IMPLEMENTATION OF LOAD BALANCING ALGORITHMS TO EVALUATE PERFORMANCE DEGRADATION FACTORS IN CLOUD COMPUTING

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ABSTRACT

Cloud computing presents the idea of elastic and highly scalable networking resources provision as a service over the internet. It is an emerging internet-based computing where shared resources, data and information are provided on demand to the end users using computers and other devices. Cloud is a significant model to access the distributed computing resources. This research is based on evaluation of performance degradation factors in cloud computing. This research covers different strategies of performance evaluation in cloud computing. There are many factors that cover performance degradation in cloud networks and unlike traditional systems; it is difficult to reveal the degradation factors and their intensity. This research discovered different types of performance degradation factors and their magnitude in cloud computing. High performance is the essential key elements in cloud computing to make the cloud users happy. The objective of this study is to highlight the significance of parameters which can create the high performance of cloud computing. The aim of this study is to present progressive advancement in understanding the implications of cloud computing performance parameters. The approach of this study has been to undertake an evaluation of the technological factors affecting the cloud computing performance and to present idea to build highly scalable cloud environments. This research study has identified the metrics through which performance of the cloud network becomes unreliable and unsuitable. This research will be helpful for those who want to deploy new cloud infrastructure.

KEYWORDS**:** *Cloud computing; performance evaluation; degradation factors; cloud infrastructure; highly scalable*

1.0 INTRODUCTION

The cloud computing is the provision of computing resources over the Internet. Cloud services authorize individuals, people, businesses, and end users to utilize software, hardware and other resources that are managed by cloud providers located at remote areas. The end users are provided the infrastructures and applications by the data centers as pay per use services. The National Institute of Standards and Technology (NIST) defines cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and release with minimal management effort or service provider interaction.

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This model is composed of five essential characteristics, three service models, and four deployment models (Mell, 2011). The people are benefitted with this remarkable technology by not investing much on the resources provided by cloud computing systems. This technology increases the capacity to use services with no investment for computer network, personnel training or getting software licenses. Users can access the cloud services which comprises of applications as a service without installing and maintaining these applications and obtain the facilities of storing data in storage databases located in remote areas.

Cloud computing is highly adoptable technology and rising rapidly in the current age because of its characteristics including security, scalability, reliability, high performance, and low cost. There should service level agreement (SLA) between customers and cloud service providers to avoid performance degradation obtaining the services of cloud. Violation of SLA rules will lead to performance degradation (Fulsoundar, 2013).

By using cloud computing technology, information and other computer resources are accessed wherever, internet connection is available. Cloud computing grants a publically shared pool of resources which are comprised of online storage space, processing power and dedicated corporate and user applications. In cloud network, the resources are ascertained and a user pays in agreement with to use these resources. Clouds can also provide deliberately varying user requests without stirring the performance and is available always for utilization without any limitation. Users can get the services of cloud from any internet enabled device, thus access to a wide group of people all over the world. This technology is very encouraging and numerous companies such as IBM, HP, Microsoft, Amazon, and Google have spent their time and invested on other resources for extra development of technologies related to cloud computing (Rawat, 2012).

The data centers may be located at different geographical locations. However, the data centers can become burdened or overloaded while servicing the requests of excessive number of client applications located on the same location at the same time. This will degrade the performance of distributed services. Different configurations are required by different in the applications and measuring the performance at various resources is still challenging (Manasrah,2016).

2.0 CLOUD COMPUTING MODEL

A cloud computing architecture is shown in Figure 1. The cloud networks infrastructure has reliable security mechanisms and delivers the resources with amazing performance. The provision of hardware and other resources are delivered also as a service in cloud environment. Clients can only use their devices having facility of internet which can be smart phones, tablets, or computers to access the services of cloud just opening the web browsers conveniently. Consequently, cloud providers ensure the delivery of resources with entire obligations for the availability, reliability, quality of service and security of the resources delivered.

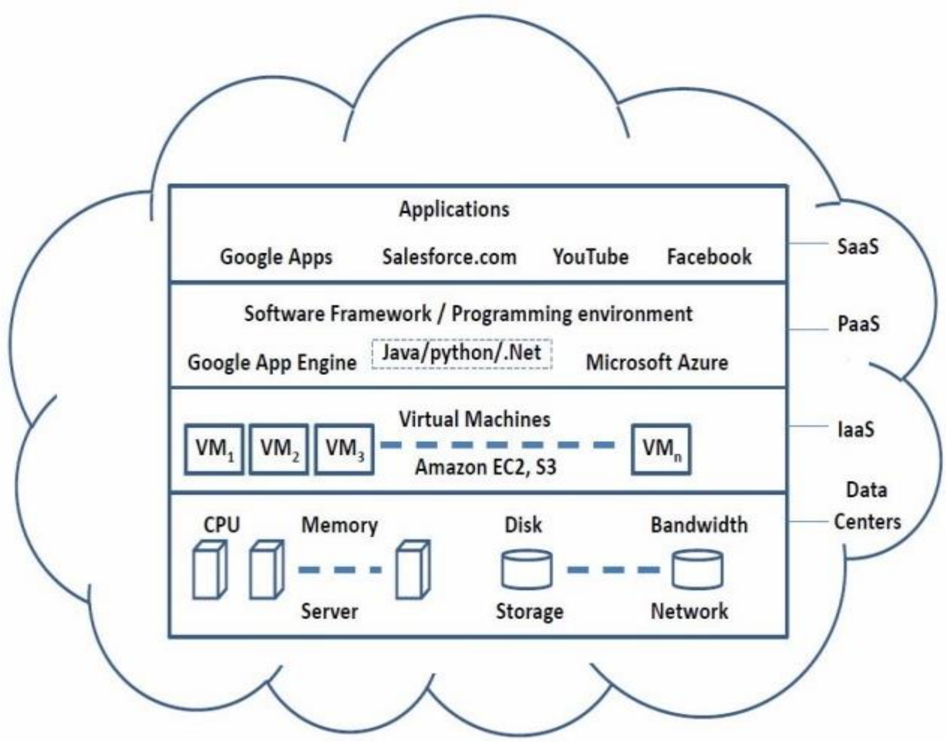

Figure 1. Graphical view of cloud computing architecture

2.1 Cloud Computing Service Models

Cloud networks and computing services can be elaborated in three different categories, which are arranged one by one as ‘Infrastructure as a Service (IaaS)’, ‘Platform as a Service (PaaS)’, and ‘Software as a Service (SaaS)’. The IaaS is elaborated as Infrastructure as a Service and it presents the online services physical computing resources, data portioning, legacy, scaling, networking, backup, location etc. (Gorelik, 2013). The term PaaS explained as “Platform as a Service” and it is used for renting the cloud resources like hardware, storage, operating system, and network capability on the internet. This service also delivers the platform for customers to use existing applications and develop new applications and perform test of these applications (Amin & Khan, 2012). SaaS allows the software availability on the internet which is used by the customers as pay-on-demand or free of cost service. Most renowned example of SaaS service is a google application which provides different applications like email and word processing (Shahzad, 2014).

2.2 Types of Cloud Computing

There are four types of models of cloud computing termed as Service Deployment Models which are discussed in this study namely private cloud, public cloud, hybrid cloud, and community cloud. Private cloud is established and controlled inside a single organization. These organizations use different software that facilitate with many cloud functionalities like virtual cloud, virtual cloud director by VMware etc. This system of cloud comprises of the applications privately hosted, and private networks take part in rivalling a cloud over the internet within the same company (Khanghahi, 2013).

Public cloud is a place of computing resources offered by third-party organizations. Enterprises might utilize cloud usefulness from other resources, separately present their own services to the clients outside of the organization. Here is the all responsibility of maintaining the cloud goes to the cloud providers. Famous public clouds are, Examples: Google App Engine, Windows Azure and Amazon (Nelson & da Fonseca, 2015). Hybrid cloud is a combination of computing resources supplied by both private and public clouds. Hybrid clouds correspond to a combined service of public and private cloud infrastructures to accomplish a thrilling decrease in cost via subcontracting as well as maintaining the preferred level of control over sensitive data by utilizing local private clouds (Ali, 2015). Community cloud in cloud computing is a mutual attempt or joint effort to share infrastructure among numerous organizations, build a community with mutual interests (compliance and security etc.). It is controlled and managed by a third-party externally or may also be hosted internally (Blokland, 2013).

2.3 Cloud Performance

Performance is generally linked to the capabilities of one of the applications within the cloud infrastructure itself. Besides all aspects of cloud computing infrastructure and resources, the most important and key point in cloud computing is its performance. Performance can be defined, as it is the execution accomplishment of a given task measured against predetermined known standards of accurateness, comprehensiveness, cost, and speed. For high performance of distributed computing, all resources should be well-matched and influential (Iosup, 2011).

High performance in cloud environments considered as it is one of the key factor that should be appropriate for each available cloud service. To get the maximum performance in cloud facilities and anything associated with cloud have great effect on cloud customers and the cloud service providers. And then evaluate the performance of the network, service providers and users are important. Testing is the activity of the league and requires new environments are created for each project. It essentially be verified for Web applications on several operating systems (OS) and their updates, platforms and various browser versions, and different kind of devices and an enormous number of simultaneous consumers to recognize their performance in actual time (Stahl, 2012).

The performance of cloud computing services for the users is the main responsibility of cloud service provider. There are some key factors which causes degradation of performance in cloud computing. The available threats for distributed online services computing such overload of frequent services, programming errors, or distributed DDoS (Distributed Denial of Service) attacks indicate the accessibility of service. Data transfer barrier is a huge obstacle. The bottleneck due to increment of data and concentration of applications are affecting the rate of transfer of data and computing cost increased. Performance unpredictability specifies performance risks causing factors, like inefficient input/output division and by immense performance of distributed network systems in cloud. Storage scalability indicates the hurdles of deploying cloud computing to get solutions required extremely extensible constant storage. Scaling speedily represents the obstacles of rapidly climbing up and down in reply in terms of load without disregarding SLAs.

To overcome these obstacles, there is a need to engage load balancing algorithm which eliminate the barriers of performance issues. In this study, the focus is on the evaluation of best load balancing algorithm which ensures the maximum performance of data centers in cloud computing.

3.0 METHODOLOGY

This research study is based on empirical methods using quantitative approach to conduct experiments to evaluate the cloud system performance using cloud performance evaluation tool. Results are presented in form of tables and graphs. The performance evaluation methods described here were used to investigate the factors that cause the performance degradation in cloud network.

3.1 Evaluation of Performance in Cloud Computing

High performance in cloud computing depends on the compatible and powerful resources of cloud computing. The facility must be satisfactory and adequate for each service because it is one of the benefit in cloud computing. One thing which has great influence on cloud service providers and users is that higher performance of services anything associated to the cloud. Therefore, it is very important to evaluate the performance for users and cloud providers.

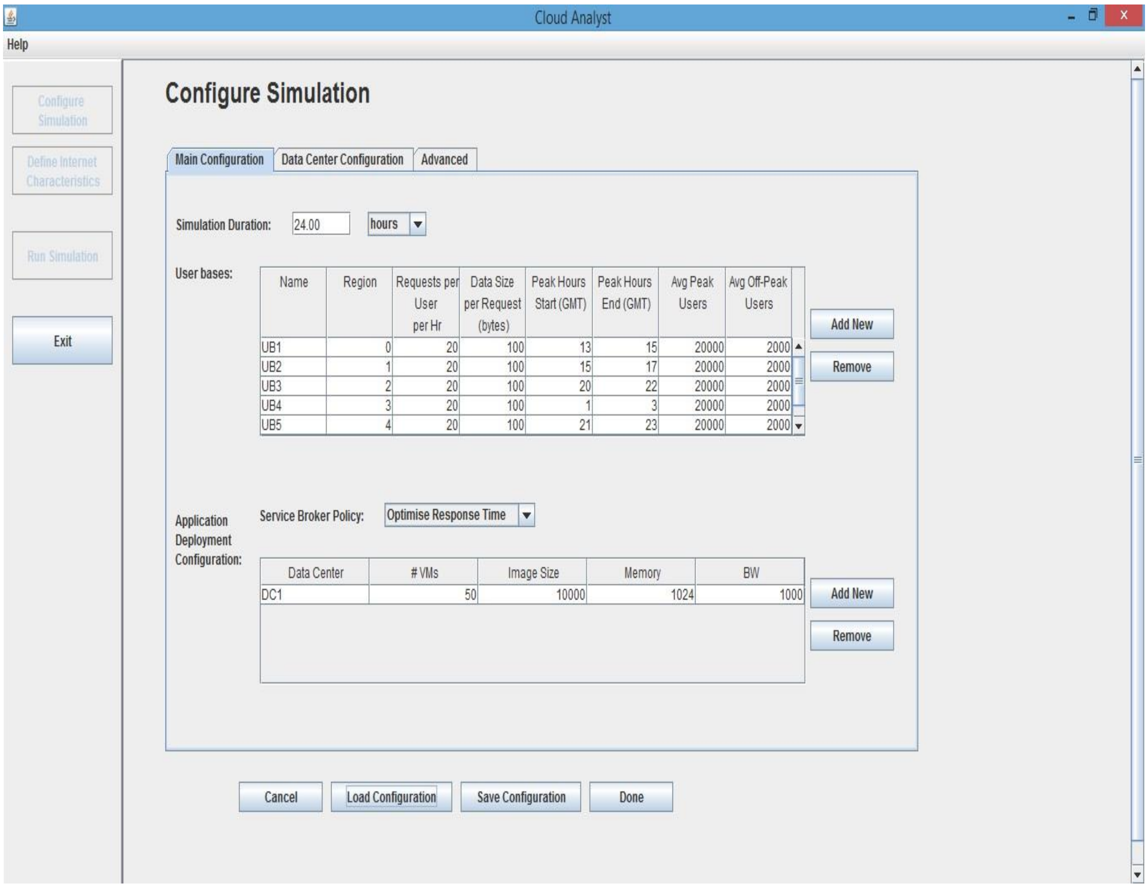

Figure 2. Main configuration view of Cloud Analyst

3.2 Performance Parameters

The term ‘performance’ is more than an exemplary idea and incorporates more broad ideas, for example energy efficiency, reliability, scalability and so on. It encompassed the extending characteristics of cloud environments and the massive figure of enterprises and typical clients whose are utilizing cloud distributed services. There are many factors that influenced the performance of distributed computing and the resources it provided. The essential, significant, and specific aspects affecting the cloud computing performance are region/location, data centers, data center controller, number of users, response time, processing time, throughput, elapsed time, latency, bandwidth, servers, memory (RAM), CPU, storage, security, availability, reliability, and scalability.

3.4 Performance Evaluation Tool

The tool that is used to evaluate the cloud performance is ‘Cloud Analyst’ which is based on Java technology. The aim of using cloud analyst as a framework tool is to inspect the prevailing simulation techniques for reviewing large scale cloud environments. Its primary purpose is to evaluate the performance of huge web applications for big organizations needed to implement appropriate simulation tools and empirical methods techniques. To fulfill all these requirements, this cloud analyst is engaged because it has the capability to evaluate large applications in cloud environment. Some view of cloud analyst is shown in Figure 2.

3.5 Load Balancing Algorithms

There are three essential, proficient, and improved load balancing algorithms, shown in Figure 3, which are used to evaluate the performance of the cloud networks using cloud analyst.

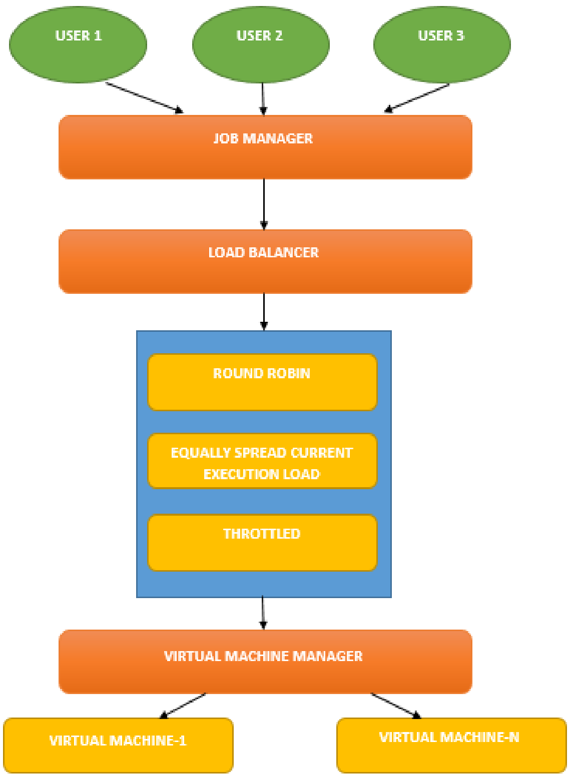

Figure 3. Execution of load balancing algorithms

3.5.1 Round Robin (RR) Algorithm

This is the first algorithm that was constructed on random sampling. It randomly chooses the load in a case that some of the servers are highly loaded and some are lightly (Behal, 2014). This algorithm executes by choosing virtual machines randomly. The primary job request of the client is allocated to a randomly designated virtual machine from the cluster of virtual machines (VMs) and the data center controller assigns the job requests in a round manner as shown in Figure 4. When the VM is assigned, it is relocated to the lower level of the group of virtual machines.

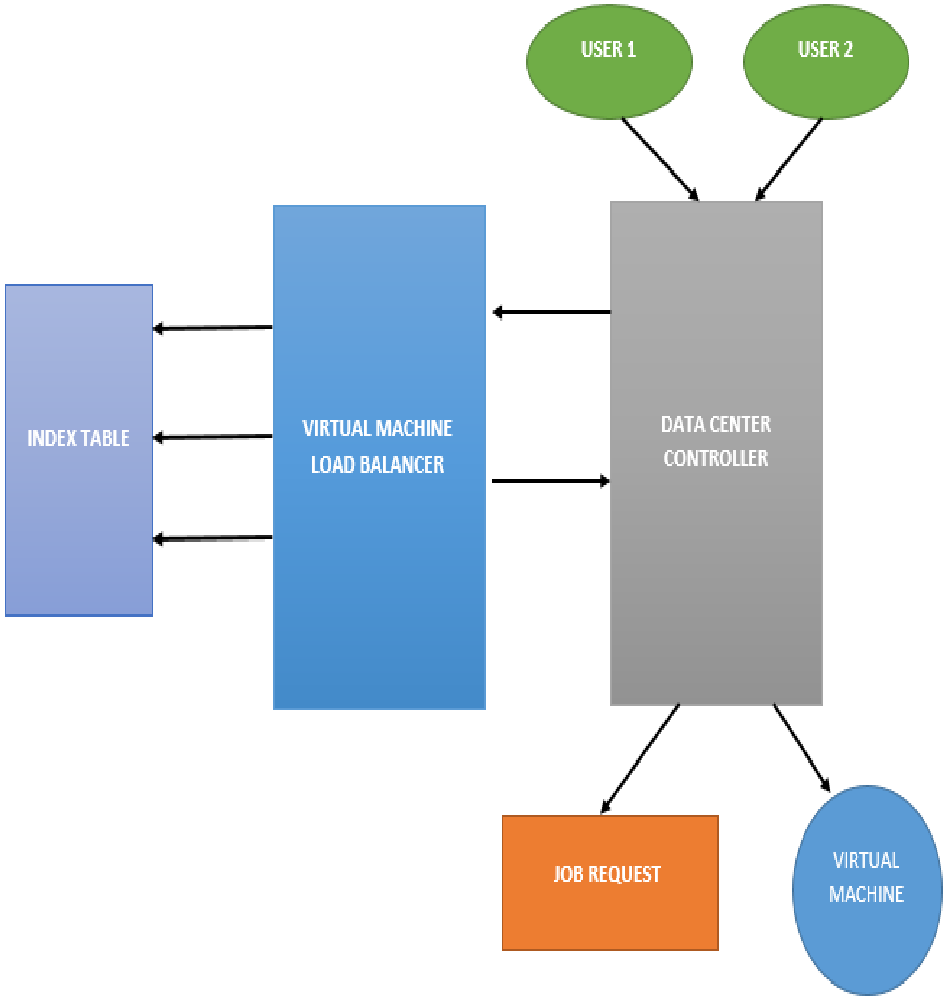

Figure 4. Working of Round Robin Algorithm

3.5.2 Throttled Algorithm

The second algorithm manages an index table in data center of all virtual machines and their relevant state for example (available or busy). When new request reaches, then the table is analyzed by load balancer and then that virtual machine is chosen having the state available not busy. After that, the identified available virtual machine is returned to the data center controller that further allocates the request to the specific virtual machine (Kumar & Prashar, 2015). The flow processes of the throttled type is shown in Figure 5.

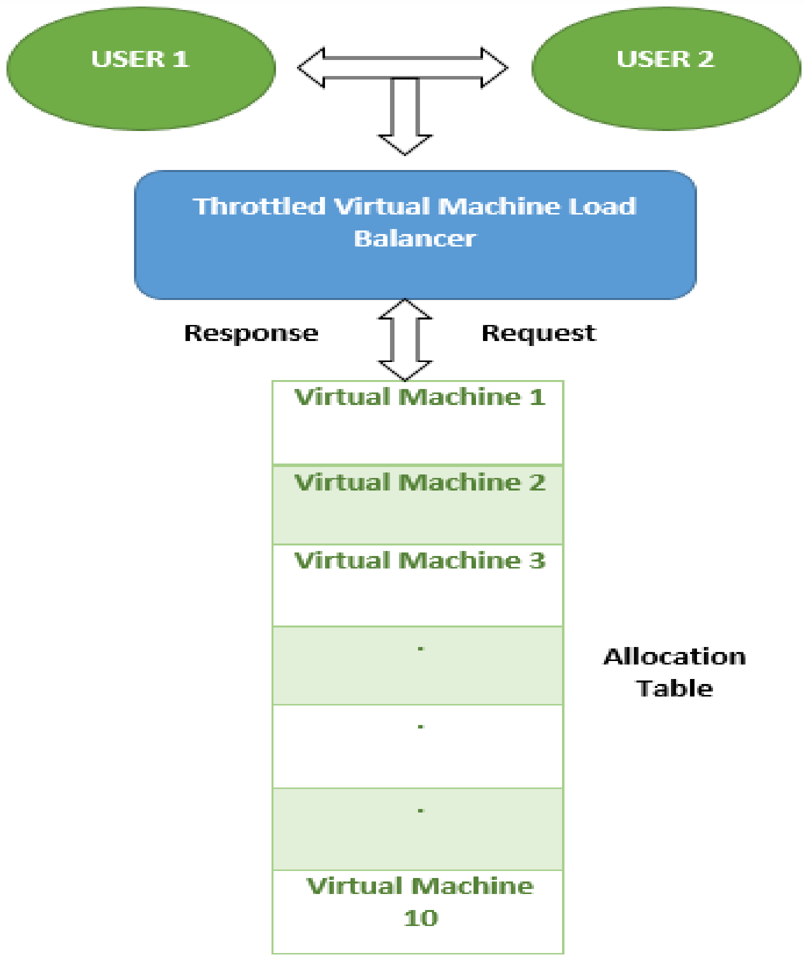

Figure 5. Throttled Load Balancing Algorithm

3.5.3 Equally Spread Current Execution (ESCE) Load Algorithm

The third algorithm is also called active monitoring algorithm for load balancing. As shown in Figure 6, it performs the tasks which are quite similar to the throttled algorithm but there are some changes in respect to virtual machine index table. By using this algorithm, the load balancer manages and maintains index table of all the deployed virtual machines and maintains the presently held number of requests allocated to the virtual machines (Kumari, 2013).

3.6 Experimental Parameters (Variables and Constants)

There are different parameters used to perform experiments on cloud analyst toolkit, which some are kept constant and others vary. Parameters used as variables include Average Peak Users, Average Off-Peak Users, and Load Balancing Algorithms. As for constant parameter, these are shown in Table 1 and Table 2.

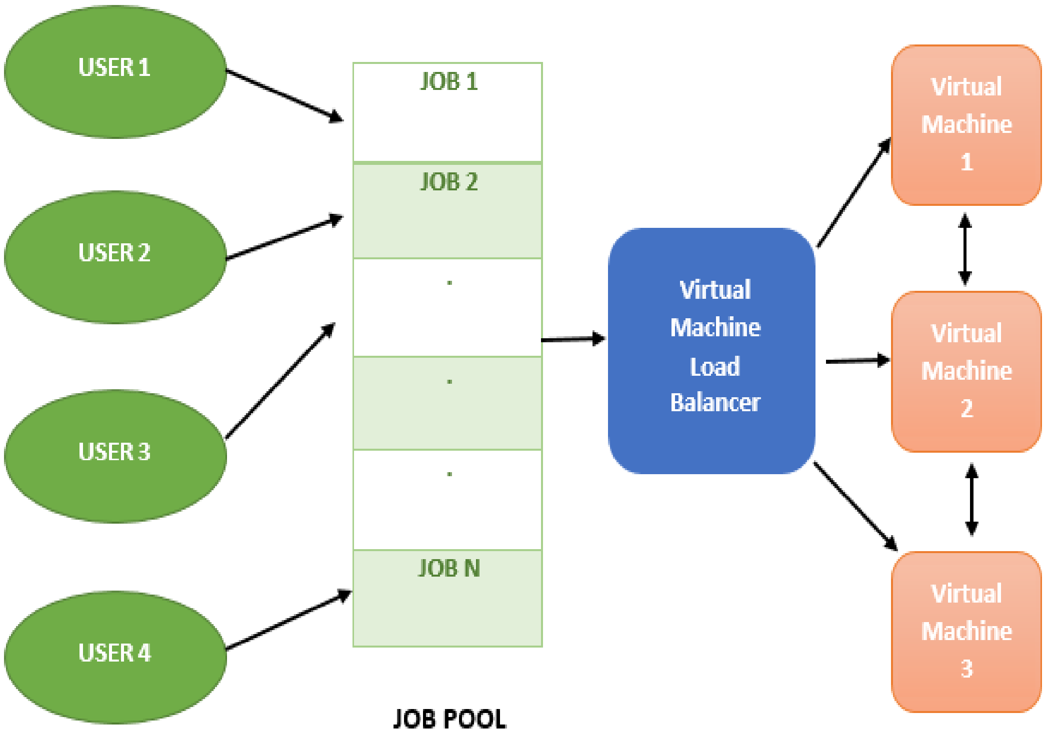

Figure 6. Equally Spread Current Execution Load Algorithm

Table 1. The profile of parameters and their values which are kept constant

Parameters	**Values**	**Parameters**	**Values**	**Parameters**	**Values**	**Parameters**	**Values**
VM Image Size	10000	Data Center – Storage per machine	100000 Mb	Data Center – VMM	Xen	User Grouping Factor	1000
VM Memory	1024 Mb	Data Center – Available BW per Machine	10000	Data Center – Number of Machines	20	Request Grouping Factor	100
VM Bandwidth	1000	Data Center – Number of processors per machine	4	Data Center – Memory Per Machine	2048 Mb	Executable Instruction Length in (bytes)	250
Data Center – Architecture	X86	Data Center – Processor speed	100 MIPS	Data Center – OS	Linux	Data Center – VM Policy	Time Shared

Table 2. Delay matrix and bandwidth matrix by region

Region	Delay matrix (in Mbps)						Bandwidth matrix (in Mbps)					
	0	**1**	**2**	**3**	**4**	**5**	**0**	**1**	**2**	**3**	**4**	**5**
0	25	100	150	250	250	100	2000	1000	1000	1000	1000	1000
1	100	25	250	500	350	200	1000	800	1000	1000	1000	1000
2	150	250	25	150	150	200	1000	1000	2500	1000	1000	1000
3	250	500	150	25	500	500	1000	1000	1000	1500	1000	1000
4	250	350	150	500	25	500	1000	1000	1000	1000	500	1000
5	100	200	200	500	500	25	1000	1000	1000	1000	1000	2000

3.7 Regions

In this study, the world is divided into six regions geographically and identified by values from 0 to 5. These correspond to the six main continents and shown in Table 3.

3.8 Experimental Description

The experiment started the real-world web application and the application is installed in a single site, say in Region 0 (North America). Simulator is configured with a single data center located at region 0 in North America, having 50 virtual machines, each of which has 1024 Mb of memory and other parameters which are configured and mentioned in the form of tables and screen shots. There are three load balancing algorithms used to perform experiments respectively which are Throttled, Round Robin and ESCE Load. In this experiment, simulation time is set to 24 hours for each scenario. For ease of calculation, a single time zone is defined with each user base and it is supposed that majority of users of the application use the applications after working hours in the evening for 2 hours. It is assumed that 5 % users remain online concurrently during peak hours and the number of users in off peak hours is assumed to be one tenth of the peak hour users. In this experiment, the request time per user per hour is set to be 20, which means that each user makes request after every 3 minutes.

Table 3. User bases and related regions/continents

User bases	Region	Continents	Distance between regions	Kilometers
UB 1	0	N. America	---	---
UB 2	1	S. America	N. America and S. America	8,418 km
UB 3	2	Europe	N. America and Europe	6,725 km
UB 4	3	Asia	N. America and Asia	9,853 km
UB 5	4	Africa	N. America and Africa	13,802 km
UB 6	5	Oceania	N. America and Oceania	13,623 km

Table 4. Configuration details of different parameters

User base	Regions	Requests per user per hour	Data size per request (bytes)	Time zone	Peak hours start (gmt)	Peak hours end (gmt)
UB1	0 – N. America	20	100	GMT– 6.00	13:00	15:00
UB2	1 – S. America	20	100	GMT – 4.00	15:00	17:00
UB3	2 - Europe	20	100	GMT + 1.00	20:00	22:00
UB4	3 - Asia	20	100	GMT + 6.00	01:00	03:00
UB5	4 - Africa	20	100	GMT + 2.00	21:00	23:00
UB6	5 - Oceania	20	100	GMT + 10.00	09:00	11:00

It is supposed that the web applications are deployed on single location only i.e. Region 0 (North America). Similarly, six user bases are defined in different regions starting from region 0 to 5. Peak hours of each user base are set to two hours, as mentioned in Table 4. Numbers of users in peak and off-peak hours are set with fixed ratio for all user bases separately based on the geographical location.

4.0 RESULTS AND DISCUSSION

Table 5 shows the results of three scenarios in the performed experiment. In each scenario, 8 difference values of variables as number of users and three different load balancing algorithms are used. All scenarios in experiments are performed on cloud analyst simulation tool. This tool generates output in the form of response time and processing time. The output results report generated on cloud analyst shows minimum, maximum, and average response time and processing time for each experiment separately. But in this research, only overall average values of response time and processing time are used for evaluation of performance. All scenarios performed in the experiment are combined in the form of Table 5. Two graphs are generated on the bases of the above combined table which presents response time and processing time. Table 5 clearly shows the overall average response time and overall average processing time of all user bases with randomly increasing numbers of users. There are three scenarios shown in Table 5 and each scenario shows different values of response time and processing time per three different load balancing algorithms and number of average peak users.

Table 5. Combined table of results values of all scenarios with different algorithms

Load balancing algorithms	User bases	Number of avg. peak users	Overall avg. response time (ms)	Overall avg. data center processing time (ms)
Scenario 1				
Throttled	UB1, UB2, UB3, UB4, UB5, UB6	20000	671.49	379.05
		50000	1074.91	777.07
		100000	1799.62	1499.36
		200000	3102.21	2805.19
		370000	5538.60	5237.74
		450000	6823.11	6518.89
		600000	9136.38	8830.14
		850000	13325.67	13013.60
Scenario 2				
Round Robin	UB1, UB2, UB3, UB4, UB5, UB6	20000	836.60	543.98
		50000	1640.50	1342.73
		100000	3016.18	2720.33
		200000	5996.79	5696.87
		370000	11335.52	11029.16
		450000	14528.07	14218.24
		600000	20424.18	20107.69
		850000	29310.05	28983.29
Scenario 3				
Equally Spread Current Execution Load	UB1, UB2, UB3, UB4, UB5, UB6	20000	836.79	544.17
		50000	1587.61	1293.66
		100000	3015.74	2719.91
		200000	5996.91	5696.99
		370000	11340.88	11034.53
		450000	14535.57	14225.74
		600000	20424.23	20107.73
		850000	29341.16	29014.38

In the experiment of scenario 1, Throttled load balancing policy is used. As for the Round Robin and ESCE Load algorithms, Scenario 2 and Scenario 3 were applied respectively. Table 5 shows the overall average response time and processing time of all user bases UB1, UB2,….to…, UB6 by varying number of users 20000, 50000…to…, 850000. For example, in Scenario 1, for 20000 number of users, the response time is 671.49 ms and processing time is 379.05 ms. On the other hand, in Scenario 2, for same number of users' response time is 836.60 ms and processing time is 543.98 ms and in Scenario 3, response time is 836.79 ms and processing time is 544.17 ms. It is observed that by using Throttled load balancing algorithm in Scenario 1, there is huge difference in response time and processing time as compared with other 2 scenarios. But it is found that the response time and processing time are almost the same in Scenario 2 and Scenario 3 with Round Robin and ESCE Load algorithms respectively. Similarly, other variations in response time and processing time can be seen by changing the load as increase in number of users. It is obvious from Table 5 that the response time and the processing time are less by using throttled load balancing algorithm. This shows that the performance of cloud network is better with Throttled load balancing algorithm.

Figure 7 shows the overall average response time in accordance with number of users and with three load balancing algorithms. The gradual upward movement of graph curves showing increase in response time to the workload on data centers as the number of users increase.

The effect of three different load balancing algorithms can also be clearly observed in Figure 7. The performance of using Throttled load balancing algorithm can be seen clearly with the decrease in response time as compared to other two load balancing algorithms. The response time nearly doubled than throttled algorithm. Round Robin and ESCE load balancing algorithm's curve shows that the response time of using these algorithms is nearly same. Performance is depending on distribution of loads on data centers and load balancing algorithms are responsible to distribute the load and to optimize the cloud resources to increase performance.

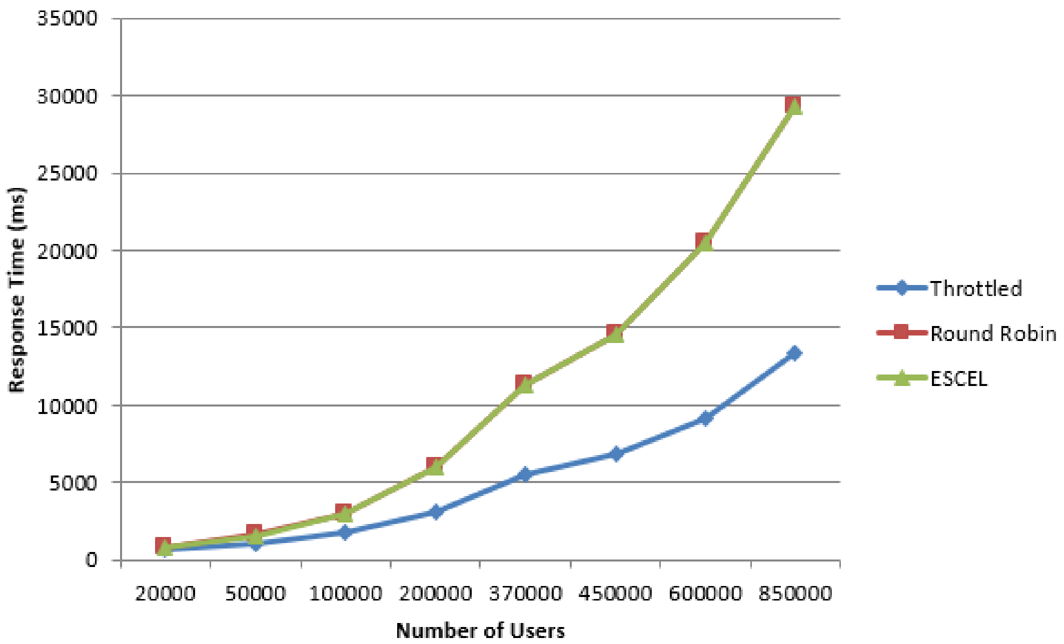

Figure 7. Performance in case of response time

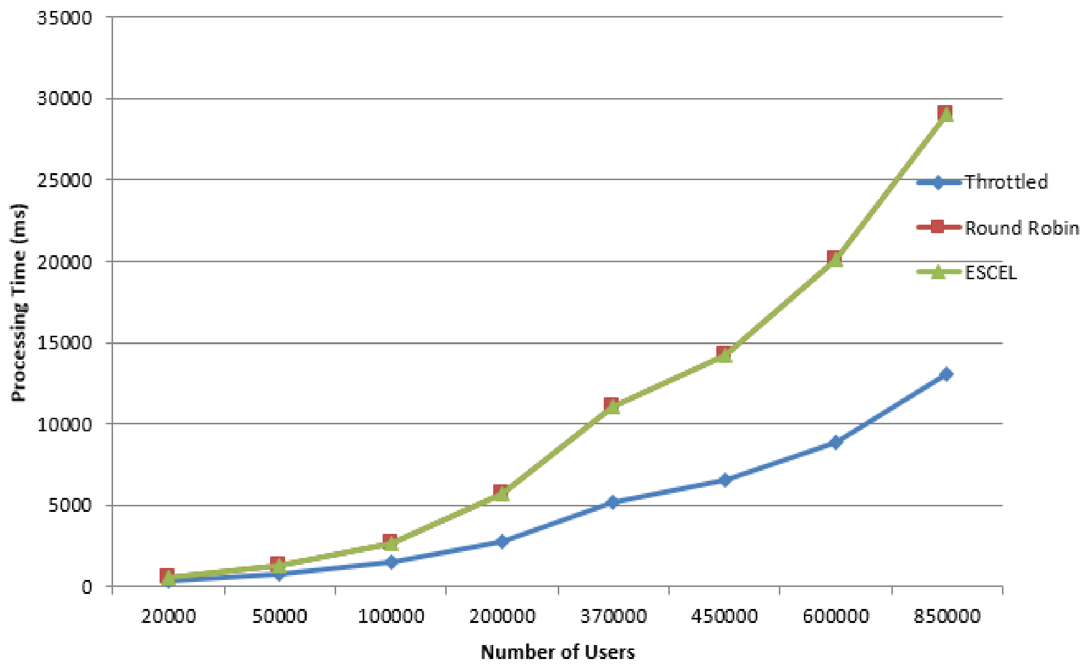

Figure 8. Performance in case of processing time

Figure 8 shows the overall average processing time of data centers to process the user's requests using different load balancing algorithms. There is also an upward movement of graph curve gradually showing the increase in data center processing time with the increase in load as number of users. The effect of three different load balancing algorithms can be seen clearly, which shows the processing time is less with same load on data centers as compared to other two load balancing algorithms which are Round Robin and ESCE Load. The processing time is almost doubled by using Round Robin and ESCE Load as load balancing algorithms than Throttled algorithm. Throttled algorithm showing better performance in terms of processing time as compared to other two load balancing algorithm. By using Throttled algorithm, resources are optimized in better way rather than Round Robin and ESCE algorithms. In term of processing time, both algorithms show similar processing time performance.

5.0 CONCLUSION

The users which are closer to the data center showing the better performance in form of response time. Performance can be enhanced using different load balancing algorithms as using Throttled algorithm, the response time is better than using others like Round Robin and ESCE Load. For attaining the improvements to be more effective, data center capacity must be increased to fulfill the demand of users at peak hours.

It is concluded that the response time of user requests and processing time of data center are better for the user bases which are located closer to the region where data center is located. It is also observed and concluded from this experiment, UB1 has better response time which is located in the same region as the data center. By using different load balancing algorithms, the better algorithm can be identified with respect to cloud performance. The number of requests, having time out issues, experienced by the increase in number of users on data centers contributes to the cloud computing performance. The most widely used load balancing algorithms is used in the experiment to evaluate cloud network performance, namely Throttled, Round Robin and ESCE. Response time depends on the distance of user base from data center and the load balancing algorithm. The purpose of load balancing algorithm is to maximize the utilization of resources, enhancing the performance of the cloud network and to ensure clients satisfaction. By implementing the load balancing algorithm, the goal of minimizing the response time and reducing jobs request rejection number can be achieved. It is concluded that proposed Throttled load balancing algorithm is found to be the best algorithm compared to the other algorithm in term of reducing response time.

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