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Simulation of a Large Scaled Web Application on the Cloud Using Cloud Analyst

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Abstract:- Cloud computing is Internet based computing where virtual shared servers provide software, infrastructure, platform, devices and other resources and hosting to customers on a pay-as-you-use basis. The advancement of Cloud technologies in the last few years has opened up new possibilities to Internet applications developers. Resources and software are shared on the basis of client's demand in cloud environment. Essentially, dynamic utilization of resources is achieved under different conditions with various previous established policies. Sometime it is very much difficult and time consuming to measure performance of the applications in real cloud environment. Cloud simulators are required for cloud system testing to decrease the complexity and separate quality concerns. This actually reduces the cost of reconstruct as changes have been made during design time. Simulation technique provides lots of advantages as the experiments can be carried out with voluminous data in different abstraction level. In this paper we introduce CloudAnalyst to simulate large-scaled web applications on the Cloud with the purpose of studying the behaviour of such applications under various deployment configurations

Keywords:- Cloud Computing; Simulation and Modelling; CloudAnalyst; Virtual Machines

I. INTRODUCTION

Cloud Computing has become an extremely attractive topic of research and application these days. NIST has defined Cloud Computing as "a model for enabling convenient, on-demand network access to a shared pool of configurable Computing resources" [1, p.1]. Cloud security and storage have grasped lots of attention in this field [2]. Vaquero et al [3] argue that to offer a comprehensive definition of Cloud Computing is like "A large pool of easily usable and accessible virtualised resources, such as hardware, development platforms, and/or services. These resources can be dynamically re-configured to adjust to a variable load (scale), allowing also for an optimum resource utilisation. This pool of resources is typically exploited by a pay-per-use model in which guarantees are offered by the Infrastructure Providers by means of customised Service Level Agreements (SLAs)". Therefore, the main Cloud Computing characteristics and features, which can be derived from the definition above, are virtualisation, dynamic scalability, resource utilisation, and a business model of on-demand services based on SLAs. Therefore, Cloud Computing can be seen as providing useful opportunities for some businesses. Basically, it can offer economical and technological benefits. In terms of economic benefits, organisations can reduce the huge costs of large capital investments in IT resources by simply paying only for offered on-demand services (during peak time) from a Cloud provider, as well as lowering the cost of labour and IT resources maintenance [4], [5]. In terms of technological benefits, Cloud Computing can offer easier group collaboration, such as sharing documents between users from anywhere, regardless of their operating systems. Also, it can offer on-demand scaling of resources, such as acquiring unlimited storage capacity [4] However, Cloud Computing comes with some disadvantages as well. For example, it requires constant connection to the Internet in order to access the services. Also, it mostly requires high bandwidth for data transfer [4].

In this consequence, simulation is very much helpful to allow users or developers with practical feedback in spite of having real environment. There are different simulation tools that can be used for the experimental development of Cloud Computing. CloudSim is an extensible toolkit used to model and simulate cloud infrastructures, including data centres, users, user workloads, and application provision environments [6], [7]. CloudAnalyst is built on top of the CloudSim toolkit; it provides visual modelling, easy to use graphical user interfaces, and large-scale application simulations deployed on the cloud infrastructure. This paper investigates into extending these techniques to study the behavior of large scaled Internet application in a cloud environment and proposes a simulation tool "CloudAnalyst" that can be used for simulating this type of large scaled applications.

The rest of paper is organized as follows. Section 2 provides a brief description of simulation in cloud. In Section 3 we discussed about related work and discussion of cloudsim is happened in section 4. We give the detail of CloudAnalyst in Section 5 and in section 6 we define the setting of simulation. Section 7 shows the simulation screen and we give our result in section 8. We draw our conclusions in Section 9.

II. SIMULATION IN CLOUD

Simulation means mimicking the actual environment towards benefit of the research. The user or researcher can actually analyze the proposed design or existing algorithms through simulation. IT companies who are willing to offer some services in the Cloud can use this tool to perform some benchmarking experiments with the services to be offered in dependable, scalable, repeatable, and controllable environments before real deployment in the Cloud. Therefore, they can test their services in a controlled environment free of cost, and through a number of iterations, with less effort and time. Also, by using simulation, they can carry out different experiments and scenarios to identify the performance bottlenecks of resources and develop provisioning techniques before real deployment in commercial Clouds. They can check the efficiency and merit of the design before the actual system is constructed. Simulation is advantageous to the users, as they can explore the benefit of that design repeatedly. Simulators easily make available various kind of virtual environment for verification and performance evaluation of the experimented system. Even most of the time researchers could carry out benchmark experiments repeatedly in scalable environment for evaluating different aspects [8].

III. RELATED WORK

The cloud is where we go to use technology when we need it, for as long as we need it, and not a minute more. We do not install anything on our desktop, and we do not pay for the technology when we are not using it [9]. According to the IEEE Computer Society Cloud Computing is: "A paradigm in which information is permanently stored in servers on the Internet and cached temporarily on clients that include desktops, entertainment centers, table computers, notebooks, wall computers, handhelds, etc". “Cloud Computing is a type of parallel and distributed system that consists of a collection of computers interconnected, virtualized and presented as a single processing unit based on a SLA with a negotiation mechanism between the service provider and the consumer of this service” [10].

Cloud computing is typically divided into three levels of service offerings: Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a service (IaaS). These levels support virtualization and management of differing levels of the solution stack [11].

Some of this simulators are GridSim [12] MicroGrid [13], GangSim [14], SimGrid [15] and CloudSim [16]. While the first three focus on Grid computing systems, CloudSim is, for the best of our knowledge, the only simulation framework for studying Cloud computing systems. GridSim toolkit was developed by Buyya et al to address the problem of near impossibility of performance evaluation of real large scaled distributed environments (typically Grid systems but also P2P networks) in a repeatable and controlled manner. The GridSim toolkit is a Java based simulation toolkit that supports modelling and simulation of heterogeneous Grid resources and users spread across multiple organizations with their own policies. It supports multiple application models and provides primitives for creation of application tasks, mapping of tasks to resources and managing such tasks and resources.

GangSim is a Grid simulation toolkit that provides support for modeling of Grid-based virtual organisations and resources. SimGrid is a generic framework for simulation of distributed applications in Grid platforms.

IV. CLOUD SIM

CloudSim is a self-contained platform which can be used to model data centers, service brokers, scheduling and allocation policies of a large scaled Cloud platform. It provides a virtualization engine with extensive features for modelling the creation and life cycle management of virtual engines in a data center.

4.1 CAPABILITIES

CloudSim has some compelling features and capabilities that can be extended to model a custom Cloud Computing environment. CloudSim can offer flexibility and applicability and with less time and effort to support initial performance testing. It can support simulating, from small-scale up to large-scale cloud environments containing data centres, with little or almost no overheads in terms of initialisation and consumption of memory. Also, it has a virtualisation engine that allows the creation of multiple virtualised services that can be independently managed on a single node of the data centre.

4.2 LIMITATIONS

CloudSim is a powerful tool for modelling and simulating Cloud computing, but it has some limitations. Firstly, it is not a ready-to-use tool that that would just require setting parameters only. Actually, it does require writing some Java code to use its library. Also, the capabilities of CloudSim are sometimes limited and require some extensions. For instance, CloudAnalyst has been developed as an extension of CloudSim capabilities to offer a separation of the simulation experimentation exercise from the technicalities of programming, using the library in order to ease modelling by simply focusing on the complexity of the simulated scenario, without spending much effort and time on the language in which the simulator is interpreted.

V. CLOUD ANAYLST

Cloud Analyst separates the simulation experimentation exercise from a programming exercise. It also enables a modeler to repeatedly perform simulations and to conduct a series of simulation experiments with slight parameters variations in a quick and easy manner. CloudAnalyst can be applied to examining behavior of large scaled Internet application in a cloud environment.

5.1 CLOUDANALYST DESIGN

The Cloud Analyst is built on top of Cloud Sim tool kit, by extending Cloud Sim functionality with the introduction of concepts that model Internet and Internet Application behaviours as in Figure 2.

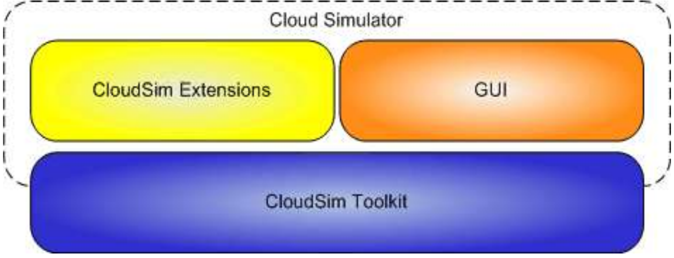


Figure 2: Cloud Analyst built on top of Cloud Sim toolkit

5.2 FUNCTIONALITY

In addition to the Data Center operations provided by the CloudSim toolkit, following additional functionality is required for the CloudAnalyst.

- Application users – Autonomous entities are required to act as traffic generators and their behaviour needs to be configurable.
- Internet – The data transmissions across the Internet needs to be realistically modelled with network delays and bandwidth restrictions.
- Simulation defined by time period – CloudSim as a toolkit is designed to process a pre-defined series of events. But for our purpose we need to convert the simulation to a time-frame limited execution where events are continuously generated by users until a pre-defined time period expires.
- Service Brokers –For CloudAnalyst, DataCenterBrokers assigned to two different entities. The DataCenterController extends DataCenterBroker and is primarily responsible for the VM management within a single data center and load balancing of VM's etc within that single data center. The new entity CloudAppSeriveBroker was introduced to handle the responsibility of managing the routing of user requests between data centers based on different service brokerage policies.
- GUI - CloudAnalyst also introduces a comprehensive GUI which can be used to configure the simulation at a high level of detail.
- Ability to save simulations and results – The CloudAnalyst also allows users to save a simulation configuration as a xml.file and also the exporting of results into PDFl format.

VI. SETTING UP A SIMULATION

We need to carry out the following steps.

1. Define user bases – Using User Base entities define the users of the application, their geographic distribution, and other properties such as the number of users, the frequency of usage and the pattern of usage such as peak hours. This is done in the Main tab of the Configure Simulation screen.
2. Define data centers – Using the Data Centers tab of the Configuration screen define the data centers we wish to use in the simulation. Define all the hardware and accounting aspects of the data centers here.
3. Allocate Virtual Machines for the application in Data Centers – Once the data centers have been created, we need to allocate virtual machines in them for the simulated application using the Main tab of the Configurations screen. A data center defined in step 2 above does not get included in the simulation unless it is allocated in this step. We can allocate multiple types of virtual machines in the same data center during this step.
4. Review and adjust the advanced parameters in the Advanced tab of the Configuration Screen.
5. Review and adjust the network latency and bandwidth matrices on the Internet Characteristics screen.

VII. SIMULATOR SCREENS

7.1 MAIN SCREEN WITH SIMULATION PANEL

Main screen has the simulation panel with a map of the world on the right and the main control panel on the left as shown in Figure 3. As mentioned the CloudAnalyst divides the world in to 6 regions that coincide roughly with the 6 main continents. Control Panel options are: Configure Simulation, Define Internet Characteristics, Run Simulation and Exit.

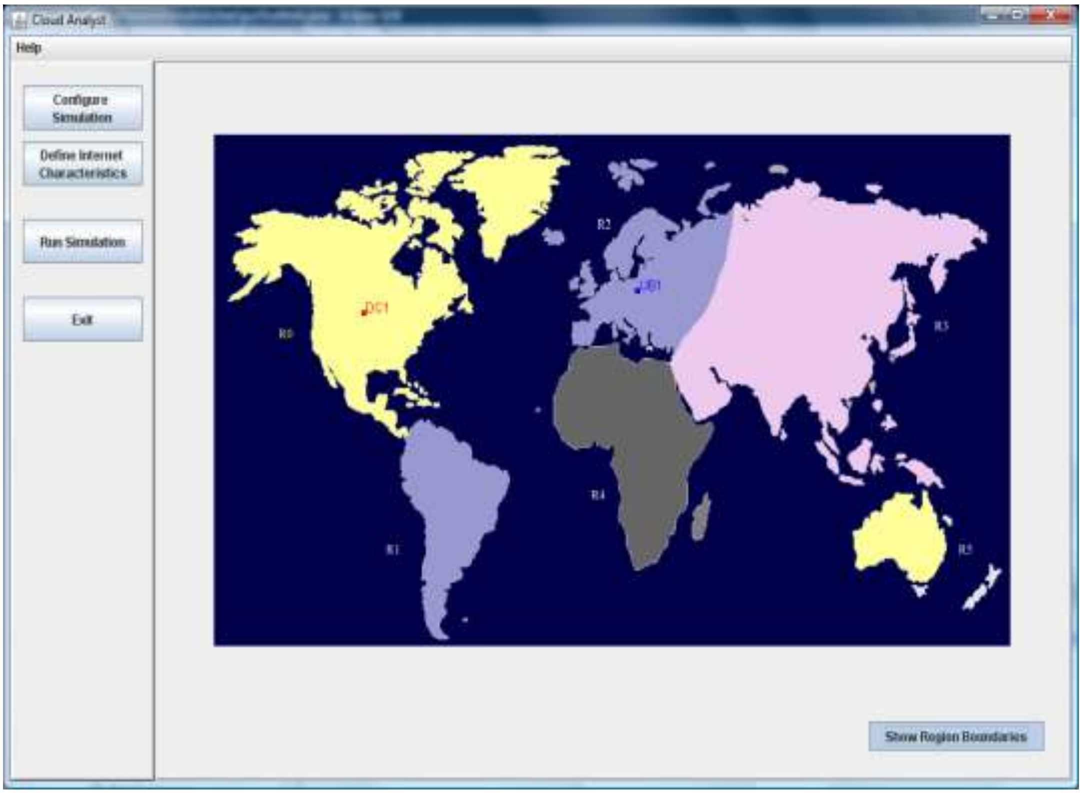


Figure 3: Cloud Analyst Main Screen

7.2 CONFIGURE SIMULATION SCREEN

Configure Simulation screen has three tabs.

7.2.1 MAIN TAB

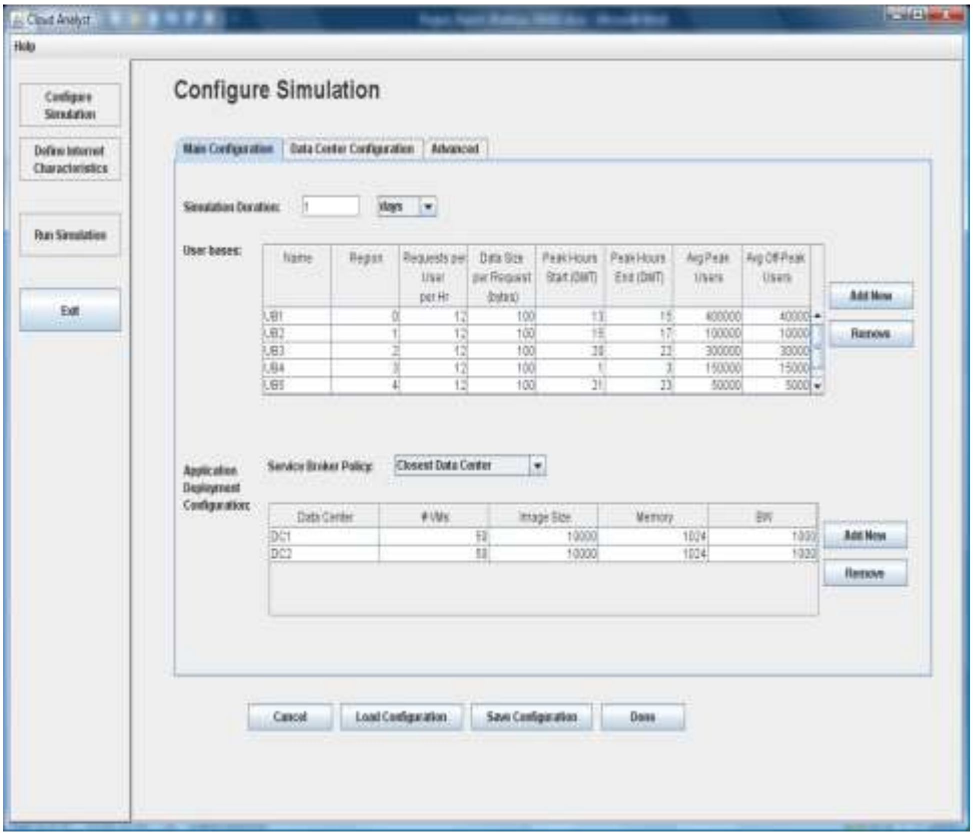
In Figure 4, the configuration options on the main tab are:

1. Simulation time – the duration of the simulation which can be given in minutes, hours or days, e.g.1 day
2. User Bases Table – Each user base has following configurable fields, represented by a single row in the table.

a. Name, e.g. UB1, UB2, UB3, UB4, UB5
b. Region, e.g. 0, 1, 2, 3, 4
c. Requests per user per hour, e.g. 12 Hr for each
d. Data size per request (in bytes), e.g. 100 for each
e. Peak hours (in GMT), e.g. Start- 13,15, 20, 1, 21; End- 15, 17, 22, 3, 23
f. Average users during peak hours, e.g. 400000, 100000, 150000, 50000
g. Average users during off-peak hours, e.g. 40000, 10000, 15000, 5000

3. Application Deployment Configuration – This table lists how many virtual machines are allocated for the application in each data center from the Data Centers tab, along with the details of a virtual machine. The fields are:

a. Data Center – names of data centers created e.g. DC1, DC2.
b. Number of VMs – How many VMs to be allocated to the application from the selected data center, e.g. 50, 50
c. Image Size – VM image size in bytes, e.g. 10000 for each
d. Memory – available to a single VM e.g. 1024 mb for each
e. BW – available to a single VM, e.g. 1000



Configure Simulation

Simulation Duration: 1 days

User bases:

Name	Region	Requests per User per Hr	Data Size per Request (bytes)	Peak Hours Start (GMT)	Peak Hours End (GMT)	Avg Peak Users	Avg Off-Peak Users
UB1	0	12	100	13	15	400000	40000
UB2	1	12	100	15	17	100000	10000
UB3	2	12	100	20	22	300000	30000
UB4	3	12	100	1	3	150000	15000
UB5	4	12	100	21	23	50000	5000

Application Deployment Configuration:

Service Broker Policy: Closest Data Center

Data Center	# VMs	Image Size	Memory	BW
DC1	50	10000	1024	1000
DC2	50	10000	1024	1000

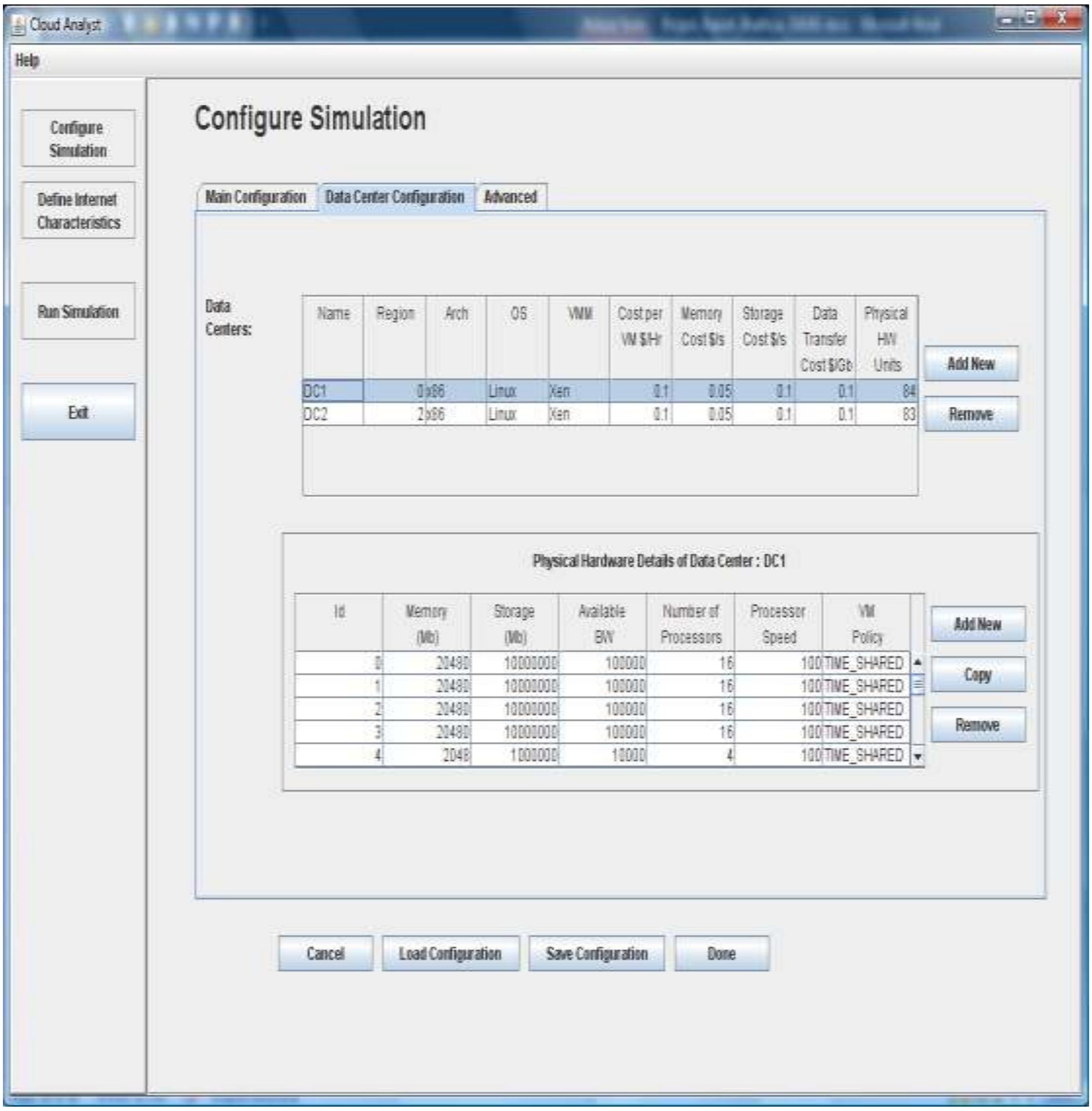
Figure 4: Configure Simulation Screen - Main Tab

4. Service Broker Policy – This drop down allows to select the brokerage policy between data centers that decide which data center should receive traffic from which user base. The available policies are: a. Closest data center – The data center with the least network latency (disregarding network bandwidth) from a particular user base is sent all the requests from that user base. b. Optimize response time – This policy attempts to balance the load between data centers when one data center gets over loaded.

7.2.2 DATA CENTER TAB

The data center tab allows to define the configuration of a data center (see Figure 5 below). The parameter fields are:
1. Name, e.g. DC1, DC2
2. Region, e.g. 0, 2
3. Architecture – Architecture of the servers used in the data center, e.g. X86 for each
4. Operating System , e.g. Linux for each
5. Virtual Machine Monitor (VMM) , e.g. Xen for each
6. Cost per VM Hour, e.g. 0.1for each
7. Cost per 1Mb Memory Hour, e.g. 0.05 for each
8. Storage cost per Gb, e.g. 0.1 for each
9. Data Transfer cost per Gb (both in and out), e.g. 0.1
10. Number of servers, e.g. 84, 83

When we select a data center from this table a second table will appear below it with the details of the server machines in the data center. The parameters for each machine can be given according to the available fields.
1. Machine Id, e.g. 0, 1, 2, 3, 4
2. Memory, e.g. 20480, 20480, 20480, 20480, 2048
3. Storage, e.g. 10000000, 10000000, 10000000, 10000000, 1000000
4. Available network bandwidth, e.g. 100000, 100000, 100000, 100000, 10000
5. Number of processors, e.g. 16, 16, 16, 16, 4
6. Processor speed (MIPS), e.g. 100 for each
7. VM allocation policy, e.g. TIME_SHARED for each



Configure Simulation

Data Centers:

Name	Region	Arch	OS	VMM	Cost per VM $/Hr	Memory Cost $/s	Storage Cost $/s	Data Transfer Cost $/Gb	Physical HW Units
DC1	0	x86	Linux	Xen	0.1	0.05	0.1	0.1	84
DC2	2	x86	Linux	Xen	0.1	0.05	0.1	0.1	83

Physical Hardware Details of Data Center : DC1

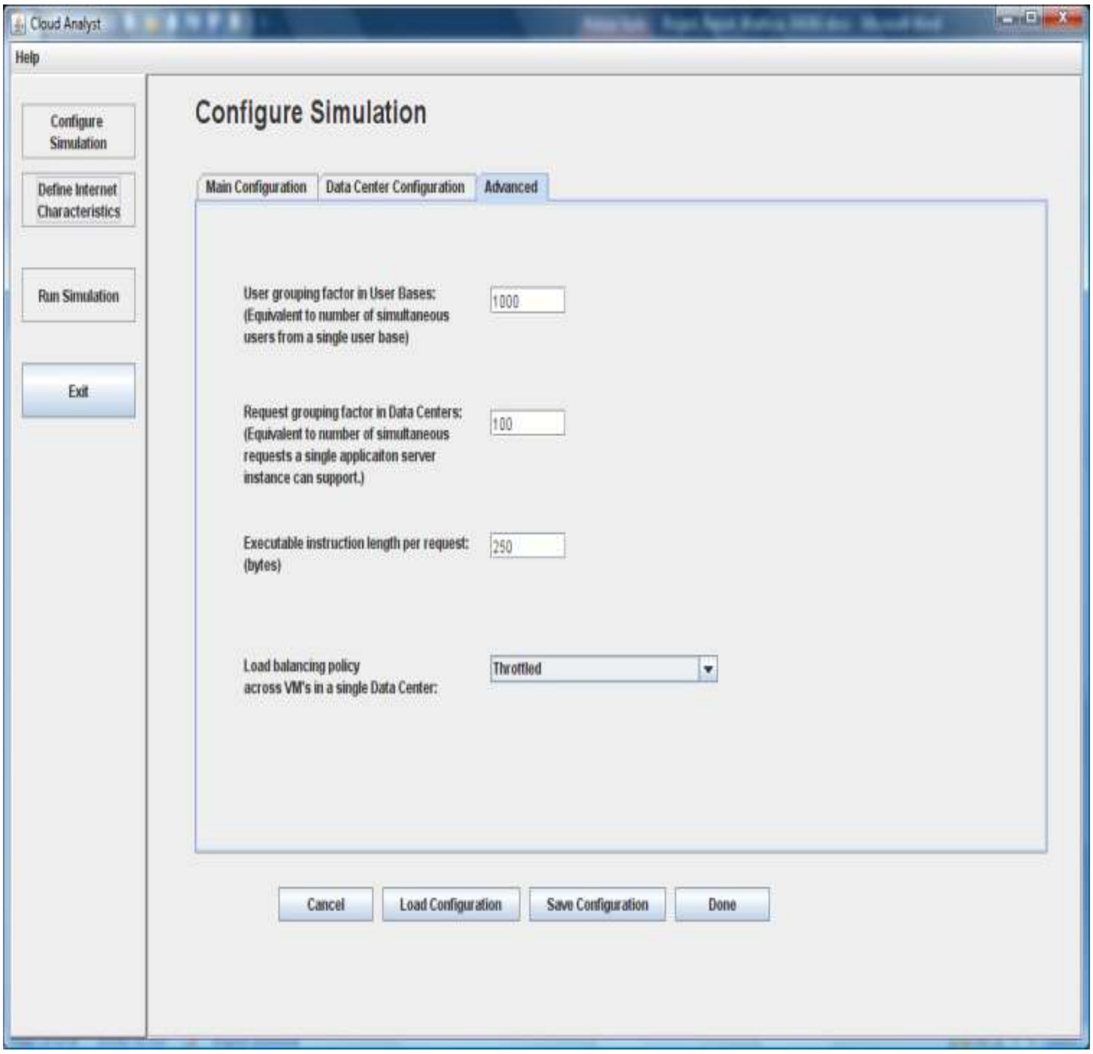
Id	Memory (Mb)	Storage (Mb)	Available BW	Number of Processors	Processor Speed	VM Policy
0	20480	10000000	100000	16	100	TIME_SHARED
1	20480	10000000	100000	16	100	TIME_SHARED
2	20480	10000000	100000	16	100	TIME_SHARED
3	20480	10000000	100000	16	100	TIME_SHARED
4	2048	1000000	10000	4	100	TIME_SHARED

Figure 5. Configure Simulation Screen - Data Center Tab

7.2.3 ADVANCED TAB

In Figure 6, the advanced tab contains some important parameters that apply to the entire simulation.

1. User Grouping Factor (in User Bases) – This parameter tells the simulator how many users should be treated as a single bundle for traffic generation. The number given here will be used as the number of requests represented by a single InternetCloudlet, e.g. 1000
2. Request Grouping Factor (in Data Centers) – This parameter tells the simulator how many requests should be treated as a single unit for processing i.e. this many requests are bundled together and assigned to a single VM as a unit, e.g. 100
3. Executable instruction length (in bytes) – This is the main parameter that affects the execution length of a request, e.g. 250
4. Load balancing policy – the load balancing policy used by all data centers in allocating requests to virtual machines, e.g. Throttled.



User grouping factor in User Bases: (Equivalent to number of simultaneous users from a single user base) 1000

Request grouping factor in Data Centers: (Equivalent to number of simultaneous requests a single applicaiton server instance can support.) 100

Executable instruction length per request: (bytes) 250

Load balancing policy across VM's in a single Data Center: Throttled

Figure 6: Configure Simulation Screen - Advanced Tab

7.3 INTERNET CHARACTERISTICS SCREEN

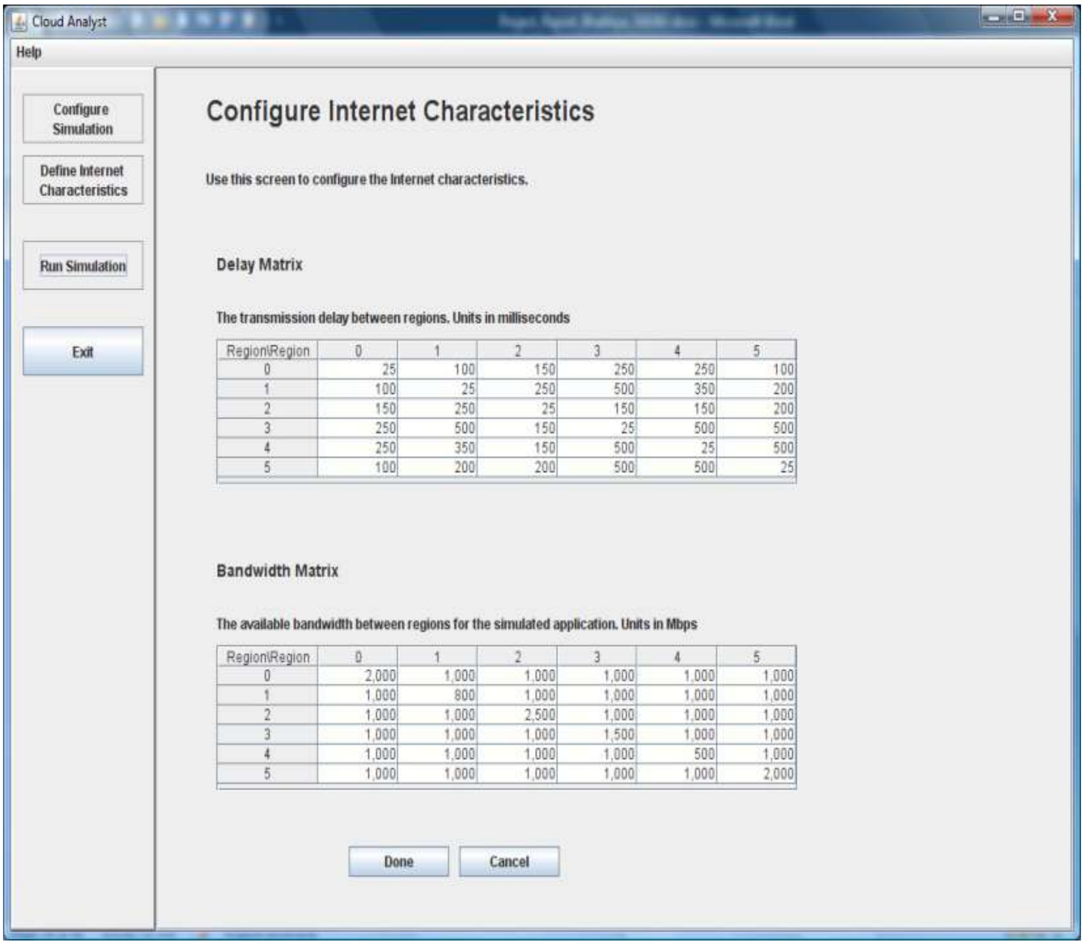
The Internet Characteristics screen can be used to set the Internet latency and bandwidth parameters (See Figure 7). It presents two matrices (Table 1, and Table 2) for these two categories.

Region	0	1	2	3	4	5
0	25.0	100.0	150.0	250.0	250.0	100.0
1	100.0	25.0	250.0	500.0	350.0	200.0
2	150.0	250.0	25.0	150.0	150.0	200.0
3	250.0	500.0	150.0	25.0	500.0	500.0
4	250.0	350.0	150.0	500.0	25.0	500.0
5	100.0	200.0	200.0	500.0	500.0	25.0

Table 1: Latency Matrix values (in milliseconds)

Reg-ion	0	1	2	3	4	5
0	2000.0	1000.0	1000.0	1000.0	1000.0	1000.0
1	1000.0	800.0	1000.0	1000.0	1000.0	1000.0
2	1000.0	1000.0	2500.0	1000.0	1000.0	1000.0
3	1000.0	1000.0	1000.0	1500.0	1000.0	1000.0
4	1000.0	1000.0	1000.0	1000.0	500.0	1000.0
5	1000.0	1000.0	1000.0	1000.0	1000.0	2000.0

Table 2: Bandwidth Matrix values (in Mbps)



Configure Internet Characteristics

Use this screen to configure the Internet characteristics.

Delay Matrix

The transmission delay between regions. Units in milliseconds

Region\Region	0	1	2	3	4	5
0	25	100	150	250	250	100
1	100	25	250	500	350	200
2	150	250	25	150	150	200
3	250	500	150	25	500	500
4	250	350	150	500	25	500
5	100	200	200	500	500	25

Bandwidth Matrix

The available bandwidth between regions for the simulated application. Units in Mbps

Region\Region	0	1	2	3	4	5
0	2,000	1,000	1,000	1,000	1,000	1,000
1	1,000	800	1,000	1,000	1,000	1,000
2	1,000	1,000	2,500	1,000	1,000	1,000
3	1,000	1,000	1,000	1,500	1,000	1,000
4	1,000	1,000	1,000	1,000	500	1,000
5	1,000	1,000	1,000	1,000	1,000	2,000

Figure 7: Internet Characteristics Screen

7.4 RUNNING A SIMULATION

The simulation screen (in Figure 8) will display a simple animation showing which user bases are sending messages to which data centers. A simulation can be cancelled before the completion of the run, using the cancel button at the bottom right hand corner.

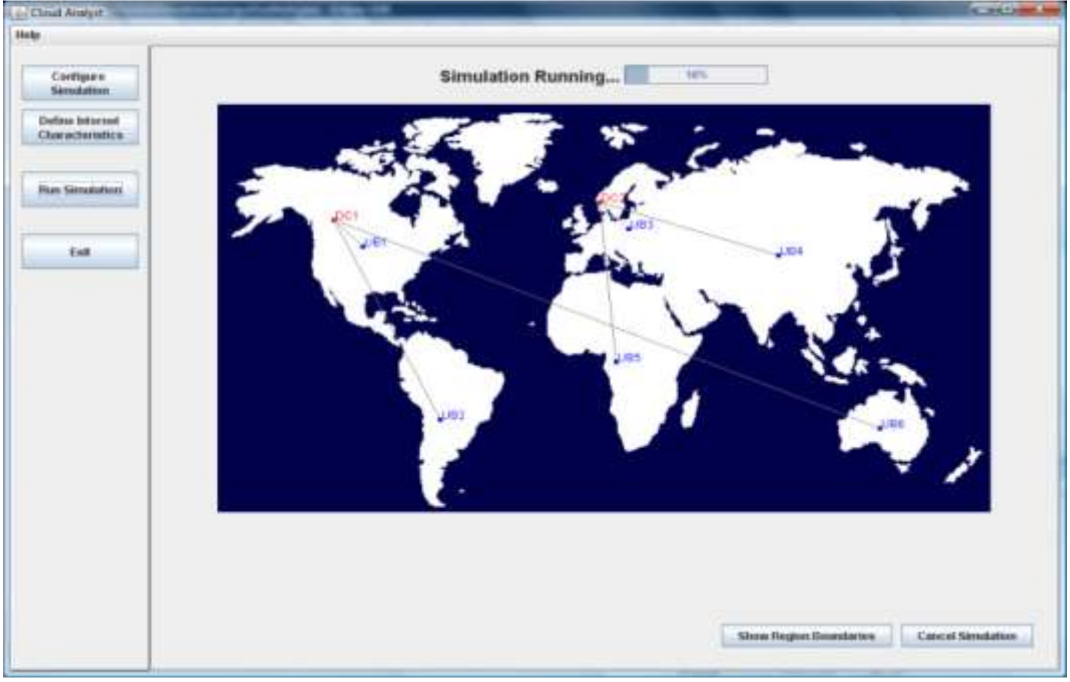
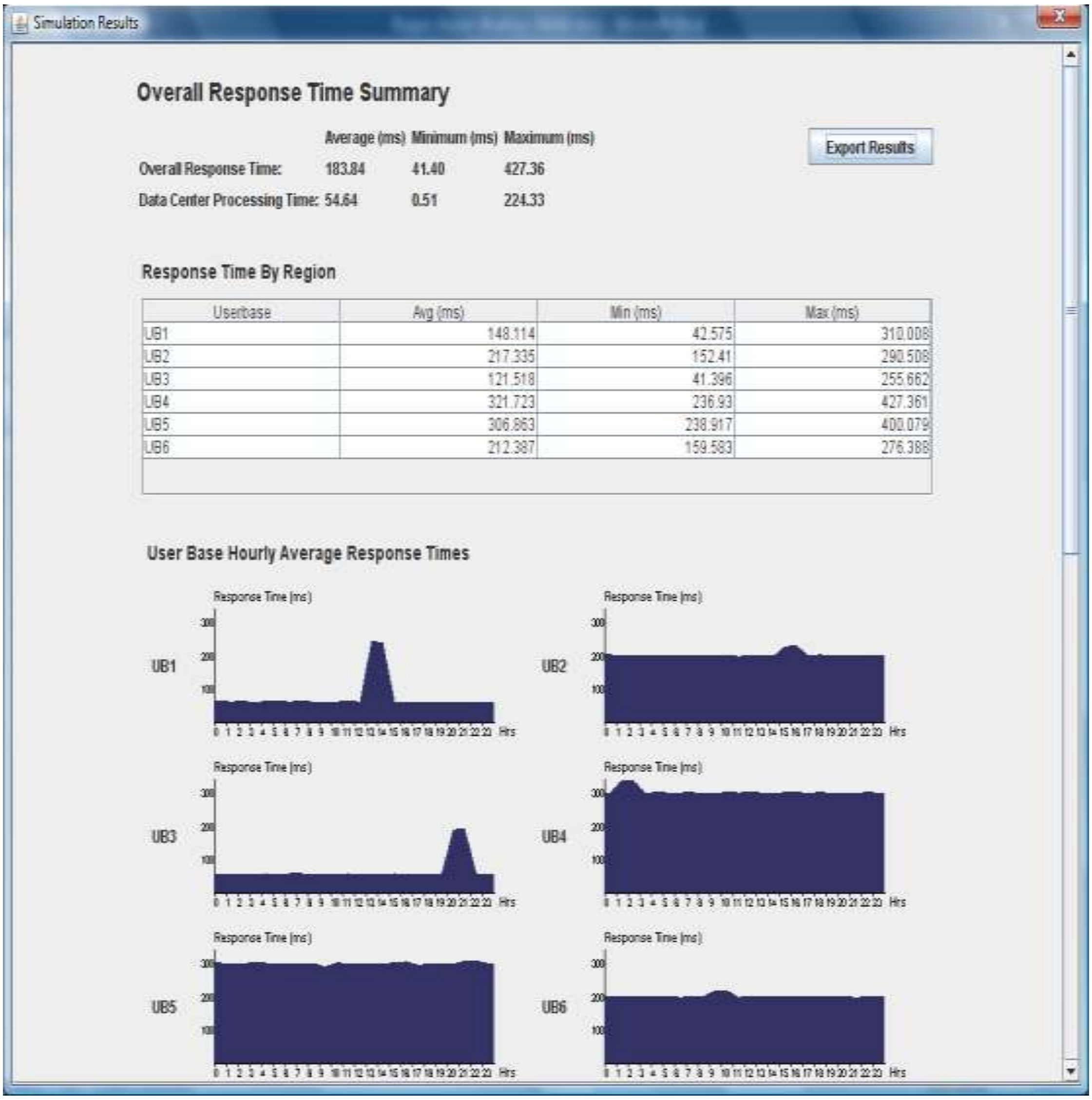


Figure 8: Simulation Panel During a Simulation

VIII. RESULTS SCREEN

The detailed results can be viewed by clicking the “View Detailed Results” button that appears at the right hand bottom corner of the screen after the simulation has completed (In Figure 9). The results screen will list out the data collected from the simulation. This includes:

1. Overall response time summary (for all the user bases)
2. Response time by user base in tabular format
3. Response time by user base in graphical format broken down into the 24 hours of the day
4. Request servicing time by each data center in tabular format
5. Request servicing time by data center in graphical format broken down into 24 hours of the day
6. Data center loading (number of requests serviced) in graphical format broken down in to 24 hours of the day
7. Cost details



Overall Response Time Summary

	Average (ms)	Minimum (ms)	Maximum (ms)
Overall Response Time:	183.84	41.40	427.36
Data Center Processing Time:	54.64	0.51	224.33

Response Time By Region

Userbase	Avg (ms)	Min (ms)	Max (ms)
UB1	148.114	42.575	310.008
UB2	217.335	152.41	290.508
UB3	121.518	41.396	255.662
UB4	321.723	236.93	427.361
UB5	306.863	238.917	400.079
UB6	212.387	159.583	276.388

User Base Hourly Average Response Times

UB1
UB2
UB3
UB4
UB5
UB6
Response Time (ms)
100
200
300
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 Hrs

Figure 9: Results Screen

Therefore we obtained the following results for the same experiments with more powerful hardware configurations of:

Data Center – Processor speed-	10000 MIPS
VM Image Size-	100000
VM Memory-	10240 Mb
VM Bandwidth-	10000

And the results obtained are shown in Table 3 and Figure 10 presents the graphical representation of our result.

Table 3: Result with More Powerful Hardware

S. N.	Scenario	Overall average response time (millisec-onds)	Overall average data center processing time(millis-econds)
1	1 data center with 50 VMs	284.98	46.79
2	2 data centers with 25 VMs each	249.20	119.97
3	2 data centers with 50 VMs each	183.85	54.65
4	2 data centers with 50 VMs each with peak load sharing	184.92	54.60
5	2 data centers with 50 VMs each with peak load sharing and throttling	157.56	28.45
6	3 data centers with 50 VMs each with peak load sharing and throttling	124.12	29.12
7	3 data centers with 75,50,25 VMs, with peak load sharing and throttling	121.07	23.96

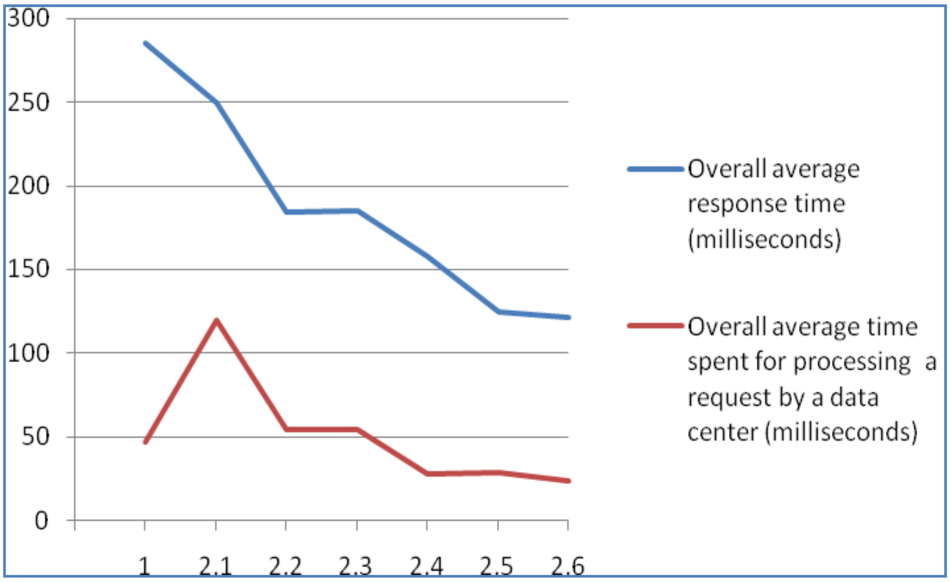


Figure 10: Summary of Simulation Results with More Powerful Hardware

XI. CONCLUSION

This paper presents a concept of Cloud Computing and simulators. In this paper, a broad survey of CloudAnalyst toolkit is carried out. It also focus on how a large scaled web application running on a cloud can be simulated using CloudAnalyst. We showed how the simulator can be used to effectively identify overall usage patterns and how such usage patterns affect the data centers hosting the application. We also showed how the simulator can be used to study how different deployment configurations would tackle these usage patterns. Such a study would benefit the application designers greatly in identifying the optimal configuration for their application. But more importantly such a study will generate valuable insights in to designing Cloud infrastructure services in areas such as coordination between Data Centers, load balancing algorithms and possible value added services such as Service Brokers to coordinate between Data Centers to optimize the application performance and cost to the owners.

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