A Comprehensive Survey on Cloud Simulation Tools available for Cloud Computing Environment

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Abstract

*Cloud computing is an emerging parallel and distributed service-oriented computing model that offers various types of services to the user, such as software as a service(SaaS), platform as a service(PaaS) and infrastructure as a service(IaaS) through computing resource virtualization. The development of real cloud for commercial use is quite expensive. Various kinds of cloud simulation tools are available for cloud computing environment. The main problem for researchers is to choose the correct simulator for their cloud research as there are cloud simulators for specific. Therefore, this paper aims to support researchers to choose cloud simulators for using cloud simulators and to do for modeling and simulation cloud computing data centers. This paper reviews and discusses the comparative analysis of **16** cloud simulators available for cloud environment based on **10** evaluation criteria which enables new researchers to choose a suitable cloud simulator.*

Keywords – Cloud computing, Cloud simulators, CloudSim, Comparative analysis

1. Introduction

A cloud is a combination of infrastructure, software, and services that are not local to a user. There are different resources like Virtual Machine, CPU, Resource, Memory, Hard disk space of server machines located in datacenter in cloud computing environment. For analyzing the resource allocation in cloud computing environment which is scalable to servers then we will require Cloud simulation and modeling tool which will take create the cloud as per requirement. Therefore, it eliminates the need for maintaining expensive computing facilities. The characteristics of cloud computing are: on-demand access, scalability, elasticity, cost reduction, minimum management effort, and device/location independence. As the adoption and deployment of cloud computing increase, it is critical to evaluate the performance of cloud environments. Modeling and simulation technologies are suitable for evaluating performance and security issues. Testing for cloud-based software systems are needed techniques and tools with infrastructure-based quality concerns of clouds. These tools can be built on the cloud platform to take advantage of virtualized platforms and services as well as substantial resources and parallelized execution.

2. Background

[24] reviews, analyses and compare features of the existing cloud computing modeling and simulation tools. It has projected numerous cloud simulation tools. It has also shown their properties with respect to their TCP/IP support, GUI Support, under lying platform and the programming language. Research [19] focuses on investigating the level of accuracy of existing known simulators in the field of cloud computing. A predictive model based on a data set from a realistic data center is delivered as an alternative model of simulators as there is a lack of their sufficient accuracy. This work addresses the problem of investigating the accuracy of different modeling tools by developing and validating a procedure based on the performance of a target micro data centre.

An extensive study on the various available Cloud simulators has been made. The list of Cloud simulators that included in this paper are:

CloudSim, CloudAnalyst, Green-Cloud, iCanCloud, Network CloudSim, GroudSim, SmartSim, MDCSim, DCSim, CloudSimSDN, Dynamic CloudSim, PICS, EMUSIM, SimIC, SPECI and TeachCloud.

3. Why Cloud Simulation Tools are required?

The real deployment of cloud is very expensive. Research scholars need to test their algorithms in a cloud environment. Using of simulation tools is considered a better option in spite of being on the real. Therefore, it is needed to choose the appropriate simulator depending on the user requirement. Benefits provided by simulators over establishing a physical cloud are as follows:

- **Minimal Cost:** Purchasing software costs less when compared to purchasing hardware and proprietary software (operating systems, hypervisor, etc).
- **Repeatable and Controllable:** The experimental is set up (simulation) as many times until the desired output is got.
- **Environment:** A simulator provides an environment for the evaluation of various scenarios under different workloads.

4. Cloud Simulation Tools

Some of the published and available today clouds simulators for evaluating cloud computing systems performance are described briefly in this section.

4.1. CloudSim

CloudSim [21] is a famous simulator for cloud parameters developed in the CLOUDS Laboratory, at the University of Melbourne. It is an event driven simulator built up on grid simulator GridSim [9]. CloudSim is written in Java. It modules are easy to extend. This simulation tool used in large data centers. One unique feature of CloudSim is the federated policy, which is rarely available in any other simulators. It supports both system and behavior modeling of cloud system components [22].

4.2. CloudAnayst

Cloud Analyst is the most popular visualized type of simulators. This tool was derived from CloudSim and extends some of its capabilities proposed in [4, 5]. It can be used easily and produces output in graphical format. This tool has a very attractive GUI interface.

4.3. Network CloudSim

It is an extension of CloudSim as a simulation framework that supports generalized applications such as high performance computing applications, workflows, and e-commerce besides real cloud data centers modeling proposed in [17]. It provides an extension to CloudSim by implementing network layer.

4.4. GreenCloud

GreenCloud is a complex open source distributed computing test system. It is a sophisticated packet-level simulator for energy-aware cloud computing data. It is quite different from CloudSim. It offers a detailed fine-grained modeling of the energy consumed by the data center IT equipment [3]. GreenCloud can be used to develop novel solutions in monitoring, resource allocation, workload scheduling as well as optimization of communication protocols and network infrastructures. One of the drawbacks is that it takes minutes for simulation. Also, it requires the user to learn both C++ and Octal programming language.

4.5. iCanCloud

This simulator does not require any modifications when there is requirement to test cloud in different architectures. It is based on SIMCAN. It concentrates on policies which charge users as pay-per-use model [19]. It has full GUI which facilitates simple design and execution of experiments. It also supports in

parallel experiment execution over several machines.

4.6. GroundSim

GroudSim is an event based simulator that needs one simulation thread for scientific applications on grid and cloud environments based on a scalable simulation independent discrete-event core [10]. It is an event driven simulator used for grid and cloud servers. It can also be extended for PaaS or SaaS services of cloud. It provides set of features to handle complex simulation scenarios like background load on resources, cost calculation, task execution on leased computing resources.

4.7. SmartSim

SmartSim [15] is uniquely built for simulating applications and the first ever simulator for mobile cloud computing. Its main feature is to model mobile cloud application running in mobile devices. It supports both the system and behavior modeling of Smart Mobile Device (SMD) components such as application processor, memory, resources provision, etc. and computational intensive mobile application modeling for SMD.

4.8. MDCSim

It is used to analyze and predict the hardware related issues of the servers and data centers. It can simulate hardware characteristics of various components available in a data center and helps to estimate the power consumption. The data center topology is represented as directed graph [8] by the network package of MDCSim.

4.9. DCSim

It is Data Center Simulator, offering IaaS service of cloud and used to develop datacenter management techniques. It can model dependencies between VMs which belongs to multi-tiered application [13]. It can also simulate replicated VMs sharing incoming workload and easily measure the SLA achievement.

4.10. CloudsimSDN

CloudSimSDN [14] based on CloudSim is a lightweight and scalable simulation environment to analyze the network allocation capacity policies like measuring the network performance and host capacity allocation approaches simultaneously within a data center.

4.11. Dynamic CloudSim

DynamicCloudSim [11] is an extension of CloudSim which is able to simulate instability caused due to heterogeneous nature of cloud computing, dynamic changes due to several factors at runtime and failures during task execution. Its drawbacks are it considers only one task at a time and data locality issues have not been addressed.

4.12. PiCS

PICS (Public IaaS Cloud Simulator) is a simulator designed from cloud user perspective to evaluate the cost and performance of public IaaS cloud along dimensions like VM, storage service, resource elasticity, job scheduling and diverse workload patterns [20]. Drawbacks of PICS are there is no support for heterogeneous cloud deployment feature and for the communication costs model.

4.13. EMSIM

It is an integrated architecture to anticipate service's behavior on cloud platforms to a higher standard [23]. It combines emulation and simulation to extract information automatically from the application behavior via emulation and uses this information to generate the corresponding simulation model.

4.14. SimIC

SimIC is a discrete event simulator built up on the SimJava Package [12]. It aims of

achieving interoperability, flexibility and service elasticity while at the same time introducing the heterogeneity of multiple cloud configurations. This tool uses Inter-Cloud Meta Scheduling (ICMS) algorithm for inter-cloud scheduling which depends on several distributed parameters.

4.15. SPECI

SPECI is Simulation Program for Elastic Cloud Infrastructure. It enables exploration of scaling properties of large data centers. The aim is to simulate the performance and behavior of data centers, given the size and middleware design policy as input [25].

4.16. TeachCloud

TeachCloud is specially made for education purposes. It provides a simple graphical interface through which students and scholars can modify a cloud's configuration and perform simple experiments [2]. This tool fills a large gap in teaching cloud computing caused by the lack of such a comprehensive and easy-to-use tool, in addition to the high-risks and costs of allowing students to experiment using a real cloud system.

5. Evaluation Criteria

This section describes several attributes based on the comparative analysis of the cloud simulation tools. The criteria for comparison are chosen based on the previous work of several researchers [1][18][7][24] and are as follows:

Underlying Platform: All the features of the base platform/framework are incorporated in to the new simulation application.

Availability: This parameter specifies whether the simulator is commercial or free to download and use as in open source.

Programming Language: It is important to know in which programming language a simulator has been developed to modify the underlying framework or features of the simulator.

Cost Modeling: This attribute informs us whether the simulator contains a module to model costs or includes our own policy to determine the price of the service usage or not.

Graphical User Interface (GUI): This attribute tells us whether a simulator provides a GUI or not to perform their simulations in a simple and efficient way.

Communication Model: This attribute tells us whether the simulator supports communication module or not.

Simulation Time: This attribute tells us how long a simulator takes to perform the simulation and present the required results.

Energy Modeling: This attribute tells us whether the simulator allows researchers to model the energy or not.

Federation Policy: This attribute tells us whether a simulator allows researchers to model federated cloud applications or not.

6. Comparisons of Cloud Simulators

Various cloud simulators were presented in the previous section; their features and drawbacks have been presented briefly. Main problem for researchers is to choose the correct simulator for their cloud research as there are cloud simulators for specific purpose like SimIC for inter-cloud, SmartSim for mobile cloud computing etc. In this section, the comparisons of different cloud simulators are presented as Table 1 based on the evaluation criteria discussed in the previous section.

Table 1. Comparisons of various Cloud Simulation Tools

Simulator	Underlying Platform	Available	Language	Cost	GUI	Communication Model	Simulation Time	Energy Model	Federation Policy	Cloud Service
CloudSim	SimJava	Open Source	Java	Yes	No	Limited	Second	Yes	Yes	Large data centers
CloudAnalyst	CloudSim	Open Source	Java	Yes	Yes	Limited	Second	Yes	Yes	Large scaled Internet application
NetworkCloudSim	CloudSim	Open Source	Java	Yes	No	Full	Second	Yes	Yes	High performance computing applications
GreenCloud	NS-2	Open Source	C++, octal	No	Limited	Full	Minute	Yes	No	Energy-aware cloud

iCanCloud	SIMCAN	Open Source	C++	Yes	Yes	Full	Second	No	No	Framework for huge storage networks
GroudSim	-	Open Source	Java	No	No	Limited	Second	No	No	Scientific applications
SmartSim	CloudSim	Open Source	Java	Yes	No	Limited	Second	Yes	Yes	Mobile cloud computing
MDCSim	CSIM	Commercial	Java/C++	No	No	Limited	Second	Rough	No	Data center power consumption
DCSim	-	Open Source	Java	Yes	No	No	Minute	No	No	IaaS service of cloud
CloudSimSDN	CloudSim	Open Source	Java	Yes	Yes	Full	Second	Yes	Yes	Network allocation capacity policies
Dynamic CloudSim	CloudSim	Open Source	Java	Yes	No	Limited	Second	Yes	Yes	Heterogeneous nature of cloud computing
PICS	-	Open Source	Python	Yes	No	No	Second	No	No	Public IaaS Cloud Simulator
EMUSIM	CloudSim	Open Source	Java	Yes	No	Limited	Second	Yes	No	Integrated architecture on cloud platforms
SPECI	SimKit	Open Source	Java	No	No	Limited	Second	Rough	No	Elastic Cloud Infrastructure
SimIC	SimJava	Open Source	Java	Yes	No	Limited	Second	Rough	Yes	Inter-cloud scheduling
TeachCloud	CloudSim	Open Source	Java	Yes	Yes	Full	Second	Yes	Yes	Education purposes

7. Analysis of various Cloud Simulation Tools

This section presents the details of comparative evaluation of different cloud simulators based on the evaluation criteria. The main results along with explanations are given below. From Table.1, it is observed that some of the simulators have been extended from CloudSim. Most of them are open source and are available for free download.

It is observed that the base programming language used for most of the simulators (87%) was Java. C++ is the second predominant base programming language. A few simulators were developed by Python. 87% of the simulators allow cost modeling. Only 25% of the simulators provide full to limited GUI for researches. Availability of GUI attracts more number of researchers to use the simulator.

Around 87% of the simulators perform the simulation in seconds. The only simulators that do the simulation in minutes are GreenCloud and DCSim. 87% of the simulators support modeling communications in a data center, 56% of the simulators support energy modeling and only 50% of the simulators provide federated cloud support.

Finally, it is worth to mention about some of the special purpose cloud simulators. EMUSIM is the only simulator which allows researchers to evaluate the performance of cloud applications on real hardware. EMUSIM and PICS are the only simulators that allow researchers to evaluate the performance of cloud application from cloud user perspective. SmartSim is the only cloud simulator that supports Mobile Cloud Computing (MCC). CloudSimSDN is the only simulator that allows research on cloud architectures with support for SDN (Software Defined Networking). Cloud Analyst is the most popular visual simulation tool available to handle datacenter in an efficient manner. Network CloudSim extends the CloudSim tool by including network communication features in it. MDCSim analyzes the hardware related issues involved in any type of resource in cloud environment. SPECI simulation tools analyze the increasing power of the datacenters. GroudSim provides the IaaS service of the cloud in simulation tool and may also be used to provide PaaS and SaaS services of the clouds. iCanCloud does not require any modifications when any change in the architecture of cloud occurs.

8. Conclusion

Cloud computing is growing at a faster rate. Also, it's faced with so many challenges to its infancy. Order to carry out a fundamental research in cloud computing, cloud simulators are considered to be a better option than real deployment of cloud. A survey of various cloud simulation tools is presented in this paper, also done a comparison of the basic of some

evaluation criteria and comprehensive analysis of various simulators. In this paper, many cloud simulation tools have been discussed. We can't say, some tool is better than another because every tool has some pros and cons over the other. So, it depends upon the requirements of users according to which he/she will choose the appropriate one. Although there are a lot of other cloud simulation tools, these 16 simulation tools are compared in this paper because most of them are based on CloudSim and esay to simulate for cloud. As a general purpose CloudSim simulator is recommended based on its features and popularity in the research community. Availability of GUI attracts a number of researchers to use the simulator. At least the most popular simulator CloudSim should have a GUI.

References

[1] A. Ahmed and A. S. Sabyasachi, "Cloud computing simulators: A detailed survey and future direction," Souvenir 2014 IEEE Int. Adv. Comput. Conf. IACC 2014, pp. 866–872, 2014.

[2] A. Bashar, "Modeling and Simulation Frameworks for Cloud Computing Environment: A Critical Evaluation," Int. Conf. Cloud Comput. Serv. Sci., pp. 1–6, 2014.

[3] A. Nunez, J. L. Vazquez-Poletti, A. C. Caminero, G. G. Castane, J. Carretero, I. M. Llorente, "iCanCloud: a flexible and scalable cloud infrastructure simulator", Journal of Grid Computing 10:1, 2012, pp. 185–209.

[4] B. Wickremasinghe, "CloudAnalyst: a cloudSim-based tool for modeling and analysis of large scale cloud computing environments".

[5] B. Wickremasinghe and R. N. Calheiros, "CloudAnalyst: a cloudSIm-based visual modeler", International Conference on Advanced Information Networking and Application, pp.446-452, 20

[6] D. Alshammari, "Evaluation of Cloud Computing Modelling Tools: Simulators and Predictive Models", Ph.D Thesis, December 2018.

[7] D. Puthal, B. P. S. Sahoo, S. Mishra, and S. Swain, "Cloud Computing Features, Issues, and Challenges: A Big Picture," 2015 Int. Conf. Comput. Intell. Networks, no. Cine, pp. 116–123, 2015.

[8] G. Keller, M. Tighe, H. Lutfiyya and M. Bauer, "DCSim: A Data Centre Simulation Tool", 2013 IFIP/IEEE International Symposium on Integrated Network Management (IM2013).

[9] GridSim - http://www.buyya.com/gridsim/ (last accessed on Nov, 2015)

[10] http://greencloud.gforge.uni.lu/

[11] I. K. Kim, W. Wang, and M. Humphrey, "PICS : A Public IaaS Cloud Simulator," 2015.

[12] I. Sriram, "SPECI, a simulation tool exploring cloud-scale data centres", CloudCom 2009, LNCS 5931, pp. 381-392, Springer-Verlag Berlin Heidelberg 2009

[13] J. Son, A. V. Dastjerdi, R. N. Calheiros, X. Ji, Y. Yoon, and R. Buyya, "CloudSimSDN : Modeling and Simulation of Software-Defined Cloud Data Centers."

[14] M. Bux and U. Leser, "DynamicCloudSim: Simulating heterogeneity in computational clouds," Futur. Gener. Comput. Syst., vol. 46, pp. 85–99, 2015.

[15] M. Shiraz, A. Gani, R. H. Khokhar, and E. Ahmed, "SmartSim: An extendable simulation framework for modeling application processing potentials of smart mobile devices for mobile cloud computing," Proc. - 10th Int. Conf. Front. Inf. Technol. FIT 2012, pp. 331–336, 2012.

[16] P. Kumar and G. Kaur , "Study of Comparison of Various Cloud Computing Simulators", IITT College of Engineering & Technology, 2nd National Conference in Intelligent Computing & Communication, GCET Greater Noida, India

[17] R. Buyya, R. Ranjan, and R. N. Calheiros, "Modeling and simulation of scalable cloud computing environments and the CloudSim toolkit: challenges and opportunities," The International Conference on Hign Performance Computing and Simulation, pp.1-11, 2009. http://arxiv.org/pdf/ 0907. 4878.pdf

[18] R. Kaur and N. S. Ghumman, "A Survey and Comparison of Various Cloud Simulators Available

for Cloud Environment," Ijarcce, vol. 4, no. 5, pp. 605–608, 2015.
[19] R. Malhotra, P. Jain, "Study and Comparison of Various Cloud Simulators Available in the Cloud Computing", IJARCSSE, ISSN: 2277 128X, Volume 3, Issue 9, September 2013, pp. 347-350
[20] R. N. Calheiros, M. A. S. Netto, C. A. F. De Rose, R. Buyya, "EMUSIM: An Integrated Emulation and Simulation Environment for Modeling, Evaluation, and Validation of Performance of Cloud Computing Applications", Wiley InterScienceonline (www.interscience.wiley.com), 2012, 7.
[21] R. N. Calheiros, R. Ranjan, A. Beloglazov, C. A. F. De Rose, R. Buyya, "CloudSim: A Toolkit for Modeling and Simulation of Cloud Computing Environments and Evaluation of Resource Provisioning Algorithms", Wiley Press, New York, USA, January, 2011, pp. 23-50.
[22] R. Shaikh, M. Sasikumar, "Cloud Simulation Tools: A Comprehensive Analysis, International conference on Green Computing and Technology", 2013.
[23] S. Sotiriadis, N. Bessis, N. Antonopoulos, and A. Anjum, "SimIC: Designing a new Inter-Cloud Simulation platform for integrating large-scale resource management," Proc. 2013 IEEE 27th Int. Conf. Adv. Inf. Netw. Appl., pp. 90–97, 2013.
[24] U. Sinha1, M. Shekhar, "Comparison of Various Cloud Simulation tools available in Cloud Computing", International Journal of Advanced Research in Computer and Communication Engineering, Vol. 4, Issue 3, March 2015, DOI 10.17148/IJARCCE.2015.4342171.
[25] Y. Jararweh, Z. Alshara, M. Jarrah, M. Kharbutli, M. N. Alsaleh, "TeachCloud: A Cloud Computing Educational Toolkit", 2012, The 1st International IBM Cloud Academy Conference, April, North Carolina, USA, 2012