UGANDA TECHNOLOGY AND MANAGEMENT UNIVERSITY

(UTAMU)

FACULTY OF COMPUTING AND ENGINEERING

DEPARTMENT OF COMPUTING

RESEARCH PROPOSAL FOR MASTER'S DEGREES IN COMPUTING (INFORMATION SYSTEM)

2016/2017

UGANDA TECHNOLOGY AND MANAGEMENT UNIVERSITY

Topic

Systematic Evaluation of Cloud Simulators

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SEP15COMP0639X

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A Research Proposal Submitted to Uganda Technology and Management University in Partial Fulfilment for the Award of Master's Degree in Computing Uganda Technology and Management University

September, 2016

DECLARATION

I, the undersigned, declare that to the best of our knowledge, this proposal is my original piece of work, and has never been published and/or submitted for any award in any other University or Higher Institution of Learning.

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APPROVAL

This proposal has been submitted with my approval as supervisors and my signature here appended against my names below:

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Table of Contents

ABSTRACT

Cloud computing is an emerging technology, advancing quickly in ICT due to its flexibility of using computing infrastructure without buying them but by using as pay-per-use model. Cloud computing has become the standard for providing hardware and software infrastructure. Organizations are moving from traditional computing towards cloud computing as it provides a number of advantages like on-demand access, broad network access, rapid elasticity, cost reduction, scalability etc. Evaluating cloud parameters, performances, security, and robustness e.t.c, become difficult for some of these organizations. To simulate and schedule the different applications and services of cloud infrastructure system is a tremendous challenging task which requires different load and energy performance configuration. Simulation technology has become a powerful tool in cloud computing research community to address such issues of cloud computing such performance evaluation, security, cost and so on. Various cloud simulators have been precisely developed for testing and performance analysis of cloud computing environments. We evaluate the performance and appropriative of cloud simulation for the real life cloud environment and user needs.

1 Introduction

1.1 Background

Cloud computing is a technology in which data and different applications are kept on storage networks and servers which are located in a remote place and accessed by the user via internet. According to NIST, cloud computing is a pay per usage, distributed model for enabling on demand network access to a wide variety of resources like hardware, software, network etc., that is provided by the cloud service provider to the customer as per his request [1]. Cloud computing mainly relies on the sharing of resources for achieving coherence and economies of scale like utility computing. The architectural modularity (hardware layer, infrastructure layer, platform layer, and application layer) allows cloud computing to support a wide range of application requirements while reducing management overhead. The essential characteristics of cloud are; on-demand self-service, broad network access, Resource pooling, rapid elasticity, and measured service. Cloud computing has three main service model; Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). While the cloud deployment models are; Private cloud, Public cloud, Community cloud, and Hybrid cloud. People, today, are shifting from traditional computing towards cloud as it provides higher reliability, fault tolerance, broad network access, on demand usage etc. But Cloud applications execution may not show regular rules in cloud computing environment which is different from HPC (High Performance Computing) and grid applications. Grid/HPC applications are mostly computation intensive which requires heavy workload on computation than other type resources [3]. Cloud suffers from some serious issues as well, the most challenging is security and privacy been someone different handling data, another issue is monetary cost involved in using cloud resources and also cost involved in making sure that internet is always available, as cloud computing is purely an internet based technology [2]. For many reasons, there is need to have some costly less solution, more effective and appropriate tools, and thus we have an option of using simulation tools in the cloud, with cloud simulation tools, performance analysts can analyze the system behavior by concentrating on specific components quality under different scenarios. However, simulation tools, like other modeling approaches may not address all the characteristics of the cloud leading to unsteady condition.

1.2 Problem Statement

Due to technological advancement, the adoption and deployment of cloud computing increases, users are moving toward cloud computing from traditional computing due. But it become hard for them to make a suitable choice among cloud computing services and cloud deployment models and to avoid unnecessary expenditure. Also researchers have challenges in evaluating cloud performances because they use tools that may misrepresent some aspects of the cloud leading to the simulated implemented seeing different from the actual cloud performance.

1.3 Justification

It is essential to study, evaluate and analyses the performance and other related problems that might be encountered in cloud computing, because:

1. A cloud is a product of research having that correct project of the cloud strengthen knowledge generation of the cloud.
2. Increase use of cloud efficient use is paramount important.
3. Researcher and cloud users should a clear knowledge about the cloud. The solution to these problems is trying out simulation tools, these tools may include the different algorithms used by different organizations. The use of simulation tools leads to decrease in overall conceptual or operational problems of the cloud to the organization.

1.4 Objectives

General Objective

The main objectives of this dissertation is to provide a suitable road map, which will provide organizations and researchers with important insight of different simulation tools in order to:

1. Provide a comprehensive picture of cloud computing by modelling different cloud computing services and deployment models using different cloud simulation tools to see how all the components fit together and also to provide clear suggestion to the user and to avoid overhauled service delivering model by cloud service providers.

Specific Objective

The specific objectives of the research are:

1. To provide practical framework approaches of cloud computing parameters in cloud systems and how they are represented.
2. To study and compare cloud simulation tools on appropriation to evaluate the cloud QoS parameters.
3. To provide a comprehensive picture of what is happening in cloud computing with some actual example and some rough descriptions of the services currently offers in the market place.

1.5 Scope

This research focused mainly on the cloud end-user, IT organizations and cloud service providers as they have to guarantee security and other potential requirements to the end users. The research will also compare various functionalities cloud simulation tools.

2 Literature Review

2.1 Introduction

Origin of the Cloud

Cloud computing has evolved through a number of phases which include grid and utility computing, application service provision (ASP), and Software as a Service (SaaS). This trend has led to the development of cloud computing, a paradigm that harnesses the massive capacities of data centers to support the delivery of online services in a cost-effective manner. The traditional role of cloud computing providers is divided into Cloud providers and Service providers.

The deployment model tells you where the cloud is located and for what purpose. The cloud deployments models are Public, Private, Community and Hybrid. By leveraging the economies of scale of data centers, cloud computing can provide significant reduction in operational expenditure, it also supports new applications such as big data analytics that process massive volumes of data in a scalable and efficient fashion. The rise of cloud computing has made a profound impact on the development of the IT industry in recent years. Cloud Computing describes about different types of computing concepts that involve a large number of computers connected through a real time communication network such as internet. Cloud computing mainly relies on sharing of resources for achieving coherence and economies scale like utility computing [10].

2.2 Architecture of Cloud Computing

The architectural modularity allows cloud computing to support a wide range of application requirements while reducing management and maintenance overhead. The Cloud Computing Architecture is made up of four layers [27]:

1. **The hardware layer:** This is responsible for managing physical resources of the cloud, such as physical server, routers, switches, power and cooling system. The typical challenges at hardware layer include hardware configuration, fault tolerance, traffic management, power and cooling resource management.
2. **The Infrastructure Layer:** Also known as the virtualization layer, the infrastructure layer creates a pool of storage and computing resources by partitioning the physical resources using virtualization technologies such as Xen [4], KVM [5], and VMware [6]. The infrastructure layer is an essential component of cloud computing, since many key features,

such as dynamic resource assignment, are only made available through virtualization technologies.

3. **The platform layer:** Built on top of the infrastructure layer, the platform layer consists of operating systems and application frameworks. The purpose of the platform layer is to minimize the burden of deploying applications directly into VM containers. For example, Google App Engine operates at the platform layer to provide API support for implementing storage, database, and business logic of typical Web applications [27].
4. **The application layer:** At the highest level of the hierarchy, the application layer consists of the actual cloud applications. Different from traditional applications, cloud applications can leverage the automatic-scaling feature to achieve better performance, availability, and lower operating cost [27].

2.3 Essential Characteristics of Cloud

The cloud through heterogeneous has some cross characteristics as follow [11]:

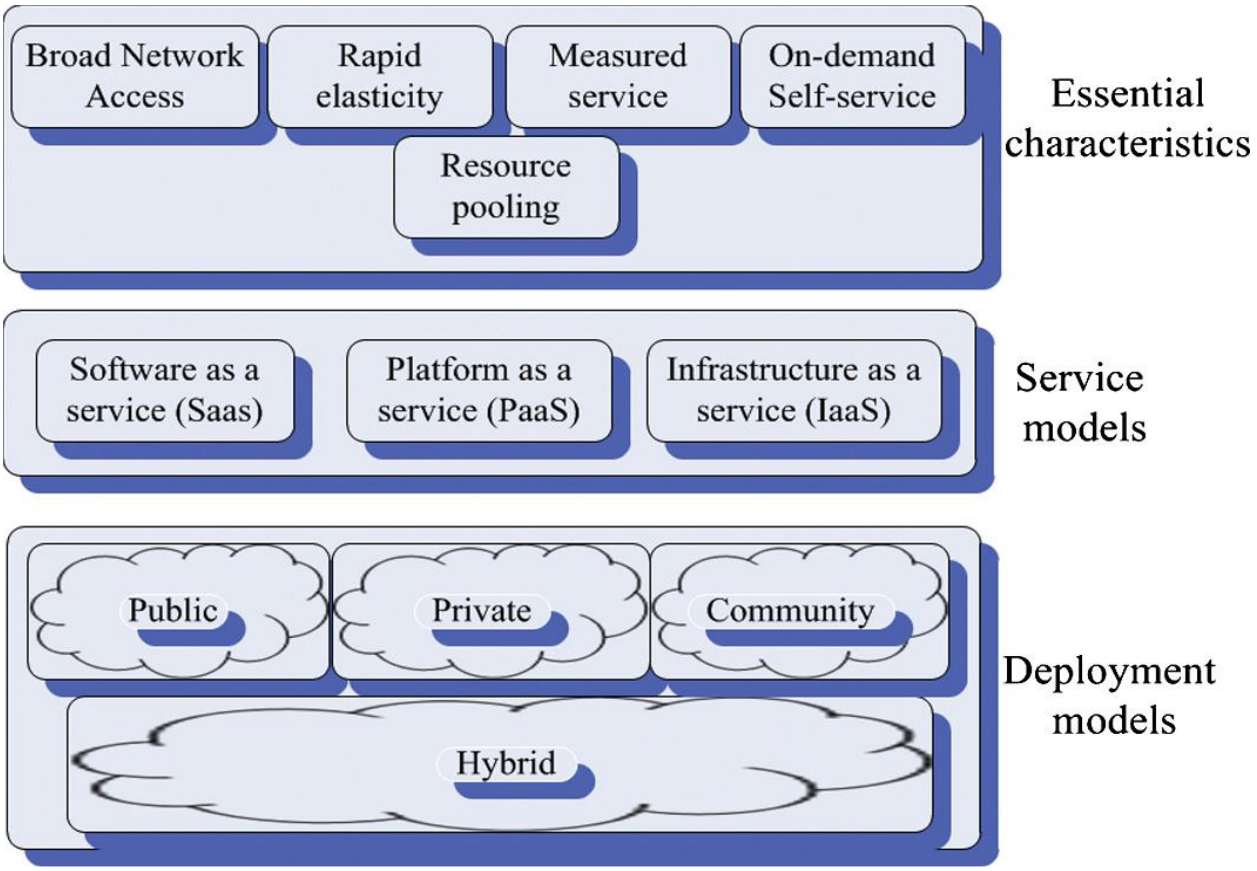
1. **On-demand self-service:** Customers can request and manage the services from the cloud without any human interaction with the CSP. The provision of the services and the associated resources is accomplished as and when required. This is usually done through Web services and management interfaces.
2. **Broad network access:** Capabilities are available over the network and accessed through standard mechanisms. The characteristic further demands that the availability of services should support heterogeneous thin or thick environment (for example, mobile phones, laptops, workstations, tablets). Broad network access is sometimes referred to as ubiquitous network access in the literature.
3. **Resource pooling:** The clouds resources are shared among multiple customers by pooling in a multi-tenant environment. The customers are transparent about the location of the resources. There is a mapping between physical and virtual resources provided to the customers.
4. **Rapid elasticity:** The resources can be rapidly and elastically scaled as per customers' demands. The customer has a view of unlimited resources that can be purchased as needed in a pay-as-you go manner.

5. **Measured service:** The scaling of resources up and down is performed dynamically and the usage of services is metered and reported to the customer and CSP. The metering also helps the optimization of resource usage automatically while the users are charged in a pay-as-you-use manner.

2.4 Cloud Deployment Models

Clouds are deployed in different modes, depending on the usage scopes. There are four primary cloud deployment models as follows [26] [10]:

1. **Private cloud** The cloud that is run and managed only for a single organization is the private cloud. The organization may or may not own the physical infrastructure and can be managed by the organization itself or by a third party. Similarly, private cloud may or may not be located at organizations geographical site.
2. **Public cloud** The clouds physical infrastructure is owned and manage by the CSP and is open to general public and organizations. The resources are shared among all the customers. The customers pay the cloud owner according to the services and resources they use. The physical infrastructure is located off-site to the customers.
3. **Community cloud** The community cloud is shared by a number of organizations and/or customers forming a community. Generally, the community shares common interests, such as the mission, security requirements, policy, and compliance considerations. The community cloud may be managed by any of the organizations in the community or a third party. Similarly, it may be located on premise or off-premise.
4. **Hybrid cloud** The hybrid cloud is the mix of two or more clouds (public, private, or community). All of the participating clouds retain their status of a unique entity, but share standardized or proprietary technology. Diagrammatic representation of cloud computing in general based on NIST is shown in fig 1 [9].



2.5 Advantages of Cloud Computing

Cloud Computing has many advantages, few are listed below [8][28]:

1. **Reduced the costs** As Cloud Computing is paid per use of the service or the length it is easier to keep cost reduced and controlled.
2. **Storage** A point to be considered when moving towards Cloud is storage space. There is the possibility to have more storage space than on the computers because of the storage provided through the Cloud.
3. **Automation of the Cloud solutions** The IT is always up to date and with the latest release, also it is managed by the provider so the IT department can focus on other tasks.
4. **Mobility** It is one of the key aspects to take in consideration when option for a Cloud solution. The employees and other people connected can gain access to data wherever they are and with many different sources like tablets, smart phones and laptops.
5. **Flexibility** The Cloud makes the IT flexible, easy to use, customize, personalize and obtainable through different sources and also makes it easier to work with.

2.6 Challenges of Cloud Computing

Some of the disadvantages of Cloud Computing are listed below [22] [28]

1. **Security and privacy** This is the biggest drawback when talking about Cloud Computing. Users have no option rather than only trust and hope the provider has a good security and privacy policy. Many companies before taking the decision to move to Cloud hesitate because data is handled by an external source.
2. **Cloud control** The involvement of an external source takes away the control from the user. Many CIOs like to have control over their data; naturally the lack of control is an issue for not choosing these services.
3. **Moving data** It is still hard to move big amounts of data through the Clouds. It is a slow operation and may cause trouble with personalize fields and missing information.
4. **Reliability** The provider may not have good reliability and there is a chance for performance issues when something goes wrong.
5. **Connectivity** The Cloud is reliable on the web and there have to be an internet connection for the Cloud service to work, there are already some offline options but to synchronize upload and download the data there is always need internet access [23].
6. **Cost** This is considered as main competitive advantage but also could be considered as a disadvantage. This technology is quite new and therefore can be expensive to implement at first. But the cost is often decreased over time.
7. **Service Level Agreements** (SLAs Cloud SLAs are standardized in order to appeal to the majority of its audience. Custom SLAs that allow for multiple data sources are difficult to obtain or enforce. Cloud SLAs do not generally offer industry standard chargeback rates, and negotiations with large cloud providers can be difficult for small users. Business risks that are not covered by a cloud SLA must be taken into consideration.
8. **Energy Efficiency** The energy consumption and maintenance in cloud computing data centers is dramatically increasing which lead to increases in data centers expenses. Different algorithms has been designed to reduce the energy consumption which also lead to environmental pollution.

2.7 Components of Cloud Computing

The Cloud Computing encompasses of three layers which cover all the computing stack of a system. Each of these layers offer different set services to the end users. These layers are [25]:

Infrastructure as a Service (IaaS)

This consider to be at the lowest layer of the cloud offering which consists of virtual machines or physical machines, storage, and clusters. Cloud infrastructures can also be heterogeneous, integrating clusters, PCs and workstations. Moreover, the system infrastructure can also include database management systems and other storage services. The infrastructure in general is managed by an upper management layer that guarantees runtime environment customization, application isolation, accounting and quality of service. The virtualization tools, such as hypervisors, also sit in this layer to manage the resource pool and to partition physical infrastructure in the form of customized virtual machines. Depending on the end user needs, the virtualized infrastructure is pre-configured with storage and programming environment, what saves time for users who do not need to build their system from scratch. IaaS gives access to physical resources with some software configuration, for designing new applications user requires advanced tools such as Map Reduce etc [25][10].

Platform as a Service (PaaS)

This layer offered Cloud users a development platform to build their applications. Google AppEngine, Aneka, and Microsoft Azure are some of the most prominent example of PaaS Clouds. PaaS includes the lower layer (IaaS) as well that is bundled with the offered service. PaaS offers only the user level middleware, which allows development and deployment of applications on any Cloud infrastructure. As noted by Appistry.com, the essential characteristics that identify a Platform as a Service solution include [12][10]:

1. **Runtime framework** It represents the software stack of the PaaS model. The runtime framework executes end-user code according to the service level policies set by the user and the provider.
2. **Abstraction** PaaS solutions are distinguished by the higher level abstraction that they provide. PaaS focuses on the applications the Cloud must support. PaaS solutions offer a

way to deploy and manage applications on the Cloud rather than a bunch of virtual machines on top of which the IT infrastructure is built and configured.

3. **Cloud Services** PaaS offerings provide developers and architects with services and APIs helping them to simplify delivering of elastically scalable and highly available Cloud applications. These services are the key differentiators among competing PaaS solutions, include specific component for developing applications, advanced services for application monitoring, management, and reporting. The major advantage of PaaS is the cost saving in development, deployment, and management cycle of new applications. The PaaS providers reduces risk in terms of upgrade cost of underlying platforms and allow Cloud users to concentrate on the application development.

Multi-tenancy is another core feature of SaaS compared to traditional packaged software, allowing providers to outsource the effort of managing large hardware infrastructure, maintaining and upgrading applications, and optimizing resources by sharing the costs among the large user base [26].

Software as a Service (SaaS)

This is a software delivery model providing on-demand access to applications. The most common examples of such service are CRM and ERPF applications that are commonly used in almost all the enterprises. SaaS providers also constitute other layers of Cloud computing and thus, maintain the customer data and configure the applications according to customer need. This scenario results in considerable reduction in upfront cost of purchasing new software and infrastructure. The customers do not have to maintain any infrastructure or install anything within their premises. They just require high speed network to get instant access to their applications [10].

Cloud Service Providers (CSP)

These are the owners and operators of cloud computing systems used to render services to the third parties cloud end user, different cloud service providers use different technologies for creating and managing cloud resources, and they also distribute applications across multiple sites, deployment of physical appliances to different locations, some cloud service providers offer users with the option for different availability zones with each having a separate infrastructure.

Most of the cloud service providers store data in an effective encrypted form. Cloud services are responsible for providing general maintenance and upgrade of the system, data security, and cloud computing service pricing and for the majority of CSP often have competency in different cloud deployment models (IaaS, PaaS, SaaS) as well as provide consultancy service to cloud End-users (CEUs) [25].

Cloud Security

The main dimensions of security are availability, confidentiality and integrity. Security is one of the most obstacles for opening up the new era of the long dreamed vision of computing as a utility. Security issues in cloud computing environments can be divided into six sub-categories, which include [23]:

1. How to provide safety mechanisms, so that to monitor or trace the cloud server.
2. How to keep data confidentiality for all the individual and sensitive information.
3. How to avoid service hijacking, where phishing, fraud and exploitation are well known issues in IT,
4. How to management multi-instance in multi-tenancy virtual environments, which assume all instance are completely isolated from each other. However, this assumption can sometime break down, allowing attackers to cross virtual machines side channel, escape the boundaries of the sandboxed environment and have full access to the host, and
5. How to develop appropriate law and implement legal jurisdiction, so that users have a chain against their providers if need'

There are several benefits that cloud computing may offer with respect to security. That is not to say that these benefits are necessarily exclusive to cloud computing, merely that they align very well with cloud computing. Cloud providers typically undergo very strict security audits. Also the cloud providers have access to the best-of-breed security solutions and procedures. They have also been forced to inculcate a deep sense of security concern in their administrative staff. Again, this is not typically matched by smaller organizations. The cloud also offers a platform for many security functions ranging from disaster recovery to monitoring, forensic readiness and password assurance or security testing. Its location makes it ideal for centralized monitoring.

Cloud Virtualization

The main aim of virtualization is to manage the workload by transforming traditional computing to make it more scalable, efficient and economical. Virtualization can be applied to a wide range such as operating system virtualization, hardware-level virtualization and server virtualization. Virtualization technology is hardware reducing cost saving and energy saving technology that is rapidly transforming the fundamental way of computing. Virtualization carries with it the inherent advantage that it is much easier to deploy preconfigured builds. It is possible to pre-harden these by locking down all traffic, eliminating unnecessary applications and features and applying the latest security patches. Since virtual images may be brought up anywhere in the cloud and tend to move frequently it makes it much more difficult for a hacker to launch a topology-based attack [12].

Data Storage

Data Storage is one of the key driving forces for cloud computing, the need to process large volumes of data in a scalable and efficient manner. As cloud data centers typically consist of commodity servers with limited storage and processing capacities, it is necessary to develop distributed storage systems that support efficient retrieval of desired data, the distributed storage system must also be resilient to failures. Distributed storage system is designed to achieve availability and high performance, while ensuring file replicas remain consistent over time. The main objective of data storage center is to achieve consistency, availability, and robustness to network failures. Data security, privacy and confidentiality most be assured by the cloud service provider. Amazon Dynamo adopts an eventual consistency model that allow replicas to be temporary out-of-sync. By sacrificing consistency, Dynamo is able to achieve significant improvement in server response time. It is evident that these storage systems provide the foundations for building large scale data-intensive applications that are commonly found in today's cloud data centers [12].

Cloud Networking

To ensure predictable performance over the cloud, it is of utmost importance to design efficient networks that are able to provide guaranteed performance and to scale with the ever-growing traffic volumes in the cloud. Therefore, extensive research work is needed on designing new data center

network architectures that enhance performance, fault tolerance, and scalability. Furthermore, the advent of software-defined networking (SDN) technology brings new opportunities to redesign cloud networks. The cloud network technology is programmable, this is what make it possible to dynamically adapt the configuration of the network based on the workload in order to achieve potential cloud provider's objectives in terms of performance, utilization, survivability, and energy efficiency.

2.8 Cloud Computing Simulations

Simulation is a designed to evaluate and test strategies that aims to study and understand the behavior of the system or evaluating various strategies. 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 [10]. In the cloud environment all operations of implementation and evaluated are very expensive, hence we cannot able to achieve all aspect of advantage or disadvantage in real world. Study of distributed, virtualized, and elastic resources can be carried out in a controlled manner with simulation to gain insight of Application performance. Alternative to real infrastructure is simulation tools that open to study before deploying in real environment. Recently, many cloud environment simulation tools were proposed to enable reproducible and controlled evaluation of new algorithms for management of cloud resources and applications [1][7].

Cloud Simulation Challenges

The following are some of the challenges of cloud simulation [5]:

1. **Restriction** The restrictions for cloud task execution are more than the grid task execution, which makes cloud simulation difficult.
2. **Cost** Generally the various types and amount of resource consumption by a cloud task may be associated to many factors like payment budgets, user bids and job priorities.
3. **Knowledge/Skills** Cloud simulation tools are of various types and characteristics, there is need of wide variety of knowledge in handling simulation tools.
4. **Security** None of the simulators is able to simulate cloud security parameters

Cost Reduction:

It is the main advantage or main reason why organizations are going to apply cloud solutions as it saves the cost involved in building infrastructure and setting up a data Centre i.e. both (CAPEX and OPEX). Even a small-scale business can adopt or go into the cloud. This allows a company to concentrate more on improvements of their core competencies. It certainly helps to be more advantageous in longer run.

2.9 Pros of running Simulation

Use of cloud computing is increasing at a very fast pace everywhere because it turns the capital expenditure cost into operational cost. The use of simulation tools is considered a better option in spite of being on the real cloud as performing experiments in a controlled and dependent environment is difficult and costly to handle. Moreover, effective resource utilization is not possible in case of Cloud. Following are the advantages of running simulation tools in cloud [1][5]:

1. **No capital cost involved** Cloud computing makes a shift from capital expenditure cost to operational cost. Having a cloud simulation tool also involves having no installation cost or maintenance cost as well.
2. **Leads to better results** Using such tools helps to change inputs and other parameters as well very easily which results in better and efficient output
3. **Evaluation of risks at an early stage** Simulation tools involve no cost while running as is in case of being on cloud, so user can identify and solve any risk that is associated with the design or with any parameter.
4. **Easy to learn** User need to have only programming abilities and rest all depend on that. If the user is well versed with the language, then simulation tools offer no problem.

2.10 Cloud Computing Simulation Tools

There are variety of simulator tools for modelling and simulation Cloud computing environments, generally these simulation tools are classified in tow groups. The first group are command line or non-graphical tools such as CloudSim, this group of simulators are based on java language, open source and event oriented. An important feature of these tools are open source tools and more flexibility. The second group are graphical tools that provides simulation and modeling operation without the need to programming skills in the less time with high capability of configuration and

repeatability such as CloudAnalyst and CloudReports. Some of the cloud computing simulators for evaluating cloud computing system performance are described below [7][3][12][4].

1. **CloudSim** This simulator is an extensible toolkit which enables the simulation, modeling and experimentation of cloud system its infrastructures and application environments of single and internetworked clouds. It is a feasible solution if access to hardware is finite. This simulation software supports modeling of cloud data centers with different hardware configurations, helps in modeling user applications with independent tasks, supports design and analysis of various VM (virtual machine) provisioning, scheduling policies. It also enables to model power consumption, network behavior. CloudSim implemented application provisioning techniques can be extended easily with less efforts. This software helps researchers to concentrate on particular design issues without considering the low level details of cloud infrastructures and services. It introduces preconfigured machines which are designed to execute common open source robotic tools. SimJava, a toolkit based on discrete event simulation kernel which is present at lowest level of cloudsim allows to develop models of complex systems. It also provides facilities to represent the simulated objects as animated icons [1][5].
2. **CloudAnalyst** This is a graphical in nature which has better visualization results. It also separates the simulation experimentation from programming exercise. It also enables perform simulations and to manage a series of simulation experiments with slight parameters variations in a fast and easy manner. It can also examine the behavior of large scaled internet application in a cloud environment [2][10].
3. **GreenCloud** It is a packet level cloud network simulator which concentrates on cloud communication, it collects fine grained information about energy consumed by various communication and computing resources of a data center in unique fashion. It also allows the examination of workload distributions. It is the application of designing, manufacturing and usage of computing resources with minimum environmental harm, by reducing the power/energy consumption. GreenCloud simulator takes high simulation time and it requires more memory, which makes its scalability to be limited to small data centers [1][2].
4. **NetworkCloudSim** This simulation tool is the extension of cloudsim. It supports high performance computing applications [16]. CloudSim network layer is implemented by

Network Topology class and this class is used by Network CloudSim tool which reads a BRITE file and produces a topological network. Topology file comprises of nodes and number of entities in simulation, which enables users to raise the scale of simulation without any modification of topology file. And each BRITE node should be mapped to one entity at a time which enables proper working of network simulation. This tool allows to model cloud data centers with fast and scalable simulations by sharing bandwidth.

5. **EMUSim** It is an-unified architecture [17] which predicts cloud services behavior to a high standard. This tool is built on Automated Emulation Framework (AEF) for emulation and on CloudSim for simulation. It automatically collects application behavior information via emulation and then uses this data to produce the particular simulation model. This generated simulation model will be used to construct a scenario which will be closer to original target production environment of application request patterns and computing resources. VM (virtual machine) related information like VM location, number of VMs per host, etc. in a given time is not required by EMUSim.
6. **MDCSim** This tool can simulate hardware characteristics of various components available in a data center and helps to estimate the power consumption. MDCSim has less simulation overhead.
7. **GDCSim** Green Data Center Simulator combines the modular and extensible entities. This tool helps to study the energy efficiency of data centers beneath various data center geometries, platform energy management schemes, scheduling algorithms and workload characteristics. It helps to design green data center by capturing the inter-dependencies between online resource management and physical behavior of data centers [5].
8. **SPECI** Analyze different scalability and performance features of data centers. Data centers expand in nonlinear fashion. SPECI helps to analyze the behavior of such data centers. This tool can be used to monitor the inconsistencies that rise when failures occur in data centers. SPECI manage distributed data center when data center size and failure rate increases.
9. **CDOSim** Simulate SLA violations, costs and response times of a cloud deployment. It is a decision maker about cloud provider, runtime adaption schemes, components deployment and instances configuration of VM. It can simulate cloud deployments which were reverse engineered to KDM models. This tool allows the combination of fine grained models and

it helps to represent the user's perspective rather than cloud provider perspective. It can tradeoff between costs and performance [19] or it can be used to compare runtime reconfiguration plans.

10. **TeachCloud** This tool is meant for education purpose where one can alter cloud configuration and can perform simple experiments with the help of its graphical interface. It uses cloudsim as design platform with some enhancements on the top of cloudsim like GUI, cloud workload generator, cloud network models(such as VL2, Portland, Dcell, etc.), new models related to SLA and Business Process Management(BPM) [2].
11. **iCanCloud** This simulator is based on SIMCAN. It is a framework for huge storage networks. For an application in a specific hardware it can tradeoff between costs and performance to give the idea to the user about the costs involved. It has full GUI which facilitates easy design and execution of experiments. It also supports experiment execution in parallel over several machines [5][2].
12. **GroudSim** Is an event based simulator which requires a simulation thread for grid and cloud environment scientific applications based on a scalable simulation independent discrete event core. It focuses on IaaS and it is easy extendable to support other cloud level services like PaaS, DaaS. It provides set of features to handle complex simulation scenarios like background load on resources, cost calculation, task execution on leased computing resources.
13. **DCSim** This tool develops data center management techniques. It concentrates on virtualized data centers. It will focus on transactional and continuous workloads. This simulator can model dependencies between VMs which belongs to multi-tiered application. It can also simulate replicated VMs sharing incoming workload. It can easily measure the SLA achievement.
14. **FlexCloud** Simulate resource scheduling and performance evaluation of VM allocation in cloud data centers. It evaluate various scheduling policies and algorithms, simulate cloud data centers initialization, model VM allocation requests and performance evaluation of different scheduling algorithms. It concentrates on IaaS, has user friendly interfaces for replaying and customized configurations and it can model VM migrations. This simulation software supports large scale simulations by reducing the computing time and memory

consumption. It has unified features to support public cloud providers, energy efficient scheduling and load balancing.

15. **GloudSim** Google Trace based Cloud Simulator with Virtual Machines, it is a distributed cloud simulator which is based on virtual machines. It can emulate the tasks that consume resources like CPU rate, memory, etc. which dynamically changes, with the closer real values. This tool can emulate different events like kill/evict, etc. accurately based on trace.

2.11 Characteristics of Cloud Simulation Tools

It is hard to say some tools are better than the others because every tool has some pros and cons over the other. So it depend upon requirements of the user according to which he/she will choose the appropriate one. A brief comparison of Cloud simulation tools is shown in fig 1 [4][7].

Simulator	Networking	GUI	Availability	Platform	S/W or H/W	Script / lang	Simulator type	TCP/IP
CloudSim	Limited	Limited (CloudAnalyst)	Open source	GridSim	s/w	Java	-	None
SPECI	Limited	Limited	-	Simkit	s/w	Java	Event based	None
GreenCloud	Full	Limited (via Nam)	Open source	NS 2	s/w	C++/ OTCL	Packet level	Full TCP/IP
MDCsim	Limited	No GUI support	Commercial	CSIM	s/w	C++/ java	Event based	None
iCanCloud	Limited	GIU supports	Open source	SIMCAN	s/w	C++	-	None
FlexCloud	Limited	NA	Open source	Any		Java	-	NA
GroundSim	Limited	None	-	NA	s/w	Java	-	Full TCP/IP
CDOSim	Limited	None	Commercial	CoudSim	s/w	Java	-	Non
NetworkCloudSim	Full	None	Open source	CloudSim	s/w	Java	Packet level	None
CloudAnalyst	Limited	NA	Open source	CloudSim	-	Java	Event based	NA
EMUSim	Limited	Limited (via NEPI)	Open source	AEF, CloudSim	s/w	Java	Event based	None
DCSim	Limited	None	-	NA	s/w	Java	-	None

OpenCirrus		None	Open source	Federation of heterogeneous data centers	Both s/w and h/w	NA	-	NA
OCT (openCloudTestbed)		Limited (via open cloud test monitor)	Limited registration is needed	Geographically distributed cloud testbed spanning for data centers	Both s/w and h/w	NA	-	NA
GDCSim		No GUI support	-	BlueTool	s/w	C++/ XML	-	None

Table 1

2.12 Conclusion

Cloud Computing is one of the fastest growing field in IT industry. It is necessary to evaluate performance and security risks that are inherent part of cloud computing, as the users are worried about some problems and cost related issues that exits with the prevalent implementation of cloud computing. Various cloud simulators have been developed especially for performance analysis of cloud computing environment. Simulation based methodologies get to be popular in industry and academia for the conveniently assess cloud computing systems, application behaviors and their security. Even though it is difficult to say some tools are better than the other, every tool have some pros and cons. Certain simulation tools may be more suitable than the other as every tools have some limitation over the other, this will give the user to select the specific tool based on their specific requirements.

3 Research Methodology

3.1 Introduction

This chapter focuses on the action plans and guidelines which will be followed to make sure the whole research is carried out professionally. Having portrayed a very good picture of the study in the literature review prior to this chapter, the framework that shows the relationship and relevance of the questions with respect to research problem was developed will be tested. This phase of the research defines the boundary of the research design, the selection of the study based on the research framework, the sources of the data and how the data will be collected and the techniques and instruments to be in collecting the data will be discussed, as well as how the data will be analyzed and displayed.

3.2 Research Design

The main purpose of this research is to have clear knowledge on cloud computing and compare different functionalities of cloud simulation tools. Qualitative research method will be adopted and the aim was to get both the overall understanding of Cloud Computing along with the perceived benefits and drawbacks related to them and also compare different cloud simulation tools and point out some of their functions. This will done by reviewing previous researchers work, by conducting interviews, and by distributing questionnaire. The study research is broadly divided into the following phases. The first phase of this research identified the research problem and constructed the research questions. Comprehensive literature review to give a clearer understanding of the topics which are centered on this study was conducted in the second phase afterwards; identified gaps of skill mismatch among cloud providers and cloud users and also factors that can be positively influents skills development. Following the literature reviewed, a research framework was developed which examines the relationship between interest, cloud computing users, cloud service providers, and Academia. The third phase of the research covers the survey phase by distributing questionnaire and interview.

This survey range from a feedback form via simple short paper form to one-in-one in-depth interview. The first part of this phase of research is an interview with cloud service providers to know about the societal awareness of cloud computing. The identified cloud service providers will produce a reliable list of cloud computing users which will be used to assess the awareness about cloud users; to confirm the current cloud service providers is one of the research questions.

The questionnaires will be developed and administered to some of the cloud users. The survey will then be modified after the feedback from the organizations. Upon receive of a complete questionnaire in the main survey, the data collected will be check and examine to identify omissions, eligibility to ensure a consistent classification. In the last phase of this research will be centered on the validation process of the model of this study. The data collected in this research will be well analyze.

3.3 Sources of Data

The data collection for this research will be done through both primary data secondary data.
Both methods will be employed extensively to get substantial information.

Secondary Data

This is the main data collection method, data will be collected in qualitative approach from different sources such as journals, periodic publications, newsletters, books, internet, organizational reports and pullouts. Also the researcher experience as a student of computing. These will help the researcher ascertain the weaknesses, challenges and study cases of cloud computing users. Secondary data will be used to outline possible solution to improve cloud computing using the appropriate simulation tool.

Primary Data

Primary data is important for a research as the credibility and reliability of the research depend to the extent of the primary data used. There are different methods of primary collection which include surveys, observation and experiment. This research is planned to be conducted mainly on survey. Qualitative method approach will be use. The researcher will administers to collect the data from the target respondent. Questionnaire will be used as the main channel for primary data collection. The researcher will also use interview guide paper collect data from cloud users and cloud providers from various locations.

3.4 Research Instrument

General Format

The survey will be designed more of a self-reporting questionnaire. According to the research model, there are basically three subscales in the research model and there will a demographic section in the survey as well. The subscales will be designed with a 5-point like scale. (5 = strongly

agree; 4 = agree; 3 = uncertain; 2 = disagree; 1 = strongly disagree) to determine users agreement with statement as regarding the test of the entire hypotheses. The scores will represent in each agreement in each statement.

Development of Survey Questions

The first part constitutes demographic information such as gender, age range, and knowledge about cloud computing, knowledge about cloud simulations tools, knowledge about IT. The second section will provide the answers that pertain to the question; what are the attitudes of cloud service providers toward customers. The third section will help to meet the research objective on identification and evaluation of cloud environment factors that influents in development.

The last section will show the current cloud computing user's demands and how ready are cloud providers to fulfil their demands.

3.5 Data analysis

Collected data from questionnaires and interview guide will be analyzed for certain correctness and completeness. The researcher will compile, sort, and edit the collected data. Data collected from the interview will be analyzed using the content analysis techniques which is the most preferred for qualitative data. The researcher will use content analysis technique to analyze interview and observation in order to establish cloud computing and cloud simulation technique. The collected and analyzed data will enable the researcher to develop, test, and validate the proposed model in accordance to data finding.

3.6 Conclusion

In conclusion, this chapter summarizes the various approaches researchers will use to achieve objectives of the study. Both quantitative and qualitative data analysis will be used since questionnaire and interview will be used to gather information from the selected respondents.

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