Cloud Simulation Tools for Evaluating the Performance in Multi-Tenant Cloud Environments: A Review

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Abstract: Cloud Computing is a dynamic and emerging paradigm for parallel and distributed computing in which cloud service providers provides the resources like infrastructure, platform, software etc. to the clients. Whenever they request for the resources, they have to pay according to their usage. This enables everyone to access the resources quite easily over the shared network. But as clients are concerned about the confidentiality of their data, there is a need of evaluating and analysing the problems related to the security of the service provided over cloud. The purpose of this review paper is to provide comparative study of the existing cloud simulation tools to directly analyse the behaviour of cloud in terms of various parameters.

Keywords: CloudSim, CloudAnalyst, Network CloudSim, GreenCloud, MDCSim, DCSim, GROUDSim, EMUSIM, GDCSim, SPECI.

Introduction

In today's digital and connected era, each and every organisation as well as individual is migrating from legacy computing to cloud computing as it provides scalability, higher reliability, fault tolerance, on-demand usage and many more benefits. National Institute of Standards and Technology (NIST) [7] defines cloud computing as "Cloud Computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This model is composed of five essential characteristics, three service models, and four deployment models". Some of the features of cloud computing technology are mentioned in Figure 1. But there are some issues which can't be ignored while using the cloud. As this technology is purely based on internet, the major concern is the cost involved for the continuous availability of internet and using the cloud services or resources. There are various simulation tools available for cloud computing and the analysis of the same will certainly help in choosing the best option.



Figure 1: Features of Cloud Computing

Figure 2: Layered Architecture of Cloud Computing [6]

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Cloud Service Models

There are three types of service models in Cloud Computing, namely, IaaS, PaaS&SaaS.

Infrastructure as a Service (IaaS):

In this, virtual hardware or computing infrastructure is provided by the cloud service providers. This includes network connections, virtual server space, load balancers, etc. This capability enables the clients to deploy and run their applications on the provided infrastructure. Amazon Web Services (AWS), Cisco Metapod, Microsoft Azure, Google Compute Engine (GCE), Joyent are some of the examples of IaaS [5].

Platform as a Service (PaaS):

Clients are provided with the platform and environment in this service model. This includes operating system, server-side scripting environment, DBMS, programming languages, libraries, services, tools, etc [4]. They simply deploy applications and services over the cloud which is further used by the users via their web browser. Apprenda is one of the providers of a private cloud PaaS for .NET and Java [5].

Software as a Service (SaaS):

Instead of buying the software, this service enables the clients to utilize the software applications on-demand over the internet. This is a broader service model which also includes IaaS and PaaS. Google Apps, Salesforce, Facebook, Twitter, Gmail, Workday, Concur, Citrix GoToMeeting, Cisco WebEx are some of the examples of SaaS [5].

Literature Survey

A comparative study has been done on various cloud simulation tools which includes: CloudSim, CloudAnalyst, SPECI, Green-Cloud, OCT (Open Closed Testbed), OpenCirrus, GroudSim, Network CloudSim, EMUSIM, DCSim, iCanCloud, GDCSim, DCSim, CDOSim, TeachCloud.To evaluate the performance and security of cloud computing, overview of various cloud simulation tools has been discussed below.

Cloudsim

CLOUDS Laboratory, CSE Department of University of Melbourne, Australia had developed a toolkit for modelling and simulation of cloud computing environments, namely CloudSim. To evaluate the performance of cloud provisioning policies, application and resource performance model, CloudSim is extensively used [6]. It focuses on implementing generic application provisioning techniques which are easily extendable with limited effort. With the help of classes it maintains the feature of extendibility or replacement by coding the desired scenario.

Figure 3 shows the seven-layered architecture of CloudSim 2.0. It is clear in this figure that the task of managing the communication between the components is done by the lowermost layer and second sub layer includes the cloud components. The communication medium, among all the components in CloudSim, is the message-passing. User can model and simulate the virtual hardware, data centers, network behaviour, etc. Other extended versions of CloudSim are: CloudSimEx, WorkflowSim, CloudMIGXpress, RealCloudSim, CloudReports, CloudAuction, CloudAnalyst [1].

CloudAnalyst

CloudAnalyst is the extended version of CloudSim as it overcomes the major limitation of CloudSim that, it is unable to generate graphical analysis or results. For better improved results, we can opt for CloudAnalyst. This tool is easy to use and understand as graphical results give more effective understanding rather than theoretical results. Like CloudSim, we can do experiments repetitively with either same or different parameters [2]. Relationship between CloudSim and CloudAnalyst is shown in the Figure 4.

NetworkCloudSim

Another extension of CloudSim is NetworkCloudSim in which network layer is implemented in CloudSim, which further reads a BRITE file and a topological network is generated. In this, we are having a topological file which provides the information about the nodes and entities that are involved in simulation. To stimulate the network traffic, it can be used. Mapping of BRITE nodes with entities is done for the proper working of Network CloudSim. It supports modelling and simulation of real cloud data centers.



Figure 3: Layered Architecture of CloudSim [6]

Figure 4: Architecture of GreenCloud Simulation [14]

Greencloud

GreenCloud simulation tool, proposed by Kliazovich, is generally designed for energy-efficient cloud computing. It provides an environment for energy-aware data centers. It offers a detailed fine-grained modelling of the energy consumed by the data centre IT equipment, such ascomputing servers, network switches, and communication links [8]. In this, data centers which are utilizing the energy efficiently increase performance and better utilize the data center's space. Figure 4 shows the architecture of GreenCloud simulation.

MDCSim

One of the variant of CloudSim tool is MDCSim which is used to analyse and predict the characteristics of hardware that is used in the data centers like switches, servers, routers, NIC, etc. It is prominently used because it produces low overhead. The architecture of MDCSim is shown in figure 5.



Figure 5: Architecture of MDCSim [10]

Figure 6: Architecture of DCSim [12]

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DCSIM

DCSim is the acronym for Data Center Simulator. It is implemented in Java and provides the framework for simulating the techniques and algorithms for data center management [12]. DCSim is an event-driven simulator, which offers IaaS to the multiple clients. As shown in the figure 6, Data Center is the primary class containing Hosts, Virtual Machines & different management components and policies. It develops and evaluates the techniques for dynamic resource management.

GDCSim

Developed as a component of BlueTool infrastructure project, GDCSim implies Green Data Center, which is used to design green data centers. GDCSim basically overcomes the drawback of MDCSim i.e. when we are going to analyse the parameters of data center, there is no as such well-defined simulator. Figure 8 shows the architecture of GDCSim.

There are four main modules in GDCSim Architecture:

- a. BlueSim Toolkit: It further consists of three modules: pre-processing, processingand post-processing.
- b. Input/output Management: It is responsible for getting input to the system and showing the output.
- c. Resource Management: Mainly, power, cooling and workload management is done by this module.
- d. Simulator: Activities which are related to simulation are performed and managed in this.



Figure 7: Architecture of GDCSim [13]

Figure 8: Architecture of EMUSim [11]

EMUSIM

EMUSIM integrates the functionalities of emulation and simulation to build a simulated scenario. It extracts the information to generate the respective simulation model. It doesn't require the information about the virtual machines i.e. location, number of virtual machines per host, etc. Figure 8 represents EMUSIM components.

GROUDSim

GROUDSim is an event-driven simulation tool designed for Grid and Cloud Simulation environments. It provides a specific set of features to simulate in complex environments. It also offers some basic analysis views and statistics. SimEngine, the main Class of GROUDSim, implements the clock, time advance algorithm, the Future Event List, and keeps the track of registered entities used during a simulation [9]. Modeling of Grid and Cloud resources (computational & network), file transfers, integration of failures, etc. is supported by this framework [15].

SPECI

Simulation Program for Elastic Cloud Infrastructures, abbreviated as SPECI, makes us capable to analyse the scalability and performance of future data centers. It simulates the behaviour of data centers by taking size and middleware design policy as the input [9].

However, these are the different simulation tools which are used now-a-days.

Comparative Analysis

Parameters → Tools ↓	Platform	Language	GUI	Simulation Time*	Availability	Speed	Energy Model	Cost Model
CloudSim	GridSim	Java	Limited	Seconds	Open- Source	Fast	Yes	Yes
Cloud Analyst	CloudSim	Java	Excellent	Seconds	Open Source	Fast	Yes	Yes
Network CloudSim	CloudSim	Java	None	Seconds	Open- Source	Fast	Yes	Yes
Green Cloud	NS2/OTCL	C++	Limited	Minutes	Open- Source	Slow	Yes	No
MDCSim	CSIM	C++/Java	No GUI	Seconds	Commercial	Fast	Yes	Yes
DCSim	None	Java	-	Minutes	Open- Source	Slow	No	Yes
GDCSim	BlueTool	C++/Java	No GUI	Seconds	Open- Source	Fast	Yes	Yes
EMUSim	CloudSim	Java	Limited	Seconds	Open- Source	Fast	Yes	Yes
GroudSim	-	Java	No GUI	Seconds	-	Fast	No	No
SPECI	SimKit	Java	Limited	Seconds	Open- Source	Fast	Yes	No

Table1: Comparative Analysis of various Simulator Tools

*Simulation Time of different simulation tools taken from Wikipedia.com and research papers.

Conclusion

Cloud Computing is a buzzword in the IT industry as it provides many services to the clients. So, it is required to evaluate the security risks and performance of the cloud services. Clients are concerned about the issues related to costs and security, due to which various simulators are designed for analysis of cloud environments. In this review paper, we have discussed about some cloud simulation tools. Each one of the tool is having some merits or demerits over the other one. It's only up to the clients, that what kind of analysis they want to do, and then select the respective tool as per their requirements. Continuous approach for improving and developing the functionalities of simulation tools is required to overcome the existing limitations.

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