International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 02 Issue: 06 | Sep-2015 www.irjet.net p-ISSN: 2395-0072

Throtelled: An Efficient Load Balancing Policy across Virtual Machines within a Single Data Center

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Abstract---- ***Cloud computing is the field of computing that is growing rapidly day-by-day both in academic and industry in order to fulfill requirements of end-users. Cloud computing enables a wide range of users to approach Distributed, Scalable, and Virtualized assests over the net. Cloud Computing is a part of Distributed Computing. Cloud Computing intended to influence next creation data centers and allows application service providers to hold data center capabilities for deploying applications depending on user's Quality of Service (QoS) requirements. One major issue that the web application developer or designer faces before deploying his or her application on cloud is meeting quality of service (QoS) with efficient performance based on the user needs. Above query can be dealed with analyzing the performance of application in a massively distributed environment through detailed comprehensive studies done through simulation techniques. CloudAnalyst is one of the simulation tools that extends GridSim and CloudSim techniques and is used by application developers or designers, to study the nature of large-scaled internet applications in cloud environment. Nature of cloud application depends on it's performance fulfilling user needs and performance depends on the load on the server (i.e. on data center). Load on a single data center depends on the load balancing policy used across virtual machines in a single data center, processing the end-user request. If load balancing policy used is effective and efficient then the speed and performance of the cloud application is improved. In this paper, first we are giving a short description on existing load balancing policies and then making comparison among them on the basis of results of simulation experiments that we performed in two different scenarios. And on the basis of that comparison, we are proving that throtelled load balancing policy is more effective and efficient than other load balancing policies. Thus, presenting an efficient virtual machine(s) load balancing policy within a single data center in cloud computing environment.***

Key Words- *Cloud Computing, VmLoad Balancer, Modeling, Simulation, Cloud Simulators, Virtual Machine, Performance Analysis, Load Balancing Policy, CloudAnalyst.*

1. INTRODUCTION

Now-a-days progress in computer science and Internet technology made computing on real cloud a high demand. Cloud computing in real sense is performing any task by making use of services that are provided by cloud providers. Cloud computing is the field of computing that is growing rapidly day-by-day both in academic and industry in order to fulfill requirements of end-users. Cloud server is a combination of data storage server and computation server. Cloud Computing is a part of distributed computing. Aim of cloud computing is to provide distributed, virtualized and flexible resources as services to users.

Cloud computing includes services that are provided both by service provider and data centers. Cloud computing involves distributed and grid computing theories. Cloud computing has made the computing as a quality of practical use. Cloud Computing shares the server memory, data and applications simultaneously with multiple users. Cloud computing supports reliable, secure, fault tolerant, sustainable and scalable services. It not only provides physical hardware resources but also provides platform, data and applications to multiple end-users simultaneously. Cloud Computing provides on demand service model and pay-as-you-go service model to consumers.

Cloud Computing provides Infrastructure (IaaS), Platform (PaaS) and Software or Application (SaaS or AaaS) as utilities to cloud consumers or end-users. It not only supports storage services but also provides hosting of web applications on real cloud. Earlier, while designing a web application it's deployment and hosting was main concern or main issue. But with cloud infrastructure it is possible to solve above issue more economically and more responsively. Overall study of above dispute in a heavily distributed environment is very difficult. So, to study such a dynamic environment again and again in a controlled manner application developers or designers uses simulation tool. CloudAnalyst is one of the simulation tools that extends GridSim and CloudSim and is used by application developers, to study the nature of large-scaled internet applications in cloud environment.

Nature of cloud application depends on it's performance fulfilling user needs and performance depends on the load on the server (i.e. on data center). Load on a single data center completely depends on the load balancing policy used across virtual machines in a single data center, processing the end-user request. If load balancing policy used is effective and efficient then the speed and performance of the cloud application is improved. There are three existing load balancing policies which are discussed in the next section.

2. RELATED WORK

Simulating something requires that the model should be developed first. A model representing the system itself has some features or characteristics that it possess. These features are simulated by some simulation technique to check the behavior of the system for it's trait affirmation. Simulation is the process of finding out the behavior of system or application at some instance of time during it's decapitation. In case of cloud computing surroundings, applications are simulated using some simulation tool. CloudAnalyst is one of the simulation tools that extends GridSim and CloudSim and is used by application developers, to study the nature of large-scaled internet applications in cloud environment. Nature of cloud application depends on it's performance fulfilling user needs and performance depends on the load on the server (i.e. on data center). Load on a single data center completely depends on the load balancing policy used across virtual machines in a single data center, processing the end-user request. Load balancing is the mechanism of balancing load across various servers or resources in order to maximize throughput, optimize resource utilization, minimize the cost of machine, improve performance and minimize overall response time. If load balancing policy used is effective and efficient then the speed and performance of the cloud application is improved. There are mainly three existing load balancing policies : Round-Robin, Equally Spread Current Execution (ESCE) and Throtelled.

2.1 Round-Robin Load Balancing Policy

It is based on the round-robin algorithm that uses a time slot to execute a tasks or job. It is the simplest algorithm in which processors execute the user query or request or task within a particular time interval or time slot provided to it. Suppose there are two processors P1 and P2. P1 is given time slot 5 and P2 is given time slot 10. So, P1 will complete it's task earlier than P2. This means that after time slot 5, P2 continues to execute while P1 will remain idle which is not an optimize resource utilization. This is one major drawback of round-robin load balancing policy.

2.2 Equally Spread Current Execution Load Balancing Policy

This policy removes the drawback of Round-Robin load balancing policy by equally distributing the workload among various servers or data centers or resources. The upcoming user request or load on server is equally distributed and processed among it's virtual machines. This helps to improve performance of overall system and also minimizes overall response and processing time. But if number of upcoming user requests is more than the available virtual machines at a particular data center then in that case Throtelled load balancing policy will be appropriate to use.

2.3 Throtelled Load Balancing Policy

This policy ensures that only a pre-defined number of cloudlets are allocated to single virtual machine at any particular time. But if there are more number of user requests and if these user requests are more than the available virtual machines at a particular data center then some of the requests are queued until the next virtual machine becomes available. This helps in improving the performance as compared to round-robin and equally spread current execution load balancing policies.

We performed simulation of a large-scaled web application deployed on cloud using CloudAnalyst simulator and analyzed it's performance in two different scenarios using all three load balancing policies one by one within each scenario in order to check which policy (i.e. Vm Load balancing policy) is improving performance of the application. These simulation experiments and their results are given in next section

3. SIMULATION EXPERIMENTS AND THEIR RESULTS

Before running simulation first configure or set simulation parameters like user bases, data centers, application deployment on data center, service broker policy, load balancing policy, VMs within single data center, etc. then run simulation and evaluate or analyze results based on overall response time, data center processing time, data center request servicing time, total virtual machine cost and total data transfer cost.

3.1 Scenario 1 : When application is deployed on two data centers DC1 and DC2 with 10 virtual machines in both data center

Case 1 : Using Round-Robin Load Balancing Policy

Table -1: Simulation summary

Parameters	**Values**
User Bases	UB1, UB2, UB3, UB4, UB5, UB6
Data Center(s)	DC1, DC2
Data Center Region(s)	R0, R5
Service Broker Policy	Closest data center
Application deployment	DC1,DC2
No. of Virtual machines in each data center	10 VMs both in DC1 and DC2
Load Balancing Policy across VMs in a single data center	Round-Robin

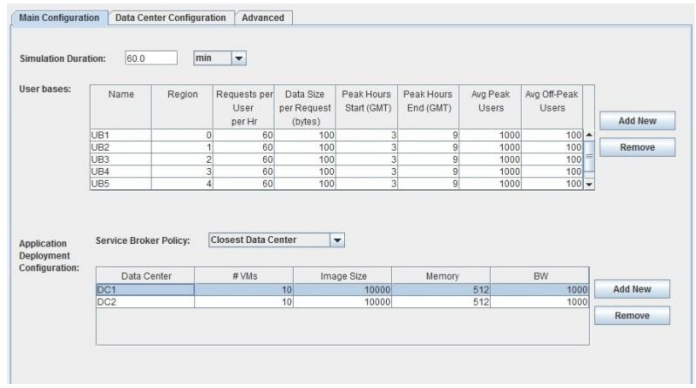

Fig. 1 : Main Configuration

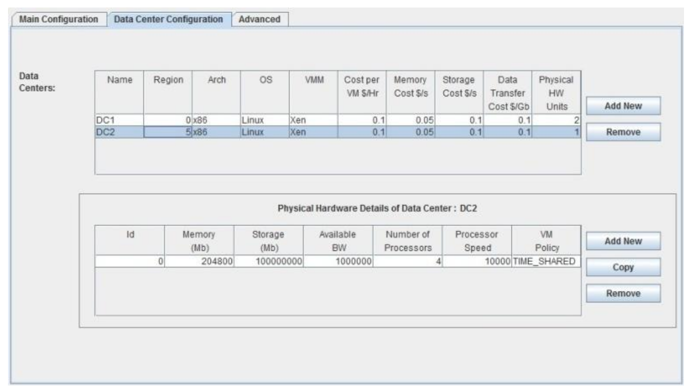

Fig. 2 : Data Center Configuration

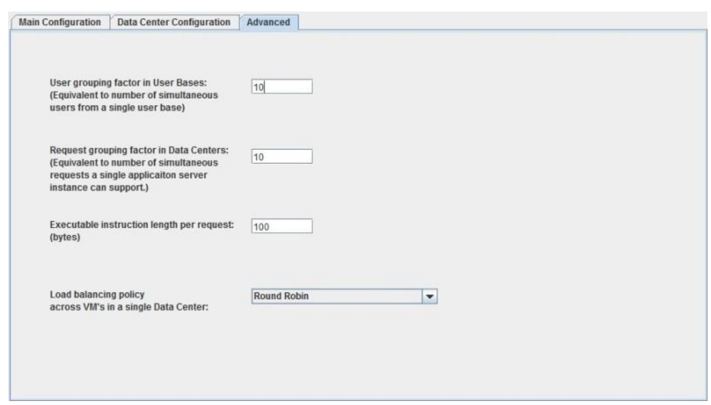

Fig. 3 : Advanced Configuration

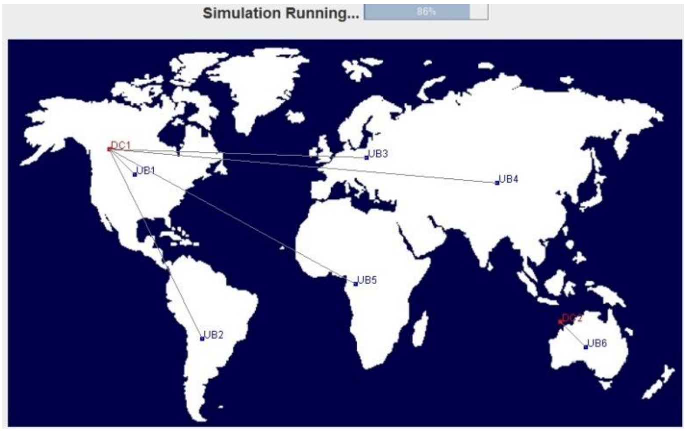

Fig. 4 : Partial Simulation at it's run time

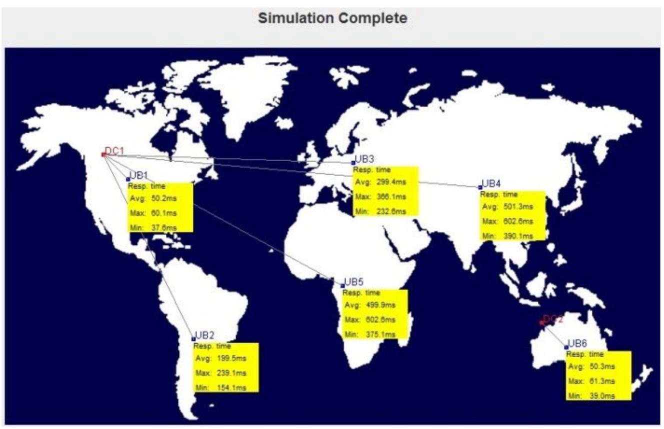

Fig. 5 : Complete Simulation showing response time by regions

Overall Response Time Summary

	Avg (ms)	Min (ms)	Max (ms)
Overall response time:	267.14	37.63	602.64
Data Center processing time:	0.39	0.02	1.01

Fig. 6 : Summary showing overall response time and data center processing time

Response Time by Region

Userbase	Avg (ms)	Min (ms)	Max (ms)
UB1	50.20	37.63	60.13
UB2	199.45	154.14	239.14
UB3	299.37	232.64	366.07
UB4	501.29	390.14	602.64
UB5	499.91	375.14	602.64
UB6	50.27	39.01	61.26

Fig. 7 : Response time by different regions

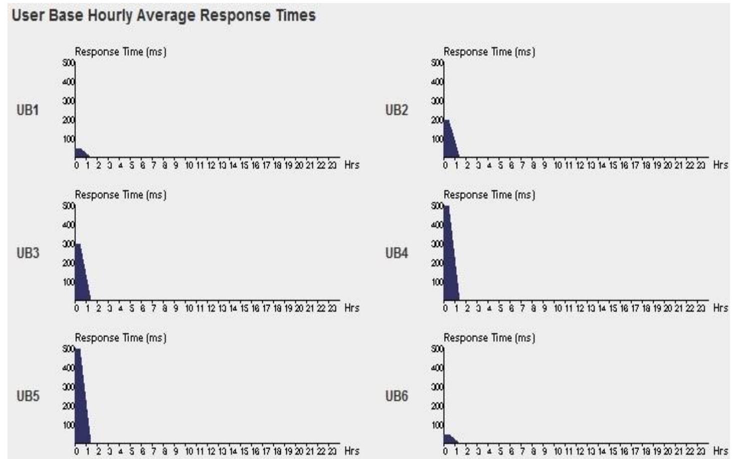

Fig. 8 : Hourly average response time by different user bases

Data Center Request Servicing Times

Data Center	Avg (ms)	Min (ms)	Max (ms)
DC1	0.34	0.02	0.88
DC2	0.61	0.03	1.01

Fig. 9 : Request servicing times by both data center DC1 and DC2

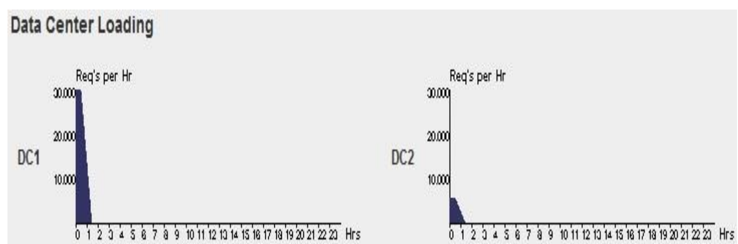

Fig. 10 : Data center hourly loading

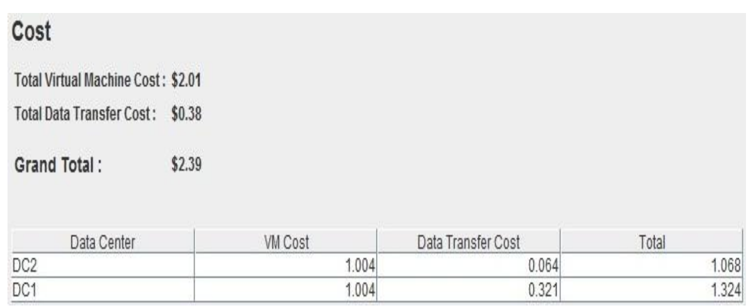

Fig. 11 : Cost of virtual machine and data transfer

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 02 Issue: 06 | Sep-2015 www.irjet.net p-ISSN: 2395-0072

Case 2 : Using Equally Spread Current Execution Load Balancing Policy

Table -2: Simulation summary

Parameters	**Values**
User Bases	UB1, UB2, UB3, UB4, UB5, UB6
Data Center(s)	DC1, DC2
Data Center Region(s)	R0, R5
Service Broker Policy	Closest data center
Application deployment	DC1,DC2
No. of Virtual machines in each data center	10 VMs both in DC1 and DC2
Load Balancing Policy across VMs in a single data center	Equally Spread Current Execution Load Balancing Policy

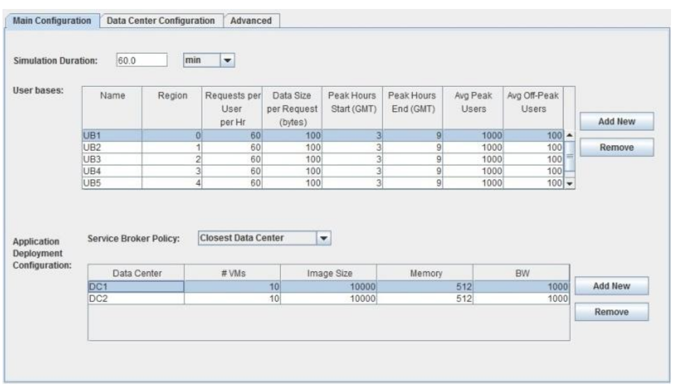

Fig. 12 : Main Configuration

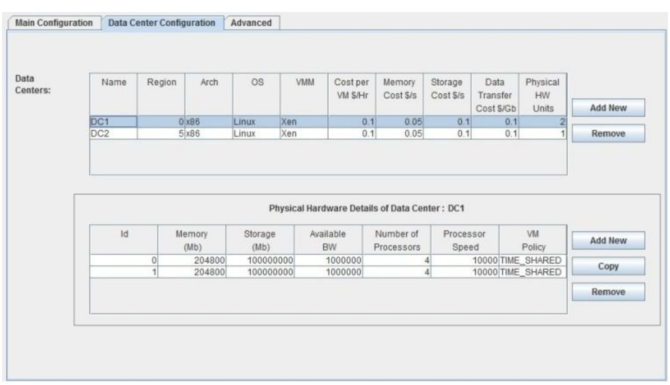

Fig. 13 : Data Center Configuration

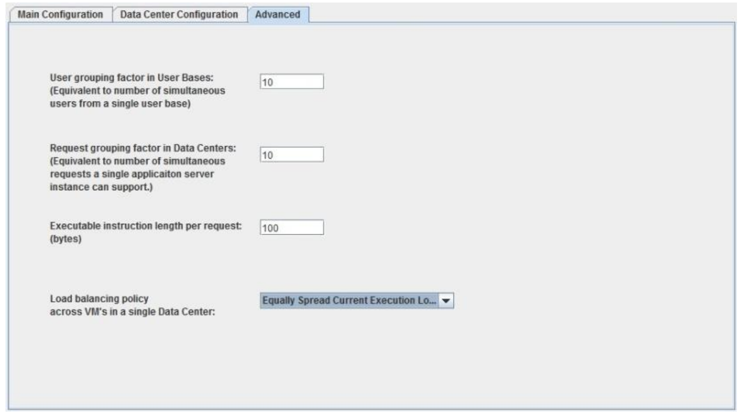

Fig. 14 : Advanced Configuration

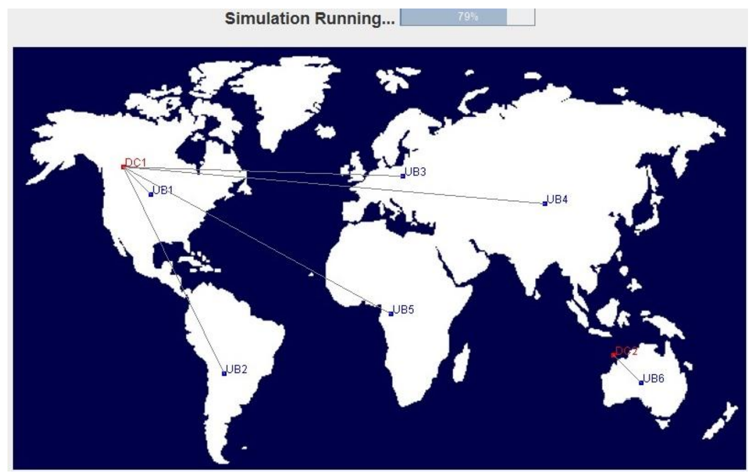

Fig. 15 : Partial simulation at it's run time

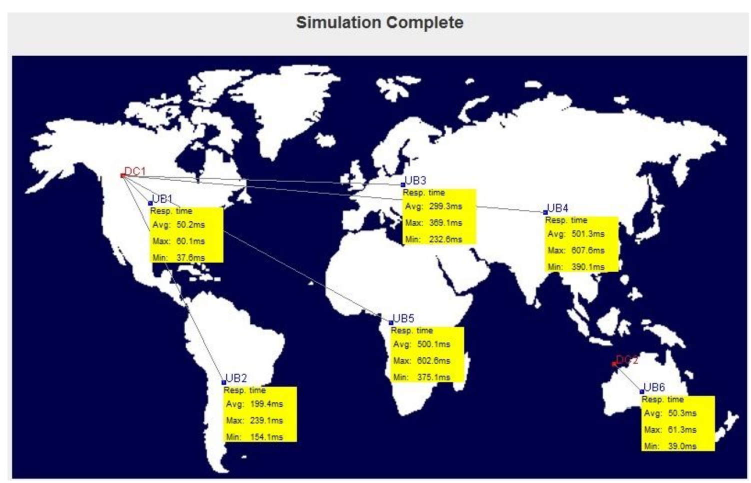

Fig. 16 : Complete simulation showing response time by regions

Overall Response Time Summary

	Avg (ms)	Min (ms)	Max (ms)
Overall response time:	267.13	37.63	602.64
Data Center processing time:	0.39	0.02	1.01

Fig. 17 : Summary showing overall response time and data center processing time

Response Time by Region

Userbase	Avg (ms)	Min (ms)	Max (ms)
UB1	50.20	37.63	60.13
UB2	199.55	154.14	239.14
UB3	299.18	232.64	369.14
UB4	500.85	390.14	600.14
UB5	500.33	375.14	602.64
UB6	50.27	39.01	61.26

Fig. 18 : Response time by different regions

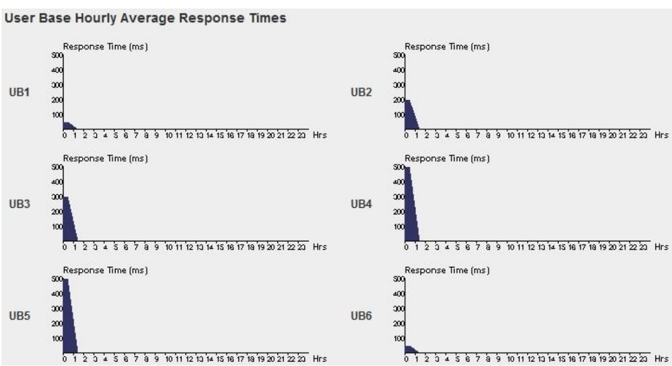

Fig. 19 : Hourly Average Response Times by different User Bases

Data Center Request Servicing Times

Data Center	Avg (ms)	Min (ms)	Max (ms)
DC1	0.34	0.02	0.88
DC2	0.61	0.03	1.01

Fig. 20 : Request servicing time by both data centers DC1 and DC2

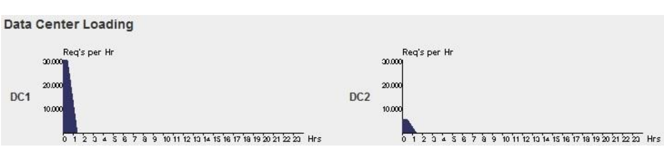

Fig. 21 : Data Center Hourly Loading

Cost

Total Virtual Machine Cost : $2.01
Total Data Transfer Cost : $0.38

Grand Total : $2.39

Data Center	VM Cost	Data Transfer Cost	Total
DC2	1.004	0.064	1.068
DC1	1.004	0.321	1.324

Fig. 22 : Total cost of virtual machine and data transfer

Case 3 : Using Throttled Load Balancing Policy

Table -3: Simulation summary

Parameters	Values
User Bases	UB1, UB2, UB3, UB4, UB5, UB6
Data Center(s)	DC1, DC2
Data Center Region(s)	R0, R5
Service Broker Policy	Closest data center
Application deployment	DC1,DC2
No. of Virtual machines in each data center	10 VMs both in DC1 and DC2
Load Balancing Policy across VMs in a single data center	Throttled

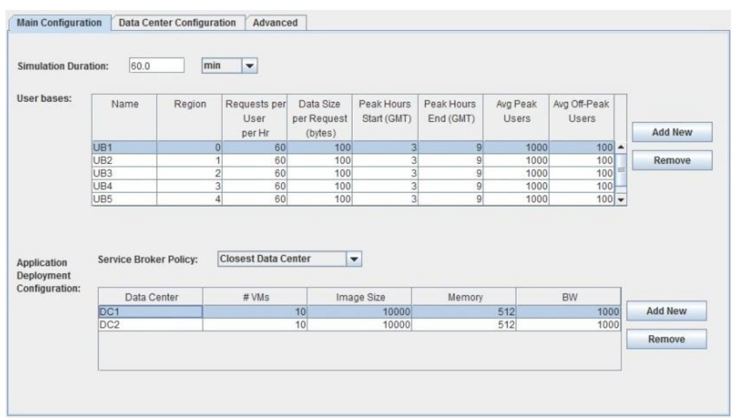

Fig. 23 : Main Configuration

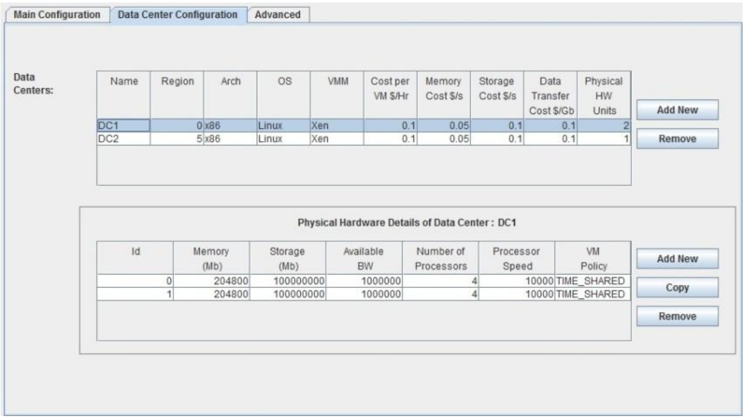

Fig. 24 : Data Center Configuration

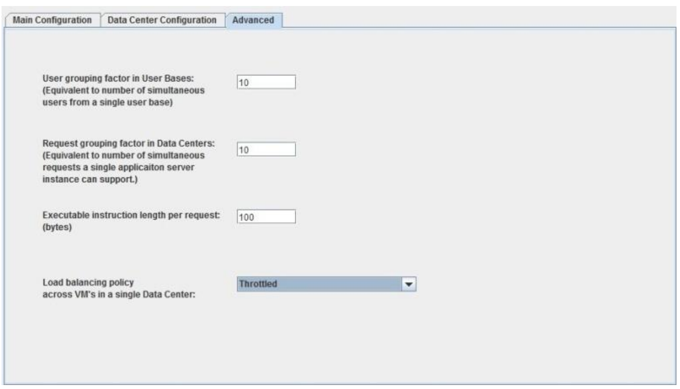

Fig. 25 : Advanced Configuration

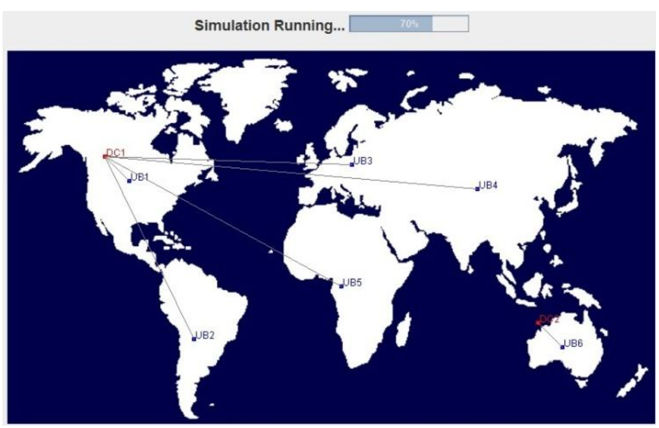

Fig. 26 : Partial simulation at it's run time

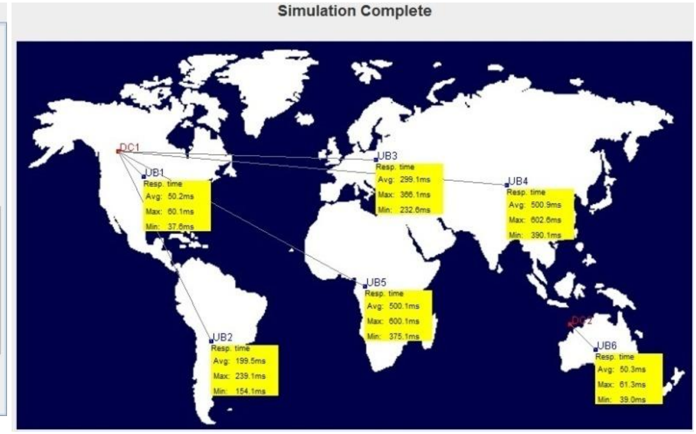

Fig. 27 : Complete simulation showing response time by regions

Overall Response Time Summary

	Avg (ms)	Min (ms)	Max (ms)
Overall response time:	267.10	37.63	602.64
Data Center processing time:	0.39	0.02	1.01

Fig. 28 : Summary showing overall response time and data center processing time

Response Time by Region

Userbase	Avg (ms)	Min (ms)	Max (ms)
UB1	50.24	37.63	60.13
UB2	199.55	154.14	239.14
UB3	299.11	232.64	366.07
UB4	500.90	390.14	602.64
UB5	500.14	375.14	600.14
UB6	50.26	39.01	61.26

Fig. 29 : Response time by different regions

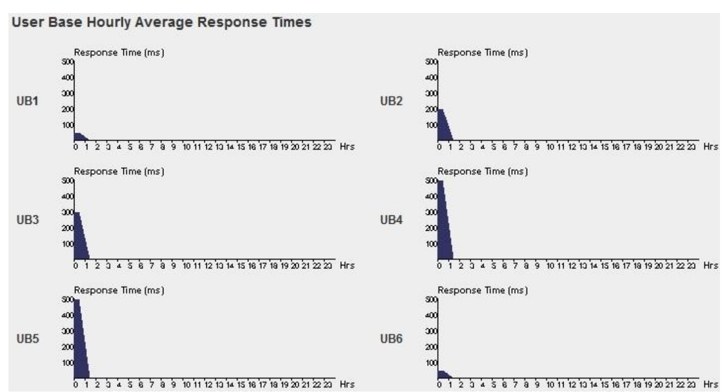

Fig. 30 : Hourly average response time by different user bases

Data Center Request Servicing Times

Data Center	Avg (ms)	Min (ms)	Max (ms)
DC1	0.34	0.02	0.88
DC2	0.62	0.03	1.01

Fig. 31 : Request servicing time by both data centers DC1 and DC2

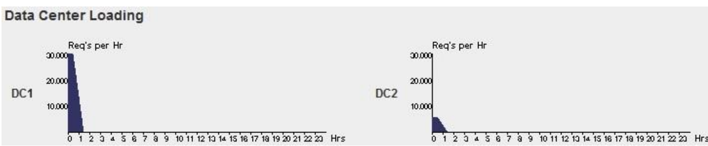

Fig 32 : Data center hourly loading

Cost

Total Virtual Machine Cost : $2.01
Total Data Transfer Cost : $0.38

Grand Total : $2.39

Data Center	VM Cost	Data Transfer Cost	Total
DC2	1.004	0.064	1.068
DC1	1.004	0.321	1.324

Fig. 33 : Total cost of Virtual machine and data transfer

3.2 Scenario 2 : When application is deployed on two data centers DC1 and DC2 with 20 virtual machines in both data centers

Case 1 : Using Round-Robin Load Balancing Policy

Table -4: Simulation summary

Parameters	Values
User Bases	UB1, UB2, UB3, UB4, UB5, UB6
Data Center(s)	DC1, DC2
Data Center Region(s)	R0, R5
Service Broker Policy	Closest data center
Application deployment	DC1,DC2
No. of Virtual machines in each data center	20 VMs both in DC1 and DC2
Load Balancing Policy across VMs in a single data center	Round-Robin

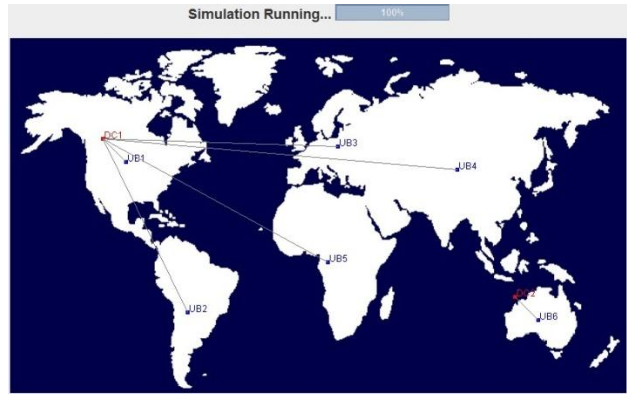

Fig. 34 : Partial simulation at it's runtime

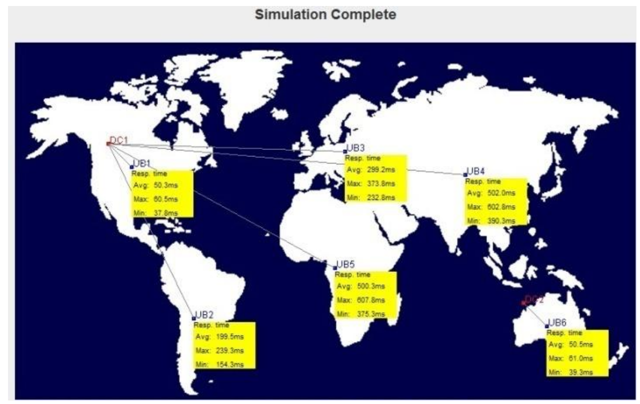

Fig. 35 : Complete simulation

Overall Response Time Summary

	Average (ms)	Minimum (ms)	Maximum (ms)
Overall Response Time:	267.36	37.76	607.77
Data Center Processing Time:	0.53	0.03	1.26

Fig. 36 : Summary showing overall response time and data center processing time

Response Time By Region

Userbase	Avg (ms)	Min (ms)	Max (ms)
UB1	50.311	37.756	60.508
UB2	199.472	154.262	239.264
UB3	299.229	232.766	373.764
UB4	501.957	390.266	602.764
UB5	500.285	375.266	607.768
UB6	50.502	39.256	61.007

Fig. 37 : Response time by different regions

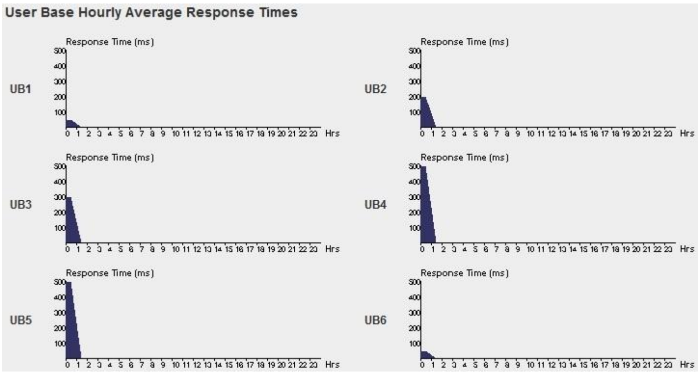

Fig. 38 : Hourly average response time by different user bases

Data Center Request Servicing Times

Data Center	Avg (ms)	Min (ms)	Max (ms)
DC1	0.462	0.031	1.006
DC2	0.851	0.055	1.256

Fig. 39 : Request servicing time by both data centers DC1 and DC2

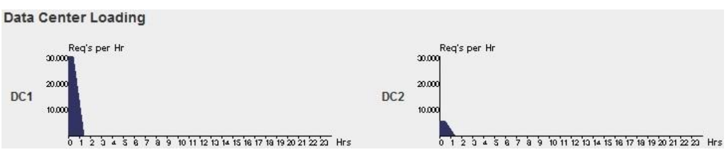

Fig. 40 : Data center hourly loading

Cost

Total Virtual Machine Cost : $4.01
Total Data Transfer Cost : $0.38

Grand Total : $4.40

Data Center	VM Cost	Data Transfer Cost	Total
DC2	2.007	0.064	2.071
DC1	2.007	0.321	2.328

Fig. 41 : Total cost of virtual machine and data transfer

Case 2 : Using Equally Spread Current Execution Load Balancing Policy

Table -5: Simulation summary

Parameters	**Values**
User Bases	UB1, UB2, UB3, UB4, UB5, UB6
Data Center(s)	DC1, DC2
Data Center Region(s)	R0, R5
Service Broker Policy	Closest data center
Application deployment	DC1, DC2
No. of Virtual machines in each data center	20 VMs both in DC1 and DC2
Load Balancing Policy across VMs in a single data center	Equally Spread Current Execution Load Balancing Policy

Fig. 42 : Partial simulation at it's runtime

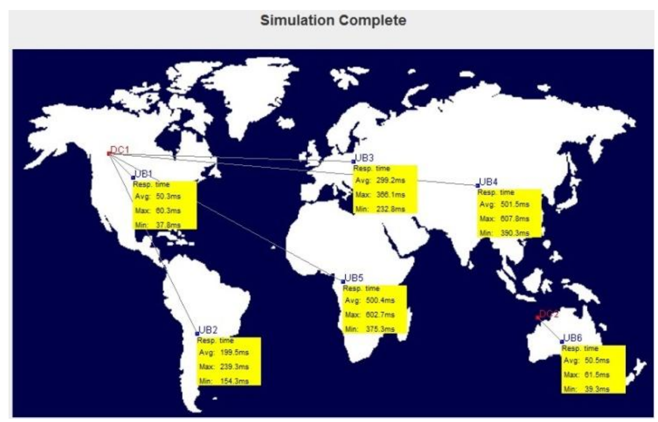

Fig. 43 : Complete simulation

Overall Response Time Summary

	Avg (ms)	Min (ms)	Max (ms)
Overall response time:	267.31	37.76	607.77
Data Center processing time:	0.53	0.03	1.26

Fig. 44 : Summary showing overall response time and data center processing time

Response Time by Region

Userbase	Avg (ms)	Min (ms)	Max (ms)
UB1	50.31	37.76	60.26
UB2	199.66	154.26	239.26
UB3	299.34	232.77	366.12
UB4	501.64	390.27	607.77
UB5	500.00	375.27	600.26
UB6	50.50	39.26	61.01

Fig. 45 : Response time by different regions

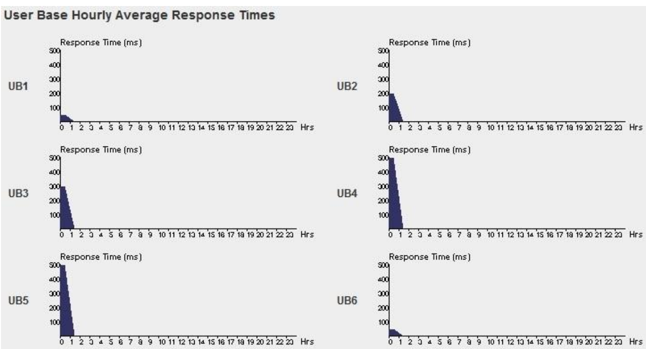

Fig. 46 : Hourly average response time by different user bases

Data Center Request Servicing Times

Data Center	Avg (ms)	Min (ms)	Max (ms)
DC1	0.46	0.03	1.01
DC2	0.85	0.05	1.26

Fig. 47 : Request servicing time by both data centers DC1 and DC2

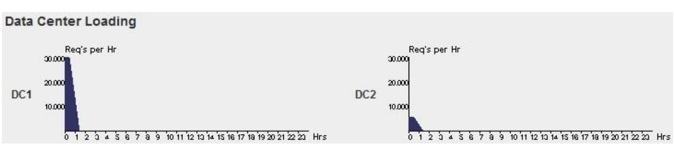

Fig. 48 : Data center hourly loading

Cost

Total Virtual Machine Cost : $4.01
Total Data Transfer Cost : $0.38

Grand Total : $4.40

Data Center	VM Cost	Data Transfer Cost	Total
DC2	2.007	0.064	2.071
DC1	2.007	0.321	2.328

Fig. 49 : Total cost of virtual machine and data transfer

Case 3 : Using Throttled Load Balancing Policy

Table -6: Simulation summary

Parameters	Values
User Bases	UB1, UB2, UB3, UB4, UB5, UB6
Data Center(s)	DC1, DC2
Data Center Region(s)	R0, R5
Service Broker Policy	Closest data center
Application deployment	DC1, DC2
No. of Virtual machines in each data center	20 VMs both in DC1 and DC2
Load Balancing Policy across VMs in a single data center	Throttled

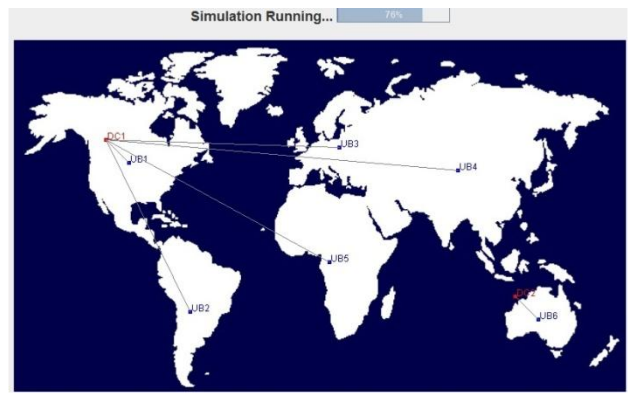

Fig. 50 : Partial simulation at it's runtime

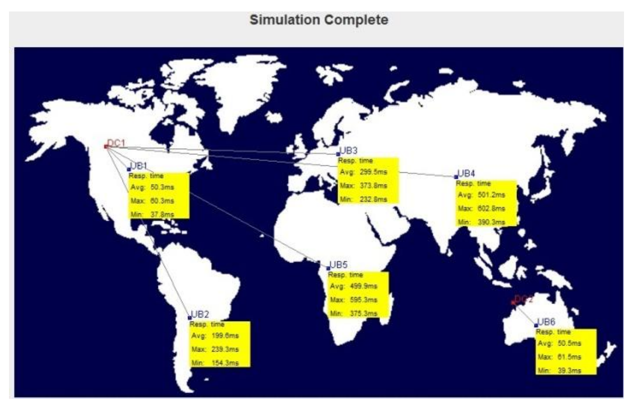

Fig. 51 : Complete simulation

Overall Response Time Summary

	Avg (ms)	Min (ms)	Max (ms)
Overall response time:	267.24	37.76	602.76
Data Center processing time:	0.53	0.03	1.26

Fig. 52 : Summary showing overall response time and data center processing time

Response Time by Region

Userbase	Avg (ms)	Min (ms)	Max (ms)
UB1	50.33	37.76	60.26
UB2	199.63	154.26	239.26
UB3	299.51	232.77	373.76
UB4	501.17	390.27	602.76
UB5	499.88	375.27	595.26
UB6	50.52	39.26	61.51

Fig. 53 : Response time by different regions

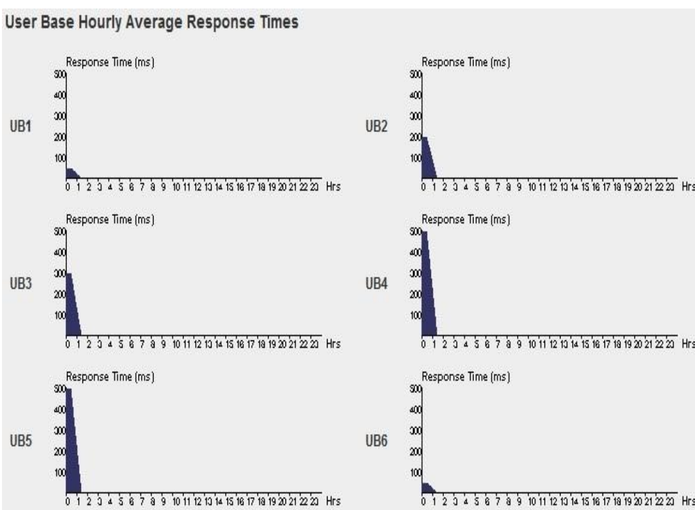

Fig. 54 : Hourly average response time by different user bases

Data Center Request Servicing Times

Data Center	Avg (ms)	Min (ms)	Max (ms)
DC1	0.46	0.03	1.01
DC2	0.85	0.06	1.26

Fig. 55 : Request servicing times by both data centers DC1 and DC2

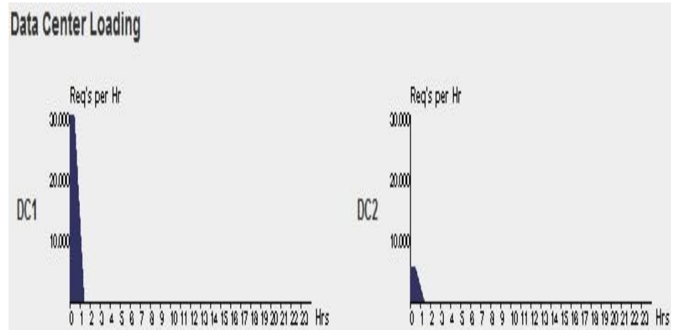

Fig. 56 : Data center hourly loading

Cost

Total Virtual Machine Cost : $4.01

Total Data Transfer Cost : $0.38

Grand Total : $4.40

Data Center	VM Cost	Data Transfer Cost	Total
DC2	2.007	0.064	2.071
DC1	2.007	0.321	2.328

Fig. 57 : Total cost of virtual machines and data transfer

4. CONCLUSION

From the simulation experiment that we performed in two different scenarios and from their results we analyzed and concluded that the performance of web application deployed on cloud depends on the load faced by the server or load across virtual machines in a single data center. Load across virtual machines is balanced by virtual machine load balancer that uses one of the above existing load balancing policies depending on the simulation setup by the user who is simulating the cloud application. We performed simulation of a large-scaled web application deployed on cloud using CloudAnalyst simulator and analyzed it's performance in two different scenarios using all three load balancing policies one by one within each scenario in order to check which policy (i.e. Vm Load balancing policy) is improving performance of the application. Our performed simulation summary is given in the Table 7 below. From this table it is clear that the overall average response time(milliseconds) is less in case when Throtelled load balancing policy is used. Hence, Throtelled load balancing policy is considered to be more efficient and effective than the other two.

Table -7: Summary of simulation experiments performed and their results

Parameters	Values					
	Scenario 1			Scenario 2		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
User Bases	UB1, UB2, UB3, UB4, UB5, UB6	UB1, UB2, UB3, UB4, UB5, UB6	UB1, UB2, UB3, UB4, UB5, UB6	UB1, UB2, UB3, UB4, UB5, UB6	UB1, UB2, UB3, UB4, UB5, UB6	UB1, UB2, UB3, UB4, UB5, UB6
User Base Region(s)	R0, R1, R2, R3, R4, R5	R0, R1, R2, R3, R4, R5	R0, R1, R2, R3, R4, R5	R0, R1, R2, R3, R4, R5	R0, R1, R2, R3, R4, R5	R0, R1, R2, R3, R4, R5
Data Center(s)	DC1, DC2	DC1, DC2	DC1, DC2	DC1, DC2	DC1, DC2	DC1, DC2
Data Center Region(s)	R0, R5	R0, R5	R0, R5	R0, R5	R0, R5	R0, R5
Service Broker Policy	Closest Data Center	Closest Data Center	Closest Data Center	Closest Data Center	Closest Data Center	Closest Data Center
No. of Virtual Machines	10 VMs in each single data center	10 VMs in each single data center	10 VMs in each single data center	20 VMs in each single data center	20 VMs in each single data center	20 VMs in each single data center
Virtual Machine Load Balancing Policy	Round-Robin Load Balancing Policy	Equally Spread Current Execution Load Balancing Policy	Throtelled Load Balancing Policy	Round-Robin Load Balancing Policy	Equally Spread Current Execution Load Balancing Policy	Throtelled Load Balancing Policy
Overall Average Response Time (ms)	267.14	267.13	267.1	267.36	267.31	267.24
Data Center Average Processing Time (ms)	0.39	0.39	0.39	0.53	0.53	0.53
Data Center Average Request Servicing Time (ms)	**DC1** 0.34	**DC1** 0.34	**DC1** 0.34	**DC1** 0.462	**DC1** 0.46	**DC1** 0.46
	DC2 0.61	**DC2** 0.61	**DC2** 0.62	**DC2** 0.851	**DC2** 0.85	**DC2** 0.85
Total Virtual Machine Cost	$2.01	$2.01	$2.01	$4.01	$4.01	$4.01
Total Data Transfer Cost	$0.38	$0.38	$0.38	$0.38	$0.38	$0.38
Grand Total Cost	$2.39	$2.39	$2.39	$4.40	$4.40	$4.40

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