PROPOSED CLOUD INFRASTRUCTURE FOR RESEARCH AND EDUCATION IN HIGHER LEARNING INSTITUTION IN KENYA

By

Michael N. Gitau

A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS IN DATA COMMUNICATION IN THE SCHOOL OF COMPUTING AT KCA UNIVERSITY

AUGUST 2014 TO THE GRADUATE SCHOOL

DECLARATION

"I declare that the work in this Research project is my original work and has not been previously published or submitted elsewhere for award of a degree. I also declare that this Research project contains no material written or published by other people except where due reference is made and author duly acknowledged.

Student Name: Michael N. Gitau **Reg, No:** 12/00313

Sign: _____ Date: _____

I do hereby confirm that I have examined the master's Research project of

Michael N. Gitau

AND have certified that all revisions that the Research project panel and examiners recommended have been adequately addressed.

Sign: _____ Date: _____

Professor Ogao

PROPOSED CLOUD INFRASTRUCTURE FOR RESEARCH AND

EDUCATION IN HIGHER LEARNING INSTITUTION IN KENYA

ABSTRACT

Today education has become associated with information and technology in its delivery of content. Cloud computing provide solution of computing based on the internet where it allows sharing of resources, software and information to computers on demand like the electricity grid. Cloud computing is a recent concept that has come about from virtualization and grid computing. Both public and private organizations have adopted the cloud computing concept recently but there are concerns which have been raised regarding adoption and use of public cloud solution. Thus private cloud solutions are being taken into consideration as an alternative to a companies and institutions of higher learning. In majority of the Universities the infrastructure is either underutilized or over-utilized and thus the need for elastic technology adoption. The new technologies should be taken into consideration for project based learning and virtualization and this is why this is why the current study proposed an infrastructure for the higher institutions of learning in Kenya through embrace of cloud technology. The infrastructure model will be based on users, staff and students and their devices. The learning institutions will benefit by reducing the cost of IT staff from maintenance, reduce the updating of software and also cut the costs of software support. The learners demand for new software technology can be met with ease and lower costs and also sharing of information. The functions available for users through cloud service is sufficient for every user needs. Virtual open source system will give the Universities and colleges, researchers and learners use with less efforts. The study results will play key role in informing the stakeholders on the benefits or prospects of using cloud computing to solve the e-learning sustainability problems that have plagued the implementation of the e-learning especially in the institutions found in rural area.

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

3G	Third Generations
APIs	Application Programming Interfaces
Apps	Applications
CC	Cloud Computing
CERNET	Red China Education and Research
CIFS	Common Internet File System
CPUs	Central Processing Units
CSPs	Cloud Service Providers
EC2	Elastic Compute Cloud
ERP	Enterprise Resource Planner
FISs	Financial Information Systems
HLI	Higher Learning Institutions
HP	Hewlett Packard
IaaS	Infrastructure as a service

IBM	International Business Machines
ICT	Information Communication and Technology
IDC	International Data Corporation
IP	Internet Protocol
IT	Information Technology
JANET	Joint Academic Network
LIBISs	Library Information Systems
LMS	Learning Management System
MDGs	Millennium Development Goals
NASA	National Aeronautics and Space Administration
NFS	Network File System
NIST	United States National Institute for Standards and Technology
NUNet	Nigeria University Network
PaaS	Platform as a service
PCs	Personal Computers
RCA	Royal college of London of Arts
SaaS	Software as a Service
SOA	Service Oriented Architecture
SOAS	London University School of Oriental and African Studies
SPSS	Statistical Package for the Social Sciences
SRMSs	Student Records Management Systems
UK	United Kingdom
URL	Uniform Resource Locator
US	United States

TERMS AND DEFINITIONS

Cloud Computing: Form of cost-efficient and flexible usage of IT services, the services are offered just-in-time over the internet and are paid per usage.

Clusters: Locally distributed units with the same kind of hardware and operating systems being capable of processing a large amount of data collaboratively.

Grids: Globally distributed units with different operating systems and hardware being capable of processing a large amount of data collaboratively.

Hybrid Cloud: A mixture of a private and public cloud.

Infrastructure as a Service: Users being able to use servers, storage, network settings on-demand from other providers on a pay-per-use basis.

Platform as a Service: Developers being able to build their own applications offered on development platforms that are maintained and secured by other providers.

Private Cloud: Clouds that are used in a private network providing more security.

Public Cloud: Clouds that can publicly run anywhere in the world.

Scalability: Refers to the performance of handling growing amounts of work.

Software as a Service: Users can utilize software being offered over the internet without worrying about its maintenance, back-ups or security.

Utility Computing: The very idea of computing resources being offered as a service.

Virtualization: With virtualization servers are utilized more efficiently enabling one server to be used by several customers.

CHAPTER ONE: INTRODUCTION TO STUDY

1.0 Introduction

The university has various departments that require students and staff to access software and hardware computer resources. Cloud computing technologies have been established in similar working environments. The idea of cloud is the virtualization of resources. These resources are shared by users simultaneously. The users will connect to the cloud using the internet when accessing the servers. Today's cloud platforms such as Google provide free services to staff and students at educational institutions through their Google app program which includes e-mail, calendars, document storage, creation and sharing of documents. The main goal of the cloud infrastructure is to effectively manage the technological needs of the university such as providing a platform for computer science to test their web based and database projects, storage of shared data and delivery of software. Students will be able to access software development platforms, code applications and store them on the university infrastructure.

1.1 Background

Despite the adoption of technology in all aspects of the organization, there is a paradigm shift in the technology that powers the majority of education initiatives and existing research, such as the Joint Academic Network (JANET) Red China Education and Research (CERNET), Nigeria University Network (NUNet). Technology has experienced a quantum leap with accompanying reduction in the cost of creation and maintenance. Before now, collaboration can only be achieved through the interconnection facilities nodes, where hardware and software are hosted and managed by the user. Then with the advent of the Internet using web sites that stand between server data (the data warehouse) and the user. With the widest range of Internet, there is a minimal cost compared to the predecessor of self-managed and cloud computing has been the backbone of the reduction in costs associated with technology, (Science & Engineering, 2013).

Cloud computing is a model for enabling convenient access to on-demand network access to a shared pool of configurable computing resources (like, networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal effort set management or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models, (Mell & Grance, n.d.)

1.1.1 Cloud Computing Worldwide

The potential of cloud computing to improve efficiency, cost and convenience for the education sector is being recognized by a number of United States educational (and official) establishments (Dineva & Nedeva, n.d.). Benefits of cloud education are obtained through (www.microsoft.com/educloud): Flexible services - Drive innovation with the data services in the cloud that students, teachers, professors and employees be reused. Offer your own data mashups in a portal. Infrastructure - Get all IT resources you need, when you need them, operated safely and predictably. And pay only for what you use. Applications and content - Instead of waiting in line acquisition software, get hosted software, databases, and services so fast you'll have plenty of time to work on their mission. Policies and Regulations - Proceed with caution, but consider how cloud computing can help meet compliance requirements of your institution. Creative IT - Free your IT department a keep-the-lights-on approach of promoting some creative problem solving that can help teachers better engage their students.

According to (Budnikas & Cien, 2011) cloud computing has a prominent role to play in the classrooms of tomorrow. Cloud computing can democratize education. For example, many schools suffer from low graduation rates directly attributable to inadequate infrastructure - Personal shorthanded, small classrooms, lack of teachers. Cloud computing solutions can solve many of these problems.

The Higher Education Funding Council for England announced a plan to allocate £ 12.5 million for a new program that will fund shares on cloud computing in colleges

and universities around the country (Dineva & Nedeva, n.d.). In October 2007, Google and IBM jointly announced the academic cloud computing with six American research universities: Carnegie Mellon University, the Massachusetts Institute of Technology, Stanford University, the University of California-Berkeley, the University of Maryland, and the University of Washington. As part of this initiative, IBM and Google have dedicated a large group of several hundred computers for use by teachers and students of the participating institutions. By making these resources available, companies hope to encourage faculty to adopt cloud computing in their research and the integration of technology in the classroom. (Dineva & Nedeva, n.d.).

1.1.2 Cloud Computing Africa

Several institutions have started adopting various cloud services to reduce ICT investment costs as well as making teaching and learning more efficiently. For example, over 30 institutions across Africa have partnered with Google to use Google cloud services (Sultan, 2010). The partnership includes grants, technical, consulting, and training. These institutions include University of Pretoria (South Africa), University of Ibadan (Nigeria), University of Mauritius (Mauritius), and University of Ghana (Ghana). Interestingly, to date none of these institutions reported in the literature come from Tanzania. Clearly, intensive awareness is needed to HLIs in order to realize the benefits of cloud services in education.

Microsoft is helping our neighboring country Ethiopia to roll out 250,000 laptops running on Microsoft's Azure cloud platform to its school teachers. The laptops are meant for downloading curriculum among other things (Sultan, n.d.).

1.1.3 Cloud Computing in Kenya

Education and Research are key sectors targeted by Kenya's Vision 2030 blueprint which closely relates to the Millennium Development Goals (MDGs). Science, Technology and Innovation is a key foundation to Vision 2030 due to its capacity to enhance the attainment of the other pillars. The absence of a common digital platform for collaboration hampers this capacity. CC implementations in these sectors with a

package of e-learning, research portal connected to online libraries will not only fast track attainment but endear the country towards a research and innovation based economy. In Kenya, Researchers work in isolation and often less innovative due to the high cost of their trade while educationist suffer from classroom shortage, few qualified teachers and absence of proper teaching aids. There is a tremendous gap of absence of a digital platform that unites these two noble sectors. As a result, each work in disparity. The immediate effect of this is the country's high cost of living caused by the local industry independence on technology importation due to the absence of innovation. CC, a utility way of service consumption of centralized computing resources loaded with an e-learning component with Research portal promises to deliver such a missing platform hence the significance of this study.

1.2 Background of the Problem

Maintaining the current IT infrastructure is increasingly unable to accommodate the growing number of personal devices such as tablets, smartphones and laptops, the students and teachers bring in the higher education landscape. It is necessary for these solutions to accommodate growing numbers. According (Pantić & Babar, 2012) one of the main reasons for a meteoric rise in popularity and acceptance of cloud computing to its enormous flexibility for the increase or reduction software and hardware infrastructure without large upfront investments. There is no need for students, services and educational materials accessible at any time, day or night. So there is a need to have an infrastructure that has a high availability. According to (Tønnesland, 2013) A self-service virtualization system could be of benefit to institutions by enhancing the availability of computing resources and improving the utilization of hardware resources to its students and researchers

According to (Erkoç & Kert, n.d.) There are gains to cloud computing for the institutions of higher learning; opening up infrastructure for enterprises and industry for study progress.

1.3 Problem Statement

Cloud Computing aims at reducing the institution of higher learning's IT infrastructure and cost (Erkoç & Kert, n.d.). Cloud Computing is aimed at reducing at costs while enhancing access to learning tools to students and colleges as a whole, (Erkoç & Kert, n.d.). Due to the continuous increase in computing power and storage, education and research institutes are opting to resort to cloud computing. This is why in the present scenario; many education institutions are facing the problems with the growing need of IT and infrastructure. Cloud computing which is an emerging technology and which relies on existing technology such as Internet, virtualization, grid computing etc. can be a solution to such problems by providing required infrastructure, software and storage. There is tremendous need to handle the resources efficiently and effectively. The purpose of this study is to develop a private cloud infrastructure that provides efficient shared services in higher learning institutions for research and education.

1.4 Aims & Objectives of the Study.

The aim of this study is to evaluate and implement a prototype private cloud solution based on open source software with regards to the needs of the staff and students at Institutions of Higher learning in Kenya. The objectives of the study were:-

a) To identify the requirements and define challenges for the cloud platform with regards to higher learning institutions.
b) To design the solution for cloud computing in higher learning institutions in Kenya
c) To implement the cloud solution in higher learning institutions in Kenya
d) To Evaluate and validate the use of cloud computing in higher learning institutions in Kenya

1.5 Justification

The study proposed a suitable cloud infrastructure for research and education in Institutions of Higher learning in Kenya. The proposed infrastructure will improve the availability of computing resources and services to staff and students in both the Main campus and satellite campuses of the university anytime, day or night.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The term cloud computing comes from the use of cloud images representing internet or large networked environment. According to (Buyya, Yeo, Venugopal, Broberg, & Brandic, 2009) cloud computing in increasingly being perceived as the 5th utility after water, electricity, gas and telephone) that will provide the basic level of computing that is considered basic to meet essential to meet the needs of the community. There are a number of competing definitions of cloud computing. United States National Institute for Standards and Technology (NIST) provided guidelines on defining cloud computing with this all-encompassing definition (Mell & Grance, n.d.):

Cloud computing is a model for enabling convenience and on-demand access to a pool of configurable computing resources such as; servers, storage, applications and services that can be provisioned and released with minimal management effort or service provider interaction. The Cloud model promotes availability and is composed of five essential characteristics, three services models and four deployment models.

National Institute for Standards and Technology (Computer & Division, 2011) provides the characteristics of cloud computing as:

- On-demand self-service; this is where a consumer can provision computing resources such as supplications on the cloud without any human interaction with the server provider.
- Broad network access; the resources are available over the network and accessed through standard mechanisms using different platforms (such as, smart phones, laptops and desktop computers).
- Rapid elasticity; the computing resources available to the user may appear unlimited and can be allocated at any time though, they can be automatically provisioned according to the user demand.
- Measured service; computing resources can be monitored, controlled and reported on their utilization to enable the provider charge their consumers on their usage.

(Computing, 2010) defined a new style of computing that is scalable and resources virtualized and provided as services on the internet as cloud computing. (Armbrust, Joseph, Katz, & Patterson, 2009) see hardware and system software found in data

centers as well as applications delivered as services over the internet as cloud computing.

2.1.1 Service Models

Cloud services provide easy access to applications, resources and services. Cloud computing is divided into three service models that characterize the levels in which a cloud platform can operate:-

Software as a Service (SaaS) – this is an application available to users as a service. It eliminates the need to install and run applications on local computers for simplified maintenance and support. The applications can be accessible from either a thin client interface like web browser or through a program interface. An example of this is Google drive.

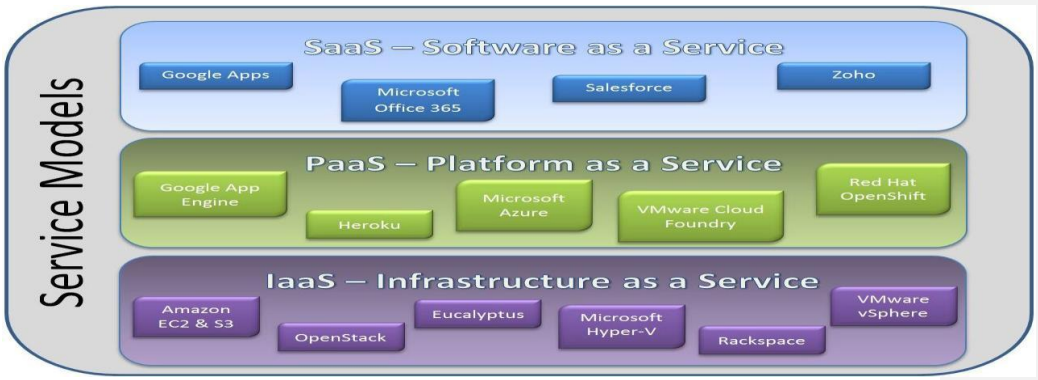
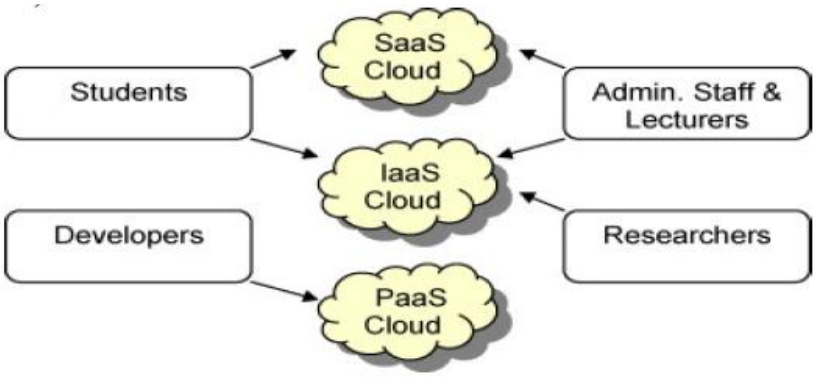


Figure 1: Cloud Computing Service models

- Infrastructure as a service (IaaS) – the user has control of configurations and operations of the operating system, software and Databases even though the user doesn't manage the underlying infrastructure. The infrastructure is delivered as a resource such as processing power, storage capacity and bandwidth. An example is Amazon.
- Platform as a service (PaaS) – the user is empowered to be able to deploy self-made or acquired software using programming languages and tools supported by the provider. The user has the control of the deployed application but not the underlying infrastructure. An example is the Google Apps Engine. The

operating environment in which applications run. Platform as a Service (PaaS) is a way to rent hardware, operating systems, storage and network capacity over the Internet. PaaS is an outgrowth of *Software as a Service* (SaaS), a software distribution model in which hosted software applications are made available to customers over the Internet (Dineva & Nedeva, n.d.).

- *Infrastructure as a Service (IaaS)*: in the on-demand data centers there are flexible options about which service to access in cloud and which one to keep on-site. An example with SaaS you can add services such as email affordably and you can delivery services broadly without having to manage the infrastructure. With IaaS you pay the data center for adding CPUs storage, networking or web hosting. Many higher learning institutions do not have the capacity to give their learners sufficient hardware and software to enable a complete learning experience. This problem becomes pronounced in the technical institutions and new colleges. Outsourcing some capabilities to the cloud makes most of what is on site by feeing time, budget and human resource. However with SaaS and IaaS limited budget will still allow students to access the latest technology and software on offer (Budnikas & Cien, 2011).



Source: (Sultan, 2010)

Figure 2: Simplified structure a typical university cloud computing

2.1.2 Deployment Models.

The following are the commonly known cloud deployment models:-

- Private Cloud: this is a cloud infrastructure that is internal to an organization / institution and is not available to the general public. It is normally managed by the organization / institution that owns it or outsourced to a 3rd party service provider. An example open stack and VMware Vcloud.
- Community Cloud: this is a cloud infrastructure setup by several organizations that have common requirements and shared concerns.

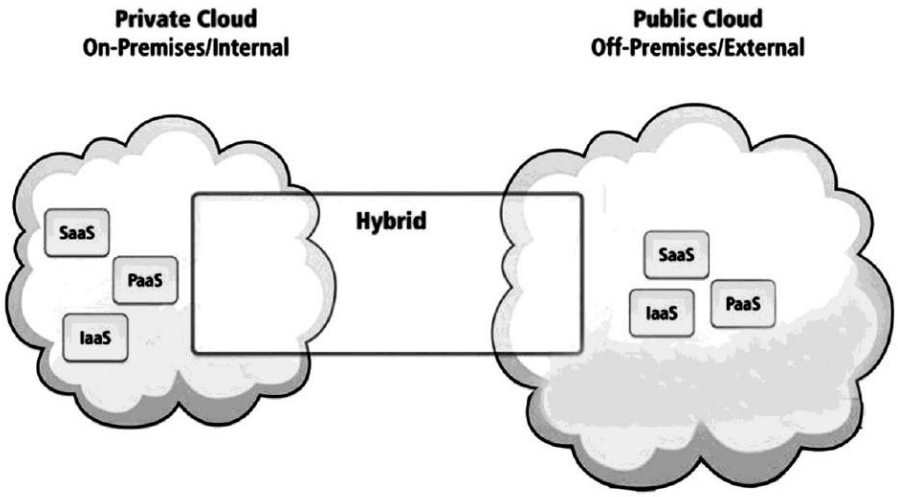


Figure 3: The deployment models

Public clouds; this is the cloud infrastructure that is available to the general public such as Google apps engine

Hybrid cloud; this is a combination of two or more clouds system via private community or public.

2.2 Clouds of Institutions of Higher Learning

According to (Dineva & Nedeva, n.d.) the benefits of cloud computing has been recognized to improve efficiency, costs and convenience in the education sector and has been supported by number of higher institutions of learning such as University of California at Berkeley found cloud computing to be very useful.

Schools are also adopting cloud computing i.e. Kentucky's Pike Country district introduced cloud computing to its schools with population of 10,200 students. This is done by transforming 1400 old computers virtual machines. Pike Country projects 5 years the cost of ownership for hosted virtual desktop solution will be less than half of the cost of supporting the desktops on-premise and also it was able to avoid additional infrastructure and staffing costs of administering the servers (Sultan, 2010).

According to (Sultan, 2010) cloud computing is also finding its way in the British academia, a number of UK higher education institutions like Leeds Metropolitan University of Glamorgan, the University of Aberdeen, the University of Westminster, the London University school of Oriental and African Studies (SOAS) and Royal college of London of Arts (RCA) have adopted Google Apps. Popular demand from students (many of whom were already abandoning the unreliable in-house email systems) and cost were said to be the main factors behind this move.

Google has been successful in providing cloud computing in East Africa education market. For example it has partnered with National University of Rwanda, Kigali Institute for education, University of Nairobi, United States International University, Kenyan Methodist University and University of Mauritius to provide Google cloud services like Gmail, Google Calendar, Google Talk and Google Docs and

Spreadsheets to their students. These universities were also helped by an existing World Bank grant that supports bandwidth subsidy in universities.

Also Microsoft is helping Ethiopian to roll out 250,000 laptops to its school teachers with all of them running Microsoft Azure cloud platform. The laptops allow teachers to download curriculum, keep track of academic records and securely transfer student data throughout education system without any extra costs of building support system of hardware and software to connect them (Sultan, n.d.). This has shown that the ability of cloud computing to help African education is not only in reducing the costs of IT but also making education efficient than it was before and its is powerful tool for empowerment and advancement of education in the under-developed continent with poor resources.

2.3 Africa Adoption of Cloud Computing

According to (Mujinga, 2011) alluded to define that mobile devices accessing the internet perform mobile cloud computing due to their limited resources and have to borrow storage and computing power from the cloud. Accessing data in the cloud from mobile devices has become a basic need with initiatives like M-Pesa and M-Banking using the service.

M-Pesa a Swahili word meaning the transfer of Mobile Money has been a success in Kenya (Mujinga, 2011) and was introduced to countries like south Africa. Small businesses and learning institutions in developing economies have problems adopting cloud computing as shown below;

2.3.1 Infrastructure Related barriers

(Mujinga, 2011) argues that most African communities lack the basic substructure; electricity, roads, telecommunication and water, these infrastructure are backbone of development initiatives, this is a challenge to bridging the existing gap of digital divide and the absence of infrastructure leads to unavailability and escalation of costs of services and the cost of devices of accessing the internet.

2.3.2 Devices Related Challenge

(Mujinga, 2011) posits that majority of the households in Africa do not have the access to computers and thus relying on mobile phones to access internet. Countries like South Africa mobile providers have rolled more 3G networks coverage in all their access areas with internet network bring internet access to many areas outside the city centers.

2.3.3 Internet Coverage

Because of lack of infrastructure availability in the developing countries internet connectivity is a big challenge (Mujinga, 2011). (Mujinga, 2011) also states that Africa has 15% of the world population and accounts for 5.7% of the world internet users. The lack of infrastructure in the continent has resulted to low bandwidth and high costs of access.

2.3.4 Physical Location of data challenge

Major CSPs are located overseas companies such as the Google, Amazon and Microsoft hence the infrastructure is usually not located in the premises of the consumer let alone in the same country.

2.4 Higher Education Institutions Cloud Computing

Cloud computing adoption embrace is growing very fast, more and more institutions are migrating their computing services into the cloud.

Similarly, Microsoft package (called Live@edu) is available to educational institutions at no cost ("By:- sewale belachew demeke," 2012). Consisting of Microsoft documents, Windows SkyDrive, Shared View and Outlook. Microsoft has also introduced cloud computing services for commercial purposes (Sultan, 2010). Apart from Google and Microsoft, there are other companies that offer several cloud services to education institutions.

In fact, there are already several successfully deployments of cloud services in education in US, UK, Asia, and Africa. Some few examples of such institutions in the US are: North Carolina State University (- et al., 2012), Colorado State University (- et al., 2012), University of California, and Washington State University (Sultan, 2010).

Likewise, cloud services have found its way in African institutions. Several institutions have started adopting various cloud services to reduce ICT investment costs as well as making teaching and learning more efficiently. For example, over 30 institutions across Africa have partnered with Google to use Google cloud services ("By:- sewale belachew demeke," 2012). The partnership includes grants, technical, consulting, and training. These institutions include University of Pretoria (South Africa), the University of Ibadan (Nigeria), University of Mauritius (Mauritius), and University of Ghana (Ghana). In Eastern Africa for example For example it has partnered with National University of Rwanda, Kigali Institute for education (Sultan, 2010). Other institutions include the United States International University, the Kenyan Methodist University, and the Makerere University Business School (MUBS). Interestingly, to date none of these institutions reported in the literature come from Tanzania. Clearly, intensive awareness is needed to HLIs in order to realize the benefits of cloud services in education.

Higher education is a significant pillar of society development. In higher education, cloud computing will enable institutions use internet resources for data analysis and data storage. Cloud computing can be used to improve accessibility to education. The virtualization of the class environment helps address the issue of overcrowded and small classrooms. Students are able to go online and attend classes outside the classroom environment. Lecturers can now focus on creating online content for students. The cloud platform allows students to share their ideas, educational infrastructure and tools that in turn result in reduction of the educational institution's expenditure.

Implementation of cloud computing in educational institutions provides opportunities and benefits to its users. In a typical university scenario, server rooms and computer labs are under-utilized at night and during semester breaks. In turn, resources are on demand towards the end of each semester. Developing technology affects research and educational needs of educational institutions. Software and hardware are renewed in accordance with the changes. An example is Microsoft Navision Dynamics that has to been renewed every year so as to receive benefits of the updates.

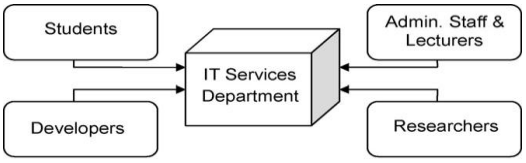


Figure 4: Cloud Computing in Higher Learning

To demonstrate how services can be utilized processes involved in their utilization in typical University with information technology infrastructure, the IT infrastructure is required is to cater for developers, staff & students. IT services in institutions of higher learning is directed to the ICT department whose job includes;

i. Providing email accounts and operating systems ERP and hardware (workstations and servers) to both learners and staff
ii. Providing the students with needed software and hardware for research projects and experiments that involve computer processing and computation
iii. Proving developers of applications with adequate development tools to code, host and develop applications

All above arrangements can be migrated to the cloud as shown and accessible through thin clients. Applications and software used will reside within the SaaS platform, additional requirements by the user like disk space and processing power will be executed by the IaaS cloud provider. The students and researchers can be able to use software for their projects online and host their applications through PaaS cloud provider.

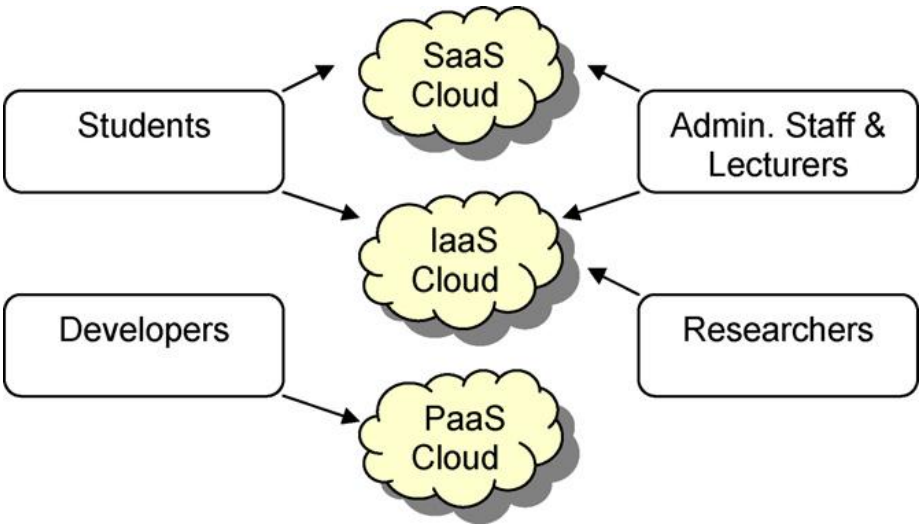


Figure 5: Cloud Computer Usage in Higher Learning

2.4.1 Issues related to cloud computing in the Intuitions of Higher learning

(Boja, Pocatilu, & Toma, 2013) posit that there are valid concerns that have been identified regard to cloud computing adoption in institutions of higher learning which include;

Integration and security concerns, this has been challenge that has been of concern to ICT departments in the higher education institutions. Also challenges include security issues of facility where data is stored. Risk of compliance,

Risk and Compliance Issues: cloud computing raises a number of red flags in regard to risk (for the risk-averse) like in a shared services environment, an institution doesn't control where information is stored or by whom it is accessed.

IT staffs implications; IT personnel will be directly impacted by the change to cloud computing. Institutional leaders need to not only concern themselves with impacts of cloud computing on IT staffing levels but also discern the implication of the cloud for the skills and experience required by IT employees going forward.

2.5 The Future of Higher Education and Cloud Computing

Cloud computing can be a catalyst to achieving some goals in the education sector such as education for all and affordable education. A meta-university would operate a web-based platform with a network of focusing on collaborative learning and knowledge. Collaborative learning could become the norm since cloud is on an ideal platform as it takes care of the technological challenges. Research and Innovation would no longer be something limited to laboratories of developing nations since developing countries shall be able to contribute to the global intelligentsia. Commercial clouds will have a pivotal role in realizing the goal of meta-universities.

2.6 Strategies of Cloud Adoption in Higher Institutions of Learning

The migration to cloud computing needs a well-defined strategy that will support its capabilities. Implementation of the strategy will depend on the existence of a service-oriented architecture (SOA) at the level of the institution that offers the necessary infrastructure for cloud. In relation to the transition to cloud computing and the experience of universities, the researcher suggests a migrating strategy towards cloud having the following phases.

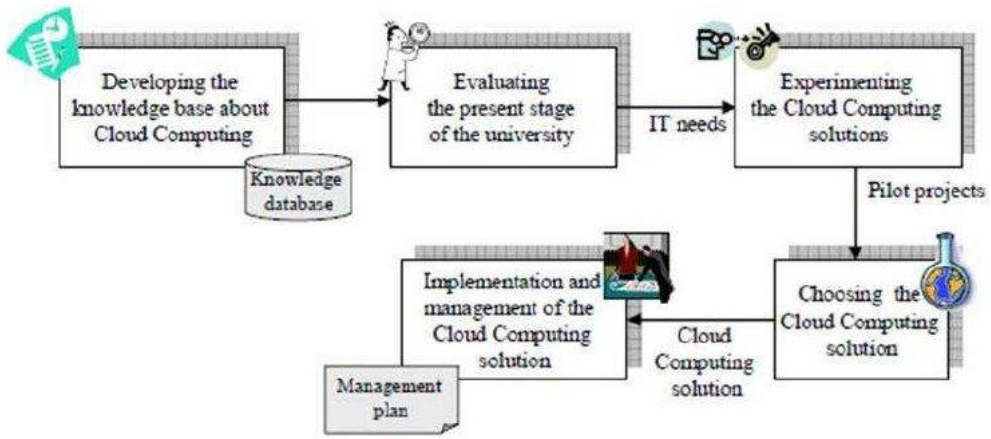


Figure 6: Cloud Computing Adoption Strategy

2.6.1 Project Planning

The design and architecture of openstack with its different components will be presented. Openstack is the preferred solution as it is an open source system and has an active community. The figure below shows the different stages of the project

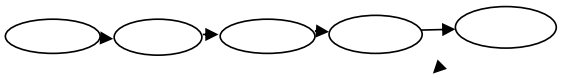


Figure 7: Prestudy-Planning-Implementation-Operation-Evaluation

2.6.1 Openstack

Openstack is a global collaboration of developers and cloud computing technologists producing the open source cloud computing platform for public and private clouds. The aim of openstack is to enable organizations create and offer cloud computing services on standard hardware. Openstack was founded by Rackspace Hosting and NASA. All the code for openstack is available for anyone to run it, build on it or submit changes back to the project.

There are currently seven core components of openstack:-

- Object store (Swift): It doesn't allow you to mount directories like a file server but allows you to store or retrieve files.
- Image (Glance): it provides a catalog and repository for virtual disk images that are mostly used in openstack compute.
- Compute (Nova): it provides virtual servers upon demand. It originated from NASA.
- Dashboard (Horizon): it provides a modular web- based user interface for openstack services. It allows you to perform operations on your cloud like launching an instance, assigning IP addresses and setting access controls.
- Identity (Keystone): it provides the authentication and authorization for openstack services.
- Network (Quantum): it provides network connectivity as a service between interface devices managed by other openstack services. It allows users to create their own network and attach interfaces to them.
- Block storage (Cinder): it provides persistent block storage to guest virtual machines. It should be noted that this is block storage or volumes and not file systems like NFS or CIFS.

The openstack project is designed to deliver a scalable cloud operating system. Services are designed to work together to provide Infrastructure as a Service. (IaaS). The integration is facilitated through public Application Programming Interfaces (APIs) that each service offers. APIs allow each of the services to use another service and also allows an implementer to switch out any service as long as they maintain the API.

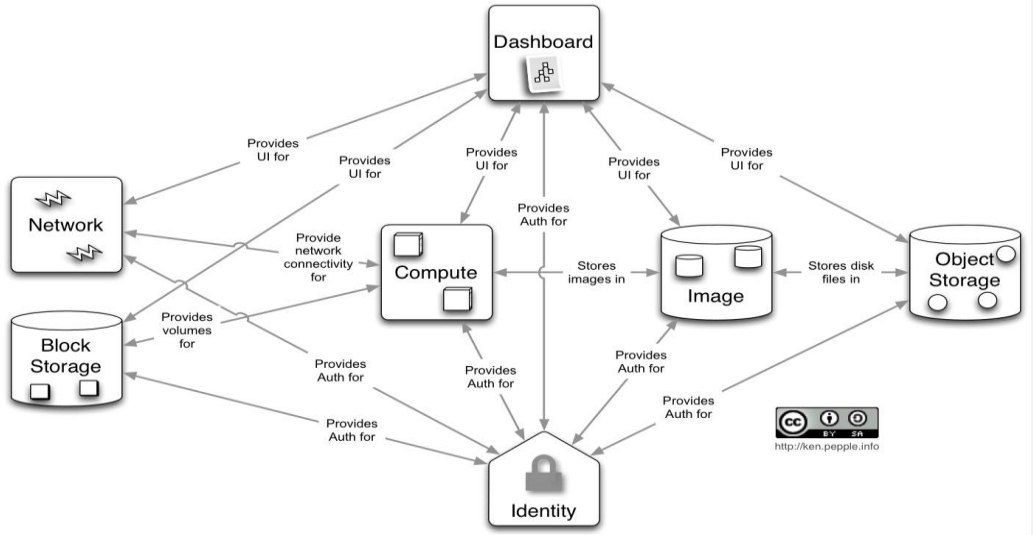


Figure 8: Openstack Cloud Computing

2.7 Cloud Computing Challenges

(Mujinga, 2011) argues that there are challenges in cloud computing; access to high speed internet, standardization and privacy which is one area of security concern. (Priščáková, Rábová, Ph, & Salák, n.d.).

In a recent survey of IT executives 75% of the respondents rated information security as their main concern and argue that Google cloud server does not encrypt data in its servers (Sultan, 2010).

Also failure of cloud provider which owns data centers cause serious repercussions to the uses who have entrusted their data with such provider. In early 2009, Google's Gmail (its Webmail service) went down for 3 h, thus preventing its 113 million users from accessing their emails or the documents which they store online as "Google Docs" (Sultan, 2010). Vendors often provide service credits for outages. However, those credits, according to a director of a US market research firm, are "cold comfort for sales opportunities missed and executives cut off from business information" (Sultan, n.d.)

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This study sought to demonstrate the viability of computing for institutions of higher learning and the huge benefits that come with establishment and adoption of cloud computing. This chapter explains how the study was conducted and how information will be obtained.

3.2 Research Approaches

The study utilized both primary and secondary data, the literature review from past studies done. The activities undertaken during the study included; Formulation of questionnaires and interview questions, identification of data sources (key respondents/ informers; selection of sample sizes among others), administration of questionnaires, interviews and field visits for data collection, data collection and analysis of research findings.

3.3 Methodology

The study aimed at developing a virtual server prototype to be used by both; staff and students in institutions of higher learning in Kenya. Comprehensive literature review was done to enable the researcher address the study objectives and come up with study model that will be used in the implementation of the system prototype.

Although computer virtualization can be used in all sectors of the economy the study was based in institutions of higher learning where learners can access resources with necessarily after software's or personal computers. A few institutions of higher learning have embraced virtualizations in Kenya and thus Karatina University was used since the prototype was tested in the University.

3.4 Population and sampling

The questionnaires were administered to the employees and the students in computer science department in Karatina University. A sample of 10 employees and 20 students were given questionnaires to answer. Purposive sampling was used to capture employees and students who were frequently accessing and using the implemented

virtual system. The researcher used logs of both staff and students registered to use the virtual system.

3.5 Data collection and analysis

Data was collected using a semi-structured questionnaire served to respondents. The respondents were given questionnaires and requested to fill them and submit to the researcher in hard copy or email it. From the 30 administered questionnaires 25 were returned giving a response rate of 83%. Data was entered to SPSS and analyzed descriptively to give tables and charts. The questionnaires were also followed with interviews and instant chats with the respondents to verify facts on the questionnaires and also get to know the challenges and how to improve on the prototype for better efficiency and reliability.

CHAPTER FOUR: SOLUTION ANALYSIS

4.1 Research Design

In the present study the cloud technology based conceptual framework is designed for higher technical education system. The proposed model will be useful to improve the effectiveness and efficiency of higher technical education system. It is also helpful to bring the uniformity throughout all universities and institutes or colleges. This will be also helpful for reducing the cost and time.

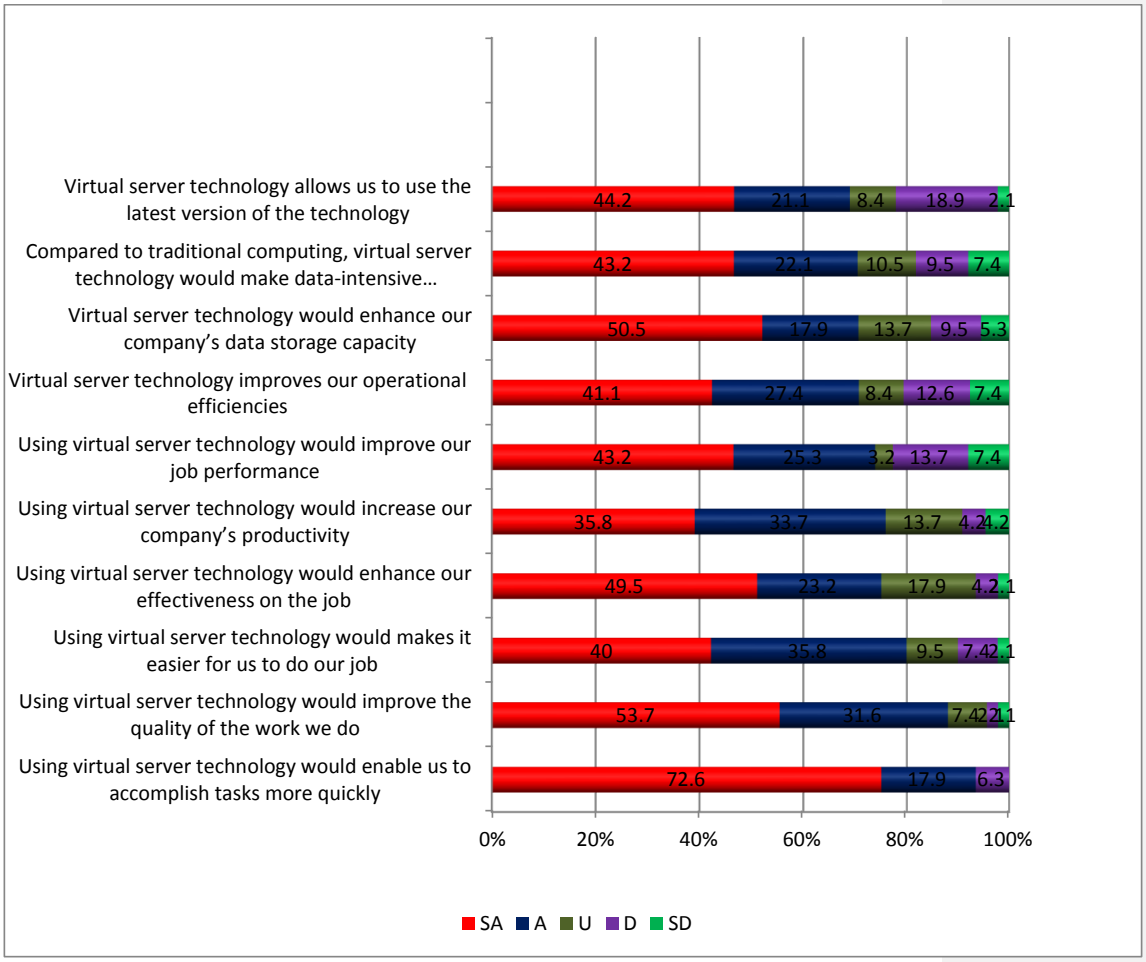
4.2 Findings from Data collected

This section presents the findings from the data collected from the respondents.

4.2.1 Benefits from using virtual system

The survey findings showed that the respondents agree that; 90.5% virtual server has enabled them accomplish their projects more quickly, 85.3% it has improved the quality of their work, 75.8% it has made it easy for them to do their jobs, 72.7% agree that it has enhanced their effectiveness of work, 68.4% agree that the virtual system has enhanced their storage capacity, 65.8% agree that compared to traditional computing, virtual server technology would make data-intensive computing faster while 65.8% also support that the virtual technology has enabled them to access and use the latest version of technology cheaply and effectively as shown in figure 9.

Figure 9: Benefits from using virtual system



4.2.2. Virtual server technology knowledge

The analysis the results revealed that most of the respondents who are using of the system were in agreement as supported by mean greater than (~2.0) and standard deviation (~1), 72.6% that their knowledge underlying server technology was good, 53.7% have very good knowledge of benefits of virtual server usage, 49.5% have good knowledge of difference between virtual server and other technology, 41.1% compared to other users feel that they have fair understanding of virtual server technology as shown in table 1.

Table 1: Virtual server technology knowledge

	Poor	Fair	Good	Very Good	Excellent	NR	Mean	Stdv
My knowledge about the underlying structure of virtual server technology is:	6.3	17.9	72.6			3.2	**3.0978**	**6.07972**
My knowledge about the benefits of using virtual server technology is:	2.1	31.6	7.4	53.7	2.1	3.2	**2.1000**	**.92211**
My knowledge about the difference between virtual server technology and other types	17.9	23.2	49.5	4.2	2.1	3.2	**2.1954**	**.98355**
My knowledge about various models of virtual server technology	4.2	27.4	45.3	14.7	5.3	3.2	**2.1932**	**1.10952**
My information about different types of virtual server technology (public, private and hybrid)	13.7	33.7	35.8	4.2	4.2	8.4	**2.1628**	**.84964**
In comparison to the people in similar positions I would rate my own understanding of virtual server technology as	27.4	41.1	8.4	12.6	7.4	3.2	**2.5652**	**1.23964**

SD –Strongly disagree D- Disagree U-Undecided A- Agree, SA-Strongly Agree NR-Non Responsive STDV- Standard Deviation

4.2.3 Complexity of usage

The survey results analysis revealed that most of the respondents who are using of the system were in agreement as supported by mean greater than (~2.0) and standard deviation (stdv) (~1),66.3% of the users strongly disagreed (SD) when asked if they find working with technology complicated, 65.3% also strongly disagreed when asked if it takes long to learn use of virtual technology, 54.7% also strongly disagreed when

asked if it takes them too much time when they want to use virtual technology and 45.3% strongly disagreed when asked if they find virtual server technology complex to use as shown in table 2.

Table 2: Complexity of virtual server usage

	SD	D	U	A	SA	NR	Mean	Stdv
Working with virtual server technology is complicated, it is difficult to understand what is going on	66.3	23.2	2.1	3.2		5.3	**2.3804**	**3.69860**
It takes too long to learn how to use the virtual server technology to make it worth the effort	65.3	23.2	2.1	3.2	3.2	3.2	**1.5109**	**.94081**
It takes too much time for me if I want to use virtual server technology to do my normal duties	54.7	32.6	3.2	2.1	2.1	5.3	**1.5667**	**.84629**
In general virtual server technology is very complex to use	45.3	34.7	8.4	6.3		5.3	**1.7444**	**.87881**

SD –Strongly disagree D- Disagree U-Undecided A- Agree, SA-Strongly Agree NR-Non Responsive STDV- Standard Deviation

4.2.4 Security and Privacy

The analysis of the results revealed that most of the respondents who are using the system were in agreement as supported by mean greater than (~2.0) and standard deviation (~1), 41.1% strongly agree that virtual server technology gives them secure service, 50.5% strongly feel that it provides data security, 44.2% strongly feel that their data is secured while they are using the system, 33.7% strongly feel that virtual server provides confidentiality of their data while 35.8% do not have any security concerns on virtual server usage as shown in table 3.

Table 3: Security and Privacy of the virtual server use

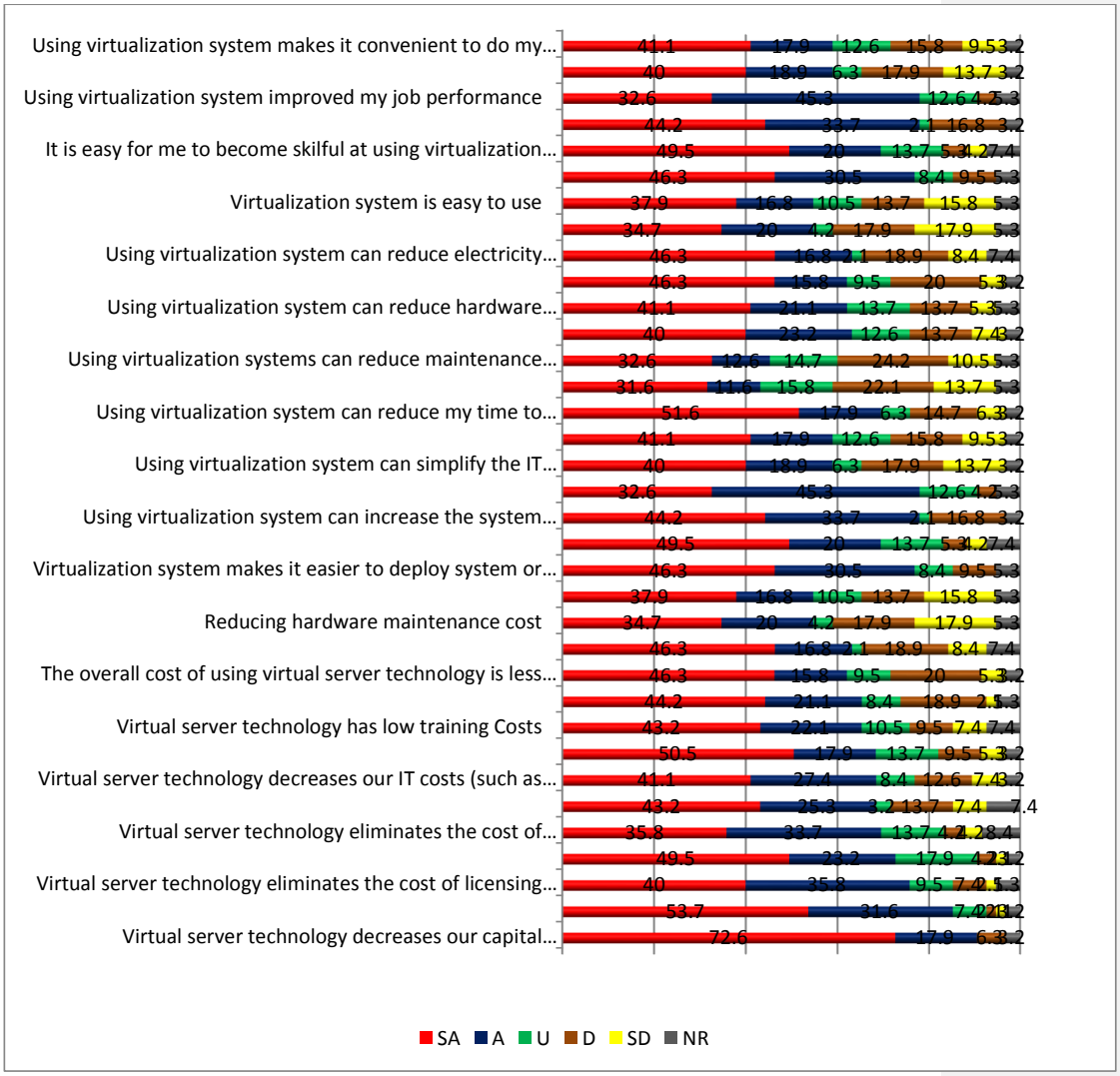
	SA	A	U	D	SD	NR	Mean	Stdv
Virtual server technology provides a secure Service	41.1	27.4	8.4	12.6	7.4	3.2	**2.5652**	**1.23964**
Virtual server technology providers' servers and data centers are secure	50.5	17.9	13.7	9.5	5.3	3.2	**2.2000**	**1.01607**
Virtual server technology maintain the privacy of our data we are using	44.2	21.1	8.4	18.9	2.1	5.3	**2.0543**	**1.11976**
Virtual server technology maintain the confidentiality of our data	33.7	28.4	4.2	12.6	13.7	7.4	**2.4444**	**1.08942**
Overall I do not have any concern about the security and privacy of virtual server technology services	35.8	25.3	15.8	17.9		5.3	**2.2826**	**1.08970**

SD –Strongly disagree D- Disagree U-Undecided A- Agree, SA-Strongly Agree NR-Non Responsive STDV- Standard Deviation

4.2.5 Reduction of Cost

The main aim of virtual servers is to cut the costs that come with technology adoption and according to the survey data; were in agreement that virtual technology cuts the; capital expenditure, investments on infrastructure, costs of licensing, deployments of technology, upgrading costs, system maintenance, personnel costs, opening costs, training related costs, installations and development, hardware establishment, electricity, flexibility, space and maximum utilization (no wastage) as shown in figure 10.

Figure 10: Reduction of Cost



4.2.6 Benefits and limitations of Cloud computing use

Cloud computing in institutions of higher learning must analyze both the benefits as well as the risks and also take into consideration the limitation that may be encountered as shown in (Table 4).

Table 4: Benefits and limitations of Cloud computing use

Benefits	Limitations
Access to applications from anywhere	Not all applications run in cloud
Support for teaching and learning	Risks related to data protection and security and accounts management
Software free or pay per use	Organizational support
24 hours access to infrastructure an content	Dissemination politics, intellectual property
Opening to business environment and advanced research	Security and protection of sensitive data
Protection of the environment by using green technologies	Maturity of solutions
Increased openness of students to new technologies	Lack of confidence
Increasing functional capabilities	Standards adherence
Offline usage with further synchronization opportunities	Speed/lack of Internet can affect work Methods

Decision to adopt cloud computing must take into account risks of not implementing but also implementation risks associated with this solution. If by implementation risks associated exceeds capital costs and compensates the associated must be obtained. As mentioned by (Catteddu & Hogben, n.d.)many risks specific cloud environment may be transferred to cloud providers as regard to implementation risks. Research conducted by IDC Enterprise Panel (Computer & Division, 2011) found out that

primary concerns of cloud adoption was related to security, performance and availability to customize, worried that on-demand it will cost more.

According to (Budnikas & Cien, 2011) there are many solutions for ensuring security and protection of sensitive data in the cloud such as mask or de-identity, firewalls, encryptions and key management, federated identity management. Data encryption is the simplest solution of data protection against any unauthorized access in cloud environment whereby data should be encrypted at source before being sent to the cloud (Viswanath, Kusuma, & Gupta, 2012).

4.3 Proposed Model for Virtual server

Figure 11 shows a proposed university cloud with satellite campuses.

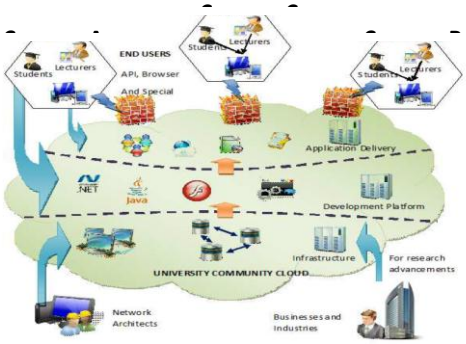


Figure. 11: Proposed cloud computing structure schematic diagram

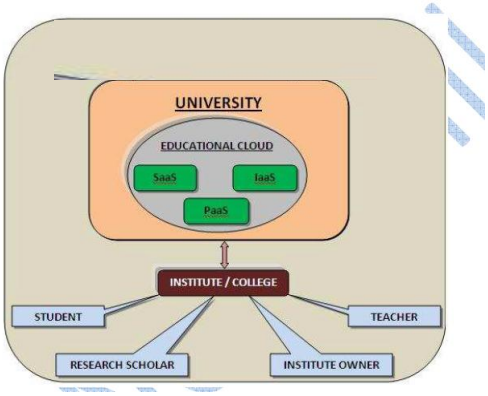


Figure 12: Simplified model

4.3.1 Proposed cloud deployment options for blended learning in higher education in Kenya

In this sub-section, two deployment options for CC services are proposed: for small or new institution, and for established institution. The choice of which option to adopt, will obviously depend on a well-developed cloud adoption strategy. Additionally, it will also vary from institution to institution depending on cost constraints, security and privacy requirements, number of users, Competence of internal IT staff, and institutional policies

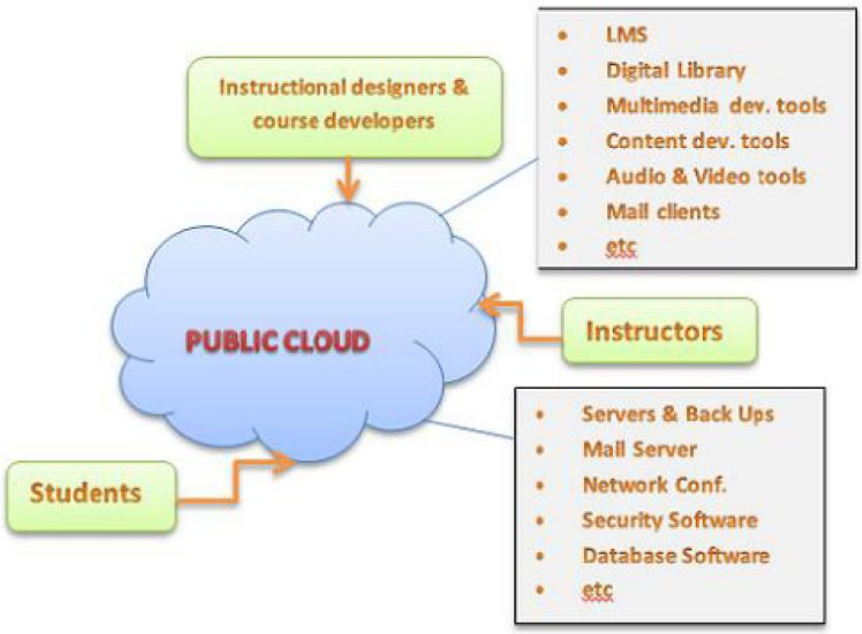
4.3.2 Small or new institutions

Many small or new institutions normally do not have competent and dedicated in-house servers and/or staff to support their CC courses. Moreover, these institutions have limited budgets to run most of teaching and research activities. However, these institutions can still engage in BL delivery without necessarily investing on ICT infrastructures by adopting public cloud. With the public cloud, all ICT infrastructures such as mail servers, LMSs servers, and related network accessories will be hosted into the cloud providers. Similarly, software application that support CC delivery such as LMS, digital library, course content development tools, and multimedia tools will be accessed directly from cloud provider's servers via internet.

There are numerous companies that provide public cloud services. These companies include Microsoft, Google, IBM, Amazon, Salesforce.com and HP Cloud Computing, and many others. The selection of the provider will depend on proposed evaluation criteria as well as institutional cloud adoption strategy. However, as pointed earlier, due to financial constraints, institutions may opt to partner with providers that offer free cloud services or at a discount and complement with commercial services.

Figure 11 shows a proposed public cloud set-up that can be adopted by HLIs to deliver BL courses. As shown in Figure 13, students, instructors, and other stakeholders will be accessing these resources via the internet. The main challenge of public model, is security and privacy concerns on confidential and valuable data such as research results, students' and employees' records, and financial data (Boja et al., 2013). However, institutions can migrate low risk CC services such as learning resources, timetable, emails and other learning activities, until they have developed enough capacity to deal with security issues.

Figure 13: Proposed Public cloud option for virtual learning delivery



4.3.3 Established Institutions

The second deployment option is proposed for institutions which have already invested their own ICT infrastructures over the years, and have enough technical staff to manage such infrastructure. In addition to hosting CC services, they have procured a number of servers to host other information systems. These systems include Student Records Management Systems (SRMSs), Financial Information Systems (FISs), and Library Information Systems (LIBISs) (Science & Engineering, 2013). Therefore, these institutions are recommended to combine the best of private and public cloud to create a *hybrid cloud* computing environment.

By hosting these services into the private cloud, institutions will be able to provide better control, security, and privacy protection of sensitive data. The cost of hosting into the cloud is far cheaper than in-house hosting. For example, the server with memory (RAM):15GB, 4 virtual cores, Outgoing bandwidth: 30, Hard drive: a least 800GB hosted by Google (https://cloud.google.com/pricing/compute-engine) is charged at US$ 381.6 per month, while Amazon through Elastic Compute Cloud (EC2) (http://aws.amazon.com/ec2/#pricing) charges at US$ 345.60 per month. All vendors have flexibility of paying for services you use, clearly, the prices will go down.

On other hand, low risk CC services as well as teaching activities which are only needed for a short time can be hosted in the public cloud (Bristow, Dodds, Northam, & Plugge, n.d.). These BL services include LMSs, multimedia development tools, mail services, student projects, websites for faculty, news and announcements and non-sensitive research activities, and similar services. The main advantage of adopting public cloud is that, normally new technologies from developed countries are quickly available in public clouds so students can access these technologies instantly (Bristow et al., n.d.). Additionally, institutions may opt to partner with cloud providers that offer free services for education such Google and Microsoft.

Figure 12 shows how BL services can be shared between private and public to create a hybrid cloud. Just like in the public cloud, students, instructors and other users will access BL services via internet. This option requires institution to create a very good

plan and strategies that differentiates services to be hosted in the public cloud and in private cloud.

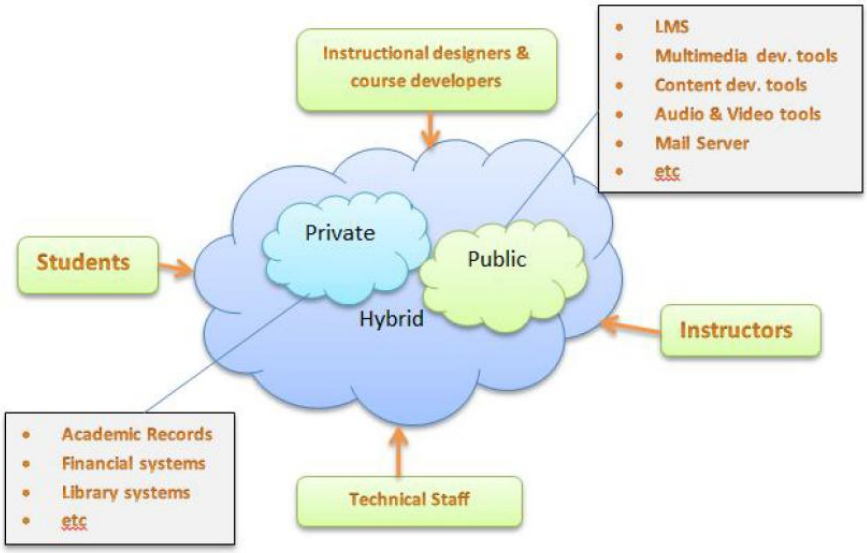


Figure 14: Proposed Hybrid cloud option for virtual learning delivery

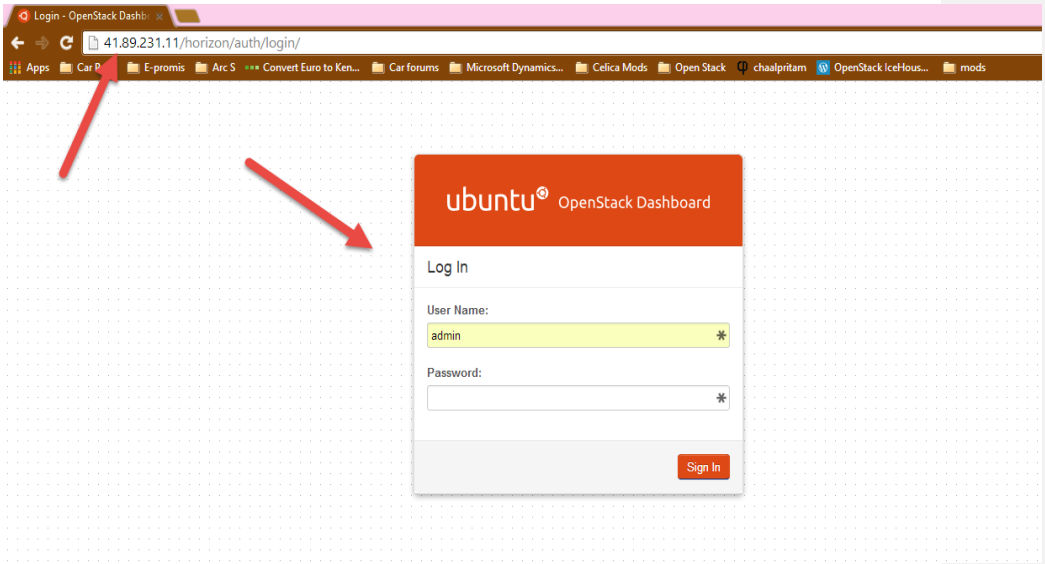
CHAPTER FIVE: IMPLEMENTATION AND TESTING

The screenshots below shows how the user accesses the system and usage.

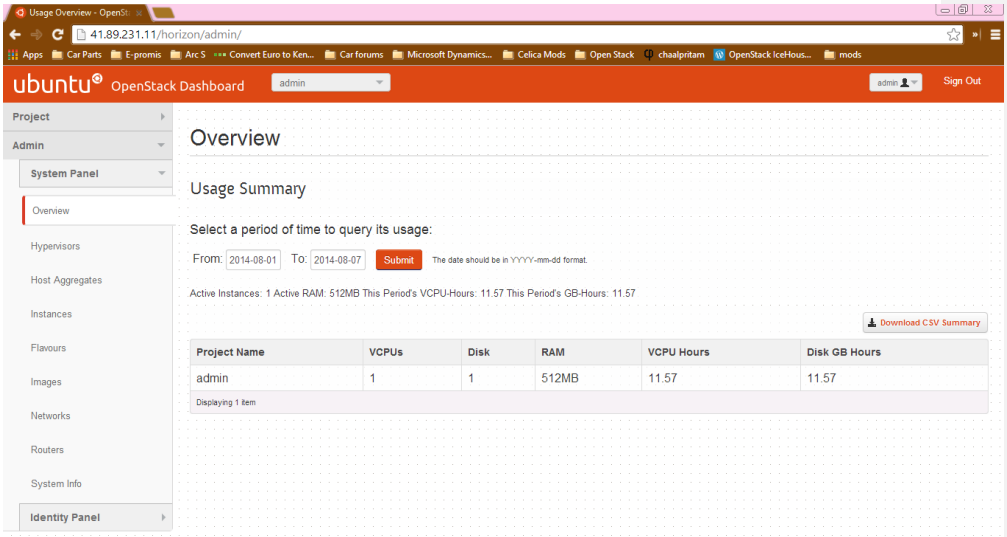
Logging in as Admin

To access the cloud interface, the user will have to login in using their credentials.

The url is http://41.89.231.11/horizon



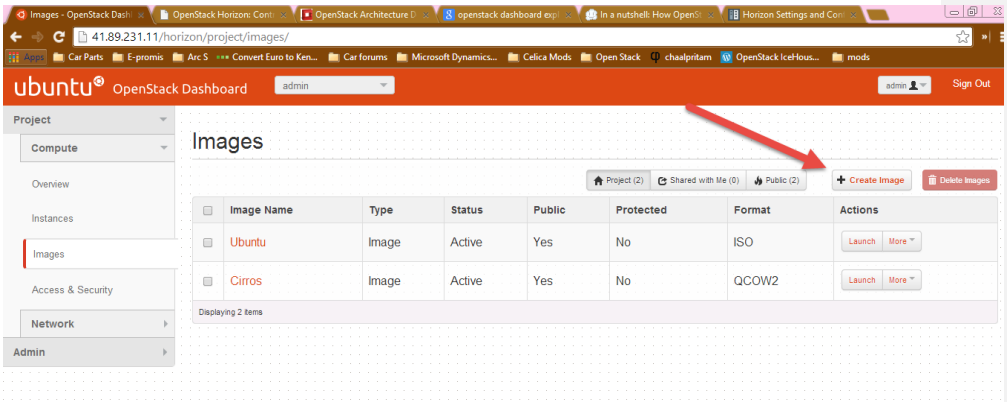
On logging in, the first screen displays the overview of the instances currently running.

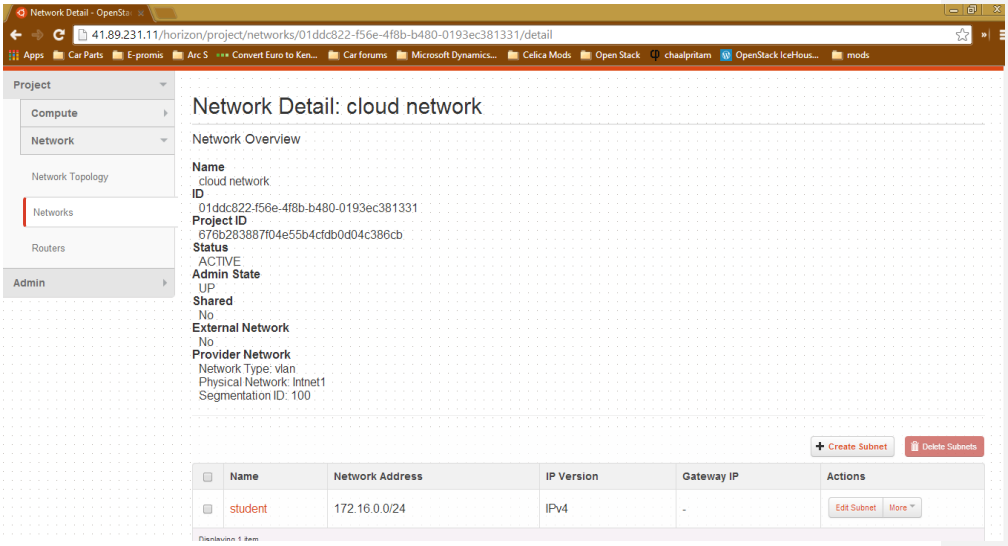


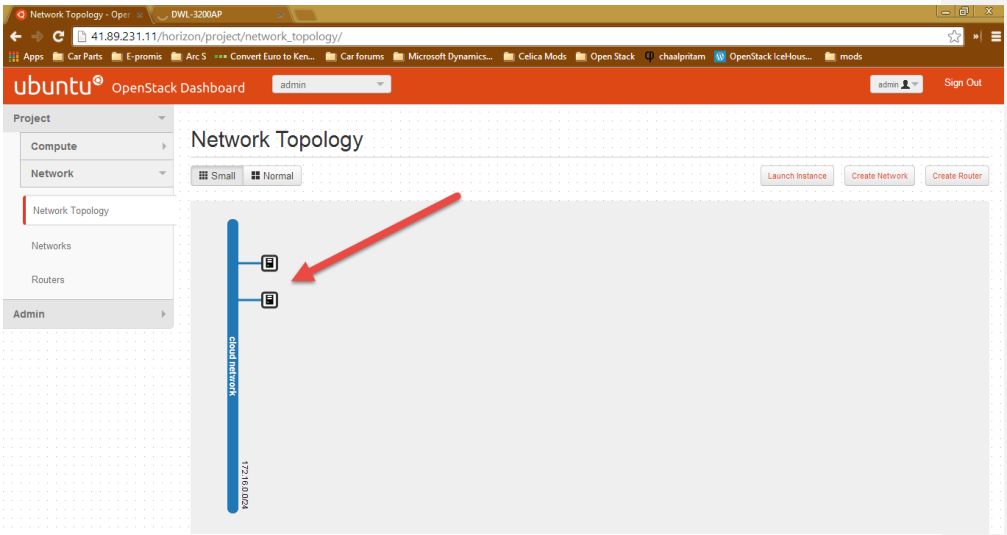
There are two main tabs:

1. Project: the project tab contains the computer and network sub tab
2. Admin: the admin tab contains the system panel and identity panel.

Operating system images are uploaded under the project>compute>images

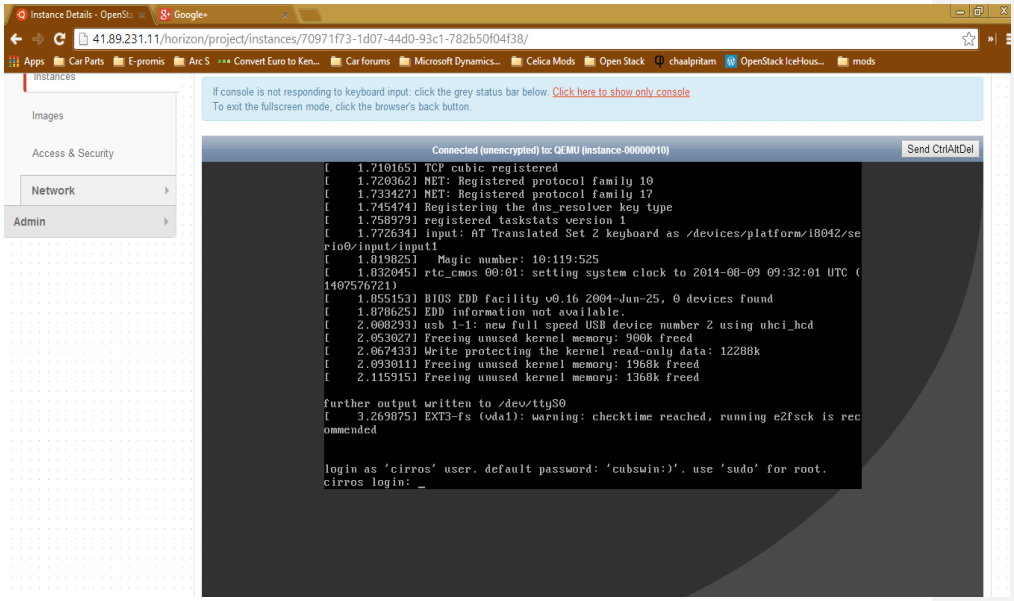




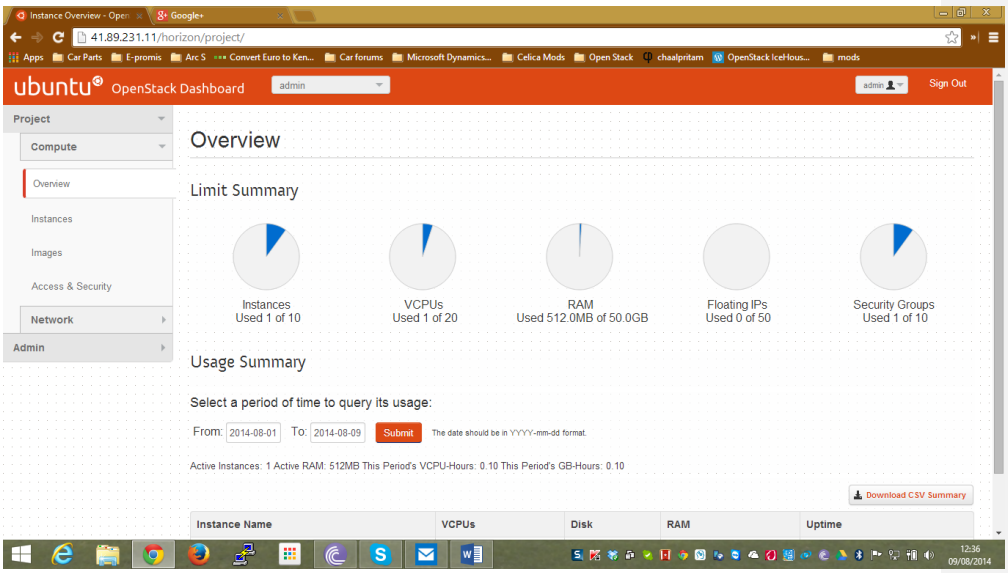


The network topology shows the launched instances in the network

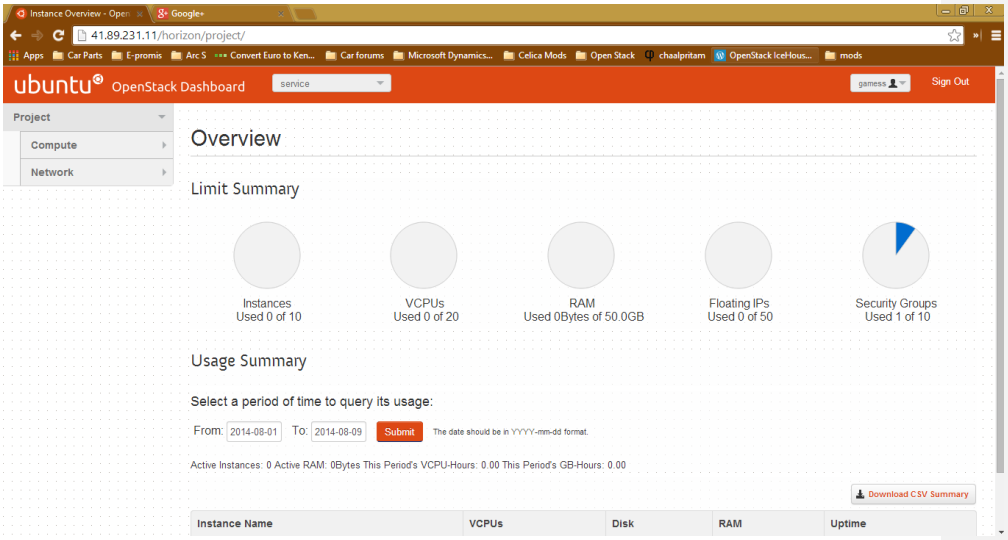
After launching an instance, you can view the console and now work on the virtual machine via the console.



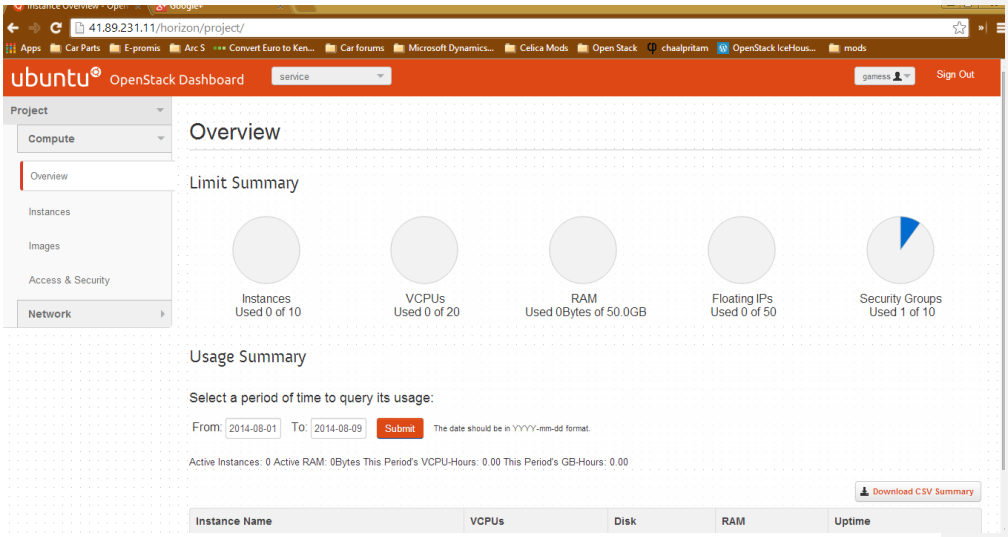
The project overview will show a summary of the running processes.



We will now show the user display screen



The user is limited to view the project tab only, that entails compute and network



CHAPTER SIX: DISCUSSION OF RESULTS

6.1 Discussion of Results

The aim is to develop a prototype that users all over the country can access services such as doing their projects and storing them and be able to access them anywhere with condition that they have internet access.

Cloud computing is considered an emerging computing paradigm which will become next generation platform that will be of tremendous value in information of any size access and storage. The shirt towards adopting cloud computing will enable Universities and educational institutions and college but in developed and developing communities to save money and take benefit of this developing technology. It will provide to both public and private institutions the computational facility on demand of use without any expense and create a common platform for sharing resources from various institutions across the globe.

In spite of limitations that may be faced in cloud computing and keeping in mind the present scenario of economic crisis facing Universities in developing countries like Kenya institutions of higher learning are trying their best to adopt the cloud computing as a solution to developing technologies and cut expenses. The main aim of this study was to identify new dawn in the institutions of higher learning that will revolutionize field of education. The benefits of cloud computing are the following as revealed by this study results;

Portability of the data was found to be very important to education institutions since students' projects and research in diverse fields and also collect information and materials associated with study like slides on lecture notes.

Also due to the poor economic conditions the government can only provide funds for few computers to each institution of higher learning which in most cases is not enough and students share 1 computer per about 50 students. However, according to this study the fulfillment of software for the computers requirements are even severe than hardware fulfillments since the government cannot afford the high costs that come with software that need constant upgrading and the costs are also increasing day by day. It has been found that pirated software has a lot of problems and does not give the exact performance which legitimate ones give and in addition the vendors of software are depriving from getting their revenue due to increasing used of pirated software. Also since the current system does not have any concept of resource sharing the government cannot meet the individual demand in supplying the needed unique resources for each person given the poor economic condition of the country. From this survey 50% of the PCs are not utilized fully as expected. But in cloud computing this wastage will be minimized since cloud computing will have knowledge of all unused resources from the free portions any request that will arrive will be assigned the un-used resource. Also the government will only have to buy the images of the software and distributed them among the institutions at minimum costs and this will cut software related costs and avoid any third party involvement in software purchasing and upgrading.

Also distance learning education will greatly benefit from this model of cloud computing since virtual systems provides opportunities to people in both urban and rural setting to access the distance learning with ease and efficiently. In urban areas we find some serious flaws in number of teachers, the quality of teachers or the availability of various updated resources such as different e-Learning toolkits. Moreover some people stay and work in a distant area has little access to higher education or their responsibility to job prevent them from catching the scheduled lectures.

6.2 Challenges

Just like for many new innovations, the adoption of cloud computing in institutions of higher learning have challenges. One being for adopting cloud services for service delivery is limited bandwidth in many parts of the country. Cloud needs the internet, thus with limited bandwidth it becomes a challenge to deliver services. However, internet access and speeds in Kenya just like in many developing countries is improving very fast. This is due to several broadband submarine cable systems initiatives such as SEACOM cable which has been implemented in the country. These initiatives and many others demonstrate that bandwidth problems in Tanzania will no longer a problem in very near future.

Moreover, ICT policies in many institutions of higher learning in Kenya have been developed without considering complexity of cloud computing. In addition to developing the virtual adoption strategy, institutions will have to review their policies and rules to accommodate cloud services in virtual delivery.

Security; There are several concerns surrounding the implementation of security in cloud computing and one of them is data privacy. The users do not have control or know where their data is being stored.

Performance and Availability: experiments that are research endeavors computing power. Some of the concerns include how to guarantee such performance from an outside vendor. Availability of services is another related concern in terms of the possibility of massive vendor outages. This is especially true since it may impact student learning or the timely delivery of the research results, which are typically tied to strict timelines.

Integration with in house IT and customizability: University IT administrators typically use their own in house applications with a considerable portion that is customized to their own lab structure. The concern is the transition of such in – house

applications to the cloud environment and how much of the customizability will be lost in that process.

Cost is another factor that may be introduced by additional vendor relationship management or possibly additional measures that are unique to cloud computing.

Control: The amount of control that the user has over the cloud environment varies.

Latency: All access to be cloud is done via the internet, introducing latency into every communication between the user and the environment.

Reliability: Many existing cloud infrastructures leverage communication

Finally, cloud computing is a new form of technology, clearly, many institutions of higher in Kenya like in many developing countries lack cloud computing professionals. There is a need for institutions of learning in the country to invest in capacity building.

6.3 Conclusions

Cloud computing provides a good solution which should address some of the IT challenges and bring new opportunities to distance learning. Institutes/Universities have begun to adhere to this initiative and there are proofs that indicate significant decreasing of expenses due to the implementation of cloud solutions.

The adoption of cloud computing has seen the users experience a lot of benefits. Cloud computing affords opportunities for greater student choice in learning. Using an Internet-connected device, students can access a wide array of resources and software tools that suit their learning styles and interests.

Cloud-based services can help institutes reduce costs and accelerate the use of new technologies to meet evolving educational needs. Students can use office applications

for free without having to purchase, install and keep these applications up to date on their computers. It also provides the facility of Pay per use for some applications.

Availability of the services is the most important and desired by the user using the education cloud 24 x7 is the availability that is needed by this system without failure. From anywhere one can login and access the information.

Colleges and governments are now free to focus on their goals that is making more research facilities available to the students and making the environment global in spite wasting time on worrying about the buildings, laboratories, and teachers and also education cloud will surely reduce the carbon footprint. This new facility is user friendly and no need to worry about the complexity. It is easy to understand and easy to operate.

6.3 Future Research

The study was limited to virtual learning in the institutions of learning and thus study recommends further study in following areas;

i. To find out if there is significant difference in adoption of virtual technology between the newly established Universities and the old ones
ii. To find out learners perception towards the adoption of virtual learning in the institutions of higher learning

6.4 Summary

In this research, the study reviewed how virtual computer will benefit the institutions of higher learning. The results shows that the benefits of virtual learning outweighs the disadvantages and although the institutions faces myriad of challenges overcoming them is key to enjoying the new learning mode where institutions do not have option but adopt it since in the near future everyone will be learning through the virtual options.

References

-, F. a. A., -, A. a. A., & -, A. M. A. (2012). Effective Use of Cloud Computing Services in Education. *Journal of Next Generation Information Technology*, *3*(4), 62–77. doi:10.4156/jnit.vol3.issue4.7

Armbrust, M., Joseph, A. D., Katz, R. H., & Patterson, D. A. (2009). Above the Clouds : A Berkeley View of Cloud Computing.

Boja, C., Pocatilu, P., & Toma, C. (2013). The Economics of Cloud Computing on Educational Services. *Procedia - Social and Behavioral Sciences*, *93*, 1050–1054. doi:10.1016/j.sbspro.2013.09.328

Bristow, B. R., Dodds, T., Northam, R., & Plugge, L. (n.d.). the.

Budnikas, G., & Cien, R. M. (2011). Application of Cloud Computing at KTU : MS Live @ Edu Case, *10*(2), 259–270.

Buyya, R., Yeo, C. S., Venugopal, S., Broberg, J., & Brandic, I. (2009). Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility. *Future Generation Computer Systems*, *25*(6), 599–616. doi:10.1016/j.future.2008.12.001

By:- sewale belachew demeke. (2012).

Catteddu, D., & Hogben, G. (n.d.). The European Network and Information Security Agency (ENISA) is an EU agency created to advance This work takes place in the context of ENISA ' s Emerging and Future Risk programme . C ONTACT DETAILS : This report has been edited by :

Computer, N., & Division, S. (2011). The NIST Definition of Cloud Computing Recommendations of the National Institute of Standards and Technology.

Computing, C. (2010). *Handbook of Cloud Computing*. (B. Furht & A. Escalante, Eds.). Boston, MA: Springer US. doi:10.1007/978-1-4419-6524-0

Dineva, S., & Nedeva, V. (n.d.). Cloud Computing And High Education, *1*(1).

Erkoç, M. F., & Kert, S. B. (n.d.). Cloud Computing For Distributed University Campus : A Prototype Suggestion.

Goldstein, P. J. (2009). Alternative IT Sourcing Strategies : From the Campus to the Cloud, (September), 1–12.

Mell, P., & Grance, T. (n.d.). The NIST Definition of Cloud Computing Recommendations of the National Institute of Standards and Technology.

Mujinga, M. (2011). Cloud computing concerns in developing economies.

Pantić, Z., & Babar, M. A. (2012). *Guidelines for Building a Private Cloud Infrastructure*.

Pocatilu, P., Alecu, F., & Vetrici, M. (n.d.). Using Cloud Computing for E-learning Systems 2 Cloud Computing, 54–59.

Priščáková, M. Z., Rábová, I., Ph, D., & Salák, J. (n.d.). The usage of cloud computing technology in university environment Department of informatics , Faculty of Business and Economics ,.

Science, C., & Engineering, S. (2013). International Journal of Advanced Research in Role of Cloud Computing in Higher Education, *3*(7), 966–972.

Siegle, D., & Ph, D. (2010). Cloud Computing: A Free Technology option to Promote Collaborative learning, 41–45.

Sultan, N. (n.d.). Author ' s personal copy Cloud computing : A democratizing force ?

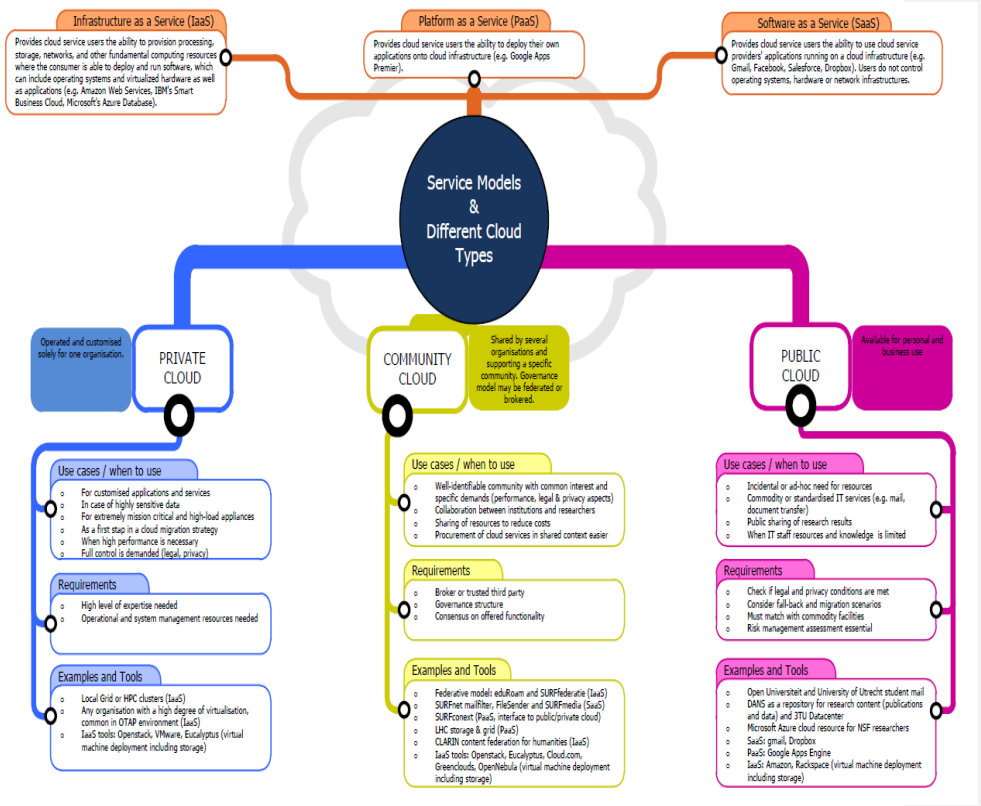
Sultan, N. (2010). Cloud computing for education: A new dawn? *International Journal of Information Management*, *30*(2), 109–116. doi:10.1016/j.ijinfomgt.2009.09.004

Tønnesland, T. A. (2013). Evaluation of a Private Cloud for Higher Education, (June).

Viswanath, D. K., Kusuma, S., & Gupta, S. K. (2012). Cloud Computing Issues and Benefits Modern Education, *12*(10).

Appendices

APPENDIX I: Cloud Services for Higher Education and Research



Appendix II: Questionnaire

Kindly fill in the following questions. Please respond to the questions as honestly as possible. The participation in the process is voluntary. In some questions you are required to fill in the details while others make a choice and tick appropriately.

1. ***The benefits from using virtual system***

Please tick the appropriate box (1-5) using the rankings below:-

1 = Strongly Disagree 2 = Disagree 3 = Undecided 4 = Agree 5 = Strongly Agree

Statement	SA	A	U	D	SD
Using virtual server technology would enable us to accomplish tasks more quickly					
Using virtual server technology would improve the quality of the work we do					
Using virtual server technology would makes it easier for us to do our job					
Using virtual server technology would enhance our effectiveness on the job					
Using virtual server technology would increase our company's productivity					
Using virtual server technology would improve our job performance					
Virtual server technology improves our operational efficiencies					
Virtual server technology would enhance our company's data storage capacity					
Compared to traditional computing, virtual server technology would make data-intensive computing faster					
Virtual server technology allows us to use the latest version					

of the technology					
Overall I think using virtual server technology would be advantageous for my business					

2. Virtual server technology knowledge

Please tick (√) the appropriate box (1 - 5) using the ranking below:-

1 = Poor, 2 = Fair, 3 = Good, 4 = Very Good, 5 = Excellent

Statement	Poor	Fair	Good	Very Good	Excellent
My knowledge about the underlying structure of virtual server technology is:					
My knowledge about the benefits of using virtual server technology is:					
My knowledge about virtual server technology is					
My knowledge about the difference between virtual server technology and other types					
My knowledge about various models of virtual server technology					
My information about different types of virtual server technology (public, private and hybrid)					
My knowledge about the pricing model of virtual server technology					
In comparison to the people in similar positions I would rate my own understanding of virtual server technology as					

3. Complexity of usage

Please tick (√) the appropriate box (1 - 5) using the ranking below:-

1 = Strongly Agree, 2 = Agree, 3 = Undecided, 4 = Disagree, 5 = Strongly Disagree

Statement	**SA**	**A**	**U**	**D**	**SD**
Working with virtual server technology is complicated, it is difficult to understand what is going on					
It takes too long to learn how to use the virtual server technology to make it worth the effort					
Learning to operate the virtual server technology system is easy for me It takes too much time for me if I want to use virtual server technology to do my normal duties					
If you are still reading this, please select strongly agree					
In general virtual server technology is very complex to use					

1. ***Security and Privacy***

Please tick (√) the appropriate box (1 - 5) using the ranking below:-

1 = Strongly Agree, 2 = Agree, 3 = Undecided, 4 = Disagree, 5 = Strongly Disagree

Statement		**SA**	**A**	**U**	**D**	
Virtual server technology provides a secure Service						
Virtual server technology providers' servers and data centers are secure						
The media that is used to transmit our data to virtual server technology providers' data center is secure						
Virtual server technology maintain the privacy of our data we are using						
Virtual server technology maintain the confidentiality of our data						
Overall I do not have any concern about the security and privacy of virtual server technology services						

Formatted: Font: Font color: Auto

2. Reduction of Cost

Please tick (√) the appropriate box (1 - 5) using the ranking below:-

1 = Strongly Agree, 2 = Agree, 3 = Undecided, 4 = Disagree, 5 = Strongly Disagree

Statement	**SA**	**A**	**U**	**D**	**SD**
Virtual server technology decreases our capital expenditure					
Virtual server technology decreases the investment in new infrastructure					
Virtual server technology eliminates the cost of licensing new software					
Deployment process of virtual server technology involves a negligible amount of time and effort					
Virtual server technology eliminates the cost of upgrading the system					
Virtual server technology decreases the cost of system maintenance					
Virtual server technology decreases our IT costs (such as IT personnel)					
Virtual server technology decreases our operating cost					
Virtual server technology has low training Costs					
Virtual server technology has high training Costs					
The overall cost of using virtual server technology is less than the cost of installing or developing a technology in-house					
Reducing hardware establishment cost					
Reducing hardware maintenance cost					
Reducing electricity usage by facilities					
Virtualization system makes it easier to deploy system or services					

Virtualization system can flexibly adjust to meet the needs of the user					
Using virtualization system can increase the system development and testing flexibility					
Using virtualization system can save space of computer room					
Using virtualization system can simplify the IT infrastructure					
Virtualization system can use the server resources fully					
Using virtualization system can reduce my time to management system					
Using virtualization systems can reduce the number of physical servers					
Using virtualization systems can reduce maintenance manpower					
Virtualization systems better than the physical servers to reduce service downtime					
Using virtualization system can reduce hardware implementation cost					