Performance Evaluation of Load Balancing Algorithms Using Cloud Analyst

Archana Singh
Department of Computer Science and Engineering
Madan Mohan Malviya University of Technology
Gorakhpur, 273010
archanasingh7971@gmail.com

Rakesh Kumar
Department of Computer Science and Engineering
Madan Mohan Malviya University of Technology
Gorakhpur, 273010
rkiitr@gmail.com

***Abstract*—Today cloud computing is the trending technology and has been proven as a viable business model. We can see fastest growth in the recent years because of it's easy to access mechanism. As the number of cloud users are increasing exponentially, so to handle this, the concept of load balancing is needed to minimize the overhead and maximize the throughput on the cloud. In this paper, we analyze three cloud algorithms namely Round Robin, Throttled, Equally Spread Current Execution Load and their performance in terms of average response time, hourly data center response time and the cost of Virtual Machine (VM) etc. with the help of Cloud Analyst simulator. Cloud Analyst is the simulator which is best among all simulator for algorithm testing in cloud environment. Simulation results demonstrate that Throttled outperforms among these algorithms as number of users increases.**

Keywords—Cloud Analyst; Virtual Machine(VM); Data Center Controller; Performace matrix; Userbase (UB);

I. INTRODUCTION

In Computer Science, Cloud Computing is one of the emerging technologies, it has so many advantages or you can say them as characteristic of cloud computing some of which are reliability, virtualization, multitasking, low cost, less infrastructure based etc. and with the help of these features Cloud Computing become trending technology. Today Cloud Computing is used by many entrepreneurs which saves their money, time and space of working infrastructure by using cloud computing. They use personal computer according to their need and buy processors and memory as much as they need and also pay as much they use, in short Cloud Computing work on the pay as use model. Due to use of Cloud Computing new entrepreneurs save their money and now days thousands of user's daily use cloud computing for their work.

There are number of organizations which are providing cloud services such as Amazon, Microsoft etc., They provide cloud services as platform as a service (Paas), Infrastructure as a service (Iaas) , Software as a service (Saas) .With the reference of ease of doing ,user friendly, profitable business model and interactive model cloud is used by many of the users due to which the load on Cloud increases and load becomes a problem to handle it then the concept of Load Balancing come into picture of cloud for handling excess load on cloud . Generally, before the use of any algorithm we need to know about the efficiency of algorithm that means how efficient the algorithm is for our proposed work, according to which we select the algorithm. For the same reason many of researcher's works on the analysis of algorithms [16][17]. Here in this paper we analyze the performance of algorithms that which is best using Cloud Analyst simulator. Here the algorithms are Equally Spread current execution load, Round Robin and Throttled and analyze them according to their Response time and Data Center Processing Time, VM cost and Data transfer cost.

Rest of paper is organized as follows. Section II is about the concept of Load Balancing and its type. Section III is about the literature review. Various load balancing algorithms are shown in Section IV. Section V describes the Cloud Analyst. Section VI shows the result analysis and finally Section VII present the conclusion and future work of this paper.

II. LOAD BALANCING TECHNIQUES

As the number of users of cloud computing increases day by day so the load on Cloud becomes an issue of service provider and this problem can be addressed by using load balancing mechanism. Load balancing helps in providing maximal utilization of network and other resources, assuring as much as throughput with lesser response time. It performs two steps of hierarchy in cloud environment [3]:

- The first step virtual machine means mapping within the applications which are overhead in cloud on virtual machine, next LAPD balancer distributes load on different virtual machine to the physical computers.

- The second step is about the host that means mapping of virtual machine and host resources so that allow processing of various request of applications.

When client requests, then request reaches to the service broker and then service broker consult with each other broker about the cost and performance analysis of the resources. And after analysis broker transfer the request to the data center, which is selected by the requester. Data center controller take the request for further processing, data center consists of

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physical resources (machine) and take the request and transfer to the load balancer on the server, which distributes the requests to the virtual machines to execute and also returns availability of virtual machine from state table and also updates it for further use. If there is no free virtual machine then data center controller transfers the request in queue so that, when virtual machine available then, assign virtual machine to it. For the case of load balancer, when a virtual machine executes its operations then load balancer assign new request to it and also maintains the state table. Here actual performance of load balancing is measured in the form of overload and under load means if these two cases occurs then, the performance and quality of service will get deteriorated. So, it is important to handle this and processing can be shown in Fig.1 bellow. There are basically two type of load balancing algorithms:

A. Static Method

In static methods, pre knowledge and assumptions related to the status of system globally known such as requirement of job resources, time of computation system node processing power, capacity of memory and storage device. In static method, type of assignment from a group of tasks to a group of resources, can take two types of forms one is deterministic and second is probabilistic form [6]. Addition to that, the approach is easy to understand or can say implementation of static approach is not difficult [7]. The advantages are as follows:

- Stability should be high.
- Less resource utilization.
- Predictively is more than Dynamic.

The disadvantages are as follows:

- Not good for fault tolerance.
- Reliability is less.

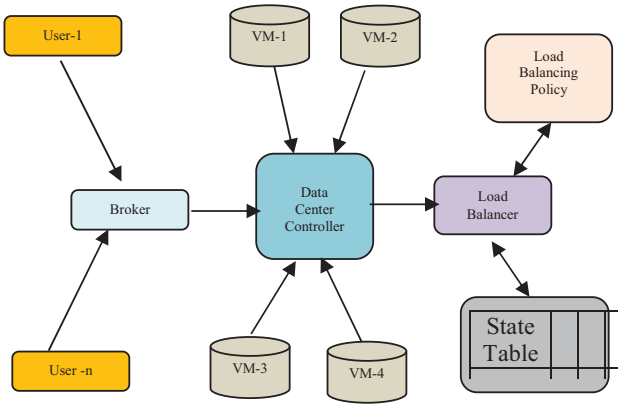

Fig.1 Load Balancing Structure

B. Dynamic Method

Dynamic method is based on current state of the decision-making system. In this approach task can move from highly loaded node to less loaded nodes which is one of advantage of this type of load balancing. These algorithms are changes simultaneously according to the current state of system. So that it is complex and complicated to implement dynamic load balancing and when it compared to static one static implementation is much easier than dynamic method of load balancing but at the performance and efficiency point of view Dynamic is best [8,9]. The advantages are as follows:

- Adaptive in nature.
- Good for fault tolerance.

The disadvantages are as follows:

- Stability is less.
- High utilization of resources

III. RELATED WORK

To select an algorithm for purpose of load balancing, we need to know about some performance matrix of any load balancing algorithms and for this, we need to compare algorithm accordingly their performance matrix. Many of the researches work on load balancing such as Volkova et al. [1], Muhammad et al. [2], Pawan Kumar et al. [3], and their work review can be shown in TABLE.1. Load balancing mechanism based on ant colony which is proposed by Marco Dorigo [13], where at beginning of searching, under loaded node find out. Ant Colony Optimization (ACO) is a population-based approach for solving combinatorial optimization problems that inspired by foraging behavior of ants and their inherent ability to find shortest path from a food source to their nest. ACO inspired from the ant colonies that work together in foraging behavior.

Research proposed by Volkova et al. [1], analyzes three algorithm namely Round Robin , Throttled and Active load balancing algorithm and justify the analysis by using cloud analyst with referencing some performance parameter such as average response time, hourly cloud center response time etc. [14], after the analysis with cloud analyst, he observed that Throttled is best among them and also shown that Throttled have less response time as compare to Round Robin and Active load balancing.

Another researchers Muhammad et al. [2] also worked in the same direction of analysis of algorithm and performs the analysis for Round Robin, Equally Spread Current Load balancing. They performed simulation for few cloud users and concludes that Round Robin is best among them.

Patel et al. [4] works on the analysis of the load balancing algorithm for the different performance matrix and shows, how the load balancing algorithms works and stated that performance of any algorithm depends on many factors such as response time, processing time etc. by using the simulation, which concludes that performance of three different load balancing algorithm depends on various performance parameter.

TABLE.1 Work on Load Balancing

	Used Algorithms	Simulator	Analysis
Mesbahi et al. [16]	Round Robin, Throttled Equally Spread	Cloud Analyst	Throttled
SomulaRam asubbareddy et al. [15]	Round Robin, Throttled Equally Spread	Cloud Analyst	Throttled
Alnazir et al. [17]	Round Robin, Throttled Equally Spread	Cloud Analyst	Throttled
Panwar et al. [18]	Static and Dynamic	Cloud Analyst	Mixed is better
Veerawali Behal et al. [19]	Active Monitoring Round Robin, Throttled	Cloud Analyst	Active Monitoring
Shakir et al. [2]	Round Robin, Throttled Equally Spread	Cloud Analyst	Round Robin
Volkova et al. [1]	Round Robin, Throttled Equally Spread	Cloud Analyst	Throttled

From the above researcher's point of view, we conclude that anyone can't say that, this algorithm is best rather than comparing their performance parameter. Some are best in case of response time and some are best in processing or some is best on cost comparison, apart from these parameter some time performance dependents on number of users and at some point broker policy also considered so there are number of way to conclude that this is best and here in paper, analysis of algorithm on the basis of their response time and data center processing time with the help of closet data center broker policy and simulation time estimated as 60 min, for the same parameter with different algorithm.

IV. Load Balancing Algorithms in Cloud Environment

There are many cloud load balancing algorithms and here we describe three of them, with the help of cloud analyst simulator [10]. We are going to compare these three algorithms according to some cloud performance matrix such as total response time, data center time, processing cost and hourly data center load. The algorithms are Round Robin, Throttled load balancing, Equally Spread current execution load:

A. Round Robin

Round Robin based on the terminology of time quantum, each node has time quantum, that is some fixed amount of time interval between which they can execute their operations. Time quantum is the deciding factor of load balancing algorithms as shown in Fig.2. When time quantum is large then its efficiency is same as first come first serve (FCFS) [10]. So, for the large quantum size there is no advantage of Round Robin. Deciding the time quantum is a big task or in other word you can say, that deciding time quantum is the big challenge of algorithm maker.

There are some disadvantages of Round Robin, the one is its simplicity and also deciding time quantum size generates addition load on the scheduler. It has also highest context switching that increases the turnaround time and low throughput.

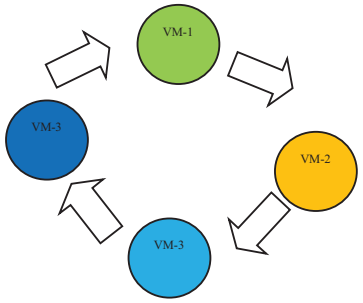

Fig.2 Round Robin Algorithm

B. Equally Spread current execution load

In this approach of load balancing, load balancer maintains a list of all virtual machine and their availability. When client requests to the load balancer, then it scan the entire list of virtual machines and if any virtual machine found, according the need of client request, then request is allocated to that virtual machine [11][12].

This algorithm works on the principle of equal load distribution among all the virtual machines. For equal load distribution to all virtual machine, there is need to know about the current allocation of load on each virtual machine and for this it maintains a current allocation table for handling equal load among all virtual machine. It maximizes the throughput. It has some drawback which are:

- It provides centered failure.
- It has not fault tolerance feature.

C. Throttled Load balancing

This algorithm is based on record maintenance, that is load balancer maintains a table of index of virtual machine and also maintains their states either available or busy. The first step of algorithm is that, client makes a request to data center for finding desirable virtual machine for performing desired task, then data center requested to the load balancer for distributing the virtual machine.

Next load balancer scans the table from top to the last until the first vacant virtual machine is found or fully scan the table. If virtual machine is finding out then data center transfers the request to the virtual machine which is identified by the identifier.

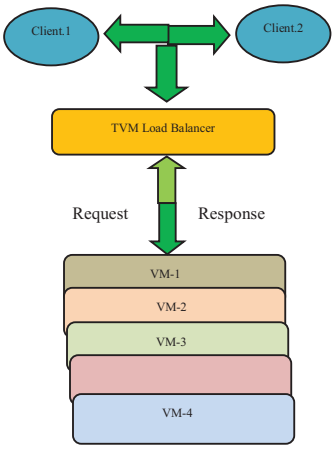

Fig.3 Throttled Load Balancing

Next data center notifies the load balancer about new selection of virtual machine and according to selection, data center revised the index table. For negative case that means not finding desirable virtual machine load balancer return "0" to data center. Processing structure of the algorithm is shown in Fig.3.

V. About Cloud Analyst Simulator

We use "Cloud Analyst " simulation tool for the analysis of performance of these three algorithms namely Round Robin, Equally spread current execution load, and Throttled. The structure of cloud analyst is shown in Fig.4, it has many features like:

- location of data center can be customized according to your need.
- location of user, who creates the applications can also be customized.
- We can perform number of simulations by changing small parameters.

For testing we divided the world into 5 region and there modeling is also different for each other region means number of users are different at different place which can be shown as Fig.6 (View of divided region).

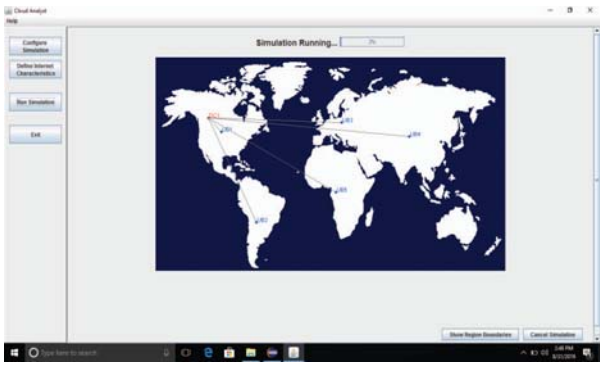

Fig.4 Cloud Analyst Simulator

There is some terminology of Cloud Analyst:

a) Region: For algorithm performance analysis, we divide the world into 5 regions, that are from 5 different continents of the world.

b) User Base: User base is the single unit and this is used for traffic in the cloud.

c) Data Processing Center: Data center are the provider of data, that is virtual machine to the requester. It forwarded the request to the balancer

d) VmLoad Balancer: It is responsible for the allocation of virtual machine to requester in other word, it allotted the load to the data centers based on balancing algorithms (policy).

VI. Simulation and Result

Result analysis of algorithms based on various performance parameter and according to their performance parameter, they are select for work like if anyone want fast processing that means their need is less response time and if anyone want cost effective that means cost of the processing play crucial role for selecting best one. Apart from all these, there are various performance parameter used in cloud environment which are:

- *Response Time:* Total time taken to compete processing by requested process.
- *Data Center Processing Time:* It is the time taken by data center for processing request to load balancer.
- *Throughput:* It is the number of process per unit of time processed. More the value of throughput more the performance of system.
- *Efficiency:* Efficiency of system should be calculated by comparison between various technique. It should be calculated with the reference to other one that means one is best as compare to another one.
- *Scalability:* It can be defined as the capability of system that, how many nodes/requests can be processed using the particular technique.
- *Fault Tolerance:* It is another capability of load balancing technique, that how well the algorithm performs in case of breakdown.
- *Migration Time:* Time taken to transfer an extra load from overloaded machine to under loaded machine. Less the number of migration time more the technique is efficient.
- *Cost:* Cost is another factor for selecting algorithm and also depends on comparison with other algorithms.
- *Resource Use:* It is strongly related to the cost of resource, that means if smaller number of resources used, then the cost of overall system should be automatically minimized.
- *Degree of Imbalance:* This can be described as the version between virtual machine.
- *Makespan:* It is total time taken to assign resource to the user.

Simulation is one of best way for algorithm testing in cloud environment. Here we represent algorithm testing with

the help of Instagram social media as example, which is maximally used social media now days. The reason to take Instagram, is its popularity so, that we can test our purposed work for greater number of user and this data is taken at evening time because at evening time probability of users is more. Number of Instagram user as per region, shown in TABLE.2.

TABLE.2 Instagram User Around World

Region Id	Region	User
4	Africa	8 million
3	Asia	5 million
2	Europe	60 million
0	North America	80 million
1	South America	60 million

We defined the data center processing configuration, which is used for processing of database request as shown in Fig.5 and uses closet data center as a broker policy and we know very well about impact of broker policy on the performance evaluation of load balancing algorithm[4] and also define the configuration of data center, that is the hardware and software of data center virtual machines. Here the data center configuration can be defined as architecture (x86), Os (Linux), VMM (Xen), cost per vm $/hr (0.1), memory cost $/s(0.05), storage cost $/s (0.1) , data transfer cost $/Gb (0.1) and physical hardware unit is 1.

More the number of users, more the crowd in the region, like in region 0, greater number of users as compare to other region and these are shown in cloud analyst with different colors, as you can see in Fig.6 there are five different color regions. After all these configurations, we perform the same simulation process three times with different load balancing policy, which are Round Robin, Throttled and Equally spread current execution load. Here the Service broker policy is closest data center and for simulation period of 60 min.

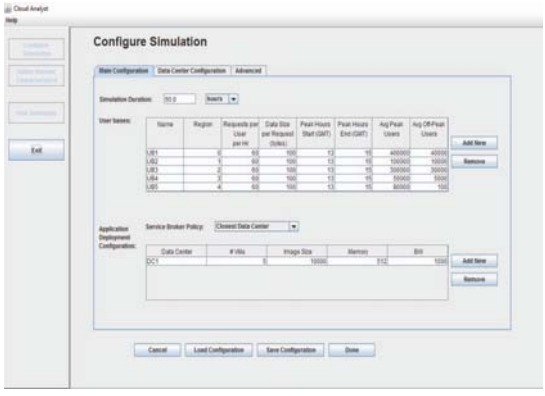

Fig.5 Data Center Configuration

Fig.6 Used regions of world

A. Response Time by Region

Response time by region shows the response time of each region, it is shown by TABLE.3 for Round Robin, TABLE.4 for the Equally spread current execution load, TABLE.5 for the Throttled, where regions are presented as UB1, UB2, UB3, UB4, UB5.

TABLE.3 Response Time by Region (Round Robin)

Userbase	Avg (ms)	Min (ms)	Max (ms)
UB1	140.57	38.29	186.14
UB2	203.31	147.04	312.99
UB3	326.27	218.64	420.75
UB4	501.09	363.14	365.22
UB5	502.56	412.64	602.64

TABLE.4 Response Time by Region (Equally Spread)

Userbase	Avg (ms)	Min (ms)	Max (ms)
UB1	95.55	37.99	181.93
UB2	202.37	147.04	276.22
UB3	315.17	218.64	418.21
UB4	501.05	363.14	653.22
UB5	502.37	412.64	602.64

TABLE.5 Response Time by Region (Throttled)

Userbase	Avg (ms)	Min (ms)	Max (ms)
UB1	140.52	38.29	186.26
UB2	203.03	147.04	311.90
UB3	325.97	218.64	420.65
UB4	501.09	363.14	653.22
UB5	501.91	412.64	602.64

B. Hourly Data Center Processing Time

Here in this section, hourly response of each data center should be described. As per the simulation result for each load balancing policy such as for Round Robin in Fig.9 for equally spread current execution in Fig.10 and for throttled in Fig.11, is shown.

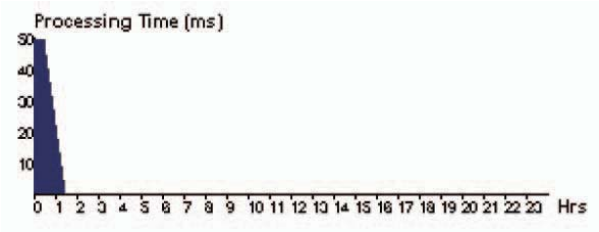

Fig.9 Hourly Data Center Processing Round Robin

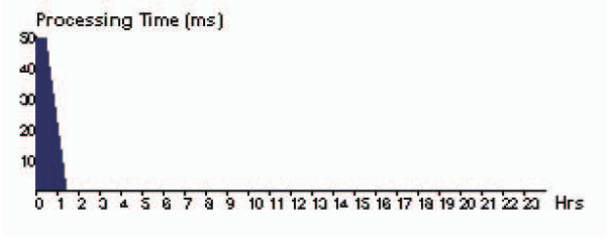

Fig.10 Hourly Data Center Processing Equally Spread

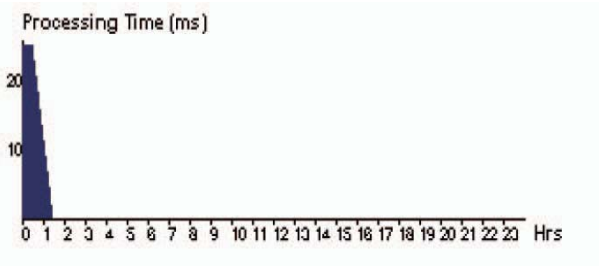

Fig.11 Hourly Data Center Processing Throttled

C. Cost

Cost analysis is another factor for performance analysis by which we can say that this algorithm is cost effective, for this reason cost analysis is considered for analyzing. Total cost for each algorithm is same and we can calculate total data transfer cost as:

Total Cost= Total VM cost + Total Data transfer cost

As we can see that all these three algorithms take equal amount of cost for VM as well as data transfer so, can not distinguish them on basis of cost analysis.

TABLE.7 Total Cost Comparison

Data Center / Load Balancing Policy	VM Cost ($)	Data Transfer Cost ($)	Total Cost ($)
DC1 / Round Robin	0.50	53.84	54.34
DC1 / Equal Spread	0.50	53.84	54.34
DC1 / Throttled	0.50	53.84	54.34

D. Average Response Time

Response time can be defined as total time taken to compete processing by requested process. We find three different result of total response time as shown in given graph Fig.7 and the comparison of total response time of each load balancing policy can be defined as Round Robin (234.21ms), Equally spread current execution (234.05ms) and throttled (208.98ms) so, it conclude that Round Robin have maximum response time which is not good for any load balancing algorithm and throttled have less response time as compare to both of them(Round Robin and Equal Spread). In this paper, we also show the response time by each userbase for each balancing policy.

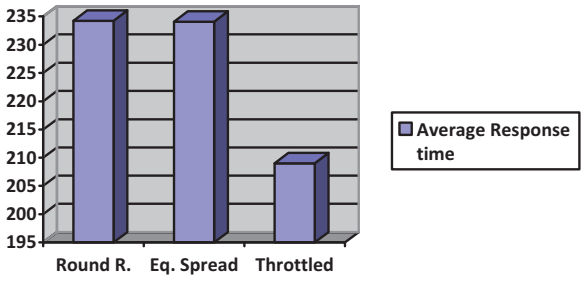

Fig.7 Average response time comparison

E. Average Data Center Processing Time

Data center processing time is the time taken by data center for processing request to load balancer, find three different result of data center processing time for three different load balancing policy namely Round Robin, Equally spread current execution and Throttled, here the processing time is almost same of Round Robin and Equally spread current execution, which is shown in given graph Fig.8 comparison of data center processing time of each load balancing policy.

Data center processing time for Round Robin (50.53ms), Equally spread current execution (50.36ms) and Throttled (25.47 ms) that means Round Robin, data center processing time is more as compare to Throttled and Equal Spread and we can conclude it from the given graph that throttled is best for data center processing time.

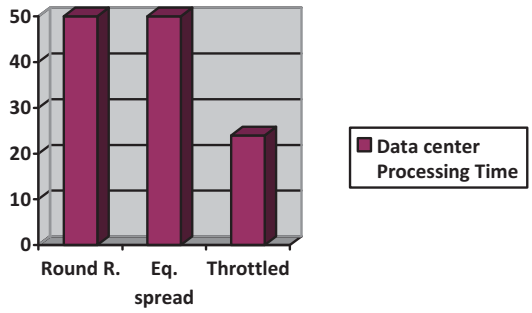

Fig.8 Data Center Processing Time Comparison

VII. Conclusion and Future work

From above simulation result we can conclude that which one is best among them according to their total response time and their data center processing time but still we can't justify that the which algorithm is best because we have studied that the performance of load balancing algorithms is different in different scenario. As per our knowledge, performance of load balancing algorithms depends on many factors such broker policy or number of users as well. Here we use the closet data center broker policy and for the 60 min time duration of simulation for analysis of the algorithms, separately for each algorithm and demonstrated, the best one is Throttled among Round Robin and Equally Spread Current Execution because Throttled take less time as compare to both of them.

For the Future work, we can improve the response time of any of algorithms by some manipulation in algorithm and we can choose another load balancing algorithms for analysis of their performance according to their matrix such throughput ,processing cost etc. and also can analyze these algorithms with different parameter and different broker policy and can get different result as there shown such as there are many broker policy namely optimized response time and reconfigure dynamic, these are some broker policy, you can use them in your future research work.

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