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Execution Study of Cloud Simulators Load Balancing Approach

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***Abstract*— Cloud computing is a virtual pool of computing resources. Integrated cloud computing provides a whole dynamic computing system for application program environment to the users. It can deploy, allocate or reallocate computing resource dynamically and monitor the usage of resources at all times. Quantifying the performance of scheduling and allocation policy on a cloud infrastructure for different application and service models under varying load, energy performance and system size is an extremely challenging problem to tackle. Simulator plays the role for designing a model of a real system and conducting experiments with this model for the purpose of either of understanding the behaviour of the system or of evaluating various strategies for the operation of the system. It is a process of reassigning the total load to the individual resources nodes of the collective system to make resource utilization effective and to improve the response time of the job. This paper presents a thorough comparative study of a few existing cloud simulators. It also proposes a load balancing approach in cloud computing environment.**

***Keywords*— cloud computing; simulators; load balancing; performance evaluation**

I. INTRODUCTION

Cloud computing is concerned with the dynamic allocation of these virtual computing resources and the delivery of information technology services over the network in response to rapidly changing business needs. It is based on the concept of distributed computing paradigm that provides a wide range of user with distributed access to scalable to virtualized hardware, software and infrastructure over the internet. Cloud computing collects all the computing resources and manages them automatically through software. Cloud Services may be of software resources (e.g. Software as a Service, SAAS) or physical resources (e.g. Platform as a Service, PAAS) or hardware/infrastructure (e.g. Hardware as a Service, HAAS or Infrastructure as a Service, IAAS).

The development of Future Internet, Internet of Things, Service oriented architecture and cloud computing creates a new challenge and possibilities for simulation engineering. One of the most effective methods to verify possible solutions while saving financial resources and minimizing security risks is simulation. Simulation is a critically vital component of decision making before approaching to the actual execution scenario. Hence, simulation nowadays plays an increasing role in the discovery of possible solutions and situation analysis.

The service provided by the *public cloud* is known as utility computing. Recently, *public cloud* is made available as a pay per usage model while *private cloud* can be built with the infrastructure of the organization itself. Web Services, Google AppEngine, and Microsoft Azure are examples of *public cloud*. As benefit, users can access this service “anytime, anywhere”, share data and collaborate more easily, and keep data safely in the infrastructure. Although there are risks involved with releasing data onto third party servers without having the full control of it.

In cloud computing environment, the random arrival of tasks with random utilization of CPU service time requirements can load specific resources heavily, while the other resources are idle or are less loaded. Hence, resource control or load balancing is major challenging issue in cloud computing. Load balancing is a methodology to distribute workload across multiple computers, or other resources over the network links to achieve optimal resource utilization, maximize throughput, minimum response time, and avoid overload [32].

In order to allocate job as providing services to the consumer, cloud provider needs to balance the load of each resources running at that point of time. Load balancing is a major demanding and tricky task in cloud computing environment. In case of load balancing the proper scheduling of job is very important. Scheduling of jobs depends on load of each resource. Jobs need to be scheduled from the heavily loaded resource to least loaded resource to balance the load and also maintain the quality of service agreed with the cloud provider and consumer [33].

Organization of the paper is as follows. Section 2 presents importance of simulators in cloud computing environment briefly. Section 3 discusses a comparative study of different cloud simulators. This research work concentrates on providing services for infrastructure where the clients or consumers can execute their jobs or application in the infrastructure or resources offered by the provider. Section 4 proposes a load balancing approach and compares the preliminary results through these cloud simulators. Finally Section 5 concludes the paper.

II. IMPORTANCE OF SIMULATORS

Simulation is the imitation of the operation of a real world process or system over time. Simulation modelling and analysis is the process of creating and experimenting with a computerized mathematical model of a physical system. Cloud-based services because are expected to become one of the main information technology market requirement and as a consequence many large companies are working on the creation of their own solution to retain a competitive position. Due to the reason mentioned above it would be rational to provide cloud-based simulation service as integral component of the Internet of Services. Simulation is a common approach to deploy access, join and exploit the different and heterogeneous cloud models in distributed environment.

Although cloud computing puts business more ease but the different services are need to be accessed on pay per package basis. As the data centres that under the clouds consist of huge computing resources that consume large amounts of power. Therefore, cloud applications have different composition, configuration, and deployment requirements. Quantifying the performance of resource allocation policies and application scheduling algorithms at finer details in cloud computing environments for different application and service models under varying load, energy performance (power consumption, heat dissipation), and system size is a challenging problem to tackle.

To simplify this process, this paper deals with different cloud simulators: namely, iCanCloud, GreenCloud and CloudSim cloud simulators. Simulation-based approaches in evaluating cloud computing systems and application behaviours offer significant benefits, as they allow the cloud developers to test performance of their provisioning and service delivery policies in a repeatable and controllable environment free of cost. It also permits users to tune the applications performance bottlenecks before real-world deployment on commercial clouds. Next section presents a comparative study of the above-mentioned cloud simulators.

III. A COMPARATIVE STUDY OF SIMULATORS

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. 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. 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. 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.

Sometime it is very much difficult and time consuming to measure performance of the applications in real cloud environment. In this consequence, simulation is very much helpful to allow users or developers with practical feedback in spite of having real environment. This section presents brief overview of simulation environment of well-known cloud simulators, namely iCanCloud, GreenCloud, CloudSim including their special architecture or basic layered schema, characteristics or functionalities.

A. *ICAN CLOUD*

iCanCloud simulation platform is used to model and simulates cloud computing systems to befit users. The main objective of iCanCloud [16] is to predict the trade-offs between cost and performance of a given set of applications executed in a specific hardware, and then provide to users useful information about such costs. It can be widely used by a large number of cloud users.

It has been developed on the top of OMNeT++ and INET frameworks. Thus, both frameworks are need to be installed for execution and development of new modules in iCanCloud. This simulation platform provides a scalable, flexible, fast and easy-to-use tool, which let users, obtains results quickly in order to help to take a decision for payment of using cloud application at particular machines.

Figure 1 shows the layered architecture of iCanCloud.

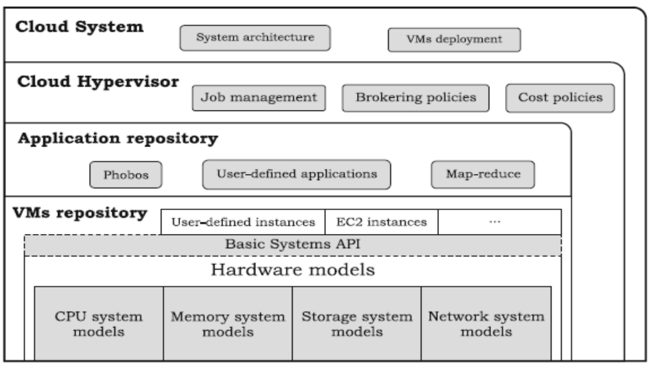


Figure 1: Basic layered schema of iCanCloud architecture [16]

Characteristics

iCanCloud simulation platform is used to simulate and model systems, Although each user is intersected on different features provided by the cloud ,all of them have same objective to optimize the trade-off between cost and performance which is a hard task that iCanCloud tries to alleviate. This lets the users to take an easy decision for paying corresponding budget of machines. iCanCloud has following essential characteristics:

a) Both existing and non-existing cloud computing architectures can be modelled and simulated.

b) A flexible cloud hypervisor module provides an easy method for integrating and testing both new and existent cloud brokering policies.

c) Customizable Virtual machines can be used to quickly simulate uni-core/multi-core systems.

d) iCanCloud provides a wide range of configurations for storage systems, which include models for local storage systems, remote storage systems, like NFS, and parallel storage systems, like parallel file systems and RAID systems.

e) iCanCloud provides a user-friendly GUI to ease the generation and customization of large distributed models. This GUI is especially useful for: managing a repository of pre-configured Virtual machines, managing a repository of preconfigured cloud systems, managing a repository of pre-configured experiments, launching experiments from the GUI, and generating graphical reports.

The simulation scenario of iCanCloud is modelled using a set of existent components provided by iCanCloud; they represent the behaviour of real components that belong to real architectures like disks, networks, memories, file systems, etc. and are hierarchically organized within the repository of iCanCloud, which compose the core simulation engine.

B. GreenCloud

GreenCloud [10, 11] that allows researchers to observe, interact and measure cloud performance through simulation. There also was no provisioning for observing clouds for their energy-efficiency. GreenCloud provides a simulation environment for advanced energy-aware studies of cloud computing data centres in realistic setups.

GreenCloud is developed as an extension of a packet-level network simulator Ns2. About 80 percent of GreenCloud code is implemented in C++ while the remaining 20 percent is in the form of Tool Command Language scripts. GreenCloud extracts, aggregates, and makes information about the energy consumed by computing and communication elements of the data centres available in a never done or known before fashion. In particular, a special focus is dedicated to accurately capture communication patterns of currently deployed and future data centres architectures.

GreenCloud is a packet level simulator, meaning that whenever a data message has to be transmitted between simulator entities a packet structure with its protocol headers is allocated in the memory and all the associated protocol processing is performed. The time required for the simulation depends on many factors such as the simulated scenario or the hardware used for running the simulator software. This simulator achieves reasonable simulation times. They are in the order of tens of minutes for an hour of simulation time while simulating a typical data centre with a few thousand of nodes. Apart of the number of nodes, the simulation duration is greatly affect itself by the number of communication packets produced as well as the number of times they are processed at network routers during forwarding.

The GreenCloud provides users the flexibility to visualizes a simulated topology and a packet flow after the simulation is completed by the network animation tool Nam. However, no GUI tool is available to configure a simulation setup or display simulation graphs in a friendly way.

Simulation of Energy-Efficient Data Centre

Only a part of the energy consumed by the data centre gets delivered to the computing servers directly. A major portion of the energy is utilized to maintain interconnection links and network equipment operations. The rest of the electricity is wasted in the power distribution system, waste as heat energy, and used up by air-conditioning systems.

In light of the above discussion, in GreenCloud, we distinguish three energy consumption components:

a) computing energy
b) communicational energy
c) the energy component related to the physical infrastructure of a data centre.

The efficiency of a data centre can be defined in terms of the performance delivered per watt, which may be quantified by the following two metrics:

(a) Power Usage Effectiveness (PUE)
(b) Data Centre Infrastructure Efficiency.

Figure 2 presents the structure of the GreenCloud extension mapped onto the three-tier data centre architecture.

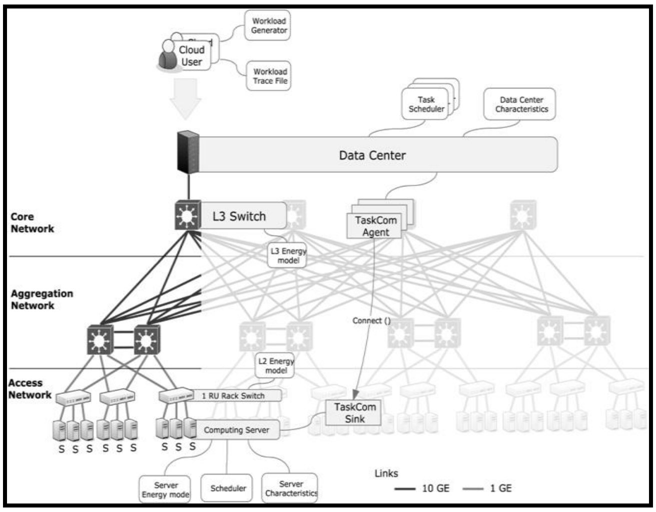


Figure 2: Architecture of the GreenCloud simulation environment [10]

Servers (S) are the staple of a data centre that are responsible for task execution. In GreenCloud, the server components implement single core nodes that have a preset on a processing power limit in MIPS (million instructions per second) or FLOPS (floating point operations per second), associated size of the memory/storage resources, and contain different task scheduling mechanisms ranging from the simple round-robin to the sophisticated DVFS- and DNS-enabled. The servers are arranged into racks with a Top-of-Rack switch connecting it to the access part of the network. The power model followed by server components is dependent on the server state and its CPU utilization. Computing servers are usually arranged into racks, the most common switch in a data centre is the Top-of-Rack switch. The Top-of-Rack switch is typically placed at the top unit of the rack unit (1RU) to reduce the amount of cables and the heat produced. The Top-of-Rack switches can support either gigabit (GE) or 10 gigabit (10 GE) speeds.

The GreedCloud is the only simulator with the support of different power saving modes. The following three algorithms are implemented: Dynamic Voltage and Frequency Scaling (DVFS), DNS, and DVFS+ DNS. Communication details and the level of energy models support are the key strengths of the GreenCloud which are provided via full support TCP/IP protocol reference model and packet level energy models implemented for all data centre components: servers, switches, and links.

C. CloudSim

CloudSim [5, 27] is designed to perform a specific function, especially to solve a problem for simulation of Cloud computing scenarios. It provides basic classes for describing virtual machines, applications, data centres, users, computational resources, and policies for management of diverse parts of the system such as provisioning and scheduling.

The components available in CloudSim can be put together for the users to evaluate new strategies which can be utilized in Clouds such as scheduling algorithms, policies, mapping, load balancing policies. It can also be used for the evaluation of efficiency of strategies from different perspectives ranging from cost/profit to speed up of application execution time. It also supports evaluation of Green IT policies.

The above mentioned scenarios that are put forward, have been explored by the users, but the utilization is not limited: the classes can be extended or improved even replaced, new policies can be added and new scenarios can also be thought of and coded.

Overview of functionalities

CloudSim is used to provide a generalized and extensible simulation framework that enables modelling, simulation and experimentation of emerging Cloud Computing infrastructures and application services allowing its users to focus of specific design issues that they want to implement.

a) It is used for modelling and simulation of large scale computing environments.
b) It is a self-contained platform for modelling clouds, services, provisioning and allocation policies.
c) It provides support for simulation of network connections among the simulated system elements.
d) It facilitates for simulation of federated Cloud Environment that inter-networks resources from both public and private domains.
e) It provides availability of a virtualization engine that aids in creation and management of multiple, independent, and co-hosted virtualized services on a data centre node.
f) It provides flexibility to switch between space-shared and time-shared allocation of processing cores to virtualized services.
g) Support for dynamic insertion of simulation elements, stop and resume of simulation is being provided.

Architecture of CloudSim

In this section the multi-layered design of the CloudSim software framework and its architectural components are illustrated. Figure 3 shows the two parts of the architecture User Code and the CloudSim.

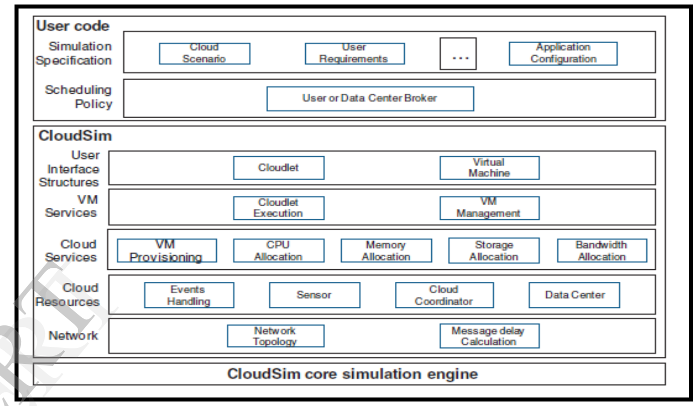


Figure 3: Layered Architecture of CloudSim [27]

The CloudSim simulation layer supports the modelling and simulation of virtualized data-centre environments that includes dedicated management interfaces for VMs, storage, bandwidth, memory. This layer handles the provisioning of hosts to virtual machines, monitoring dynamic system state and provisioning hosts to VMs.

A Cloud Provider who studied the efficiency of different provisioning policies in allocation of the hosts to VMs is known as VM provisioning would implement the strategies at this layer. The implementation of the strategies is done by extension of the programming of the core virtual machine provisioning functionality. This layer also shows us the way in which a Cloud application developer can extend the functions to perform complex workload profiling and application performance study.
Next section presents performance evaluation graph of these above- discussed cloud simulators.

D. Performance Evaluation Graph of Simulators

This section briefly presents the performance of the sample application program for each simulator, like iCanCloud, GreenCloud and CloudSim under different scenarios. The same application program has been executed under different scenario and the respective output is presented in graphical form. Different scenarios are as follows:

Scenario a:	Sole execution of sample application program.
Scenario b:	Execution of sample application program with lightly loaded application.
Scenario c:	Execution of sample program with heavily loaded application.

This performance evaluation is done in order to specify variation in execution of sample application program having different workloads. Figure 4, Figure 5 and Figure 6 presents performance evaluation graph for iCanCloud, GreenCloud and CloudSim respectively.

Observation and Discussion:

It is observed, while the sample application program get executed concurrently under *scenarios (a)*, resulting in best performance in terms of less execution time as no workload has been assigned to this sample program and also there is individual sharing of system resources like CPU usage, memory etc.

But, when the same sample application program is get executed under *scenario (b)* i.e. with lightly loaded applications then, there is a mutual sharing of resources which increases the execution time of that particular GreenCloud sample application program along with resulting in a poor performance compared to the previous scenario.

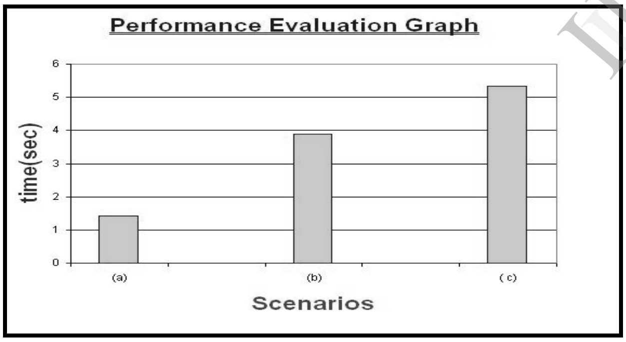


Figure 4: Performance Evaluation Graph of iCanCloud

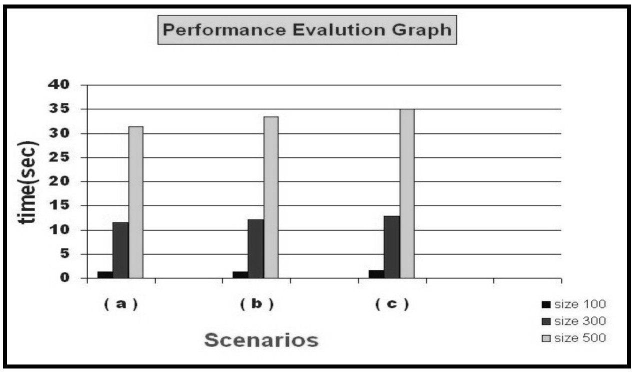


Figure 5: Performance Evaluation Graph of GreenCloud

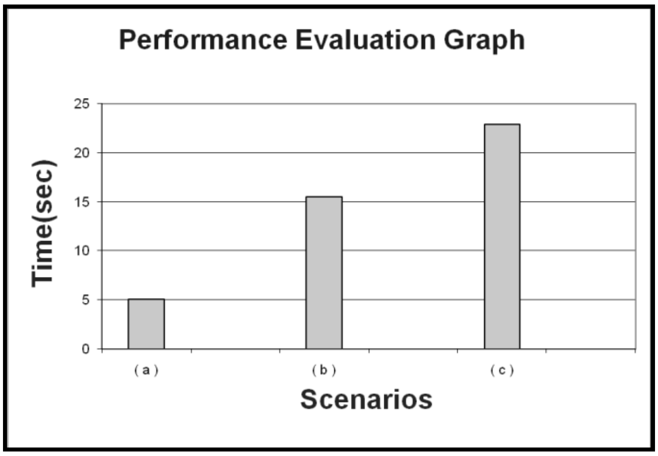


Figure 6: Performance Evaluation Graph of CloudSim

Finally, when *scenario (c)* gets executed then since execution is going on along with heavily loaded applications therefore, the same system resources (like CPU, memory) are being shared among different components of all applications. Hence, execution time gets increased resulting in a much poor performance than the scenario (b).

IV. Proposed Load Balancing Approach

Load balancing [1] is the process of improving the performance of the system by shifting of workload among the processors. Workload of a machine means the total processing time it requires to execute all the tasks assigned to the machine. Load balancing is done so that every virtual machine in the cloud system does the same amount of work throughout such that no resources would be idle or some of them would be overloaded, therefore increasing the throughput and minimizing the response time.

It is a process of reassigning the total load to the individual resources nodes of the collective system to make resource utilization effective and to improve the response time of the job, simultaneously removing a condition in which some of the nodes are over loaded while some others are under loaded. A load balancing algorithm which is dynamic in nature does not consider the previous state or behaviour of the system, that is, it depends on the present behaviour of the system.

This research considers a few important characteristics, like estimation of load, comparison of load, stability of different system, performance of system. In this context, load can be considered in terms of CPU load, amount of memory used, delay or Network load.

Proposed Load Balancing Approach

This section presents the proposed load balancing approach towards cloud computing environment for determining dynamic run time system utility of each resources having different simulator functioning on them under common cloud environment.

This computation of information will be generated by the cloud provider and it will maintain the dynamic information in a table called resource table. This table consists of CPU usage, storage, current time of the system of each resource under the cloud environment. On the basis of information available on resource table, cloud provider can take the decision regarding with accessing the particular resource.

Following are the steps that are involved in determination of dynamic run time system utility of each resource:

i. Client's or Consumer's request is submitted to the cloud provider for execution of their tasks.
ii. Cloud provider accepts the request and requires the dynamic runtime system information from all the available resources on the cloud.
iii. In order to do this, cloud provider sends the request to the entire available resource provider on the cloud and simultaneously maintains its timing.
iv. Immediately execution of dyn_res_info program takes place at each resource. And corresponding result is sent back to the cloud provider.
v. Cloud provider receives all the dynamic run time system information from all the resources and maintains it into a resource table.
vi. Cloud provider prepares a set of suitable resources to the cloud consumers or clients.
vii. On the basis of agreement, decision will be taken to use the particular resources.

Implementation of Dynamic Resource Information System

This proposed system shows the Performance Evaluation Graph for each simulator as a graph, which shows that with increase in workload the execution time of sample application program will also get increased varying scenarios as mentioned above. Figure 7 shows environment of the dynamic information system.

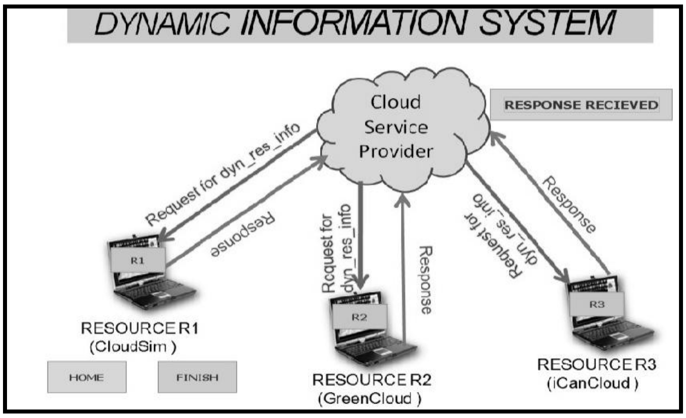


Figure 7:Dynamic Information System

This interface deals with the cloud service provider and the resources. The cloud service provider requests for the dynamic resource information of the different resources and get the information in form of response. And the response of different resources can be viewed in tabular form by clicking on "Response Received" button. The next three figures, namely Figure 8, Figure 9 and Figure 10 show the resource information of Resource R1, Resource R2 and Resource R3 respectively.


```
<? Xml version="1.0"?>
  <Dynamic_run_time_info>
    <Current time>Current time is 2:15:10</Current time>
    <Cpu>
      <User usage> 2% </User usage>
      <System usage>35 %< /System usage>
    </Cpu>
    <Memory>
      <Total>3185 kb</Total>
      <Used>1051kb </Used>
      <Free>1044kb </Free>
      <Buffers>1090kb</Buffers>
    </Memory>
  </Dynamic_run_time_info>
```


Figure 8: Resource Information of R1

The cloud provider has received the dynamic information about the resource R1each resource through xml files as shown in figures.

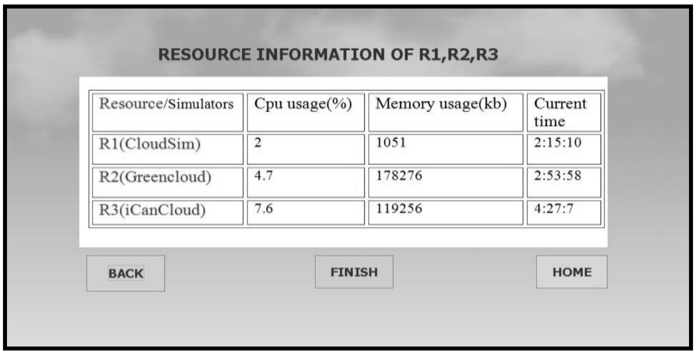

```
<? Xml version="1.0"?>
  <Dynamic_run_time_info>
    <Current time>Current time is 2:53:58</Current time>
    <Cpu>
      <User usage> 4.7% </User usage>
      <System usage>1.3 %< /System usage>
    </Cpu>
    <Memory>
      <Total>1016360 kb</Total>
      <Used>838084kb </Used>
      <Free>178276kb </Free>
      <Buffers>56848kb</Buffers>
    </Memory>
  </Dynamic_run_time_info>
```


Figure 9:Resource Information of R2


```
<? Xml version="1.0"?>
  <Dynamic_run_time_info>
    <Current time>Current time is 4:27:7</Current time>
    <Cpu>
      <User usage> 7.6% </User usage>
      <System usage>1.9 %< /System usage>
    </Cpu>
    <Memory>
      <Total>1016360 kb</Total>
      <Used>897104kb </Used>
      <Free>119256kb </Free>
      <Buffers>15204kb</Buffers>
    </Memory>
  </Dynamic_run_time_info>
```


Figure 10: Resource Information of R3

Three simulators: CloudSim, GreenCLoud and iCanCloud are installed in R1, R2 and R3 respectively. Then the same application program is being executed with varying scenarios at different time period. Figure 11 presents the comparative resource usage details for each simulator. It is observed the CloudSim gives best result in terms of CPU and memory usage.



Resource/Simulators	Cpu usage(%)	Memory usage(kb)	Current time
R1(CloudSim)	2	1051	2:15:10
R2(Greencloud)	4.7	178276	2:53:58
R3(iCanCloud)	7.6	119256	4:27:7

Figure 11: Resource Information of R1, R2 and R3

V. CONCLUSION

This section briefly concludes this paper including introduction of cloud computing basics and load blancing issues. This paper presents a comparative study of different existing cloud simulators like iCanCloud, GreenCloud and CloudSim along with their features, architectures and performance evaluation graphical form. The purpose of creating performance evaluation graph of the existing cloud simulator is to predict the different outcome of sample application program of each simulator under different scenarios (sole execution, execution when lightly loaded, execution when heavily loaded).The impact of variations is precisely shown in the graph along with the different scenarios.

A basic concept of load balancing in cloud computing and implementation of proposed load balancing algorithm are also presented in this thesis. Basically, this paper demonstrated the execution study of different simulators in different scenarios under cloud computing environment to obtain measurable improvements in resource utilization and availability of cloud-computing environment.

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