1.000

Table 4.11: Relative weights of the alternate services taking adaptability

Figure4.17 shows the ratings of QoS parameter taking adaptability according to the different cloud service provider requirements which is considered through the scale table Table 3.13.1. The x-axis shows the QoS parameters[11] and the Y-axis shows the QoS weights which is analyzed from the scale table. Adaptability is taken as the parameter and comparison among the alternate services are taken, three service as Amazon web service, Microsoft Azure and Cisco WebEx. As compared with the above scale table, for the Amazon web service, adaptability is "mostly to much more mostly favored"(value 6), for the Microsoft Azure, adaptability is "much much more mostly favored"(value 9) and for the Cisco WebEx, adaptability is "much more mostly favored"(value 7).

Figure4.18 illustrates the criteria priority for the alternate service providers where calculation of the sum of all the services in percentage is done, it will achieve 100% taking adaptability in consideration. The priorities calculated

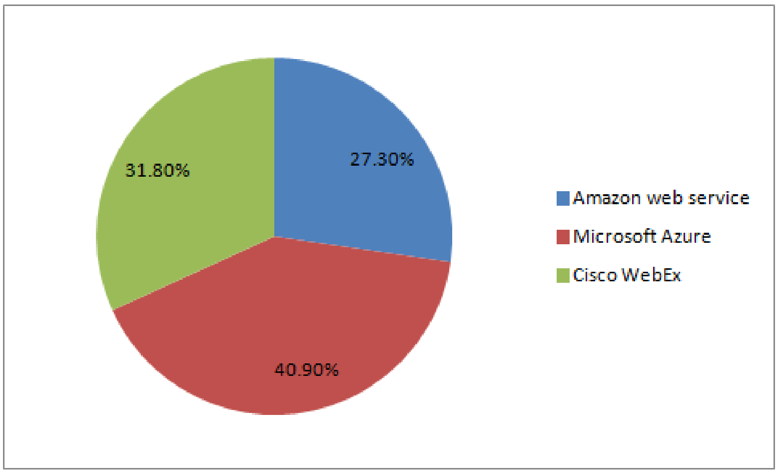

Figure 4.18: Percentage view taking adaptability in services

by dividing the $3^{rd} root$ of each parameter with the sum of all the values of $3^{rd} root$.

4.2 Performance Calculation

In this section, the evaluation of the service selection is done on the basis of the final results solved in earlier tables. The criteria priority weights of the QoS parameters solved through the pair wise comparisons from the scale table Table 3.1.The final results are evaluated as follows:

1. Finding the optimum cloud service: As depicted in the table 4.12, we are finding out the optimum cloud service by using the criteria values of all the QoS parameters considered and ranking of the services. By this we will get to know that which the best service used for the organization and business requirements. The one which gets the highest ratings of criteria priority will be the winner and that service is selected. This can be helpful for business, IT companies and user requirements. This can also be used for to know which service can be selected on basis of the required parameters according to the business and user requirements accordingly if any of the parameters lacks so the organization can select that service which fulfills its Qos requirements. Figure 4.19 shows the final results of the cloud service selection. The x-axis shows the QoS parameters considered in for cloud service selection and the y-axis shows the Criteria priority which is calculated through

	Computation power	Service response time	Cost	Availability	Security	Efficiency	Maintenance	Adaptability	Result
	0.112	0.060	0.134	0.157	0.202	0.179	0.067	0.090	1.000
Amazon web service	0.404	0.429	0.421	0.278	0.444	0.409	0.333	0.273	0.381
Microsoft Azure	0.336	0.333	0.316	0.389	0.333	0.318	0.375	0.409	0.296
Cisco WebEx	0.260	0.238	0.263	0.333	0.222	0.273	0.292	0.318	0.325
	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 4.12: Finding the optimal Cloud service provider

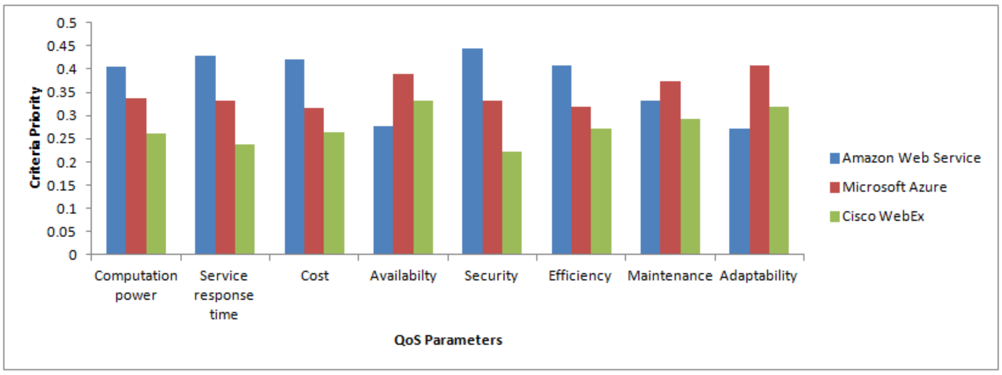

Figure 4.19: Final results of cloud service provider showing each parameter

the consideration of the values of the services in earlier tables for each parameter. Here, the Amazon service is having the highest bar among the other 3 services so, it is selected as the optimum service.

Figure 4.20 depicts the criteria priority for the alternate service providers where calculation of the sum of all the services in percentage is done, it will achieve 100% and the one which has the maximum criteria priority is the best service selected for the use in the organization and the businesses.

Also it can be concluded that “Amazon web service >Cisco WebEx >Mi-

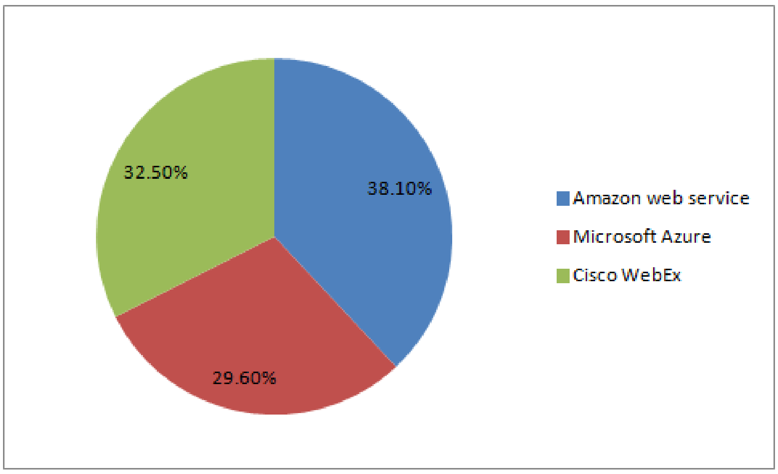

Figure 4.20: Optimal selection of Cloud service provider

crosoft Azure".

2. So, through the results we get to know that Amazon web cloud service gets the maximum score points, so it wins and it is selected for the cloud business purposes and fulfills the user requirements in the market environment. Similarly, an optimistic cloud service is obtained according to the user and business requirement.

4.3 Summary

Here, the detailed implementation is done and analyzed through tables, graphs and pie charts. The implementation of the algorithm and outputs is analyzed in this part of the report. The resultant of the cloud service provider is attained through the evaluation of various parameters' weights and criteria priority. Through this, it is analyzed that firstly the problem is integrated for relative weights and then divided for the final optimal cloud service.

Chapter 5

CONCLUSION AND FUTURE WORK

The final conclusion in the research work would give us the cloud service provider along with the task of the parameter's relative weights through the customer analysis of requirements and businesses needs. At the end, it gives the simple and an efficient method to find the solution to the problem faced by the companies, organizations, and corporate sector. The problem is also faced by the start up companies who require their data to be processed and stored, also there is computation power, bandwidth, network, etc. So, for this, there is an effective approach in this thesis work for getting the optimum result of cloud service provider that fulfills these kind of issues.

5.1 Future Work

The implementation of selecting the cloud service provider can be improved by increasing the depth of the AHP process which will give the better results like we can increase more levels and more deeper comparisons. Also QoS parameters can be correlated for more better results. Alongwith this, the scale table can be increased to sub value as from 1 to 1.1 and further sub sub values and so on. Through this, the result of the service selection of cloud provider can be deeply judged with more inner knowledge about the parameter and service judgment.

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