CLOUD SIMULATORS: A REVIEW

[1]Rahul Singh, [2]Punyaban Patel, [3]Preeti Singh
Chhatrapati Shivaji Institute of Technology, Durg, India
Email:[1]rahulsingh.academic@gmail.com, [2]punyabanpatel@csitdurg.in,
[3]preetisingh.research@gmail.com

Abstract— Computing as a Utility, the long held aspiration of the IT Industry has now been realized by the advent of Cloud Computing. As the acceptance and use of cloud computing increase, and it becomes more & more commonplace the need to evaluate the performance of cloud environments has become vital. Modeling and simulation are very suitable & economical techniques for evaluating performance and security concerns. Cloud computing simulators are needed for testing of the cloud systems to cutback the complexity and cut apart the quality issues. Various cloud simulators have been developed specifically for the purpose of performance analysis of cloud computing environments. This paper takes a stab at studying & comparing the various options available at present which can be used to simulate the cloud computing environments.

***Index Terms*—Cloud Computing, CloudSim, Review, Simulators.**

I. INTRODUCTION

Cloud computing is first and foremost a concept of distributed resource management and utilization, where resources are nothing but computing power, storage, hardware etc [14]. These computing resources are delivered not as a product, but as a utility on a pay per use basis. NIST (National Institute of Standards and Technology) defines it as 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"[11]. This is the era of cloud computing. Companies are moving their business to clouds and people are using cloud services as it provides many benefits to both the service providers and the clients. Many conventional Cloud-based application services consist of social networking, web hosting, content delivery and real time instrumented data processing. All cloud implementations have 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 [10]. Utilization of actual physical infrastructures for benchmarking the application performance under variable conditions is very complex, difficult to implement and limited by the rigidity of the infrastructure. Therefore, it is not really feasible to perform the benchmarking & testing experiments in reproducible, reliable, and scalable environments using real world Cloud systems. A more viable and attractive option is the use of cloud simulation tools. They enable performance analysts to analyze system behavior by focusing on quality issues of specific component under different scenarios [10]. These tools open up the possibility of evaluating the hypothesis in a controlled environment where one can easily reproduce results. Simulations based on the proposed approaches offer clear cut benefits to the 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.

II. CLOUD SIMULATORS

Simulation is not something new in the world of computers. Simulation software is based on the process of modeling a real phenomenon with a set of mathematical formulas. It is, essentially, a program that allows the user to observe an operation through simulation without actually performing that operation. They have been in use for a long time in several different fields such as Robotics, Networking etc. There are several cloud simulation tools available today. In this section the paper ventures to explore some of the more popular tools available.

A. CloudSim

CloudSim is probably the most famous & popular simulator for cloud environments & parameters. It was developed in the CLOUDS Laboratory, at the Computer Science and Software Engineering Department of the University of Melbourne. The CloudSim library is used for [21]:

- Large scale cloud computing at data centers
- Virtualized server hosts with customizable policies
- 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 VMs
- Support for modeling and simulation of energy-aware computational resources
- Support for modeling and simulation of data centre network topologies and message-passing applications
- Support for modeling and simulation of federated clouds
- Support for dynamic insertion of simulation elements, as well as stopping and resuming simulation
- Support for user-defined policies to allot hosts to VMs, and policies for allotting host resources to VMs

Figure 1 shows the multi-layered design of the CloudSim software framework and its architectural components. The major limitation of CloudSim is the lack of a graphical user interface (GUI). But despite this, CloudSim is still used in universities and the industry for the simulation of cloud-based algorithms.

B. iCanCloud

iCanCloud is a cloud simulator which is based on SIMCAN. In simple words, iCanCloud can be used to simulate large storage networks [12]. In order to inform the users about the costs iCanCloud can predict the trade-off between performance and cost. It focuses on policies which charge users in a pay-as-you-go manner [13]. The existing software systems can only be modeled manually it has a full graphical user interface from which experiments can be designed and run. It also allows parallel execution of one experiment over several machines [13].

C. CDOSim

CDOSim stands for Cloud Deployment Option (CDO) Simulator which simulates the response times, costs and SLA violations of a cloud deployment. It is a simulator concerned with decisions which takes decision about the selections that cloud provider makes, specific runtime adaptation strategies, components deployment of virtual machine and the configuration of its instances. Component deployment to virtual machine instances includes the possibility of creating new components out of pre-existing components. Virtual machine instance's configuration is usually the instance type of virtual machines. 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. CDOSim is designed to address the major shortcomings of other existing cloud simulators such as:

- Consequently oriented towards the cloud user perspective instead of exposing fine-grained internals of a cloud platform.
- Mitigates the cloud user's lack of

knowledge and control concerning a cloud platform structure.

- Simulation is independent of concrete programming languages in the case appropriate KDM extractors exist for a particular language.
- Workload profiles from production monitoring data can be used to replay actual user behavior for simulating CDOs.

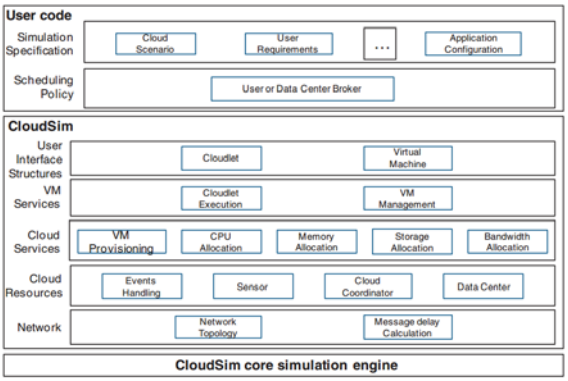

Figure 1: Layered CloudSim Architecture [4]

D. GreenCloud

GreenCloud is a sophisticated packet-level simulator for energy-aware cloud computing data centers with a focus on cloud communications. It offers a detailed fine-grained modeling of the energy consumed by the data center IT equipment, such as computing servers, network switches, and communication links [22]. GreenCloud can be used to develop novel solutions in monitoring, resource allocation, workload scheduling as well as optimization of communication protocols and network infrastructures. It is released under the General Public License Agreement and is an extension of the well-known NS2 network simulator [22]. The Key features of this simulator are:

- Focus on cloud networking and energy awareness
- Simulation of CPU, memory, storage and networking resources
- Independent energy models for each type of resource
- Support of virtualization and VM migration
- Network-aware resource allocation
- Complete TCP/IP implementation
- User friendly GUI
- Open Source

E. TeachCloud

TeachCloud is a cloud simulator which is specifically built for educational purposes. TeachCloud has a simple graphical interface through which students and scholars can modify a cloud's configuration and perform simple experiments [7]. TeachCloud uses CloudSim as the basic design platform and introduces many new enhancements on top of it such as:

- Developing a GUI toolkit.
- Adding the cloud workload generator to the CloudSim simulator.
- Adding new modules related to SLA and BPM.
- Adding new cloud network models such as VL2, BCube, Portland and DCell.
- Introducing a monitoring outlet for most of the cloud system components.
- Adding an action module that enables students to reconfigure the cloud system and study the impact of such
- Changes on the total system performance.

F. Cloud Analyst

CloudAnalyst is a CloudSim based Visual Modeler for Analysing Cloud Computing Environments and Applications. It was developed to simulate large scale Cloud applications with the purpose of studying the behavior of such applications under various deployment configurations. CloudAnalyst helps developers with insights in how to distribute applications among Cloud infrastructures and value added services such as optimization of applications performance and providers incoming with the use of Service Brokers [27]. The development of this simulator has been done using Java, Java Swing, CloudSim & SimJava and the highlighting features are [17]:

- Ease of Use
- Ability to define a simulation with a high degree of configurability and flexibility
- Graphical Output
- Repeatability
- Ease of Extension

The images below show the Design of CloudAnalyst (Figure 2) and Home Screen (Figure 3).

G. SPECI

SPECI, Simulation Program for Elastic Cloud Infrastructures, a simulation tool that enables exploration of scaling properties of large data centers. The aim of SPECI project is to simulate the performance and behavior of data centers, given the size and middleware design policy as input [15]. SPECI is a simulation tool which allows exploration of aspects of scaling as well as performance properties of future Data Centers. 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. SPECI uses an existing package for DES in Java [10]. The experimental portion of the simulator is based on SimKit, which offers the ability to schedule events as well as the functionality of random distribution drawing. It is responsible for analyzing the various scalability and performance aspects of future Data centers. A second version, SPECI 2 has also been introduced with some enhancements. It is a system for predictive simulation modeling of large-scale data-centers, i.e. warehouse-sized facilities containing hundreds of thousands of servers, as used to provide cloud services.

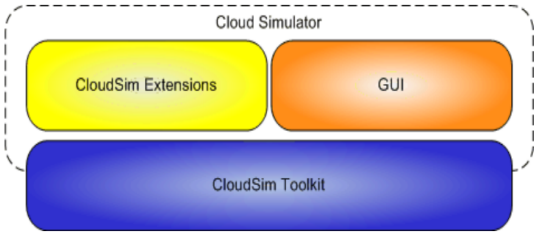

Figure 2: Design of Cloud Analyst [17]

Figure 3: Main Screen of Cloud Analyst [17]

H. DCSim

The Data Centre Simulator (DCSim) basically works on the IaaS layer and offers services to multiple tenants and concentrates on virtualized data centre in order to create a simulation to test and improve data centre management techniques. For the provisioning of computing resources Data centers are becoming increasingly popular. In DCSim [24], [25], a data centre consists of a set of interconnected Hosts (physical machines), governed by a set of Management Policies. Each host has a set of Resource Managers that handle local resource allocation, a CPU Scheduler which decides how VMs will execute, and a Power Model which models how much power is being consumed by the host at any point in time. Each host runs a set of VMs, which in turn each run a single Application. DCSim supports Virtual Machine management operations, such as VM live migration and replication by default. The resource needs of each VM in DCSim are driven dynamically by an Application, which varies the level of resources required by the VM to simulate a real workload. The Application class is abstract and can be extended to implement different types of applications, but the primary application model implemented in DCSim mimics a continuous, transactional workload, such as a web server. Incoming work can be load balanced between multiple application instances running in separate VMs, and multi-tiered applications can also be modeled [24].

I. 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 [10]. 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 [26]. 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 [26].

J. Network Cloud

Network Cloud is an extended version of

CloudSim and is designed with the ability to implement network layer in CloudSim. It takes a BRITE file as input and generates a topological network. The topology files contain the number of nodes along with the various entities involved in simulation. In simulation, each entity is to be mapped to a single BRITE node so that network CloudSim can work efficiently. Network CloudSim is usually used to simulate the behavior of network traffic in CloudSim.

K. VIM Cloud

This is a pure IaaS cloud controller with all the basic functionality of IaaS Cloud Controller. This uses proposed "Trust Based Scheduling Algorithm and Load Balancing Algorithm". It uses Cloud Architecture with Trust Management layer. It uses Qemu machine emulator and virtualizer, as virtualization software at Host. It uses Libvirt driver to interact with Qemu and to interact with its virtualization capabilities of a range of operating systems. Libvirt provides a common, generic and stable layer to securely manage domains on a node. As nodes may be remotely located, libvirt provides all APIs required to provision, create, modify, monitor, control, migrate and stop the domains, within the limits of hypervisor support for these operations. Although multiple nodes may be accessed with libvirt simultaneously, which help in maintain the Host remotely, which is the basic requirement of cloud controller. This library is used by all the web controllers and by tools like VirtualBox

III. CONCLUSION

Cloud Computing is proving to be one of the great advances in the field of information technology. As more & more companies move to cloud & new, more sophisticated algorithms are being developed, making the test runs for the algorithms & cloud deployment structures is becoming a vital part of establishing a cloud. Real world testing usually seems very costly & can prove to be catastrophic for the whole project as the defects in algorithms or structures are found after the deployment. Thus Cloud Simulators provide a very attractive & viable option for the testing of the system structures & algorithms. This paper has explored some of the popular cloud simulation tools such as CloudSim, GreenCloud, CloudAnalyst, iCanCloud, TeachCloud etc. All the simulators are good options for implementing a proposed cloud structure or some scheduling or resource allocation algorithms. Each has its own advantages & disadvantages. Some are based on older simulators and attempt to improve on the predecessors' limitations, while others are made from scratch. Most of the tools are "opensource" and are freely available. It's a delicate & complex task to choose one over others as all have some pros & cons. Thus it depends on the users' requirements & preferences, which simulator to choose.

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