# An Analysis on ECSE Load Balancing Algorithm with CDC as a Service Broker Policy in Cloud with Heterogeneous Communication and Device Characteristics

**Kumar PJ, J.Prabhu, N.Sivakumar P.S.Ramesh, Suganya P**

***Abstract: Load balancing algorithms and service broker policies plays a crucial role in determining the performance of cloud systems. User response time and data center request servicing time are largely affected by the load balancing algorithms and service broker policies. Several load balancing algorithms and service broker polices exist in the literature to perform the data center allocation and virtual machine allocation for the given set of user requests. In this paper, we investigate the performance of equally spread current execution (ESCE) based load balancing algorithm with closest data center(CDC) service broker policy in a cloud environment that consists of homogeneous and heterogeneous device characteristics in data centers and heterogeneous communication bandwidth that exist between different regions where cloud data centers are deployed. We performed a simulation using CloudAnalyst an open source software with different settings of device characteristics and bandwidth. The user response time and data center request servicing time are found considerably less in heterogeneous environment.***

***Index Terms: Data Centers, Virtual Machines, Load Balancing, Closest Data Center, Equally spread current Execution (ESCE)***

## I. INTRODUCTION

Cloud offers several types of services to its end user such as software, platform and infrastructure through Internet. The end users response time determines the performance of the cloud that consists of data centers, virtual machines, physical hosts and supported communication capacity between the user and data center. Hybrid, weighted round robin, No.of connection based, Greedy and random are the well-known load balancing algorithms that allocates tasks to different virtual machines in the cloud data centers [15]. Round robin algorithm allocates tasks to virtual machines based on a time slice. It does not consider the individual capacity of the virtual machines while allocating task. This may lead to a situation where some VMs are overloaded and others are under loaded. In order to avoid the problem that encountered in round robin based load balancing Equally Spread Current Execution (ESCE) based load balancing is proposed. It allocates tasks equally to all virtual machines considering the individual capacity of the virtual machines. The third approach called Throttled Load balancing works same as ESCE by adding an additional field in the index table that contains fields such as Available or Busy. We consider a cloud environment where the available communication bandwidth between different regions are heterogeneous. We also characterize the physical nodes on which the virtual machines are mapped as heterogeneous. i.e, memory, storage, internal bandwidth and processor speed are varied for each system. We investigate the performance of the equally spread current execution load balancing and closest data center service broker policy in this environment and present the values of user response time and data center request servicing time simulated in an open source tool called CloudAnalyst. Section II discusses about existing works in the literature. Section III presents the experimental setup. Section IV present the simulation results and interpretations. Section V concludes the paper with future extensions.

## II. LITERATURE SURVEY

The work in [1] proposed a load balancing technique named CLB (Cloud Load Balancing) that considers the individual capacity of the servers to allocate task to it. An in-depth survey has been made on load balancing algorithms that exist in the literature by the authors in [2]. The work in [3] has proposed nature inspired load balancing for cloud. The work in [4] proposed a load balancing for cloud based on particle swarm optimization. The work in [5] supports load balancing by considering various QoS measures from the user. Load balancing while handling massive data in cloud has been proposed by [6]. An artificial bee based load balancing techniques is proposed by the authors in [7]. The work proposed in [8][11][12] minimizes the response time and access time in cloud based on the QoS input of the user. The source code of the simulator CloudAnalyst used in this paper can be obtained from the online sources as mentioned in [9] [10].

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The authors in [13][14] discusses about various simulation environment available for cloud computing and also discusses the execution of load balancing algorithm in it.

## III. THE ARCHITECTURE OF CLOUD

| | | |
|---|---|---|
| Software as a Service [SaaS] | Multimedia Applications and Web services | Google App and Facebook |
| Platform as a Service [PaaS] | Software Tools | Microsoft Azure |
| Infrastructure as a Service [IaaS] | Infrastructure and Hardware (CPU, Memory and Bandwidth) | Amazon EC2, Data centers |

Table I: Various Layers of Services provided in Cloud [15]

Each and every constituting components of computing systems are provided as a service in cloud such as software, hardware, platform and infrastructure. These services are offered through internet to the end user where response time becomes a vital criteria in determining the performance of cloud services. Windows azure and App Engine examples for Platform as a service. Google App and Salesforce provide software as a service [15].

## IV. ANALYSIS OF EQUALLY SPREAD CURRENT EXECUTION LOAD BALANCING ALGORITHM WITH CLOSEST DATA CENTER WITH HOMOGENEOUS AND HETEROGENEOUS HOST

| Name | Location | Processor Family | OS | VMM | Price/VM in $/Hour | cost of Memory in $/second | Cost of Storage $/s | Cost of Data Transfer $/Gb |
|---|---|---|---|---|---|---|---|---|
| DC 1 | 3 | X86 | Linux | Xen | 1 | 0.05 | 1 | 1 |
| DC 2 | 2 | X86 | Linux | Xen | 1 | 0.05 | 1 | 1 |
| DC 3 | 0 | X86 | Linux | Xen | 1 | 0.05 | 1 | 1 |
| DC 4 | 1 | X86 | Linux | Xen | 1 | 0.05 | 1 | 1 |
| DC 5 | 4 | X86 | Linux | Xen | 1 | 0.05 | 1 | 1 |

Table II: Configuration of Data Center

### A. Experimental Setup

There are totally 5 data centers deployed in different regions across the globe. The details of data centers and the corresponding locations of deployment are shown in Table II. All physical systems are having X86 types of CPU family and running Linux operating system. The cost of virtual machine usage, storage and data transfer are also shown in Table II. Table III and IV shows the available communication bandwidth between different regions where data centers are deployed. We set the bandwidth as homogeneous and heterogeneous between regions. In homogeneous, the available bandwidth between regions are set equally to 2000 Mbps. In heterogeneous , the bandwidth is varied from 250 Mbps to 2000 Mbps in steps of 500, 750, 1000 and 1250.

| Region/Region | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 0 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| 1 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| 2 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| 3 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| 4 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |
| 5 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 |

Table III: Homogeneous Bandwidth Configuration between Regions (2000 Mbps in between all regions)

| Region/Region | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 0 | 2000 | 250 | 500 | 750 | 1000 | 1250 |
| 1 | 250 | 2000 | 500 | 750 | 1000 | 1250 |
| 2 | 500 | 500 | 2000 | 750 | 1000 | 1250 |
| 3 | 750 | 750 | 750 | 2000 | 1000 | 1250 |
| 4 | 1000 | 1000 | 1000 | 1000 | 2000 | 500 |
| 5 | 1250 | 1250 | 1250 | 1250 | 500 | 2000 |

Table IV: Heterogeneous Bandwidth Configuration between Regions (Varying from 500 Mbps to 2000Mbps)

| ID | Memory(Mb) | Storage (Mb) | Available BW | No of Processors | Processor Speed | VM Policy |
|---|---|---|---|---|---|---|
| 0 | 2048 | 1000 | 1000 | 2 | 1000 | TIME_SHARED |
| 1 | 2048 | 1000 | 1000 | 4 | 2000 | TIME_SHARED |
| 2 | 2048 | 1000 | 1000 | 2 | 3000 | TIME_SHARED |

Table V: Homogeneous Data Center Host Configuration

| ID | Memory(Mb) | Storage (Mb) | Available BW | No of Processors | Processor Speed | VM Policy |
|---|---|---|---|---|---|---|
| 0 | 2048 | 1000 | 1000 | 2 | 1000 | TIME_SHARED |
| 1 | 4096 | 2000 | 2000 | 4 | 2000 | TIME_SHARED |
| 2 | 8192 | 4000 | 4000 | 2 | 3000 | TIME_SHARED |

Table VI: Heterogeneous Data Center Host Configuration

Table V and VI shows the configuration of physical devices/hosts which are mapped into different virtual machines. As bandwidth, the hosts also configured as homogeneous and heterogeneous.

In homogeneous, the hosts are configured with same memory, storage, speed and bandwidth. In heterogeneous, each physical hosts are configured with different memory, storage, bandwidth and processor speed. In homogeneous the memory is set to 2048 MB. The storage is set to 1000MB. The available bandwidth is set to 1000Mbps. Number of processors are set to 3 for all hosts. Processor speed is set to 1000MIPS for all hosts. In heterogeneous, the memory is set as 2048 MB, 4096MB and 8192 MB. The storage is set between 1000MB to 4000MB. The available bandwidth is varied between 1000Mbps to 4000 Mbps. Number of processors are varied between 2 to 4. Processor speed is set in between 1000MIPS to 3000 MIPS for all hosts.

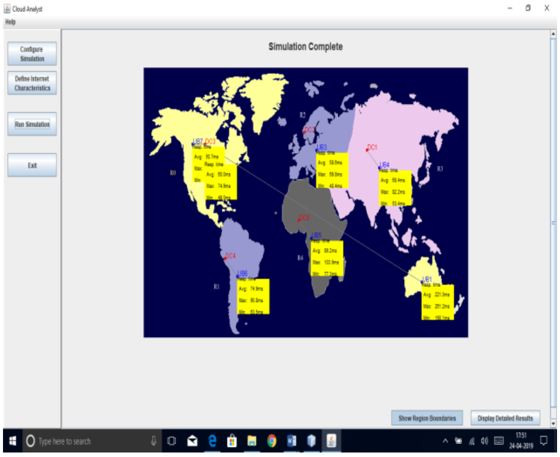


Fig.1: Assignment of user base and data center in Cloud Analyst Simulation Tool

Figure 1 shows the placement of data centers and user bases in different geographical location around the world.

## V. RESULTS AND DISCUSSION

The above configuration is simulated for 12 hours of time period in CloudAnalyst with homogeneous and heterogeneous host and bandwidth characteristics using ESCE as load balancing algorithm and CDC as service broker policy. Figure 2,3,and 4 shows the output of simulation done with ESCE and CDC with homogeneous host and bandwidth configuration. Figure 2 shows the overall response time and data center processing time. Figure 3 shows the average response time per user bases. Figure 4 shows the data center request servicing time.

| | Avg(ms) | Min(ms) | Max(ms) |
|---|---|---|---|
| Overall response time | 146.88 | 45.40 | 386.73 |
| Data Center processing time | 10.54 | 0.10 | 54.22 |

Fig.2: ESCE-CDC Over all Response time (Homogeneous host and Homogeneous bandwidth )

| **Userbase** | **Avg(ms)** | **Min(ms)** | **Max(ms)** |
|---|---|---|---|
| UB1 | 272.49 | 158.93 | 386.73 |
| UB2 | 121.88 | 47.44 | 208.04 |
| UB3 | 121.81 | 45.40 | 216.62 |
| UB4 | 121.68 | 47.63 | 205.57 |
| UB5 | 121.66 | 48.08 | 203.79 |
| UB6 | 21.66 | 46.76 | 205.56 |

Fig.3: ESCE-CDC Average Response Time per User base (Homogeneous host and Homogeneous bandwidth)

| **Data Center** | **Avg(ms)** | **Min(ms)** | **Max(ms)** |
|---|---|---|---|
| DC1 | 10.41 | 0.10 | 22.98 |
| DC 2 | 10.42 | 0.11 | 23.20 |
| DC 3 | 10.80 | 0.10 | 54.22 |
| DC 4 | 10.40 | 0.10 | 22.12 |
| DC 5 | 10.40 | 0.10 | 25.07 |

Fig.4: ESCE-CDC Data center request servicing time (Homogeneous host and Homogeneous bandwidth)

Figure 5,6,and 7 shows the output of simulation done with ESCE and CDC with homogeneous host and heterogeneous bandwidth configuration. Figure 5 shows the overall response time and data center processing time. Figure 6 shows the average response time per user bases. Figure 7 shows the data center request servicing time.

| | Avg(ms) | Min(ms) | Max(ms) |
|---|---|---|---|
| Overall response time | 153.56 | 45.40 | 468.77 |
| Data Center processing time | 10.39 | 0.10 | 38.49 |

Fig.5: ESCE-CDC Over all Response time (Homogeneous host and Heterogeneous bandwidth)

| **Userbase** | **Avg(ms)** | **Min(ms)** | **Max(ms)** |
|---|---|---|---|
| UB1 | 312.58 | 164.64 | 468.77 |
| UB2 | 121.86 | 47.44 | 210.32 |
| UB3 | 121.82 | 45.40 | 216.62 |
| UB4 | 121.68 | 47.63 | 205.57 |
| UB5 | 121.66 | 48.08 | 203.79 |
| UB6 | 121.66 | 46.76 | 205.56 |

Fig.6: ESCE-CDC Average Response Time per User base (Homogeneous host and Heterogeneous bandwidth)

| **Data Center** | **Avg(ms)** | **Min(ms)** | **Max(ms)** |
|---|---|---|---|
| DC1 | 10.41 | 0.10 | 22.98 |
| DC 2 | 10.42 | 0.11 | 23.20 |
| DC 3 | 10.34 | 0.10 | 38.49 |
| DC 4 | 10.40 | 0.10 | 22.12 |
| DC 5 | 10.40 | 0.10 | 25.07 |


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Fig.7: ESCE-CDC Data center request servicing time (Homogeneous host and Heterogeneous bandwidth)

Figure 8,9,and 10 shows the output of simulation done with ESCE and CDC with heterogeneous host and homogeneous bandwidth configuration. Figure 8 shows the overall response time and data center processing time. Figure 9 shows the average response time per user bases. Figure 10 shows the data center request servicing time.

| | Avg(ms) | Min(ms) | Max(ms) |
|---|---|---|---|
| Overall response time | 214.11 | 50.30 | 528.26 |
| Data Center processing time | 7.93 | 0.04 | 16.10 |

Fig.8: ESCE-CDC Over all Response time (Heterogeneous host and Homogeneous bandwidth )

| **Userbase** | **Avg(ms)** | **Min(ms)** | **Max(ms)** |
|---|---|---|---|
| UB1 | 338.88 | 168.46 | 528.26 |
| UB2 | 189.30 | 51.45 | 353.00 |
| UB3 | 189.30 | 50.30 | 374.90 |
| UB4 | 189.04 | 52.74 | 347.86 |
| UB5 | 189.00 | 52.87 | 360.35 |
| UB6 | 189.04 | 51.38 | 355.50 |

Fig.9: ESCE-CDC Average Response Time per User base (Heterogeneous host and Homogeneous bandwidth)

| **Data Center** | **Avg(ms)** | **Min(ms)** | **Max(ms)** |
|---|---|---|---|
| DC1 | 7.96 | 0.06 | 11.00 |
| DC 2 | 7.96 | 0.06 | 11.00 |
| DC 3 | 7.88 | 0.04 | 16.10 |
| DC 4 | 7.96 | 0.05 | 11.00 |
| DC 5 | 7.95 | 0.05 | 11.00 |

Fig.10: ESCE-CDC Data center request servicing time (Heterogeneous host and Homogeneous bandwidth)

Figure 11,12,and 13 shows the output of simulation done with ESCE and CDC with heterogeneous host and heterogeneous bandwidth configuration. Figure 11 shows the overall response time and data center processing time. Figure 12 shows the average response time per user bases. Figure 13 shows the data center request servicing time

| | Avg(ms) | Min(ms) | Max(ms) |
|---|---|---|---|
| Overall response time | 153.37 | 45.15 | 468.77 |
| Data Center processing time | 7.04 | 0.05 | 20.09 |

Fig.11: ESCE-CDC Over all Response time (Heterogeneous host and Heterogeneous bandwidth)

| **Userbase** | **Avg(ms)** | **Min(ms)** | **Max(ms)** |
|---|---|---|---|
| UB1 | 311.59 | 164.64 | 468.77 |
| UB2 | 120.58 | 47.44 | 208.04 |
| UB3 | 120.60 | 45.15 | 216.62 |
| UB4 | 120.48 | 47.14 | 205.51 |
| UB5 | 120.45 | 48.39 | 205.80 |
| UB6 | 120.44 | 46.46 | 205.56 |

Fig.12: ESCE-CDC Average Response Time per User base (Heterogeneous host and Heterogeneous bandwidth)

| **Data Center** | **Avg(ms)** | **Min(ms)** | **Max(ms)** |
|---|---|---|---|
| DC1 | 6.95 | 0.06 | 11.00 |
| DC 2 | 6.94 | 0.06 | 13.19 |
| DC 3 | 7.25 | 0.05 | 20.07 |
| DC 4 | 6.94 | 0.05 | 11.00 |
| DC 5 | 6.94 | 0.05 | 20.09 |

Fig.13: ESCE-CDC Data center request servicing time (Heterogeneous host and Heterogeneous bandwidth)

Based on the simulation result obtained, it is observed that heterogeneous host and heterogeneous bandwidth setting of cloud yields less data center processing time compared to all other configurations. It produces data center processing time as 7.04 ms. At the other end, the homogeneous host and homogeneous bandwidth produces highest data center processing time with 10.54 ms. The homogeneous host and homogeneous bandwidth configuration produces less average user response time with a value of 146.88 ms whereas heterogeneous host and homogeneous bandwidth configuration produces highest response time with a value of 214.11 ms. Hence we recommend homogeneous host and homogeneous bandwidth configuration for getting less user response time and heterogeneous host and heterogeneous bandwidth configuration for less data center processing time.

## VI. CONCLUSION

The presence of heterogeneous devices and communication bandwidth in cloud plays a crucial role in determining the performance of cloud. User response time and data center processing time are important metric that measures the performance of the cloud vendors. Several load balancing algorithms exist in the literature to allocate tasks to the virtual machines in data centers. We investigate the performance of ESCE (Equally spread current execution based load balancing algorithm) and CDC (Closest data center as service broker policy) in a homogeneous and heterogeneous cloud environment. We varied the characteristics of the physical hosts and communication bandwidth and determined the performance of ESCE and CDC using a simulation tool called CloudAnalyst.

Based on the simulation result, we suggested the usage of homogeneous systems and heterogeneous system that would improve the performance metrics such as response time and data center processing time.

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