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Fakhrun Jamal
Research Scholar, Department of Computer Science, AMU, Aligarh, Uttar Pradesh, India

Tamanna Siddiqui
Professor, Department of Computer Science, AMU, Aligarh, Uttar Pradesh, India

Correspondence
Fakhrun Jamal
Research Scholar, Department of Computer Science, AMU, Aligarh, Uttar Pradesh, India

An analytical study on simulation tools and techniques in cloud computing

Fakhrun Jamal and Tamanna Siddiqui

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Abstract
Cloud computing provides convenient and on-demand access to virtually unlimited computing resources. Mobile cloud computing (MCC) is an emerging technology that integrates cloud computing technology with mobile devices. MCC provides access to cloud services for mobile devices. With the growing popularity of cloud computing, researchers in this area need to conduct real experiments in their studies. Setting up and running these experiments in real cloud environments are costly. However, modeling and simulation tools are suitable solutions that often provide good alternatives for emulating cloud computing environments. Several simulation tools have been developed especially for cloud computing. In this paper, we present the most powerful simulation tools in this research area. These include CloudSim, CloudAnalyst, CloudReports, CloudExp, GreenCloud, and iCanCloud. Also, we perform experiments for some of these tools to show their capabilities. Today, cloud computing has become a promising paradigm that aims at delivering computing resources and services on demand. The adoption of these services has been rapidly increasing. One of the main issues in this context is how to evaluate the ability of cloud systems to provide the desired services while respecting the QoS constraints. Experimentation in a real environment is a hard problem. In fact, the financial cost and the time required are very high. Also, the experiments are not repeatable, because a number of variables that are not under control of the tester may affect experimental results. Therefore, using simulation frameworks to evaluate cloud applications is preferred. This paper presents a survey of the existing simulation tools in cloud computing. It provides also a critical and comparative analysis of the studied tools. Finally, it stands out a major challenge to be addressed for further research.

Keywords: Cloudsim, ground sim, cloud analyst

1. Introduction
Today, cloud computing has become a promising paradigm that aims at delivering computing resources and services on demand. The adoption of these services has been rapidly increasing. One of the main issues in this context is how to evaluate the ability of cloud systems to provide the desired services while respecting the QoS constraints. Experimentation in a real environment is a hard problem. In fact, the financial cost and the time required are very high. Also, the experiments are not repeatable, because a number of variables that are not under control of the tester may affect experimental results. Therefore, using simulation frameworks to evaluate cloud applications is preferred. This paper presents a survey of the existing simulation tools in cloud computing. It also provides a critical and comparative analysis of the studied tools. Finally, it stands out a major challenge to be addressed for further research.

- **Infrastructure as a service (IaaS):** According to the IETF (Internet Engineering Task Force), the providers of IaaS services offer virtual machines and other resources. The cloud user have to install the operating system images in order to deploy their cloud applications.
- **Platform as a service (PaaS):** In this model, the cloud provider delivers a computing platform. It includes the operating system, programming language execution environment, database and web server.
- **Software as a service (SaaS):** Cloud providers in this model provides access to the application software and databases to the users.

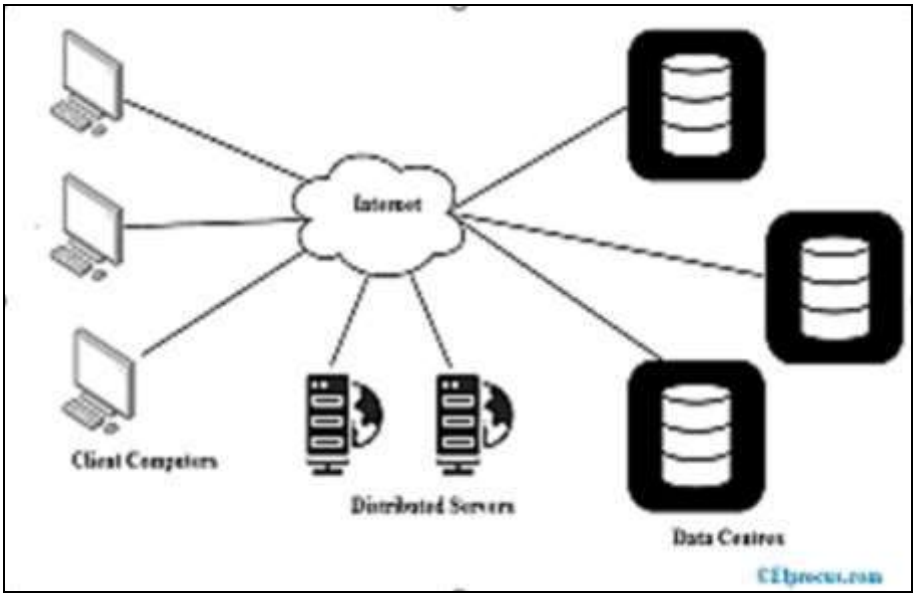

Fig 1: Infrastructure as a service

People are migrating from the traditional computing towards cloud computing because it is agile, cost reductions, device and location independence, higher reliability, fault tolerance etc. Some of the cloud based application services include social networking, web hosting, content delivery and other real time data processing. Quantifying the performance of various scheduling and allocation policies in a real cloud computing environment for different application models is extremely challenging and costly. Thus we go for cloud simulation tools to analyse the performance of a Cloud system with reduced complexity.

Virtualization is a significant as well as central cloud computing technology. This technology helps the abstraction of the primary components of processing like networking, storage, and hardware. It would facilitate the cloud data centers to efficiently boost resource consumption and decrease energy costs [5]. Load balancing is a technique in cloud computing to disburse workload regularly to every one nodes in the offered workspace so it convinced no single nodes in the system is overwhelmed or unused for each instant of time. A proficient load balancing algorithm would clarify that every single node in the system might have pretty much identical measure of work. The liability of the load balancing algorithm is truly to contract with the assignments which are placed in advance to the cloud region for the fresh services. Hence, that the whole open response time is improved and what's more it gives capable to resource utilization. Balancing the workload being one of the remarkable stresses in cloud computing, since we cannot make sense of the amount of requests that are released consistently within a cloud system. The unpredictability is credited to the always differing tendency of the cloud. The principal thought of load balancing in the cloud is in disseminating and designating the load progressively all through the nodes with a particular end objective to fulfill the client necessities and to give ideal resource utilize just by arranging the whole realistic load to differing nodes

Several simulation tools are available for carrying out research in the cloud [6, 11, 30, 23, 27]. Nevertheless, selecting the right simulator to use needs a thorough analysis of the available tools. Previous attempts to survey simulation tools for cloud computing can be seen in the literature [22]. In this survey paper, we strive to offer an updated view of this topic. We give an overview of the existing simulation tools in the cloud. Also, we present a deep comparative analysis of these tools based on different attributes. Furthermore, the paper introduces a new challenge that have to be addressed.

2. Overview of cloud computing, Virtualization and Simulation Tools in the Cloud

Cloud virtualization refers to "something that is not real" however, it acts as real [2]. This is a software application on which diverse programs are able to perform like an actual system. It is a component of cloud computing, for the reason that diverse services of cloud can be utilized by user [8]. It is really useful to boost processing productivity as well as make use of optimal hardware resources [2]. Two main types of virtualization are noticed with regard to clouds as discussed below.

2.1 Full Virtualization

In the context of full virtualization, the whole set up of a single system is carried out on another system. The major benefit of the entire application is its power transforming the platform for any user working at the server to virtual server. It has been successful for numerous reason such as allocation of PC between various clients, isolating clients from one another and from the program control, and imitating hardware on another machine [7, 9]. For example, KVM, Vmware.

2.2 Para Virtualization

In para virtualization, numerous operating systems are permitted to drive on a solitary system by utilizing framework resources such as processor as well as memory [9]. At this place, entire services are not completely out there, but the services are offered partly. It has some significant characteristics such as disaster recovery, capacity management, and migration. For example, Xen, Denali.

Resources and software are shared based on the client's demand in the cloud environment. Essentially, dynamic utilization of resources is achieved under different conditions with various previously established policies. Sometimes it is not easy 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 portrays the importance of simulation technique and simulation in cloud. In this research work, simulation is carried out with a specific cloud simulator, CloudSim.

2.3 Why Need of simulation tools

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 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 International Journal on Cloud Computing: Services and Architecture (IJCCSA), Vol. 2, No. 5, October 2012 7 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.

2.4 Types of simulators

This section presents a detailed study of cloud simulators proposed in the literature. We begin by offering the popular simulator CloudSim and its extensions. After that, we introduce the other simulators.

2.4.1 CloudSim: CloudSim [6] is a well-known cloud computing simulator built upon GridSim. It has been developed in the CLOUDS Laboratory at the University of Melbourne. It provides a toolkit for modeling and simulating the behavior of many cloud components, such as virtual machines (VMs), data centers and resource provisioning services. Also, it can represent different types of clouds (public, private, hybrid and multi-cloud environments). CloudSim is an event-driven simulation tool, that is to say, all components of the simulation maintain a message queue and generate messages, which they pass along to other entities. It can instantiate many data centers which consists of storage servers and physical host machines. These machines host multiple VMs executing several tasks (named cloudlets). CloudSim can perform simulations of assigning and executing a workload on a cloud infrastructure [7]. The communication flow among core CloudSim entities is shown in Figure

Simulation environment allows customers or users to tune the performance bottlenecks or evaluates different kinds of features under varying load distributions [7]. Different kinds of functionalities of CloudSim are presented in the following [4].

- Support for modeling and simulation of large scale cloud computing data centers
- Support for modeling and simulation of virtualized server hosts, with customizable policies for provisioning host resources to virtual machines
- Support for modeling and simulation of energy-aware computational resources
- Support for modeling and simulation of datacenter network topologies and message-passing applications
- support for modeling and simulation of federated clouds
- Support for dynamic insertion of simulation elements, stop and resume of simulation
- Support for user-defined policies for allocation of hosts to virtual machines and policies for allocation of host resources to virtual machines

2.4.2 GDCSim: Green Data Center Simulator [15] (GDCSim) is a simulator for studying the energy efficiency of data centers under various data center geometries, workload characteristics, platform power management schemes, and scheduling algorithms. GDCSim is used to iteratively design green data centers. It is suitable for online analysis.

2.4.3 CloudAnalyst: Cloud Analyst is developed at the GRIDS laboratory at the University of Melbourne and designed for some specific goals. What is so special about this simulator is its graphical presentation of output, and the repetition of simulations to suit the user's requirements. As such, Cloud Analyst is beneficial where the main objective is to simulate distributed applications among several data centers and user groups. It inherits the original features of CloudSim framework, extending it to simulate largescale Internet applications and study their behaviors in cloud environments. Furthermore, it supports the evaluation of social network tools, based on the geographic distribution of users and data centers. It is our opinion that internet application users care more about the time needed to process their requests, regardless of the server location. When a user base (a group of users) requests cloudlets (tasks), a Service Broker entity in Cloud Analyst routes user base traffic to the best data center, according to a server brokerage policy. Cloud Analyst implements three brokerage policies; service proximity policy, best response time policy, and dynamically reconfiguring router [14].

2.4.4 NetworkCloud: Network CloudSim, as proposed by S.K. Garg and Rajkumar Buyya [9], is an extension of CloudSim with a scalable network and generalized application model, which allows more accurate evaluation of scheduling and resource provisioning policies to optimize the performance of a Cloud infrastructure.

2.4.5 MDCSim: MDCSim is a variant of CloudSim tools. It helps the user to analyze and predict the hardware related parameters of the data centers like those of servers, switches, routers etc. Also it is used predominantly because of its low overhead produced [8].

2.4.6 SPECISim: SPECI is Simulation Program for Elastic Cloud Infrastructure. It is used to analyze the scalability and performance concepts related to data centers.

2.4.7 GroundSim: GroudSim is a is an event based simulator proposed by Ostermann *et al.* [7] for scientific applications on Grid and Cloud environments based on a scalable simulation independent discrete-event core. It provides a comprehensive set of features for complex simulation scenarios from simple job executions on leased computing resources to calculation of costs, and background

load on resources. Simulations can be parameterised and are easily extendable by probability distribution packages for failures which normally occur in complex environments. It is mainly concentrated on the IaaS, but it is easily extendable to support additional models such as PaaS, DaaS and TaaS [8].

2.4.8 DC Sim: DCSim, proposed by [11] is an extensible simulation framework for simulating a data centre hosting an Infrastructure as a Service cloud.

2.4.9 iCanCloud*:* iCanCloud is another tool for simulating high performance MPI applications on large storage networks [12]. This simulator is developed over SIMCAN (a simulation tool to analyze high performance I/O architectures). In this simulator, there is no need to modify the simulator code to test different architectures. It can be done just by creating a new configuration file.

10. Green Cloud*:* GreenCloud, as proposed by Kliazovich, is a sophisticated packet-level simulator for energy-aware cloud computing data centres with a focus on cloud communications. It offers a detailed fine-grained modelling of the energy consumed by the data centre IT equipment, such as computing servers, network switches, and communication links. It can be used to develop novel solutions in monitoring, resource allocation, workload scheduling as well as optimization of communication protocols and network infrastructures.

2.5 Comparison of the tools

Table 1: Comparison of simulators

Cloud simulators	GUI support	Platform	Language	Support of TCP/IP	S/w or H/w	Availability
Cloudsim	limited	Gridsim	Java	No	S/W	Open source
SPECI	Limited	Simkit	Java	None	S/W	Open source
GreenCloud	Limited	NS2	C++,otcl	TCP/IP	S/W	Open source
Open Cloud Testbed	Limited	Geographicaly distributed	NA	NA	Both s/w and h/w	limited
Open cirrus	None	Federation of heterogenous datacenters	NA	NA	Both s/w and h/w	Open source
GroundSim	No	NA	java	Full TCP/IP	S/W	NA
NetworkCloudSim	No	Cloudsim	Java	No	S/W	Open source
EMUSim	Limited		Java	None	S/W	Open source
DCSim	None		Java	No TCP/IP Support	S/W	Open source
iCanCloud	Support		OMNet,MPL,C++	None	S/W	Open source
CDOsim	None		Java	No TCP/IP Support	S/W	NA
TechCloud	Full		NA	None	S/W	Open source
MDCsim	No		C++/Java	None	S/W	Commercial
GDCsim	No		C++/Xml	No	S/W	Open source

2.6 Advantages of cloud simulation tools: Cloud simulation tools offer several advantages over the cloud service. Such as: No Capital Investment Involved Simulation tools does not requires any installation and nor even maintenance cost Provides Better Results Simulation tools helps user to change input very easily as when needed, which provide better results as an output Risk are evaluated at earlier stage Simulation tools involve no capital cost while running as in case of being on cloud. This helps in identifying of risks with design or any parameter at earlier stage.

3. Conclusion

To summarize, in this paper we have analyzed and compared the popular cloud simulators in the literature. Based on this analysis and evaluation, we have pointed out the inability of the existing simulators to deal with changes of applications at runtime. Such requirements need a new research contribution. In our ongoing work, we aim to overcome this limitation of existing simulators. We plan to provide an application model which depicts dynamic changes during execution based on some rules. The change of application model during execution necessarily needs to enhance an existing simulator. We will rely on our previous work [9] which focus on workflows which have become an effective way to the development of scientific applications.

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