I J C T A, 9(19) 2016, pp. 9071-9081

Virtual Machine Placement for Elastic Clouds with QoS

K R Remesh Babu[*], Anija V S[*] and Philip Samuel[**]

ABSTRACT

Cloud computing provides high-end computing services to the customers with low cost. Service Level Agreements (SLA) are extremely important in cloud computing to ensure Quality of Service (QoS). If SLA violation occurs, it will affect the user's satisfaction level, this will interns reduces number of customers as well as profit of the provider. Inorder to ensure the users satisfaction, provider's have to take measures to ensure the QoS. Elastic services in cloud comprise multiple virtualized resources that can be added or deleted on demand to cope with variability in the workload. Different Virtual Machine (VM) migration policies also help in maintaining QoS. This paper proposes a pre-copy approach in virtual machine migration for better service to the users. In this hot migration method; the hypervisor copies all memory pages from the source to the destination. The target VM is selected based on the auction based migration strategy.

Keywords: Cloud computing, VM placement, Cost, SLA, QoS.

I. INTRODUCTION

Cloud computing is a paradigm in which distinct IT resources can be dynamically provisioned and presented as one or unified computing resources based on SLA between service provider and customer. Many people's use the applications of cloud computing. In cloud computing the delivery computing services is carried over the internet. The cloud services are provided by the third parties called as service provider's offer their services as pay-as-you go manner. The users are the individuals or the businesses, use hardware and software offered by these third parties in the remote locations. The examples of cloud storage service include email, online file storage, online business applications etc. In cloud computing we can access the data and resources from any ware in the world ant any time over the internet. The main features of cloud computing is their service can be scaled large or small on demand [20].

The cloud computing service models can mainly classified into three types, Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as Service (IaaS) [19]. The SaaS model provide different software applications from third party providers to the users, while PaaS model mainly provides platform for developing different software applications. It also provides operating system and server software to the developers. IaaS model provide the hardware and network, which is the fundamental building block of the cloud environment. The users can install operating system, software and applications as they want on these infrastructure.

Now a days the term elasticity heavily used in cloud computing. The elasticity in cloud computing is the ability to scale or grow on demand. The term elasticity is heavily used by the cloud providers in their advertisement to attract more customers and to get more profit. Elasticity enables a service provider to add or remove the resources based on number of customers. During this scaling process the provider hire the

[*] Department of Information Technology, Government Engineering College, Idukki, Kerala, India, *E-mails: remeshbabu@yahoo.com; anija_vs@ymail.com*

[**] Division of Information Technology, Cochin University of Science and Technology, Kochi, Kerala, India, *E-mail: philipcusat@gmail.com*

resource from another service provider or from their own datacenters which are geographically located in another place in order to maintain the QoS agreed in SLA.

Another important concept in cloud computing is VM migration. Mainly VM migration can be used for load balancing, fault tolerance, reduce SLA violation etc. In the proposed system VM migration is used for reducing SLA violations and for efficient load balancing. In the VM migration proves it copies all the memory pages from the source machines to destination without stopping the services. If a service provider offers several services, when the demand for a service increased and the service provider don't have enough resources for accept new requests, then migration process started for transferring the existing VM or new VM to another cloud provider by considering the migration cost and time. The VM migration technique helps to overcome the SLA violations. A performance study about the VM startup time is carried out in [18].

SLA has a vital role in maintain QoS in cloud computing. It is an agreement between the customer and service provider of a cloud. SLA is a representation of all features of the service; that means the provided functionalities and the qualities of the service. Also SLA includes the penalty details when the service provides cannot meet the standard. SLA contains the quality of each services that are maintained by the service provider, generally defined as Service Level Objectives. In cloud computing every time each activity can been monitored and recorded. If the standard of the service is less then give penalty for the user.

(A) Proposed System

Usually the service providers want to accept all the customer requests at the same time to increase their profit and to maintain their demand in the cloud market. So if a provider rejects a user request due to the unavailability of resource, then the next time that user will associate with another service provider. But considering the high demand for a short period, the provider cannot reserve too many resources for a customer because it will result in huge profit loss to them. Also these extra reserved resources may be in idle stage in most of the time due to lack of customer demand. So scaling the resources and migrates the processes on demand is the solution to accept any number of user requests at the same. The Amazon EC2 is an example.

Several researchers are working towards the development of an efficient SLA violation monitoring mechanism. The objective of the proposed system is to maintain the user satisfaction level at any time. In the proposed system the VM migration processes is implemented in federated cloud environment to overcome SLA violations. The proposed system is focus on reducing the SLA violation as well as to increase the service provider's profit. Also it addresses the elastic service placement problem. This paper also compares two types of migration that are matrix based and auction based migration based on cost and performance.

The rest of the paper is organized as follows. Section 2 contains the various works related to VM migration in cloud computing in order to maintain QoS. The system design is given in section 3. The experimental setup and results are discussed in section 4 and finally the paper ends with conclusion in section 5.

II. RELATED WORKS

There are two types of live migration techniques can be used in cloud computing; namely post copy and pre-copy migration. In live migration the performance can be measured in terms of preparation time, downtime, resume and total time. VM migration technique is mainly used for load balancing. Better migration technique will helps to reduce the downtime and total migration time and it give better performance in low band width. The network aware migration is based on the network latency, network traffic and various other related parameters.

The paper [1] discussed about resource management issues in modern heterogeneous data centers. They have reviewed more 250 research articles in this area. The paper provided a conceptual frame work for resource management in cloud computing. They identified some challenges in resource allocation with scalability. Open cloud computing concept and its interlinking issues are discussed in the paper [2]. This study is important due to heterogeneity in cloud resources.

A customer controlled VM placement strategy is presented in [3]. In order to reduce the computation cost, here the customer can exploit the performance heterogeneity. Their experimental results in EC2 shows that proposed heterogeneity-aware VM placement strategy gives 5% improvement in performance in CPU intensive jobs and 34% improvement in bandwidth intensive jobs.

The paper [4] gives an overview of designing an auto-scaler in cloud. It is only tested for simple applications in cloud and tested for CPU intensive dynamic cloud applications. The heterogeneous resource allocation problem with varying user demands is considered in paper [5]. A generalized max-min algorithm called Dominant Resource Fairness (DRF) is used for resource allocation. They tested the method in a cluster and compared results with slot-based fair sharing scheme.

A trace based workload management is implemented in the paper [6]. A workload controller is integrated with a reactive controller to help in the case of migration and server consolidation. Here to reduce power consumption the workloads in the lightly loaded servers are migrated. The method is tested in blade and server based resource pool infrastructure.

A VM placement strategy based on bin packing method is presented in [7]. Here best-fit - worst-fit strategy is used for optimal resource allocation. Best-fit method is used for job scheduling and VMs are placed using worst-fit method. The experimental results for number of PMs used, storage space comparison, and power utilization are compared with different combinations of best and worst strategies. The results are promising.

Virtual machine migration enabled cloud resource management is a challenging task. The paper [8] discussed about various basic elements of virtual machine migration. The service providers increase their profit by using virtual machine migration. Also in this paper discussed about virtualization technique. The virtualization technique helps the service providers by enabling scalability, consolidation and utilization, isolation, manageability and robustness. In this paper they also discussed about applications of migration like load balancing, green servers etc.

The review paper [9] given a complete overview of the different virtual machine placement schemes so far invented in cloud computing. The advantages and limitations of each method is discussed and compared with different methods. It also classifies the methods based on the type of algorithm used for VM placement.

Database Scalability, Elasticity, and Autonomy in the Cloud [10] present the cloud features in data base systems that support for different applications. Scalability and elasticity related to each other. It support adding or removing any number of request at time without degrading its performance. The data base autonomy is an important factor in cloud computing. Cloud is an interconnection of large and huge systems. So the management, operation of large systems, monitoring etc. are difficult. So to use the autonomous systems have ability to manage and monitoring its self. So it reduce energy and operation cost.

SLA aware multi-virtual machine placement [11], Mobile applications in cloud [12], consumer centric dynamic provisioning [13], energy aware methods [14], market oriented cloud [15] and QoS monitoring method [16] are some of the other VM placement methods in cloud computing.

Some of the main practical cloud resource allocation methods are discussed above. Here the main focus is on VM placement with elastic cloud support. Based on the observations from these literature reviews, the proposed system design is illustrated in next section.

III. SYSTEM DESIGN

The architecture for the proposed system is given in fig. 1. A real cloud account is setup with physical servers. There are several cloud providers and manyservices are offered by these service providers. The providers assign maximum number of users in each service in physical services inroder increase the profit. The service provider can fix the cost for each service. Based on the demand the cost of a particular service can be varied dynamically. So there will not be a unique price for a particular service on datacenter at different times for different users on the same datacenter. Also remember that there are several service providers offers same service in different rate at the same time.

The service request from a customer, the system, collects the user requirements such as type of service, memory requirement, storage space requirements, etc. By analyzing these needs and providers facility, the system prepares a SLA. In SLA the cost of each service provided by a provider can be announced. In case of migration needed, cost of migration is also calculated in this stage. The service provider can increase their cost when the demand of service rises. Also decreases the cost of service when the demand goes down. The cost of SLA violation is also calculated as per SLA, in the case of a violation of SLA. Here the provider calculates the migration cost and compares the migration cost with calculated penalty cost. The migration cost based on the processing power of other physical servers are then announced. If the migration cost greater than the penalty then provider give the penalty to the user. If the penalty greater than the migration cost then the particular service can migrated to other physical server having lower cost.

In the proposed system each service provider have a virtual machine monitor to accept the request from the user and decide whether the request can be allocated to its own physical server or it can be migrated to other low cost virtual machines in another physical servers in another datacenter. The VM monitor can find out which service is need for the user. Then it calculate the remaining resources available for the service. If it is enough for accepting the new user requests, it creates new virtual machine and assign if for the users. If enough resource is not available to create VM as user requested then find out the new provider for to fulfill the user needs.

The proposed method is explained in into two parts. In the first part defines the problem and second part shows how to solve this problem using auction based method. Finally compares auction and matrix based virtual machine migration techniques. This is inorder to find out better one in terms of cost and performance.

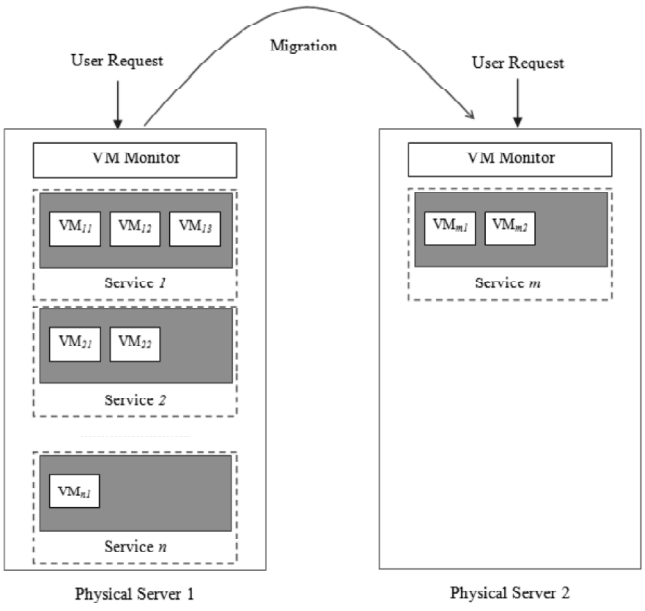

Figure 1: System Architecture

(A) Virtual Machine Placement Problem

Cloud service providers offer different services such as computing, storagese, applications, etc. The prices of these services vary from one service provider to another service provider. The price of these services also varies depends on the demand and time. One service provider offers the same service for different prices at same time based on the type, speed of execution and other functionalities provided. If several users select one service provider at the same time, in order to serve the user requests the provider need extra resources in short interval of time. In this circumstance a proper VM migration strategy is needed. So the problem is to identify the right service provider to migrate the process of customer on service provider to another. The newly selected service provider has to maintain the SLA of the previous service provider to cope with the QoS requirement of the customer. Finding an efficient service provider with user requested QoS is a challenging problem in the dynamic cloud environment.

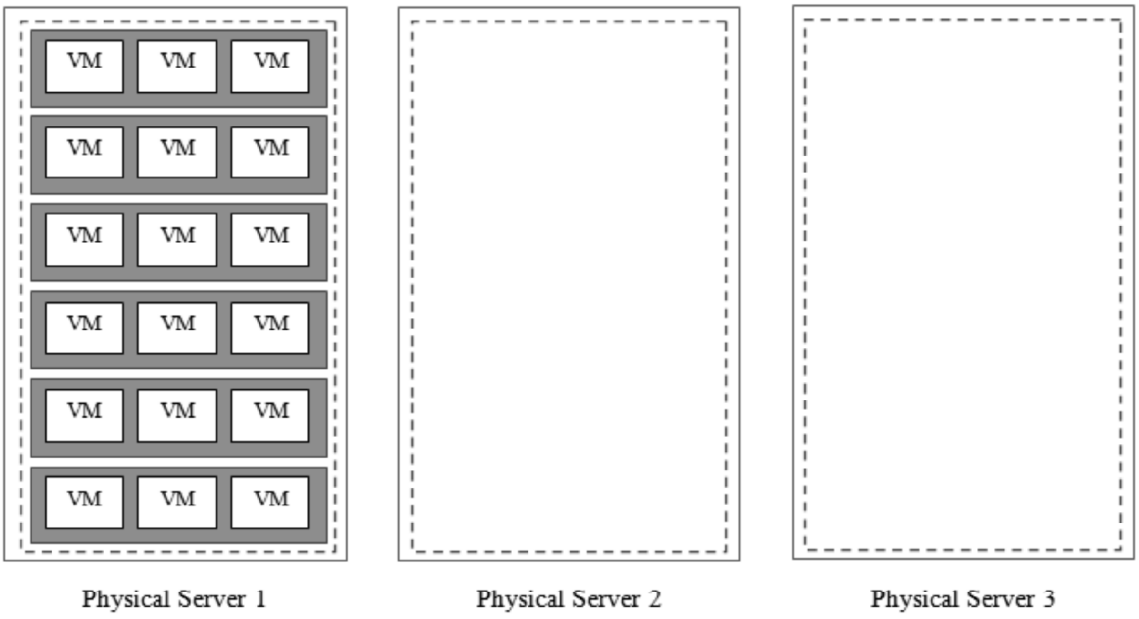

Figure 2(a): VM Placement before Migration

The fig. 2 (a) and 2 (b) illustrates the VM placement problem. Fig. 2(a) represents the state of a physical machine before VM migration. The physical server 1 contains several VMs and there is a chance of SLA violations. At the same time other servers idle or having only few VMs running on that. The scenario after the successful VM migration is shown in the fig. 2(b). Some VMs from the physical server 1 is transferred to servers 2 and 3 by considering the terms and conditions in the service level agreement. Quality terms and conditions have to agree between both service provider and customer at the time of registration itself. SLA used in this proposed system contains the penalty to the provider in case provider unable to meet quality requirements as specified in the agreement. Here the system aassigns a rank for each user based on their willingness to pay for a service. That means how much pay for that service. The highest ranked or high priority users must be migrated to reduce the penalty rate.

(B) Auction Based Migration

This auction based migration is the solution proposed for addressing the virtual machine placement to improve customer satisfaction. Since there are many service providers offers same service with different costs, an auction based migration strategy will findr virtual machine with lowest cost considering the QoS mentioned. This it is a multi-objective optimization problem. Here price and time are two contradictory objectives that we have to optimize. If we need computation in faster high-end resources, the price goes up.

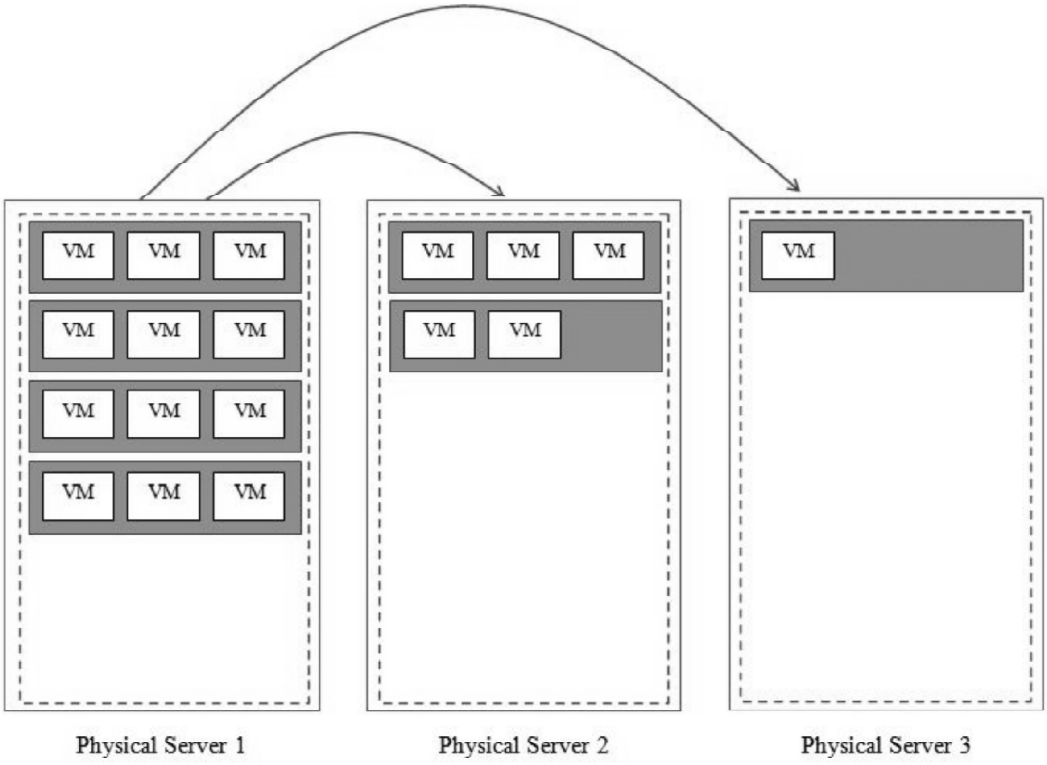

Figure 2(b): VM Placement after Migration

While the user needs low cost VMs, obliviously the time needed for computation goes up. Usually the user needs to process their applications in low cost high-end machines. From these conflicting objectives, the proposed auction based method finds suitable physical servers for VM placement. This scenario is shown in the fig. 2 with three physical servers. Then using auction based algorithm find out which service provider offer lowest migration cost for service 1 and migrate the new VM into that provider's physical server and repeated this process for all other services (here service 2 and service 3).

The auction base algorithm is shown in fig. 3. In this algorithm first accept the user request. Then examine the user request and identify the needs for the user. Then calculate the remaining resource available for the particular users. If the requested amount of resource less than the amount of available resource then accept the user request and create a virtual machine for that user for particular service, then allocate the user to new virtual machine. Else find out the priority of the request based on the willing to pay amount. The lowest priority request can be reject directly and if it have highest priority then calculate the penalty cost in case this request can be rejected. Then calculate the migration cost of each service exceeded separately to each providers. Because every providers have different rate for different services. Then find out the low migration cost for particular service and compare it with penalty cost. If the penalty cost is high then accept the request else reject the request. Then run this system in different conditions and find out the profit and migration time.

(C) Matrix Based Migration

Another migration strategy for optimal VM placement is based on cost matrix. This paper implemented cost matrix analysis for the efficient VM migration to the optimal servers. In this case the algorithm finds out service provider having lowest migration cost for a particular service.

The cost matrix algorithm first accepts the user request. Then it examines the user request and identifies their needs such as priority and cost. Then it calculates the remaining resource available for the users. If the requested amount of resource is less than the total available resource then the system accept the user

1. Start
2. Accept user requests
3. Identify the user requirements
4. Calculate remaining resources for requested services
5. If available_resource>requested_resource
   Goto step 6
   Else go to step7
6. Accept the user request and create virtual machine for allocate the user
7. Find out the priority(based on willing to pay)
   7.1 low priority: reject the request
   7.2 high priority: goto step 8
8. Find penalty cost for each service
9. Find migration cost
   9.1 n= no of services exceeded=no of service providers
   9.2 service i=1
   9.3 service_provider j=1
   9.4 For i=1 to n
       For j=1 to m
       If migration cost< penalty then accept the request ,Else reject the request and Give penalty to user
10. Calculate the profit and migration time
11. stop

Figure 3: Auction Algorithm

1. Start
2. Accept user requests
3. Identify the user requirements
4. Calculate remaining resources for requested services
5. If available_resource>requested_resource
   Goto step 6
   Else go to step7
6. Accept the user request and create virtual machine for allocate the user
7. Find out the priority(based on willing to pay)
   7.1 low priority:reject the request
   7.2 high priority: goto step 8
8. Find penalty cost for whole exceeded service
9. Find migration cost
   9.1 m=no of service providers
   9.2 service_provider j=1
   9.3 For j=1 to m
   If migration cost< penalty then accept the request
   Else reject the request and Give penalty to user
10. Calculate the profit and migration time
11. Stop

Figure 4: Cost Matrix Algorithm

request and create a virtual machine for that user for a particular service, and then allocate it them. If the requested amount of resources is not available in a physical server, the algorithm checks the priority of the request based on the amount the user willing to pay for a particular requested service. The lowest priority request can be rejected directly if there are sufficient number of highest priority requests based on the penalty to be paid to that customer in case of a request rejection. Then find out the no of exceeded services

under a service provider and find out total penalty, then also find out the lowest migration cost. If the migration cost is higher than the penalty, then the request can be rejected and give penalty to the user. Else the system accepts the user requests. Fig. 4 shows the cost matrix algorithm for optimal VM placement.

IV. EXPERIMENTAL SETUP

The objective of this paper is to reduce the SLA violation by implementing an optimal virtual machine migration technique and to find out the better migration method by considering the parameters such as service providers profit and migration time. This system tries to reduce SLA violation. In the proposed system SLA violation is measured in terms of availability of the memory. Evaluating algorithms on complex scenarios is a challenging issue.

(A) Experimental Setup

The proposed system implemented on real cloud environment using Gungoose free cloud provider. It provides free cloud hosting service. They offer most advanced free cloud hosting service without any advertisements. It has cluster of web servers that are all interconnected to act as one giant super computer. The three physical servers having 10 GB Disk Space is created. The internal bandwidth is 100 GB Bandwidth. Physical servers contain 10 MySQL databases, 10 Add-on domains, 10 Parked domains and 10 Sub domains. High performance CPU and 99.9% uptime guaranteed by the cloud provider during the experiment.

In Gungoose we created several accounts for each service. Each account contains fixed amount of resources such as memory, storage and processing power. Each service can be accessed by a limited number of users without degrading the performance level. A service have fixed amount of resource allocated. To evaluate the performance of the proposed system different users request are generated to the same resource, and the cost of resource is varied in fixed time interval based on user demand.

In the experimental scenario we considered three service providers each offer three different types of services, such as service1, service 2, service 3. The service considered as email, storage requirement and a word processing program. Service cost and migration cost for each service providers for different services are defined. The same service from different service providers will vary according to demand. Also defined penalty ratio for each service in case of violation. In the experiment the cost of services incremented or decremented based on the number of requests.

The table 1 shows the service providers, their services, service cost, migration cost and penalty defined. Based on the information from table1, if a migration situation occurs, the system finds out which server is a better target for VM migration considering the profit value. Then we created different resource demanding situations for different services and the changes the size of virtual machines. Based on this scenario, the system finds the time required for VM migration.

Table 1
Service provider - service information

Providers	*Services*	*Service cost*	*Migration cost (%)*	*Penalty (%)*
P1	S1	600	25	60
P1	S2	1000	50	90
P1	S3	800	40	80
P2	S1	800	60	60
P2	S2	800	40	90
P2	S3	600	20	80
P3	S1	600	40	60
P3	S2	1200	20	90
P3	**S3**	**1000**	**50**	**80**

One of the main difficulties of performance evaluation is the speed of internet. The speed of the network is an important term in found out the migration time. So we analyses the result in different bandwidth.

(B) Evaluation

Evaluation based on two parameters. That is cost and migration time. Based on these parameters the system find out which migration method is better.

(a) Profit Evaluation

Table 2
Providers Profit

Services	*No. of VMs (Actual + Exceeded)*	*Income*	*Migration cost*		*Profit*	
			Auction based migration	*Matrix calculation*	*Auction based migration*	*Matrix calculation*
Service 1	3+2=5	1800+820+1040=3660	150+150+150 +200=650	440+150+150 =770	3660+6400-650= 9410	3660+6400-770= 9290
Service 2	5+1=6	5000+1400=6400				
Service 3	0	0				

For profit evaluation the maximum number of acceptable VMs for service is fixed as 3, for service 2 is 5 and finally for service 3 is 4. The profit evaluation is done based auction method and matrix calculation method. If 5 request for service 1 came, then there are two virtual machines are waiting for service 1. Similarly one virtual machine queued in service 2 and there is no users requested for third service. At this time we evaluated the profit of the service provider and the values are given in table 2.

From table 2, the matrix migration method have the higher migration cost so it will reduce provider profit. For cost based analysis this result shows that, the best migration method is auction based migration, because algorithm independently finds lower cost providers for migration.

(b) Performance Evaluation

Here for the performance evaluation of the proposed method is based on the migration time for auction based migration and matrix calculation. In auction based migration, the user requests beyond the capacity

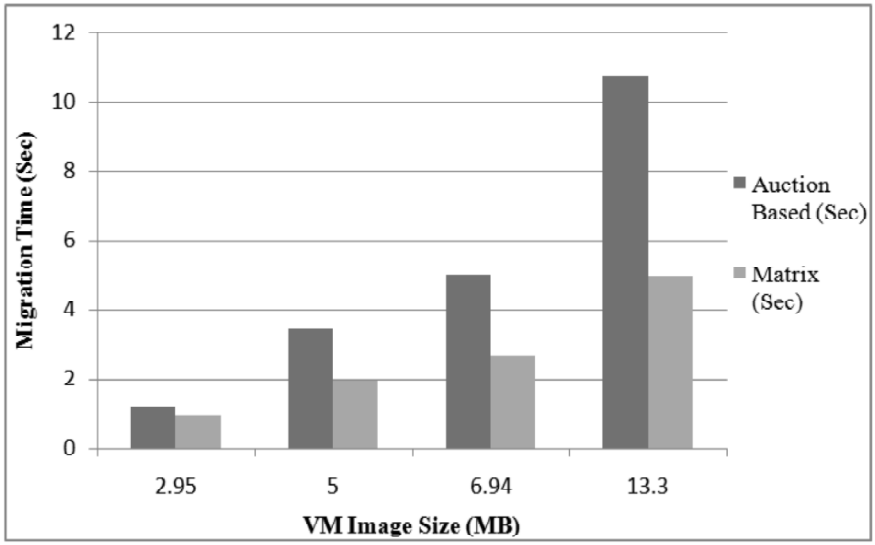

Figure 5: Performance Evaluation

of the service provider can be independently migrated at the time of the arrival itself. In matrix migration, different kinds of service request for different services in a service provider are migrated in group, rather than independently at particular period.

From the graph it is concluded that the matrix calculation method have the better performance because it migrates VMs in group. In case of the auction based method, migrations are done independently, so there are several migrations happening in the same time in cloud environment. So this will affect system performance. And also these frequent migrations also will reduce bandwidth and migration time. These migrations are depending on the network speed and time. Thus by selecting suitable service provider the proposed system provides elasticity in cloud for optimal VM placement.

Here the VM migration can be done in different ways, auction based migration method and matrix calculation approach. The experimental study shows that auction based migration gives better performance based on migration cost. While performance based analysis shows that matrix calculation method gives better results.

V. CONCLUSION

In cloud computing maintain QoS is a cumbersome task. Even though the customer and provider agreed on SLA before acquiring a service, there is greater chance for violating terms and conditions in the above said agreements. In the proposed system the SLA violation are addressed by providing elasticity to the cloud provider. The VMs are migrated in real time without service breaks. The virtual machine migration was done in two different ways; combinatorial auction method and matrix generation approach. The combinatorial auction method finds low cost provider very efficiently. The performance of the matrix method is better based on migration time and thus gives better QoS to the customers.

The service providers profit can be increased by properly employing any of the above VM migration techniques. In both cases the limitations is that the under utilization of resources to maintain certain level of QoS. Server consolidation is the good solution to overcome the under utilization of the resources. Server consolidation will reduce number of migrations required and it will increase the providers cost also. The future work will focus on server consolidation with pre-copy migration technique.

REFERENCES

[1] Brendan Jennings, Rolf Stadler, “Resource Management in Clouds: Survey and Research Challenges”, Journal of Network and Systems Management, vol. 23, issue 3, July 2015, pp. 567-619.

[2] Edmonds, A., Metsch, T., Papaspyrou, A., Richardson, A., “Toward an open cloud standard”, IEEE Internet Comput. 16 (4), 2015, pp.15–25.

[3] Farley, B., Juels, A., Varadarajan, V., Ristenpart, T., Bowers, K.D., Swift, M.M., “More for your money: exploiting performance heterogeneity in public clouds”, 3rd ACM Symposium on Cloud Computing (SoCC 2012), New York, 20.1-20.14, New York, 2012.

[4] Ghanbari, H., Simmons, B., Litoiu, M., Iszlai, G., “Exploring alternative approaches to implement an elasticity policy”, IEEE International Conference on Cloud Computing (CLOUD 2011), pp. 716–723.

[5] Ghodsi, A., Zaharia, M., Hindman, B., Konwinski, A., Shenker, S., Stoica, I., “Dominant resource fairness: fair allocation of multiple resource types”, 8th USENIX Conference on Networked Systems Design and Implementation (NSDI 2011), pp. 323–336.

[6] Gmach, D., Rolia, J., Cherkasova, L., Belrose, G., Turicchi, T., Kemper, A, An integrated approach to resource pool management: policies, efficiency and quality metrics, IEEE International Conference on Dependable Systems and Networks With FTCS and DCC (DSN 2008), pp. 326–335.

[7] K R Remesh Babu, Philip Samuel, “Virtual machine placement for improved quality in IaaS cloud”, IEEE Fourth International Conference on Advances in Computing and Communications, (ICACC 2014), pp.190-194.

[8] Ahmad, R.W., Gani, A., Hamid, S.H.A., Shiraz, M., Xia, F. and Madani, S.A., 2015. Virtual machine migration in cloud data centers: a review, taxonomy, and open research issues. The Journal of Supercomputing, 71(7), pp.2473-2515.

[9] Mohammad Masdari, Sayyid Shahab Nabavi,Vafa Ahmadi, “Review: An overview of virtual machine placement schemes in cloud computing”, Journal of Network and Computer Applications, 66 (2016), pp. 106–127.

[10] Agrawal, D., El Abbadi, A., Das, S., Elmore, A.J., “Database scalability, elasticity, and autonomy in the cloud” , 16th international conference on Database systems for advanced applications (DASFAA’11),Volume Part I, pp. 2-15, Springer Berlin Heidelberg.

[11] Breitgand, David, Amir Epstein, “SLA-aware placement of multi-virtual machine elastic services in compute clouds”, 12th IFIP/IEEE International Symposium on Integrated Network Management (IM 2011) and Workshops, 2011, pp. 161-168.

[12] Bahrami, Mehdi, “Cloud Computing for Emerging Mobile Cloud Apps”, 3rd IEEE International Conference on Mobile Cloud Computing, Services, and Engineering (MobileCloud), 2015 , pp. 4-5.

[13] Sakr, Sherif, Anna Liu, “SLA-based and consumer-centric dynamic provisioning for cloud databases”, IEEE 5th International Conference on Cloud Computing (CLOUD), 2012 , pp. 360-367.

[14] Beloglazov, Anton, Jemal Abawajy, Rajkumar Buyya, “Energy-aware resource allocation heuristics for efficient management of data centers for cloud computing”, Future generation computer systems, 28, no. 5 (2012), pp. 755-768.

[15] Rajkumar Buyya, Chee Shin Yeo, Srikumar Venugopal, “Market-oriented cloud computing: Vision, hype, and reality for delivering it services as computing utilities”, 10th IEEE International Conference on High Performance Computing and Communications, HPCC’08, pp. 5-13.

[16] Dong, Wang En, Wu Nan, Li Xu, “QoS-oriented monitoring model of cloud computing resources availability” Fifth IEEE International Conference on Computational and Information Sciences (ICCIS), 2013, pp. 1537-1540.

[17] Foster, Ian, Yong Zhao, Ioan Raicu, Shiyong Lu, “Cloud computing and grid computing 360-degree compared”, IEEE Workshop on Grid Computing Environments, 2008, pp. 1-10.

[18] Mao, Ming, Marty Humphrey, “A performance study on the vm startup time in the cloud”, IEEE 5th International Conference on Cloud Computing (CLOUD), 2012 , pp. 423-430.

[19] Rajkumar Buyya, Christian Vecchiola, S Thamarai Selvi, “Mastering Cloud Computing”, McGraw Hill Education (India) Private Limited, New Delhi 2013.

[20] Rajkumar Buyya, Chee Shin Yeo, Srikumar Venugopal, James Broberg, and Ivona Brandic, “Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility”, Future Generation Computer Systems, vol. 25, Issue 6, June 2009, pp. 599–616.