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Study and Comparison of Various Cloud Simulators Available in the Cloud Computing

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Abstract- Cloud computing is a hot topic all over the world nowadays, through which customers can access information and computer power via a web browser. As the adoption and deployment of cloud computing increase, it is critical to evaluate the performance of cloud environments. Currently, modeling and simulation technology has become a useful and powerful tool in cloud computing research community to deal with these issues. Cloud simulators are required for cloud system testing to decrease the complexity and separate quality concerns. Several cloud simulators have been specifically developed for performance analysis of cloud computing environments including CloudSim, SPECI, CDOSIM and DCSim. In this paper, to the best of our knowledge, we review the existing cloud computing simulators. Furthermore, we indicate that there exist two types of cloud computing simulators, that is, simulators just based on software and simulators based on both software and hardware. Finally, we analyze and compare features of the existing cloud computing simulators.

Keywords-Cloud Computing; Cloud Simulators; CloudSim; CDOSim; TeachCloud; iCanCloud; SPECI; GroudSim; DCSim

I. INTRODUCTION

Cloud computing is a model for enabling convenient and on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal service provider interaction [1]. Cloud computing can be viewed from two different perspectives: cloud application and cloud infrastructure as the building block for the cloud application. Now a days, most organizations focuses on adopting cloud computing model so that they can cut capital expenditure, efforts and control operating costs. These reasons trigger aggressive growth for cloud adoption in business [2]. Some of the traditional Cloud-based application services include social networking, web hosting, content delivery and real time instrumented data processing, which has different composition, configuration, and deployment requirements. Quantifying the performance of scheduling and allocation policies in a real Cloud computing environment for different application models is extremely challenging. The use of real infrastructures for benchmarking the application performance under variable conditions is often constrained by the rigidity of the infrastructure. Thus, it is not possible to perform benchmarking experiments in repeatable, dependable, and scalable environments using real world Cloud environments [2, 3]. A more viable alternative is the use of cloud simulation tools. Cloud simulators are required for cloud system testing to decrease the complexity and separate quality concerns. They enable performance analysts to analyze system behavior by focusing on quality issues of specific component under different scenarios. These tools open up the possibility of evaluating the hypothesis in a controlled environment where one can easily reproduce results. Simulation-based approaches offer significant benefits to IT companies by allowing them to test their services in repeatable and controllable environment and experiment with different workload mix and resource performance scenarios on simulated infrastructures for developing and testing adaptive application provisioning techniques [3]. None of the current distributed system simulators offer the environment that can be directly used for modeling Cloud computing environments But CloudSim which is generalized and extensible simulation framework that allows seamless modeling, simulation, and experimentation of emerging Cloud computing infrastructures and application services. This paper first gives background about various Simulators available. Section 3 define and explores various Cloud simulators such as CloudSim, CDOSIM, TeachCloud, icancloud, SPECI and DCSIM. In the section 4, it compares all Cloud Simulators with respect to networking, platform and language.

II. BACKGROUND

There have been many studies using simulation techniques to investigate behavior of large scale distributed systems and tools to support such research. Some of these simulators are GridSim [4], MicroGrid, GangSim, OptorSim, SimGrid [4] and CloudSim [5]. While the first three focuses on Grid computing systems. CloudSim is the only simulation framework for studying Cloud computing systems. However, grid simulators have been used to evaluate costs of executing distributed applications in Cloud infrastructures. GridSim is a java based event driven simulation toolkit and was developed to address the problem of performance evaluation of real large scaled distributed environments and heterogeneous Grid systems in a repeatable and controlled manner. CloudSim enables seamless modeling, simulation and experimenting on Cloud computing infrastructures. It is a self-contained platform that can be used to model data centers,

service brokers, and scheduling and allocation policies of large scale Cloud platforms. CloudSim framework is built on top of GridSim toolkit. SimGrid is a generic framework for simulation of distributed applications in Grid platforms. GangSim is a Grid simulation toolkit that provides support for modeling of Grid-based virtual organizations and resources. In particular, there is no support in existing Grid simulation toolkits for modeling of on-demand virtualization enabled resource and application management. Further, Cloud infrastructure modeling and simulation toolkits must provide support for economic entities such as Cloud brokers and Cloud exchange for enabling real-time trading of services. Among the currently available simulators discussed, only GridSim offers support for economic-driven resource management and application scheduling simulation.

III. CLOUD SIMULATORS

While grid computing simulators have good but they cannot sufficiently model the cloud infrastructure. There are still only a few options for simulating cloud architecture, possibly because virtualization has enabled the deployment of virtual private clouds on small scale physical test beds. However, there have been some notable proposals for software simulation of clouds of very large scale. The CloudSim simulation framework is based on the SimJava discrete event simulation engine at the lowest layer, while the higher layers implement the GridSim toolkit for the modeling of the cluster, including networks, traffic profiles, resources, etc. CloudSim effectively extends the GridSim core functionalities by modeling storage, application services, resource provisioning between virtual machines, and data centre brokerage, and can even simulate federated clouds [14, 15].

A. *CloudSim*

CloudSim is a new, generalized and extensible simulation toolkit and application which enables seamless modeling, simulation, and experimentation of emerging cloud computing system, infrastructures and application environments for single and internetworked clouds [2, 5, 6]. The existing distributed system simulators were not applicable to the cloud computing environment due to evaluating the performance of cloud provisioning policies, services, application workload, models and resources under varying system, user configurations and requirements [1]. To overcome this challenge, CloudSim can be used. In simple words, CloudSim is a development toolkit for simulation of Cloud scenarios. CloudSim is not a framework as it does not provide a ready to use environment for execution of a complete scenario with a specific input. Instead, users of CloudSim have to develop the Cloud scenario it wishes to evaluate, define the required output, and provide the input parameters.

CloudSim is invented as CloudBus Project at the University of Melbourne, Australia and supports system and behavior modeling of cloud system components such as data centers, virtual machines (VMs) and resource provisioning policies. It implements generic application provisioning techniques that can be extended with ease and limited efforts. CloudSim helps the researchers to focus on specific system design issues without getting concerned about the low level details related to cloud-based infrastructures and services [7]. CloudSim is an open source web application that launches preconfigured machines designed to run common open source robotic tools, robotics simulator Gazebo. SimJava is a toolkit for building working models of complex systems. It is based around a discrete event simulation kernel at the lowest level of CloudSim. It includes facilities for representing simulation objects as animated icons on screen [7,8].

B. *CDOSim*

CDOSim is a cloud deployment option (CDO) Simulator which can simulate the response times, SLA violations and costs of a CDO. A CDO is a decisions concerning simulator which takes decision about the selection of a cloud provider, specific runtime adaptation strategies, components deployment of virtual machine and its instances configuration. Component deployment to virtual machine instances includes the possibility of forming new components of already existing components. Virtual machine instance's configuration, refer to the instance type of virtual machine instances. CDOSim can simulate cloud deployments of software systems that were reverse engineered to KDM models. CDOSim has ability to represent the user's rather than the provider's perspective. CDOSim is a simulator that allows the integration of fine-grained models. CDOSim is best example for comparing runtime reconfiguration plans or for determining the trade-off between costs and performance [16]. CDOSim is designed to address the major shortcomings of other existing cloud simulators such as

1. Consequently oriented towards the cloud user perspective instead of exposing fine-grained internals of a cloud platform.
2. Mitigates the cloud user's lack of knowledge and control concerning a cloud platform structure.
3. Simulation is independent of concrete programming languages in the case appropriate KDM extractors exist for a particular language.
4. Workload profiles from production monitoring data can be used to replay actual user behavior for simulating CDOs.

C. *TeachCloud*

TeachCloud is a cloud simulator which is specially made for education purposes. TeachCloud provides a simple graphical interface through which students and scholars can modify a cloud's configuration and perform simple experiments [17]. TeachCloud uses CloudSim as the basic design platform and introduces many new enhancements on top of it such as

1. Developing a GUI toolkit.
2. Adding the cloud workload generator to the CloudSim simulator.
3. Adding new modules related to SLA and BPM.
4. Adding new cloud network models such as VL2, BCube, Portland and DCell.

5. Introducing a monitoring outlet for most of the cloud system components.
6. Adding an action module that enables students to reconfigure the cloud system and study the impact of such changes on the total system performance.

D. *iCanCloud*

iCanCloud is a cloud simulator which is based on SIMCAN. In simple words, iCanCloud is a software simulation framework for large storage networks. iCanCloud can predict the trade-off between costs and performance of a particular application in a specific hardware in order to inform the users about the costs involved. It focuses on policies which charge users in a pay-as-you-go manner [18]. iCanCloud has a full graphical user interface from which experiments can be designed and run, but existing software systems can only be modeled manually. It also allows parallel execution of one experiment over several machines[19].

E. *SPECI*

Simulation Program for Elastic Cloud Infrastructures (SPECI) is a simulation tool which allows analyzing and exploration of scaling properties of large data center behavior under the size and design policy of the middleware as inputs. SPECI is a simulation tool which allows exploration of aspects of scaling as well as performance properties of future Data Centers. The aim of SPECI is to simulate the performance and behavior of data centers, given the size and middleware design policy as input. Discrete event simulations (DES) are a type of simulation where events are ordered in time maintained in a queue of events by the simulator and each processed at given simulation time [8, 9]. SPECI uses an existing package for DES in Java. SPECI is intended to give us insights into the expected performance of DCs when they are designed, and before they are built. The size of data centers that provide cloud computing services is increasing, and some middleware properties that manage these data centers will not scale linearly with the number of components. SPECI is composed of two packages: data center layout and topology, and the components for experiment execution and measuring. The experiment part of the simulator builds upon SimKit, which offers event scheduling as well as random distribution drawing [9, 10, 12].

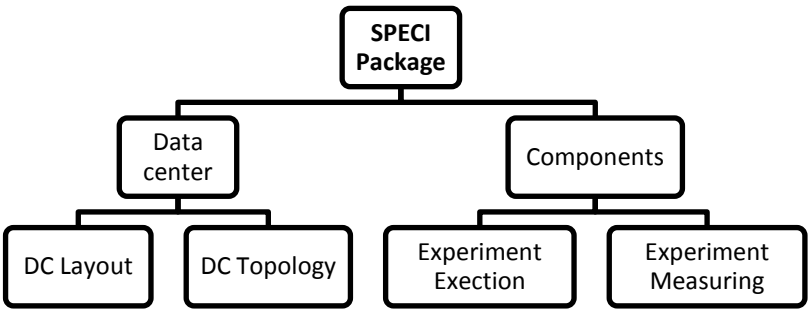

Figure 1: SPECI Package

F. *GroudSim*

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. It is mainly concentrated on the IaaS, but it is easily extendable to support additional models such as PaaS, DaaS and TaaS. The user to simulate their experiments from the same environment used for real applications by integrating GroudSim into the ASKALON environment [11]. GroudSim provides a comprehensive set of features for complex simulation scenarios such as simple job executions on leased computing resources, calculation of costs, and background load on resources. Simulations can be parameterized and are easily extendable by probability distribution packages for failures which normally occur in complex environments. Experimental results demonstrate the improved scalability of GroudSim compared to a related process-based approach [13].

G. *DCSim*

DataCenter Simulator is concentrated on virtualized data center which offers IaaS to Multiple tenants, in order to achieve a simulator to evaluate and develop data center management techniques. Data centers are becoming increasingly popular for the provisioning of computing resources. The cost and operational expenses of data centers have skyrocketed with the increase in computing capacity.

IV. COMPARISON OF VARIOUS VARIANTS OF CLOUDSIM

The number of simulation environments for cloud computing data centers available for public use is limited. The CloudSim simulator is probably the most sophisticated among the simulators overviewed. It is evolved as a built up on top of the grid network simulator GridSim developed at the University of Melbourne. The DCSim simulator is a relatively fresh data center simulator developed at the Pennsylvania State University in 2009. It is supplied with specific hardware characteristics of data server components such as servers, communication links and switches from different vendors and allows estimation of power consumption. Comparing cloud computing simulators via comparison of their characteristics such as platform, language, networking, Simulator type and availability but Most of these simulators are software based and are developed using Java. CloudSim is event-based simulators which avoid building and processing small simulation objects individually released under open source GPL license. Such a method reduces simulation time considerably, improves scalability, but lacks in the simulation accuracy. Summarizing, short simulation times are provided by CloudSim even for very large data centers due to their event-based nature.

V. CONCLUSION

Cloud computing has been one of the fastest growing parts in IT industry. Simulation based approaches become popular in industry and academia to evaluate cloud computing systems, application behaviors and their security. Several simulators have been specifically developed for performance analysis of cloud computing environments including CloudSim, SPECI, GroudSim and DCSim but the number of simulation environments for cloud computing data centers available for public use is limited. The CloudSim simulator is probably the most sophisticated among the simulators overviewed.

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