CLOUD COMPUTING INVESTIGATION FOR CLOUD COMPUTER NETWORKS USING CLOUDANALYST

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ABSTRACT

In this paper, the performances of load balancing algorithms; Round Robin, Equally Spread Current Execution, and Throttled, in two workload cases, normal and burst are investigated using CloudAnalyst simulator tool. The main objective is to examine the effect of three experiments for regular and irregular normal workloads on the performance of different load balancing algorithms as well as for bursty workload. Each test has two different configurations for parametric investigations. These parametric studies can be used to analyze any electronic service provided by cloud technology vendors in any institutions, especially those offer self-reporting details for every day.

Keywords: *Cloud Computing, Cloudanalyst, Load Balancing Algorithms.*

1. INTRODUCTION

There are numerous possible explanations for cloud computing term. The majority of them concentrate on the technological issues only. Cloud computing is described as a massive collection of various hardware, software, and other services can be managed via "cloud" environment. The entire sources of them can be retrieved at any time and anywhere as needed. Generally, the cloud provider vends his service based on as pay-per-use. Namely, it indicates that there is huge flexibility in the adoption of these services as additional resources which are constantly accessible. This technology is the most overvalued and efficient tool used in all sections of engineering, business, and other sciences to boost the capability or insert capacities with dynamism, with no supplying any new infrastructure [1].
National Institute of Standards and Technology (NIST), USA, defined cloud computing in the most

acceptable manner as a model for qualifying convenient, on-demand network access to a shared pool of configurable computing resources as in networks, servers, storage, applications, and services that can be speedily provisioned and released with marginal management effort or service provider interaction.

Various transactions of commerce and industry are presently utilizing cloud computing resources that have been classified as one of the ten leading technologies of the 21st century. It has been predicted that the worth of the cloud computing market is going to boost from $40.7 billion to $240 billion from 2011 to the 2020 year ranges. Cloud computing has promising features to distribute IT services and its huge importance is analogous to the importance of electricity, telecommunications, and water. It is also a facilitating tool to make available computing resources to hold up other technologies and applications as in the Internet of Things and mobile computing. Considering cloud computing

into account changes not merely the adopted technology by an enterprise but also the approach in which business transactions are handled. Additionally, transforming enterprise resources to a cloud environment engages decision making at the tactical, strategic and outfitted levels, and prospectively impacts all organizational aspects [2].

The virtualization, rapid elasticity, broad network access, and superior performance of cloud services are the most important factors to make this technology extremely rising continuously. With customary "off-the-shelf" software packages, an application is typically established on the corporation's foremost server, and in that case on every computer in the workplace in all over the organization [3-4].

Some cloud computing simulation tools were developed to support system administrators, experts in the cloud, academics, and network responsible in determining the performance of cloud environments in the real-time [5], and assist them to an emphasis on quality issues of the itemized component under numerous scenarios. These simulators have the advantages of no capital expenses, simplicity and optimization possibilities for getting the finest cloud performance.

In this research, the investigational parameters of load balancing algorithms of Round Robin (RR), Equally Spread Current Execution (ESCE), and Throttled, in two workload cases, normal and burst are determined with parametric studies. This part aims to examine the effect of three experiments for the normal workloads (Regular and Irregular) on the performance of different load balancing algorithms as well as for bursty workload.

2. CLOUD ARCHITECTURE

Architecturally, it is confused to understand how the cloud is equivalent to and dissimilar from accessible standards of computing and how these equivalencies and dissimilarities affect the managerial, operational, and technical segments to network and information security manners. There are mainly three significant categories of cloud employment models as in Figure 1 including Public Cloud, Private Cloud, and Hybrid Cloud. Nevertheless, there are several particular clouds treated for marketable purposes as in Community cloud and mobile cloud [6-9].
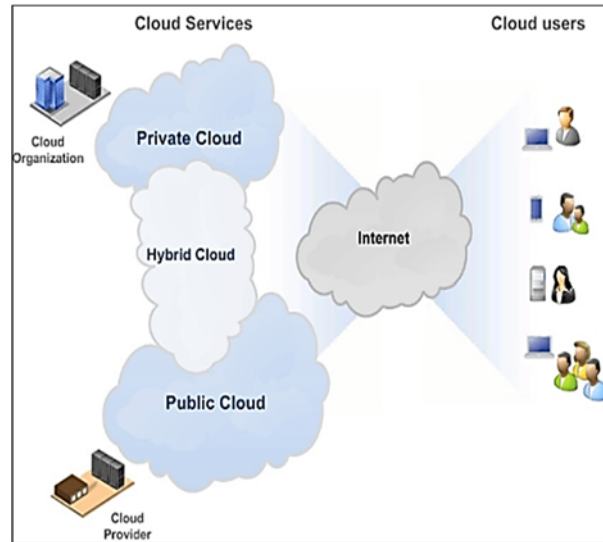

Figure 1 Essential Architecture of Cloud Computing

Public cloud architecture represents storing and other resources that are used by the universal community by a service supplier, without charge for all services or a pay per use model.
 Private cloud infrastructure is run exclusively for a particular association, whether controlled inwardly or by a third-party and held inwardly or outwardly. Some associations can host vital applications based on private clouds with somewhat fewer security matters on the public cloud. Hybrid cloud computing combine private and public cloud types together. This is the incorporation of dual or more clouds (private, community or public) that are remained as distinctive entities but they are bounded jointly, presenting the advantages of numerous deployment models.

A community cloud in computing is a cooperative determination in which infrastructure is mutual amid numerous establishments from a particular community with mutual interests (security, compliance, jurisdiction, etc.), whether administered within or by a third-party and hosted inwardly or on the exterior. The outlays are spread over fewer users than a public cloud, but further than a private cloud. Consequently, just several probable costs of cloud computing are recognized. The community cloud is a distinctive sort of service where a collection of service suppliers is joint mutually and establishes a community reliant on service category.
 Mobile cloud computing stands for the practice of cloud computing to be combined with mobile devices. It occurs when data and transactions are reserved on the Internet more willingly than on device entities, given that on-demand right of entry.

The applications of a mobile cloud are managed on an isolated server and at that time transferred to the user. These applications are a speedily emergent segment of the international mobile marketplace.

3. CLOUD DELIVERY MODELS

Cloud computing servers set up three services classified principally into three models with Infrastructure as a service (IaaS), Software as a service (SaaS) and Platform as a service (PaaS) as illustrated in Figure 2 [4].
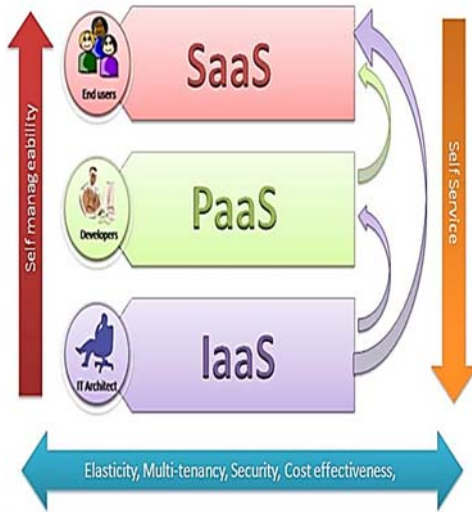

Figure 2 Delivery models of cloud services

 IaaS is the deliverance of computer infrastructur characteristically with a platform virtualization surroundings as a service. This fundamental model of cloud service offers computers and other resources as substantial or mostly as virtual machines. While SaaS conveys programs to millions of clients throughout the browser. It is regularly used in individual resource organization system and Enterprise Resource Planning(ERP). Yahoo and Google are application examples that provide this service category. Lastly, PaaS offers framework as a service layer depending on which software applications can be steadily and dependably built. Industry Analyst firm Forrester depicts PaaS as an outwardly hosted service that offers a comprehensive scheme to generate, manage, and activate applications. Various instances of PAAS can be found in Cloud Foundry, Google App Engine, EngineYard, and Mendix [6, 10].

4.   CLODANALYST

CloudAnalyst simulator tool as shown in Figure 3, uses Graphical User Interface (GUI) rooted from CloudSim. It has a number of comprehensive characteristic and qualifications. It can be used to investigate the performance of substantially scaled Internet appliance in the cloud atmosphere and disconnect the experimental tests and simulations from a programming exercise. Furthermore, it facilitates a modeler to repetitively execute simulated tasks and experiments with minor parameters deviations swiftly and straightforwardly [11]. CloudAnalyst evaluates the communal network tools along with the geographical allocation of data centers and users.

It is considered an influential simulation structure for arranging concurrent data centers and checking load balancing, cloud cluster monitoring and real-time data center and data flow. It permits operators to save simulation structures as an XML file and makes live consequences in PDF file. CloudAnalyst has accessible GUI for the creation and showing of all kinds of results of cloud computing experimental tasks.

- It has a superior level of arrangement and suppleness since it is operational with the efficient modelers of an excellent amount of control over the experiment by modeling entities like storage and bandwidth, memory, data centers and virtual machines.

- It is also very effective experiment looping and can accumulate simulated scenarios and loop them many times by particular variations.

- Lastly, CloudAnalyst provides well-organized graphical simulated outcomes in the form of charts and tables aside from all statistical data.
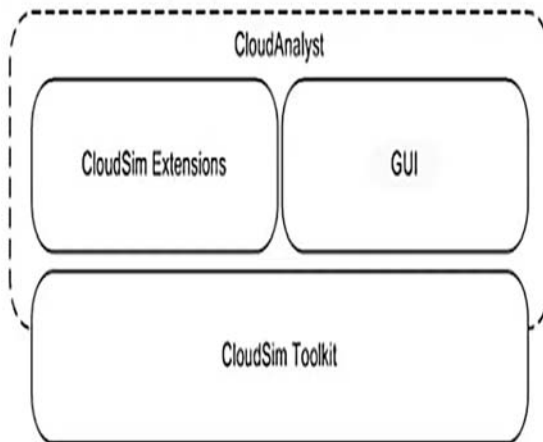

Figure 3 CloudAnalyst Structure

4.1 Cloud Analyst Startup

When CloudAnalyst starts, the foremost screen appears with a map of the world at the center of the screen. CloudAnalyst divides the world into six regions located in the six central continents. Those

regions are used in distributing DCs and UBs during the configuration process.

On the left side of the screen, there is a Control Panel with the following 4 options:

1. ' Configure Simulation': Opens the Configure Simulation Screen
2. ' Define Internet Characteristics': Opens Internet Screen with required features
3. ' Run Simulation': For simulation execution
4. ' Exit'.

4.2 CloudAnalyst Configuration

The configure option consists of 3 tabs.

1. ' Main Configuration Tab'

The configuration options on the core tab are:
' Simulation time': the simulation period that is feasibly prearranged in minutes, hours or days.
' User Bases Table': It represents the list of every user base in the simulation. All of them have the subsequent configurable fields as a solitary table row.
a. 'Name'
b. ' Region'
c. 'Request per user per hour'
d. ' Data size per request'
e. ' Peak hours'
f. ' Average users during peak hours'
g. ' Average users during off-peak hours'

The ' Add and Remove' keys adjacent to the table are utilized to insert or eliminate user bases from the arrangement.

' Application Deployment Configuration': It represents the amount of virtual machines (VMs) as a table that is distributed for the relevance in every data center from the 'Data Centers' tab, in conjunction with the features of a VM. Their elements are:
a. 'Data Center': This is a drop-down list of all data center names made in the Data Center tab.
b. ' Number of VMs': The number of virtual machines to be assigned for the relevance rof the taken ' Data Center.'
c. ' Image Size': A particular virtual machines image magnitude in bytes.
d. ' Memory': It is the quantity of memory accessible toa particular virtual machines.
e. ' BW': It is the quantity of bandwidth existing

in a solitary virtual machine.
' Service Broker Policy': This drop-down is used to indicate the brokerage strategy among data centers that selects the specific data to get traffic from the specific user base. The accessible procedures are:
a. 'Closest data center': The data center with the smallest amount of network potential ignoring network bandwidth from a specific user base has directed the requests from that user base completely.
b. ' Optimize response time': This option lets you do effectual load equilibrium amid data centers if a data center becomes overloaded.

The "Save Configuration" option lets you save the created configuration as (.sim) extension file. On the other hand, by "Load Configuration" key loading an earlier saved simulation configuration can be done.

2. Data Center Tab
This tab is used to describe the pattern of a data center. The table at the topmost catalogs the data centers and by 'Add/Remove buttons' you can insert or eliminate data centers to the structure. The main factors of this tab are:

1. ' Name'
2. ' Region'
3. ' Architecture', it is the structural design of the servers employed in the data center.
4. ' Operating System'
5. ' Virtual Machine Monitor (VMM)'
6. ' Cost per VM Hour'
7. ' Cost per 1Mb Memory Hour'
8. ' Storage cost per Gb'
9. ' Data Transfer cost per Gb '
10. ' Number of servers'

At what time you choose a data center from this table, a 2nd table is going to come into view under it with the particulars of the server machinery in the data center. The limitations of every machine are prearranged along with the existing fields:
' Machine Id'
' Memory'
' Storage'
' Available network bandwidth'
' Number of processors'
' Processor speed'
' VM allocation policy (time shared/space shared)'

3. "Advanced Tab"

This tab includes a number of significant parameters

that can be applied to the whole simulation.

a. 'User Grouping Factor (in User Bases)': It explains the simulation details about the number users must be considered as a particular collection for traffic creation. This given number can be employed as requests number in the form of single 'InternetCloudlet'. In the superlative scenario, this parameter is supposed to be '1' for each represented user autonomously. Nonetheless, this increases the simulation period.

b. ' Request Grouping Factor (in Data Centers)': It shows the number of requests must be considered as a solitary processing unit. For instance, these requests are collected jointly and dedicate to a solitary VM unit. Once more, superlatively this must be '1'. However, it possibly will be visualized as the amount of real-time threads for handled solitary relevance for VM.

c. ' Executable instruction length (in bytes)': It stands for the major limitation that influences the request implementation duration. It is equivalent to 'GridletLength' factor in 'GridSim' field.

d. ' Load balancing policy': It is a sort of policy that employed by every data centers in requests assignment to VMs. Their accessible policies are as follows:

- 'Round-robin'

- ' Equally, Spread Current Execution Load': The load balancer preserves the pathway for the number of Cloudlets that are presently being handled by every VM and tries to level out the active load.

- 'Throttled': This policy hugely restricts the requests amount for a particular VM.

4.3 'Internet Characteristics Display'

The display of Internet Characteristics Configuration is used to adjust the bandwidth and Internet latency parameters. It has two matrices for these parameters.

4.4. Results Screen

When the simulator is finished, the major response times are going to be shown on the simulator board close to every user base. The full results could be displayed by the "View Detailed Results" option that comes into view at the right bottommost corner of the screen beyond the simulation completion.

The results display has collected data from the simulator tool that consists of the following:

- ' Overall response time summary' for the entire the user bases.

- 'Response time by user base in tabular format'

- 'Response time by user base in graphical format'

- 'Request servicing time by each data center in tabular format' that is not working into twenty-four hours per day.

- 'Request servicing time by the data center in graphical format' that is not working into twenty-four hours per day.

- 'Data center loading' that represents serviced requests number in a graphical format that is not working into twenty-four hours per day.

- 'Cost details'

5.   RESULTS AND DISCUSSION

In this study, we will investigate the performance of Round Robin (RR), Equally Spread Current Execution (ESCE), and Throttled using two different configurations for normal workloads in regular environment (same number of CPU in the Data Center and same CPU speed), irregular hosts (different CPU characteristics in the Data Center) in addition to bursting(busy hours) environments. These parametric studies can be used to evaluate any electronic service provided by cloud technology in any institutions, especially those provide self-reporting facts for day by day. All experiments are based on "optimize response time" service broker policy. All user bases are distributed within 0 to 4 region IDs with repeated region 2 for UB 3 and 6 for all experiment configurations except for high burst configuration in which all user bases are adjusted within region 0 only.

5.1   Experiment 1: Workload Using Regular Hosts

This experiment is done to check the functioning of three popular load balancing algorithms in normal workload. In this experiment, we will study the performance of RR, ESCE, and Throttled using two different configurations for normal workloads in the regular environment.

For this experiment, two different configurations for user bases are used for investigating the operation of the load balancing algorithms under two different samples of normal workloads. In this experiment, the number of processors is equal in all the physical hosts. The duration of the simulation is 1 Day.

One Data Center is used with 50 Virtual Machines, and five Physical HW Units all of them have the same number of processors and the same processor

speed. Table 1 presents the Data Center configurations while Table 2 shows the configuration of the Physical Hardware of the Data Center.

Table 1 Data Center Configurations for Experiment 1

Name	Region	RUH	DR(Bytes)	PHS(GMT)	PHE(GMT)	APU	AOPU
UB1	0	15	200	13	15	20000	2000
UB2	1	15	200	15	17	10000	1000
UB3	2	15	200	17	19	14000	1400
UB4	3	15	200	1	3	15000	1500
UB5	4	15	200	21	23	5000	500
UB6	2	15	100	5	11	8000	100

Name	Region	RUH	DR(Bytes)	PHS(GMT)	PHE(GMT)	APU	AOPU
UB1	0	15	100	6	15	20000	2000
UB2	1	15	100	15	17	10000	1000
UB3	2	15	100	17	22	14000	1400
UB4	3	15	100	1	3	15000	1500
UB5	4	15	100	21	23	5000	500
UB6	2	15	100	5	11	8000	100

Data Center	#VMs	Image Size	Memory	BW
DC1	50	10000	512	1000

Table 2 Physical Hardware Configurations for DC1 for Experiment 1

No. of Physical HW Unit	Memory (Mb)	Storage (Mb)	Available BW	No. of Processors	Processor Speed	VM Policy
5	2048	100000	1000	4	100	TIME_SHARED

In configuration 1, we use normal workload with two Peak Hours for six user bases and one data center for virtual cloud environment as shown in Figure 4.
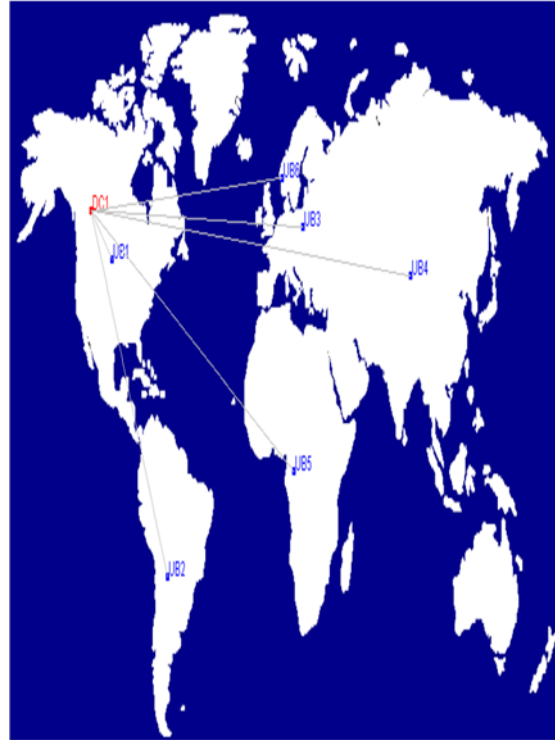

Figure 4 Datacenter and six user bases within a virtual cloud environment

The configuration1 used in this experiment is as followed in Table 3 in terms of regions, request per user per hour(RUH), data size per request(DR), peak hours start (PHS), peak hours end (PHE), average peak users(APU) and average off-peak users (AOPU).

Table 3 User Base Configuration1 for Experiment 1

In configuration 2, we increased mostly the Peak Hours for every user base and at the same average of users in the Peak and the Off-Peak periods as shown in Table 4.

Table 4 User Base Configurations for Experiment 2 (Config. 2)

5.1.1 Results

The configurations above have used for every load balancing policies in a sequence dependent on that we get the following results:
According to configuration 1 for User Base, the curve of the requests received in Data Center1 per

hour is as shown in Figure 5. In this figure, the non-uniform peaks appear in the curve of the highest hours of the user bases.
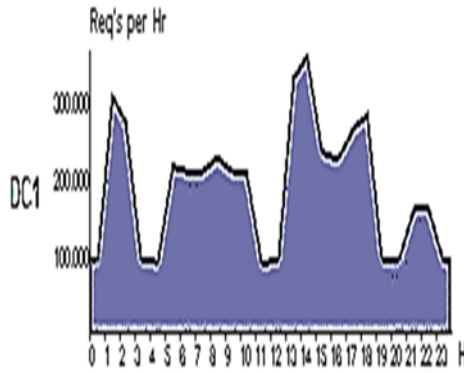

Figure 5 Data Center Hourly Loading for Normal Workload (Config.1)

When applying Configuration 2 of User Base, the Hourly Loading graph is as presented in Figure 6. As we can see in this figure, there is mostly not a clear peak in the curve as it was in Configuration 1. This is because the peak hours of the User Bases in Configuration 2 are longer than ones in Configuration 1, and there are overlaps between them.
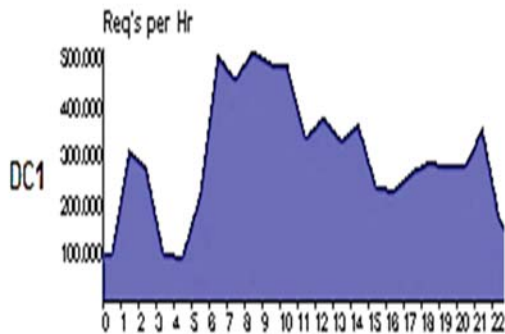

Figure 6 Data Center Hourly Loading for Normal Workload (Config.2)

Consequently, in this experiment, two loads are applied by changing the duration of Peak Hours under the same average number of users in every User Base. All the Physical Hosts have the same amount of CPU and the same CPU speed. The results in Tables 5-6 show that in both configurations,

Throttled has a better response time and processing time than ECSE and Round Robin cases. The total costs of VM and Data transfer Costs are constant for all these cases, and they are 97.73 and 123.69 $ for each configuration.

Table 5 Summary results of configuration 1 under RR, ESCE and Throttled conditions.

	RR	ESCE	Throttled
Overall response time(ms)	618.03	617.83	448.88
Data Center processing time (ms)	343.48	343.27	174.53
A grand total of VM and Data transfer Costs($)	97.73	97.73	97.73

Table 6 Summary results of configuration 2 under RR, ESCE and Throttled conditions.

	RR	ESCE	Throttled
Overall response time(ms)	794.50	794.56	508.12
Data Center processing time (ms)	577.19	577.26	291.15
A grand total of VM and Data transfer Costs($)	123.69	123.69	123.69

5.2 Experiment 2: Workload Using Irregular Hosts

This experiment is done to test the functioning of three load balancing algorithms in a normal workload. In this experiment, we will study the performance of RR, ESCE, and Throttled in two different normal workloads and irregular hosts (different CPU characteristics in the Data Center).

In this experiment, bases in experiment 1 are in the irregular environment. A different number of processors and different processor speeds in the physical hosts are used. The duration of the simulation is 1 Day.

One Data Center is used with 50 Virtual Machines and 5 Physical HW Units. The five hosts have a different number of processors and different processors speed. Table 7 presents the Data Center configurations, while Table 8 shows the configuration of every Physical Hardware in the Data Center.

Table 7 Data Center Configurations for Experiment 2

Data Center	#VMs	Image Size	Memory	BW
DC1	50	10000	512	1000

Table 8 Physical Hardware Configurations for DC1 for Experiment 2

ID	Memory (Mb)	Storage (Mb)	Available BW	Number of Processors	Processor Speed	VM Policy
0	2048	100000	10000	4	200	TIME_SHARED
1	2048	100000	10000	5	500	TIME_SHARED
2	2048	100000	10000	2	300	TIME_SHARED
3	2048	100000	10000	2	100	TIME_SHARED
4	2048	100000	10000	3	100	TIME_SHARED

In configuration 1, we use normal workload with two Peak Hours for every user base. The settings used in this experiment are as follows:

Table 9 User Base Configuration for Experiment 2

Name	Region	RUH	DR(Bytes)	PHS(GMT)	PHE(GMT)	APU	AOPU
UB1	0	15	100	13	15	20000	2000
UB2	1	15	100	15	17	10000	1000
UB3	2	15	100	20	22	14000	1400
UB4	3	15	100	1	3	15000	1500
UB5	4	15	100	21	23	5000	500
UB6	2	15	100	9	11	8000	100

In configuration 2, the Peak Hours was increased for some user bases and the average of users in the Peak and the Off-Peak periods are the same as shown in Table 10.

Table 10 User Base Configurations for Experiment 2 (Config. 2)

Name	Region	RUH	DR(Bytes)	PHS(GMT)	PHE(GMT)	APU	AOPU
UB1	0	15	100	6	15	20000	2000
UB2	1	15	100	15	17	10000	1000
UB3	2	15	100	17	22	14000	1400
UB4	3	15	100	1	6	15000	1500
UB5	4	15	100	21	23	5000	500
UB6	2	15	100	9	11	8000	100

5.2.1 Results

The configurations above had used for every load balancing policies in sequence.

According to configuration 1 for User Base, the curve of the requests received in Data Center1 per hour is as shown in Figure 7. In this figure, some distorted spiky peaks appear in the curve presenting the topmost hours of the user bases. This response is identical for all cases of RR, ESCE, and Throttled load conditions.
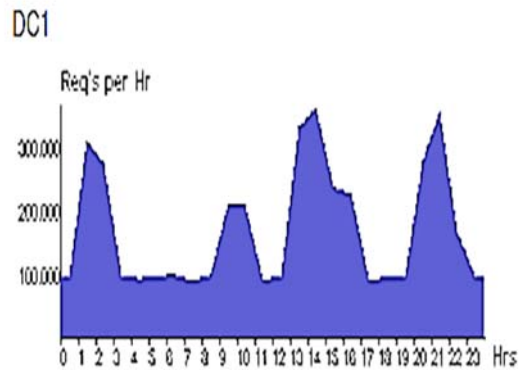

Figure 7 Data Center Hourly Loading for Normal Workload (Config.1)

When applying Configuration 2 of User Base, the Hourly Loading graph is as presented in Figure 8. As we can see in this figure, there is not a clear peak in the curve as it was in Configuration 1 and it is worse than results in Configuration 2 of Experiment 1 in peaks clarity. This is because the peak hours of the User Bases in Configuration 2 are longer than ones in Configuration 1, and there are huge overlaps

between them. This response is the same for all cases of RR, ESCE, and Throttled load conditions.
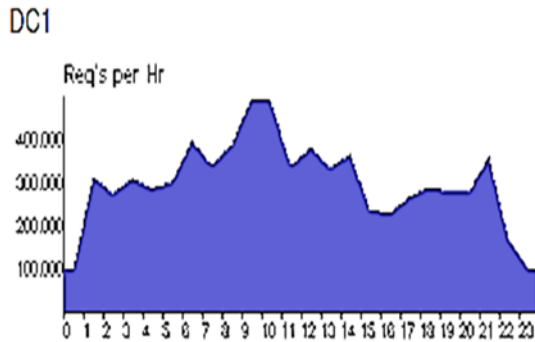

Figure 8 Data Center Hourly Loading for Normal Workload (Config.2)

So, in this experiment, the two workloads used in Experiment 1 have been used here but in the irregular environment. When the results of experiments 1 and 2 are compared, we can notice that using different configurations for the Physical Hosts in the Datacenter affect the performance of the load balancing algorithm.   The consequences explain that Throttled has the finest performance in irregular hosts as in regular hosts as explained in Tables 11-12. The total costs of VM and Data transfer Costs are constant for all these cases, and they are 92.76 and 124.92 $ for each configuration.

Table 11 Summary results of configuration under RR, ESCE and Throttled conditions

	RR	ESCE	Throttled
Overall response time(ms)	570.80	542.31	350.67
Data Center processing time (ms)	299.24	270.71	79.04
A grand total of VM and Data transfer Costs($)	92.76	92.76	92.76

Table 12 Summary results of configuration 2 under RR, ESCE and Throttled conditions

	RR	ESCE	Throttled
Overall response time(ms)	757.01	729.54	377.08
Data Center processing time (ms)	522.12	494.63	142.17
A grand total of VM and Data transfer Costs($)	124.92	124.92	124.92

5.3   Experiment 3: Burst Workload

The foremost goalmouth of this experiment is to examine the impact of the bursty workload on the performance of RR, ESCE, and Throttled. In this test, we are going to examine two level of burst, high and medium. For this goal, two different configurations will be applied.
One Data Center is used with 50 Virtual Machines and 5 Physical HW Units. The five hosts are irregular (have a different number of processors speed).   Table   13 presents the Data Center configurations   while   Table   14 shows   the configuration of every Physical Hardware in the Data Center.

Table 13 Data Center Configurations for Experiment 3

Data Center	#VMs	Image Size	Memory	BW
DC1	50	10000	512	1000

Table 14 Physical Hardware Configurations for DC1 for Experiment 3

ID	Memory (Mb)	Storage (Mb)	Available BW	No. of Processors	Processor Speed	VM Policy
0	2048	100000	10000	4	200	TIME_SHARED
1	2048	100000	10000	5	500	TIME_SHARED
2	2048	100000	10000	2	300	TIME_SHARED
3	2048	100000	10000	2	100	TIME_SHARED
4	2048	100000	10000	4	100	TIME_SHARED

Configuration 1 presents a medium level of bursty workload. For Configuration 1, all User Bases are in the different region varied from 0 to 5, and every one of these user bases has one peak hour. In this configuration, the average number of users in peak hour = the average number of users off-peak * 10 except for UB6. Table 15 illustrates the User Base characteristics.

Table 15 User Base Configuration for Experiment 3 (Config. 1)

Name	Region	RUH	D(Bytes)	PHS(GMT)	PHE(GMT)	APU	AOPU
UB1	0	15	100	13	14	20000	2000
UB2	1	15	100	15	16	10000	1000
UB3	2	15	100	20	21	14000	1400
UB4	3	15	100	1	2	15000	1500

UB5	4	15	100	21	22	5000	500
UB6	2	15	100	9	10	8000	100

For High Burst configuration, we use 6 User Bases all of them in the same region(region 0) as shown in Figure 9 to ignore the transmission delay between regions. Every user base has one hour of peeking and the average number of users in this hour is 20000 users. Table 16 lists in details User Base configuration.
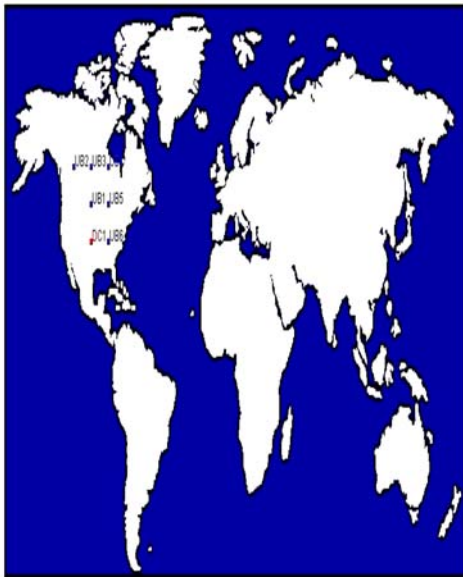

Figure 9 Datacenter and six user bases within a virtual cloud environment in Region 0

Table 16 User Base Configurations for Experiment 3 (High Burst Config.2)

Name	Region	RUH	DR(Bytes)	PHS(GMT)	PHE(GMT)	APU	AOPU
UB1	0	15	100	13	14	20000	1000
UB2	0	15	100	9	10	20000	5000
UB3	0	15	100	20	21	20000	1500
UB4	0	15	100	1	2	20000	2000
UB5	0	15	100	5	6	20000	1000
UB6	0	15	100	17	10	20000	2500

5.3.1 Results

For medium Burst Workload, as presented in Figure 10, there are five spiky peaks on the curve. Every peak takes one hour except the last peak takes two hours. Various gap lengths separate these peaks.

All through these hours, an absolute number of requests are received by the Data Center. At the end of the peak hour, the workload returns to normal. This response is the same for all cases of RR, ESCE, and Throttled load conditions.
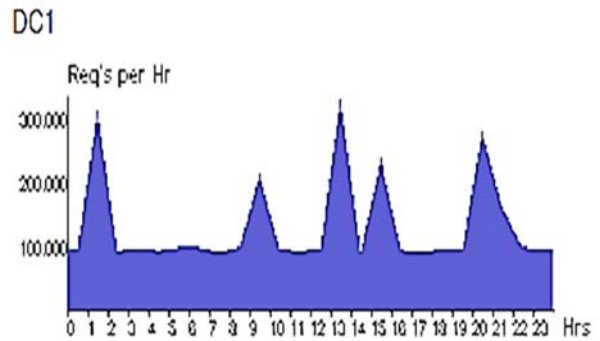

Figure 10 Data Center Hourly Loading for Medium Burst Workload (Config.1)

For High Burst Workload, from the graph below we can see that there are five peaks on the curve with different requests rate. Every peak takes one hour as shown in Figure 11 under all load conditions. There is about equal gap amid peak spikes of curve except for the gap before last peak spike.
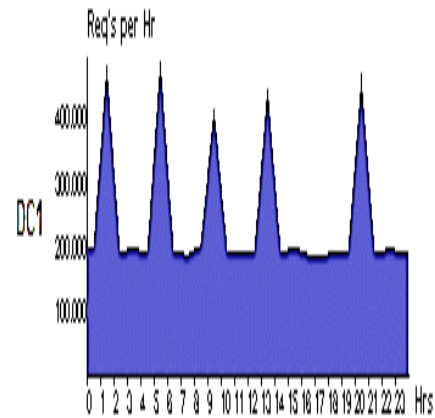

Figure 11 Data Center Hourly Loading for High Burst Workload (Config.2)

The results show that Throttled has the optimum Response Time and processing time under medium and high burst for Configurations 1 and 2 respectively. The total costs of VM and Data transfer Costs are constant for all these cases, and they are 82.67 $ for configuration1 that stands for the lowest expenses over other previous experiments and 111.06 $ for configuration 2. All details can be seen in Tables 17-18.

Table 17 Summary results of configuration 1 under RR, ESCE and Throttled conditions.

	RR	ESCE	Throttled
Overall response time(ms)	478.24	453.39	326.26
Data Center processing time (ms)	205.72	180.84	53.69
A grand total of VM and Data transfer Costs($)	82.67	82.67	82.67

Table 18 Summary results of configuration 2 under RR, ESCE and Throttled conditions.

	RR	ESCE	Throttled
Overall response time(ms)	370.23	364.95	140.88
Data Center processing time (ms)	320.46	315.18	91.14
A grand total of VM and data transfer costs($)	111.06	111.06	111.06

6. CONCLUSIONS

In this paper, three experiments have been presented and discussed using CloudAnalyst simulator. All simulation durations are adjusted to be 1 day. The results have been compared with RR, ESCE, and Throttled using two different configurations for workloads in a regular environment (same number of CPU in the Data Center and same CPU speed), irregular hosts (different CPU characteristics in the Data Center) and bursting case of medium and high levels .

The results show that Throttled has the best response time and processing time for all experiments and configurations as compared with RR and ESCE. Regardless of each experiment and

its configuration, the total costs of VM and Data transfer Costs are constant for their workloads, and the lowest expenses of 82.67 $ are found in configuration 1 in the medium bursting case in experiment 3 over other experiments.

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