UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

A MIGRATION FRAMEWORK TO DATABASE AS A SERVICE FOR UNIVERSITIES: A CASE OF A KENYAN UNIVERSITY

by

GACHANJA LYDIAH WAIRIMU

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Supervisor

Dr Andrew Kahonge

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DECLARATION

I declare that this project is my original work and has not been presented for a degree in other university.

Signature …….. Date …….

Gachanja, Lydiah Wairimu

P53/65991/2013

This project report has been submitted in partial fulfill of the requirement of the Masters of Science Degree in Distributing Computing Technology of the University of Nairobi with my approval as University Supervisor

Signature ……. Date ……..

Dr. A. M. Kahonge

School of Computing and Informatics

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ABSTRACT

Educational establishments continue to seek opportunities to rationalize they way they manage their resources. Innovation is necessary to ride the inevitable tide of change and one such hot recent area in Information Technology is cloud computing. Cloud computing is distributed cloud technology offering required software and hardware through internet. Due to the growing need of infrastructure, educational establishments have to spend a large amount of money on their infrastructure to fulfill the needs and demands of the users. The objective of this study was to design a database as a service migration framework for universities, taking into consideration Kenyan universities. The specific objectives were:- to explore the use of cloud computing in institutes of higher learning; examine the state of art of cloud computing in Kenyan universities; examine the readiness of Kenyan universities to adopt database as a service; examine the current cloud data migration frameworks and propose a cloud data migration framework for Kenyan universities. The study adopted descriptive research design. The study was done in four universities particularly in Information Communication Technology (ICT) department of each university. The target population was 200 ICT staff; the sample size of 24 respondents was used in the study.

Data collection was done through questionnaires and semi structured interviews. Quantitative data was analyzed using descriptive analysis and presented through bar charts and pie charts. Thematic analysis was used to analyze qualitative data. The findings showed that institutions with population of above 40000 were more likely to adopt cutting edge cloud computing solutions than those with less population since they were found to be more innovative than the rest. The study concludes that institutes of higher learning in Kenya are ready to adopt database as a service though this will depend on the size of the institution.

The study also concludes that the proposed framework will be very useful for universities during migration of their data in cloud because the framework is vendor and technology-independent and it ensures that institutional security constraints are achieved during and after migration. The study further concludes that the proposed migration framework will play a great role in standardizing cloud computing technology and contribute to the technology maturing since there is no other vendor-technology independent framework for database migration. This work will be

of great importance for educational establishments in Kenya as they seek to implement cutting edge cloud computing solutions. It will also be of importance to academic research as it will add literature on migrating database to cloud.

Key words: Cloud Computing, Database-as-a-service, Migration Framework, Educational establishments, Cloud data

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LIST OF ABBREVIATIONS

CC	Cloud Computing
CUE	Commission of University Education
CDBMS	Cloud Database management System
CSPs	Cloud Service Providers
DBaaS	Database as a Service
DBMS	Database Management System
DOI	Diffusion of Innovation
HEIs	Higher Education Institutions
IaaS	Infrastructure as a Service
ICT	Information Communication Technology
IT	Information Technology
NIST	National Institute of Standard and Technology
RDBMS	Relational database management system
PaaS	Platform as a Service
SaaS	Software as a Service
SLAs	Service Level Agreements
TAM	Technology Acceptance Model
TOE	Technological, Organizational and Environmental context theory
TRI	Technology Readiness Index

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Higher Education (HE) plays a major role in overall development of a country, as it is considered as a powerful mean to create a knowledge based society. The collaboration between universities, governments and industries, researchers and students has proven their contribution to the transformation of society and entire world economy. Educational establishments continue to seek opportunities to rationalize the way they manage the resources. It is increasingly recognized that using technology effectively in HE is essential to provide high quality education and to prepare students for the challenges of 21st century. The collaboration between technology and education has formed a concrete basis for societal development and advancement. In fact education feeds IT and IT in turn forms the bedrock of education. Attainment of sustainable socio-economic development in a society implies that there is need to be a sustainable development framework that enables delivery of education services with maximum benefits at minimum service cost (Abusalam & Fatima 2011; Cisco 2012; Idowu & Adenike 2012; Kumar & Murthy 2013).

HE landscape around the world is in a constant state of flux and evolution, mainly because of significant challenges arising from effort in adopting new and emerging technologies (Masud, Yong & Huang 2012). According to Horn as cited by (Golden 2009), traditional higher education has faced disruptions especially in third world countries because development is associated with expensive or complex technologies that are unsuitable for many users due to cost, difficulty in use or irrelevance to contemporary needs. The use of internet and Information Communication Technologies (ICTs) to deliver educational resources is considered mainstream in the 21st century, yet in higher education in developing countries it is often seen as luxury. This has far reaching effects on lecturers, students, administration and stakeholders in these countries, which often lack the basic IT infrastructure. It is increasingly accepted that in the near future most information resources and desktop applications will be accessed through the internet,

what is now known as “cloud” (Saidhbi 2012; Mtebe 2013). The different stakeholders of university like students, parents, employees, management and administration are continuously engaged in the process of educational planning, growth and other activities. The modern age educational scenario has lead to the growth in data as the quantity of information, data collected and processed for the planning and management of educational activities has been constantly increasing. In order to provide various facilities to the students, staff, faculty members and other stakeholders, the university needs storage and computing systems that would integrate multiple services and concerned requests.

Cloud Computing (CC) offer a solution to many challenges faced by HE worldwide and much more in developing countries where many researchers see CC as a way of making developing economies catch up with developed economies (Kshetri 2010). The push by information technology (IT) industry, coupled with significant benefits that cloud computing promises to deliver, leads the author to believe that CC will be widely used in HE. In addition, we understand that the distinctive features of higher education information management require a careful consideration concerning whether, how, where and when they might adopt cloud computing. And CC concepts enable HE to create private clouds within their infrastructure (Bansal et al. 2012). Cloud computing has become a highly attractive model for higher education today, with many options and benefits that offer excellent value and return on investment (NEC 2013).

The computing world is shifting from enterprise centric to data-centric workloads driven by the Big Data revolution, while cloud computing is becoming mainstream, reinventing utility/elastic computing as the new mantra for IT industry (Jain & Pandey 2013). Cloud computing takes benefit of many technologies such as server consolidation, huge and faster storage, grid computing, virtualization, N-tier architecture and robust networks (Britto 2011). But the cloud database will become the most adopted technology for storing huge data by many companies of the world (Waleed 2013). The key benefits of cloud database services are; it speeds application development, save money and improves IT productivity. This new environment implies great flexibility and availability of computing resources at different levels of abstraction at low cost.

Kenya like any other developing nation has suffered by limitation of education budget. Higher education institutions in this country have increased in the recent past; currently there are 22 public universities and many other private universities. Each of these universities has their own campuses and constituent colleges that are located in different parts of the country (Commission of University Education (CUE) 2013). Without quality education, establishing educational institutions by itself cannot solve the solution of eradicating poverty and economic development through education. Education should be supported through up-to-date technologies and services (Saidhbi 2012). The government has been investing millions of shillings every year to support education in higher education institutions. However, due to struggling economy, it is not able to support full ICT infrastructure requirement of all universities.

When it comes to implementations of IT, the universities in Kenya have taken a steady move. With reference to this, they offer most of their services to students, faculty members and staff via web based portals. They also have adopted some free cloud services such as Google email, calendar, Google docs and drop box. These have helped them in administration of students' needs and communication through faculties. Due to the large amount of data generated and stored during these educational activities, the current systems have proved to be ineffective because of lack of scalable services. This is so because the current systems rely on traditional relational databases.

For a long time, relational database systems have been the best technology to manage and analyze large data ware houses. On the other hand, there has been an explosion of semi structured data on the internet represented by documents, web pages, images and diverse files, which are stored and queried by search engines. Relational databases offer an extensive functionality to effective and efficient reliable update online transaction processing databases with transaction and to analyze large amount of data with queries using Structured Query Language (SQL) (Zaki 2014). However relational database systems are not flexible and efficient enough to manage and analyze large collections of semi structured data files (Ordonez et al. 2010). Therefore, there has been alternative database technology to solve such limitations. Database as a Service (DBaaS) is a cloud

service where traditional database management system (DBMS) is transformed into scalable, elastic and autonomic database platform. It can be implemented using relational database management system or non-relational database management system.

1.2 Problem statement

HEIs in Kenya face a lot of challenges in delivering quality education and meeting demands of an ever increasing number of students and faculty. Although they have implemented web based services to facilitate effective and efficient delivery of services to both internal and external constituents; the current system is being overwhelmed by increased workload. This is evidenced by outage of online services in the beginning of every semester during admission and registration. This is an indicator that in the near future, the current system will no longer sufficiently fulfill the current and future requirements of the institutions and therefore migrating to another platform is inevitable. With reduced budgets and collapsing economies, HEIs are looking for superior technology that will meet their current and future needs yet at low cost. CC has proved to offer relieve for these challenges, therefore time has come when university administrators must consider adopting CC to improve teaching agility and have a cost effective infrastructure which can bring revolution in the field of education. Migrating some of their current application databases to a private cloud, will improve efficiency and flexibility in a way that can support wide range of on-demand requirements (NEC 2013). This can only be realized if a proper readiness self-assessment is done and a proper migration framework is in place. Therefore, the need for a study to investigate state of art of cloud computing in Kenyan universities, assess HEIs readiness and develop a cloud data migration framework. This study was seeking to find out the state of cloud computing in Kenyan universities, the readiness of Kenyan universities to adopt CC, and develop a migration process framework.

1.3 General Objective

The objective of this study was to propose a database as a service migration framework for universities.

The study was to achieve the following objectives:-

1. To explore the adoption of cloud computing in institutes of higher learning
2. To investigate the state of art of cloud computing in Kenyan HE
3. To assess universities' readiness to adopt database as a service
4. To present a migration framework to database as a service in a Kenyan university

1.4 Research Questions

The study sought to answer the following questions:-

1. What are the factors that influence adoption of CC in higher education institutes?
2. Are Kenyan Universities ready to adopt database as a service cloud solution?
3. What cloud migration frameworks exist and can thye be used to migrate institutions' database to cloud?

1.5 The scope of the study

The study used a kenyan university as a case study focussing on readiness for adoption of a private cloud implemented through database as a service, and come up with a migration process framework. The study was done in four universities; these are University of Nairobi, Kenyatta University, St. Paul's university, Karatina University.

1.6 Justification

The cloud database migration framework to the stake holders was to provide the following benefits;

1. Academically, it will add to the body of knowledge, and contribute positively to the adoption of cloud computing in Higher Education Institutions in Kenya.
2. The proposed framework will help in maturation of cloud computing technology because currently the technology lacks vendor and technology independent frameworks and methodology of migrating data as concluded by Jamshindi et al. (2013)

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter reviews literature related to key concepts highlighted in the specific objectives. The chapter begins by introducing the concept of cloud computing detailing the services and deployment models available. It will also discuss adoption of cloud computing in higher education institutions (HEIs). Further, the adoption of database-as-a-service business organizations and higher education institutions will be discussed and also migration to cloud will be discussed. There is no available literature on adoption of cloud computing by Kenyan universities, therefore this study will use available literature on adoption of cloud computing by HEIs.

2.1 Cloud Computing definition

Cloud computing is growing at a tremedous pace in the IT industry around the world (Sharma 2012; Waleed 2013). Cloud computing has become very popular due to its lesser cost, scalability and pay-as-you-go model. Cloud computing can be said to be a new dimension in IT world in terms of cost saving and faster application performance. It is one of the biggest changes in IT after the rise of World Wide Web (Arora & Gupta 2012; Sanchati & Kulkarni 2011). It is a topic that have received a great deal of attention by individuals and organizations from different displines in the last decade (Ahmed 2012).

Cloud computing paradigm is a new approach to produce a solution for old problems. This model offers many advantages to enterprises, industries and universities (Sarvesh 2012). There is no concensus about what cloud exactly is. We list down some defination of cloud computinng made by researchers; According to Vouk (2008) cloud computing is the next natural step in the evolution of on-demand information technology services and products based on virtualization of computer resources. Buyya et al. (2008) define the cloud as ‘ a type of parallel and distributed system consisting of collection of interconnected and virtualized computers that are dynamically provisioned and present as one or more unified computing resources based on service level agreements (SLAs)

established through negotiation between service provider and customer‘, while Foster et al. 2008 define cloud as ‘a large scale distributed computing paradigm that is driven by economies of scale, in which a pool of abstracted virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet.’ The National Institute of Standard and Technology (NIST) of the US department of commerce define the cloud as ‘a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction’.

Attempts to cloud computing standardization are being done by various groups, including governments and industry (Shirlei et al. 2011). NIST is one of them, having defined the cloud as composed of five essential characteristics, four deployment models and three service models (Diane et al. 2010; Magilla 2012; Sahki 2012; Shirlei at al. 2011). The table 1 below summarizes the NIST proposed essential elements.

Table 1.1: Summary of NIST essential elements

Element	NIST description
On-demand self service	A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.
Broad network access	Capabilities are available over the network and accessed through standard mechanism that promote use by heterogeneous thin or thick client platforms (e.g. mobile phones, tablets, laptops and workstations)
Resource pooling	The providers computing resources are pooled to serve multiple consumers using a multi-tenant model, with

	different physical and virtual resources dynamically assigned and reassigned according to consumer demand. Example of resources include storage, processing, memory and network bandwidth
Rapid elasticity	Capabilities can be elastically provisioned and released in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropirated in any quantity at any time.
Measured service	Cloud system automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropiriate to the type of service (e.g. storage, processing, bandwidth and active user accounts)

2.1.1 The NIST deployment models

2.1.1.1Private Cloud and Public Cloud

In private cloud, the infrastrucuture is operated solely for an organization and it may be managed by the organization or a third party. It may exist on premise or off premise, while public cloud infrastructure is made available to the general public or a large industry group and it is owned by the organization selling the services.

2.1.1.2 Community Cloud

Community cloud infrastructre is shared by several organizations and supports a specific community that has shared concerns such as mission, security requirements, policy and compliance considerations. It may be managed by the organizations or a third party and may exist on premise or off premise.

2.1.1.3 Hybrid Cloud

In Hybrid cloud, is a composition of two or more clouds (private, community or cloud) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application.

2.1.2 NIST Service Delivery Models

NIST has also divided cloud computing into three main service delivery models known as SPI model (Software, Platform and Infrastrucure) Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-a-a-service (SaaS). Cloud computing enables the delivery of services through the on-demand service provisioning model to end-user on pay-as-you-go model basis over the network such as the internet.

2.1.2.1 Infrastructure –as –a Service (IaaS)

In IaaS the CSP provides a set of virtualized computing resources (e.g. network bandwidth, storage capacity, memory, power processing) in the cloud. It is the responsibility of the customer to run and maintain the operating system and the software applications on these virtual resources.

2.1.2.2 Platform-as-a-Service

In Platform-as-a-Service provides functionalities like application developments, middleware capabilities as well as functions like databases, messaging and queuing. PaaS offers the development platform to developers through a web browser while hosting all the development tools in the cloud.

2.1.2.3 Software-as-a-Service (SaaS)

Software-as-a-Service enables the consumers to use the applications that are running on provider’s cloud infrastructure. The application (software) can be accessed by using various client devices such as graphical user interface provided by the SaaS provider or through a web browser. The consumer has no control over the underlying cloud infrastructure that include network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

However, there are other emerging services besides the traditional SPI model but they all tend to fall in one of the three categories (Bashir et al. 2013; Sahki 2012). These services are Storage-as-a-Service, Security-as-a-Service, Database-as-a-Service and Testing-as-a-Service (Malliga 2012). This study will focus on migrating towards Database-as-a-Service (DBaaS) as discussed in the section 2.3 below.

2.2 History of cloud databases

In recent years, database outsourcing has become a useful component of cloud computing. Due to advancement of network technology, the cost of transmitting one terabyte over a long distance has decreased significantly for the last decade. In addition, the cost of data management is five to ten times higher than initial acquisition cost. As a result there is growing interest in outsourcing data management tasks to third parties who can provide these tasks for lower cost due to economy of scale. This new outsourcing model has the benefit of reducing cost of running Database Management System (DBMS) independently (Buyya et al. 2011). Cloud computing economics leveraging power of multi-tenancy delivers extremely shared storage at dramatically reduced cost. Virtualization then compounds these advantages by enabling users to scale elastically to pay only for the resources they use. A Cloud Database Management System (CDBMS) is a distributed database that delivers computing as a service instead of product. It is the sharing of resources, software, and information between multiple devices over network which is mostly the internet (Gelogo & Lee 2012; Monica Kadam et al. 2014).

Database Management System (DBMS) is software packaged with programs that control creation, maintenance and use of a database. It enables organizations to easily develop database for various application by Database Administrators (DBAs) and other specialists. A database is an integrated collection data records, files, and other objects. A DBMS enables different user application programs to concurrently access the same database. DBMS generally supports query languages which are high level programming languages. Due to introduction of cloud computing DBMS has emerged into a new type of service having its own benefits (Monica Kadam et al. 2014).

A cloud database is a database that involves variety designing, developing of hardware and software. Traditional DBMS are not well versed to deal with the growing demand for cloud computing. And certainly, if the DBMS was applied as a service as part of a larger package provided, it would be much more efficient in its duties and therefore much cheaper in the long run. All DBMSs, whether traditional or cloud based, acts as a communicator that function as middlemen between the operating systems and the database (Bandara 2010; Gelogo & Lee 2012). However cloud based DBMS works on larger volume of data that would exhaust a classical DBMS. Cloud DBMS combines data structures and the data querying language and utilize all the DBMS components or may devise new strategies that may combine one or more elements (Curino et al. 2010).

Database Management Systems as a cloud service are made to run as a scalable, elastic service available on a cloud platform. Cloud based DBMS are structured only as a cloud offering and are not as relational. Clouds based DBMS services are powerful and have distributed environment with flexible resources allocation for use in simple as well as complex transactions. Most of the currently available DBMS engines run on cloud infrastructure, but are not specifically structured to take advantage of the cloud. This difference is the reason why the change in name from" DBMS in the cloud" to "cloud service based on DBMS" (Gelogo & Lee 2012). DBMS as a cloud service-type model seek to capitalize on the disparity between outdated DBMS models and their lack of full cloud functionality.

We agree that traditional Database systems are an attractive interface for managing and accessing data and have proven to be successful in many financial, business and internet applications. However, the current trend of Big Data, global users and cloud computing are driving force for organizations to migrate towards cloud databases or non relational databases. The major market of relational databases is the business data processing and these are architected to run on a single machine and use a rigid and scheme based approach in modeling the data and dealing with big data and global users on cloud environment becomes more and more difficult for relational databases (Zaki 2014). Non-relational databases (commonly referred to as NoSQL) are considered to be new era databases that provide dynamic schemas, dynamic data model, scale-out architecture,

efficient big data storage and access requirements. Today the use of NoSQL databases is mainly because of its scalability and performance characteristics.

2.3 Database as a service (DBaaS)

Virtualization is the base for cloud computing because it eliminates the dependencies between software and hardware that runs it. Institutions are no longer apprehended to the traditional unproductive ratio of 1:1:1 for servers, operating systems and applications. This decoupling allows IT to turn underutilized infrastructure into an elastic, resilient, partitioned and secure pool of computing resources available to users on demand (VMware 2011). By leveraging virtualization as cloud's foundation and deploying applications to a private, hybrid or community cloud, including those provided by consortiums, IT leaders can make their organizations to be more responsive. They can offer IT as a Service, creating improvements at each critical layer of a modern IT architecture: infrastructure, applications and end-user computing.

Elmore et al. (2013) argues that the idea of virtualization can be used to consolidate databases into a unified service to reduce high cost associated with running dedicated servers and maintenance by multiple database administrators. This is referred to as Database as a Service (DBaaS). Traditional DBMS technology has focused on fully utilizing a sinlge server to meet the needs of a specific application.

We observe that enterprises are under intense pressure to do more with less, to reduce risk and increase agility. The aggressive consolidation of IT infrastructure and deployment of DBaaS is a strategy that many enterprises are pursuing to accomplish these objectives. Malliga (2012) states that DBaaS is new emerging cloud service that can be a subtype of SaaS or PaaS depending on the way it is conveyed by the providers. DBaaS provides consumers an on-demand database services in the cloud that can be accessed by the users through the internet. According to Elmore et al. (2013), DBaaS makes an efficient use of cloud computing technology by providing business with easy access to scalable, on-demand database resources while avoiding the cost and complexity

associated with the purchase, installation and maintenance of a traditional on-premise database system.

DBaaS is an architectural and operational approach enabling IT providers to deliver database functionality as a service to one or more consumers. According to Oracle (2012), DBaaS supports the following necessary capabilities: 1) Consumer-based provisioning and management of database instance using on-demand and self service mechanisms. 2) Automated monitoring of and compliance with provider defined service definitions, attributes and quality of service level. 3) Fine grained metering of database usage enabling show-back reporting or charge-back functionality for each individual consumer.

Building a DBaaS infrastructure requires several key challenges to be addressed to transform traditional DBMS into a scalable, elastic, and autonomic database platform (Curino et al. 2010). That is, efficient multi-tenancy, elastic scalability and privacy. Using NoSQL databases instead of relational databases can help overcome the challenges of elastic scalability and multi-tenancy. This is because they are efficient in scaling due to the fact that they do not use rigid schemes. Instead they store data in clusters; they are aggregate oriented databases whereby data is stored in units. These units could reside in any machine and when retrieved from the database gets all related data along with it (Sadalage 2014). Private cloud is the best model of deployment of database as a service for HEIs to ensure privacy of data. The IT department should be the cloud provider to the institutions' constituents; this ensures that all security measures are taken to protect the data from any threat.

2.4 Adoption of Cloud Computing in Kenyan universities

One of the major benefits of cloud computing is the ability to deliver the technology needs of a business as a service. This allows IT to maintain control and compliance over the environment and enable business users to access the service on-demand. The trend observed during the last few years within higher education level is the universities' evolution to research universities and continuing update of IT infrastructure as foundation

of educational activities and science research. With the transition of technology, the number of services which migrate from traditional form to online form grows as well. For these specific services, an adequate providing form must be found in the online environment, using the suitable technologies guaranteeing the access of large number of user, fast and secure environment (Ivan et al. 2009; Mircea 2010; Karim 2013).

The potential and efficiency of using cloud computing in higher education has been recognized by many universities in USA, UK, Africa (Sultan 2010) and others. Cloud computing presents to university the possibility of concentrating more on teaching and research activities rather than on complex IT configuration and software systems ((McCREA as cited by Mircrea & Andreescu 2011); Pardeshi 2013), through a fast IT implementation. CC has evolved as an improved computing paradigm that guarantees to offer affordable opportunities for delivery of education services based on existing IT infrastructures in a way that has not been experienced before (Idowu & Adenike 2012). It is essential to adopt a systematic and sustainable developmental in higher education in order to realize a functional and goal-oriented education services delivery. CC gives better choice and flexibility to the IT departments by developing multipurpose infrastructure at once and then uses it for several times. With the help of CC, the platform and application the user uses can be on campus, off campus or combination of both depending on the institution needs (Matthew 2012).

Introduction of cloud computing services in Kenya by some telecommunication companies like safari cloud for Safaricom and AccessKenya cloud services is an indicator that cloud computing is gaining ground and popularity locally. We argue that HEIs need to unnderstand that government funding is not sufficient and should seek for better and more cost effective means of offering IT services to their stake holders. The only way of doing this is by adopting emerging technologies that are offering best services at a reduced cost. The best technology that has proved to best suite this situation is cloud computing. The cloud is more than a low scaling IT capacity and savvy business leaders are using it as an engine for growth and maintaining competitive edge. By removing typical IT constraints; such as long lead times for infrastructure improvements,

inadequate resources for maintenance and incompatibilities between system and tools, cloud computing frees businesses to concentrate on business strategy and innovation. HEIs should imitate the businesses that are rapidly adopting cloud services and seek a better and more cost effective way to implement IT services, without burdensome cost of maintenance and upgrades.

In addition, research has demonstrated that cloud-based solutions can be very effective in supporting collaborative and cooperative learning as well as other socially oriented theories of teaching and learning. With the trend towards student-centered and collaborative instructional models in higher education, administrators are asking IT leaders to provide the essential training, support and resources to support these models (Oracle 2012; Bomfim 2013; Mircea 2010; Mircea & Andreescu 2011).

Most HEs in Kenya have adopted Web 2.0 technologies to increase efficiency in administering the needs of students, lecturers and other stakeholders. The university services are accesses through web portals. The students' accesses timetables, fees statements, book rooms, register courses, get their results through the university portal anywhere any time using a variety of devices. This has greatly improved universities' delivery of services to all their stakeholders. In addition, most HEs use free cloud services like Google emails, docs, Calendar, drop box to enhance communication and sharing of documents among students and lecturers. This has had a positive impact in delivery of knowledge and have increased lecturer, student contact outside classroom. Though many consider web portals as cloud computing, we tend to differ from this because CC is the technology behind the services offered the web portals. CC rides on virtualization, grid computing and web technologies. Its services are accessed through web portals and the greatest advantage to HEs is the scalability of services. Therefore we observe that HEs in Kenya are yet to enjoy the benefits of CC.

Within the present economical context, the use of CC becomes a necessity not an option for many universities (Sasikala & Prema as cited by Mircea & Andreescu 2010). Bomfim (2013) argues that, inspite of similarities of businesses and Higher education institutions,

HEIs have a unique culture and missions that affect how decisions about cloud computing are made. These missions and cultures include:- commitment to students who come to campus with their own devices and expectations about how and when they want to use them. The IT department must provide greater interoperability between campus and student devices, 24/7 access to secure and reliable network; complex financial models – higher education finance model is complex and uncertain, comprised of various combination of tuition, philanthropy, investments, public funding and research dollar; participatory decision making that is seeking consensus with all stakeholders which complicates the whole process of decision making. This requires all stakeholders to understand the benefits of cloud based models. We agree with the researcher that an effective and durable cloud strategy for higher education institution require creating a framework built around the needs of all stakeholders, from students to faculty, board members to alumni; engaging them early in the process and developing an institution-wide cloud strategy that addresses IT challenges specific to higher education.

2.5 Challenges of cloud computing

Many challenges of cloud computing for higher education correlate to its relative newness and the less developed market place for cloud services. For higher education, decisions to adopt and implement cloud computing will be powered by more than technical and cost considerations. Information is the means of higher education, and decision on how to handle that information can have far extensive political, social and economic considerations (Bansal et al. 2012). Adoption of cloud computing offers many of the same risks and challenges as deciding the use of a traditional outsourcing arrangement. The increased possibilities that the service provider or its resources may reside outside of a government legal or territorial jurisdiction, can make some of these concern more acute.

Table 2.3 Barriers to adoption of cloud computing

Security	The key concern is data privacy: users do not have control of or know where their data is being stored.

Interoperability	A universal set of standards and/or interfaces have not yet been defined, resulting in a significant risk of vendor lock-in.
Control	The amount of control that the user has over the cloud environment varies greatly.
Performance	All access to the cloud is done via the internet, introducing latency into every communication between the user and the environment.
Reliability	Many existing cloud infrastructures leverage commodity hardware that is known to fail unexpectedly.
Platform or Language Specificity	Some cloud environments provide support for specific platforms and languages only.

Source: Kevin (2013)

Many of these barriers can be mitigated by developing a private cloud with level of confidence established by the institution and tested in the institutions data center (Cisco 2010; Bansal et al. 2012).

2.6 Private clouds for universities

Private cloud is a marketing term for proprietary computing architecture that provides hosted services to a limited number of people behind a firewall. Improvements in virtualization and distributed computing have permitted corporate network and datacenter administrators to effectively become service providers to effectively meet the needs of their "customers" within the corporation (Sarvesh et al. 2012). We agree that the best cloud service model for universities is a private cloud, hosted by the IT departments to effectively meet the needs of their stakeholders without outsourcing from a third party. This will enable the university to alleviate the problems facing them that is: increased number of students leading to increased large volume of data, problem of paying for

infrastructure and cost for taking licensed software, security and privacy in data and problem of power consumption, the air conditioning and electronic waste that can be caused by number data centers.

2.7 Migrating database to cloud

In IT industry only one thing is constant, that is change, which is unavoidable in our evolving industry paradigm. Similarly, business enterprises are changing at a fast pace as well, enterprises are to keep pace with the technology trends, if technology benefits are in the interest application lifecycle of the enterprises (Yadav & Khare 2014). If an enterprise does not embrace the new prevalent technology, then the enterprise may face challenges of loosing competitive advantage to its competitors. Cloud computing has recently be the focus of attention in computing both in academic research and in industrial initiatives. Motivated by the promised benefits of cloud environments, there has been a considerable research on cloud-enabled software and aiding the migration of legacy on-premise software to cloud.

Though enterprises may be ready to embrace new technology such as cloud, the biggest challenge is that, an organization cannot abandon past investment made in the current business logic and in use applications, which is built over a period of time with significant time and cost. There are no enough literature on cloud migration process framework therefore there is no well defined steps of how to migrate to cloud (Chauhan & Babar 2013; Pooyan et al. 2013).

One of the biggest trends in IT nowadays is moving database workloads to the cloud. Migrating towards cloud requires a clear and well planned strategy that supports cloud computing capabilities. For example when taking into account migrating part of database layer to cloud, which offers data persitence and manipulation capabilities, it is essential to tackle factors of granuarity of interactions and data confidentiality, and to enable applications to interact with remote data sources. Moving database structures and their related data sets to the cloud is not an easy task. Adrian (2012) observes that migrating database to cloud cannot be done overnight and that successful migration is achieved step

by step. We review available migration frameworks both vendor-specific and independent frameworks.

2.8 Existing Migration Frameworks

According to Vario (2010), Amazon proposes a phase-driven approach migration of an application to their cloud infrastructure that consists of the following six phases: cloud assessment, proof of concept, data migration, application migration, leverage the cloud and optimization. The data migration phase is subdivided into a selection of the concrete Amazon AWS service and the actual migration of data. We will use this methodology by applying the first four phases and refine the data migration by using our proposed methodology for migrating database layer. In addition, Amazon provides recommendation regarding which of their data and storage service best fit for storing a specific type of data, e.g. Amazon Simple Storage services is good for storing large write once read many types of objects. As the methodology proposed by Amazon focuses on Amazon AWS data and storage services only, we abstract from this methodology and integrate the guidelines in our proposal. Additionally other product specific guidelines and recommendation (Microsoft, 2014), Microsoft provides Windows Azure SQL Database Migration wizard and the synchronization service Windows Azure Data Sync. We will refer these tools and tutorials during data migration phase.

Google is offering for the App Engine the tool Bulk Loader which supports both the import of CSV and XML files into the App Engine Data store, and export of CSV, XML, or text files. The potentially required transformation of the data during the imports, are customizable in configuration files. In addition Google inc. supports the user when choosing the appropriate data store, or service or during guidelines to migrating the whole application to Google App Engine data store. We will refer to the tools during migration phase and abstract from vendor-specific guidelines and recommendations in order to integrate them to our process. Laszewnski and Nauduri (2012) also propose a vendor-specific methodology for the migration to Oracle products and services by providing a detailed methodology, guidelines and recommendations focusing on

relational databases. We will base our proposal on their methodology, abstract from it by adapting and extending it.

Apart from vendor-specific methodologies and guidelines, there are also proposals independent from specific cloud provider. Jamshidi et al. (2013) identified, taxonomically classified and systematically compared existing research on cloud computing. We considered the lessons learnt from the methodology, and therefore proposed and addressed the lack of migration framework to support cloud computing maturity in HEIs. Morris (2012) specified four major rules for data migration concluding that IT staff does not need to know about the semantics of the data to migrated, which causes a lot of overhead effort. With our step by step methodology, we provide details on guidelines and recommendation on data migration. It is good to note that when considering any kind of migration, onetime costs and resistance to change are major handle that has to be overcome for a smooth process to happen. We make an assumption that the institution has already taken these factors into consideration therefore our methodology will not deal these factors. Reddy and Kumar (2011) proposed a methodology of data migration that consisted of the following phases: design, extraction, cleansing, importing and verification. Additionally, they categorized data migration into storage migration, database migration, application migration, business process migration and digital data retention. We abstract from application classification in order to define cloud migration scenarios and reuse distinctions such as complete or partial migration in order to refine a chosen migration scenario.

Strauch et al., (2014) proposed a data migration methodology that was derived from cloud migration tool consisted of the following seven phase*: select migration scenarios, describe desired cloud hosting solution, select data store or data services, describe source data store or data service, identify patterns to solve migration conflict, refactoring application architecture, migrate data.* Selection of the migration scenario which entails detailed planning of what will be migrated and how the migration will be done by formulating a migration strategy: describe desired cloud data hosting solution, which involves selecting suitable cloud data using specified functional requirements and

properties grouped into different categories drawn from established cloud service providers such as Google, Amazon etc: select cloud data store or data service; at this stage, target data store or service are identified using properties set in the previous phase.

Describe source data store or data service is the fourth phase that entails discussing the source data store so as to identify conflicts that may arise during migration: Identify pattern to solve potential migration conflicts; entailes identifying conflicts that may result from incompatibility of different database layers using patterns identified in strauch et al. (2013 c): refactor application architecture; this phase gives guidelines and hints on what to be considered for the refactoring application e.g migrating from relational to non relational data store or service. The last phase is migration of data which entails configuration of connections to source and target data store or service, by providing adapters for bridging incompatibilities between them. We adapt this methodology and extend it.

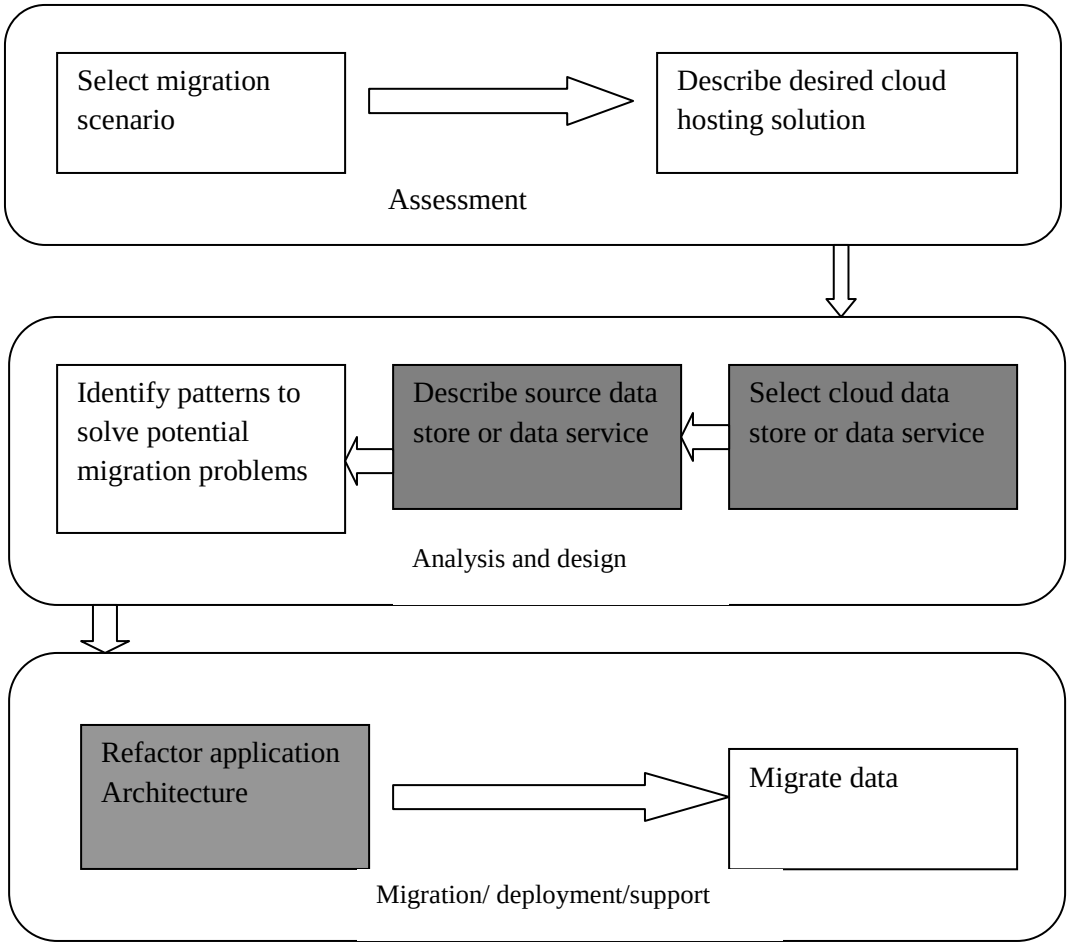

Fig. 2.1 Strauch's methodology for migrating application data to cloud

Strauch et al. (2013a) proposed using cloud data patterns in solving migration conflict which is done by mapping migration scenarios to cloud data patterns. They describe data patterns as a reusable and implementation technology-independent for a challenge related to the data layer of application in the cloud for a specific context. Presentation of patterns consists of description of context where the pattern is applicable, the challenge posed, external or internal forces that imposed constraints that make the problem difficult to solve, a proper solution for the challenge, detailed technical issues, the results of applying the proposed solution in the defined context, an example of use and other patterns to be considered. We will adopt some of migration scenarios identified in Strauch et al. (2013a). We will also adopt some database design criteria proposed by Paul, (2009) as some of categories for selecting cloud databases in our methodology.

2.8 Technology Adoption

Today Information Technology (IT) is universally regarded as an essential tool in enhancing the competitiveness of a country's economy. The world has witnessed technology explosion in the field of computing and information technology and these development have spurred research interested in predicting and explaining the adoption and use of technology (Vankatesh et al. as cited by Mukisa 2011). Review of literature on technology adoption show that research concerning technology adoption has been done for three decades (Davis 1986; Oliveira & Martins 2011; Chuttur 2009). There is consensus that IT has significant effects on the productivity of firms. These effects will be fully realized if and when, IT are widely spread and used. Therefore it is important to understand the determinants of IT adoption and the theoretical models that have arisen addressing IT adoption (Oliveira & Martins 2011). There are many theories in information system research but this study will concentrate on technology adoption theories.

The most used theories are the Technology Acceptance Model (TAM) (Davis 1986; Davis 1989; Davis et al 1989), theory of planned behavior (TPB)(Ajzen 1983; Ajzen 1991), unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al. 2003), Diffusion of innovation (DOI) (Rogers 1995) and the Technology, organization, environment framework (Tornatzky and Fleischer 1990). This study will use DOI and TOE theories because they are the only ones used at firm level (Oliveira & Martins 2011; Lin & Lin 2008).

2.8.1 Diffusion of Innovation

Robinson (2009) argues that Diffusion of Innovation seeks to explain how innovations are taken up in a population. Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. It is a special type of communication, in that the messages are concerned with new ideas (Rogers 1995). DOI is a theory of how, why, and at what rate new ideas and technology spread through cultures operating at individual level and firm level. Rogers (1995) argues that, individuals are seen as possessing different degrees of willingness to

adopt innovation and thus it is generally observed that the portion of the population adopting an innovation is approximately normally distributed over time.

Based on DOI theory at firm level, innovativeness is related to such independent variables as individual (leader) characteristics, internal organizational structural characteristics, and external characteristics of organization. The figure 2.4 below shows how these independent variables are related to innovation adoption.

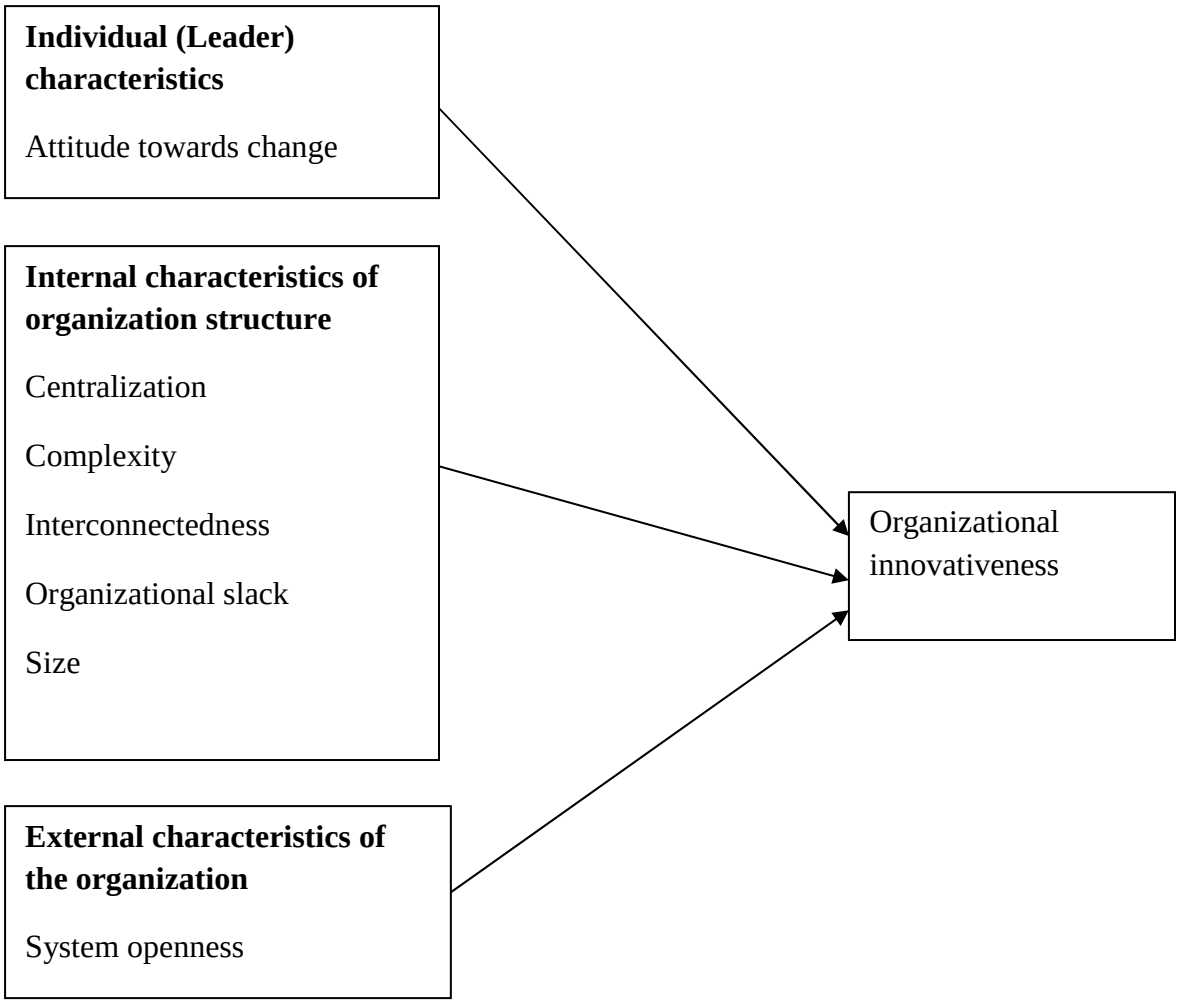

Figure 2.2 Diffusion of Innovations (Rogers 1995)

The individual characteristics describe the leader attitude towards change. The internal characteristics of an organizational structure includes observation according to Rogers 1995, whereby “centralization is the degree to which power and control in a system are concentrated in the hands of relatively few individuals”; “complexity is the degree to which an organization members possesses a relatively high level of knowledge and expertise”; “Interconnectedness is the degree to which the units of a social system are linked by interpersonal networks”; “organizational slack is the degree to which uncommitted resources are available to an organization.”; “size is the number of employees of the organization”. The external characteristics of an organization refers to the openness of the system.

2.8.2 Technology Readiness Index

Technology readiness refers to the people’s propensity to embrace and use new technology to accomplish goals at home and at work (Parasuraman 2000). It measures the extent to which a technology is suited for deployment in real operational environment. It is often used as a measure of risk associated with introducing new technologies into existing systems and standard operating procedures (Engel et al. 2012). Technology Readiness Index (TRI) measures an individual’s readiness to use new technology in general using four personality traits; optimism, innovativeness, discomfort, and insecurity.

According to Parasuraman, a person with optimism and innovativeness has little discomfort and insecurity and is more likely to use new technology. Optimism is the tendency to believe that one will generally experience good versus bad outcome. Optimists use more active coping strategies than pessimists and these strategies are more effective in achieving positive outcomes. Optimists are less likely to focus on negative events thus confront technology more openly. Therefore, optimism leads to more positive attitudes towards technology.

Personal innovativeness in IT is the willingness of an individual to try out any new information technology. Karahanna et al. (2001) showed that more innovative people

have less complex beliefs sets about new technology. On the other hand, individuals with discomfort and insecurity traits avoid new technology due to their fear of technology; persons with these traits inhibit adoption of new technology.

2.9 Conceptual Framework Model

Based on review of the literature related to technology adoption and technology adoption models and theories, the research conceptual model in figure 2.6 below is derived from a combination of DOI model and TRI will be used in this study.

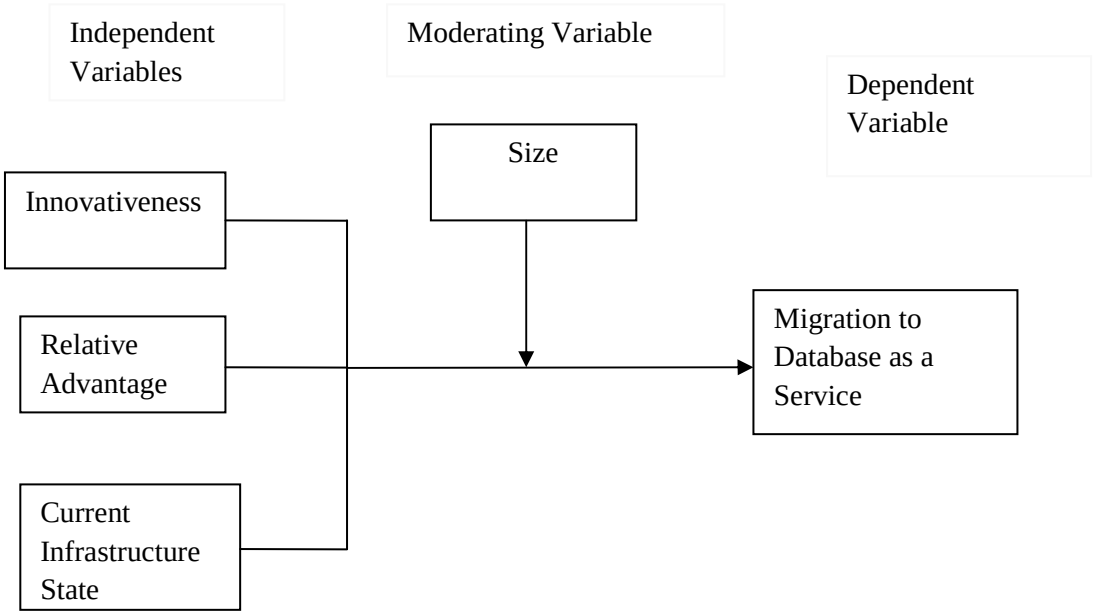

Figure 2.3 Research Conceptual Framework

This study sought to look into factors that influence the HEIs readiness to adopt CC that will eventually lead to migrating present applications data to cloud , through a conceptual model derived from Diffusion of Innovation theory (DOI) (Rogers 1995) and Technology Readiness Index (Parasuraman 2000). In the conceptual model, the primary constructs fall under the following contexts-

Relative advantage of an innovation defines the degree to which an innovation is perceived as being better than the idea it supersedes. Organizations must recognize that

the adoption of innovation will either offer solutions to the existing problems or present new production opportunities, such as improved operational efficiency and increased productivity (Mndzebele 2013). An organization will adopt a technology when they see a need for that technology, believing it will either take advantage business opportunity or close a suspected performance gap. Therefore, organization that is willing to adopt a technology must assess the potential benefits of technology to the business.

Personal innovativeness in IT is the willingness of an individual to try out any new information technology. Karahanna et al. (2001) showed that more innovative people have less complex beliefs sets about new technology. On the other hand, individuals with discomfort and insecurity traits avoid new technology due to their fear of technology; persons with these traits inhibit adoption of new technology.

For successful cloud computing adoption and implementation, there is need to have the right infrastructure in place. Universities hold large amount of data that have created large data centers. They also require high speed internet bandwidth, and power backups that will ensure high availability of services. Therefore, when the right infrastructure is in place there will a high propensity of adopting and implementing of cloud computing.

Size of a university is measured in terms of number of students and staff, number of department a university have. The size will determine the how innovative that institution is, how much infrastructure the institution have invested in and can invest in future, and the information need of the institution. This will overall determine whether the institution is ready to migrate to Database as a Service or not. Large universities possess large data centers and other infrastructures that are required in cloud computing and therefore migrating to cloud is cost effective than small universities (Andrescu 2011).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This section explains how the study will be conducted, that is methodology to be used, an explanation of data collection tools and why we have chosen the tools, data analysis tools and presentation of the analyzed data.

3.2 Methodology

Most studies on adoption of cloud computing in higher education institutions have used both qualitative and quantitative research. They have also used multiple case study design where the study covers more than one university and others have covered more than one region (a country or continent). This study intends to use survey research methodology. According to Gable (1994), survey research is a method that involves the collection of data from a number of organizations or other entities using tools such as questionnaires, telephonic interviews and published statistics. The data is then analyzed using statistical techniques to discover relationships that are common across the organizations. General conclusion can then be drawn about the object of study.

The use of survey research in information systems study is widespread (Gable 1994). As reported by Kartz et al. (2009) Educause Center for Applied Research (ECAR) used a survey approach to study the adoption and use of alternative sourcing strategies for IT services within the US education sector. The European Network and Information Security Agency also used survey technique to determine the adoption of cloud computing in European Small and Medium Scale Enterprises (SMEs) (ENISA 2009).

3.3 Population

Population is generally a large collection of individuals or objects that is the main focus in scientific query that have similar characteristics. This study will be conducted in Kenyan universities; since it was hard to collect data in all 48 universities; our accessible population was three public universities and one private university which constituted a

population of approximately 120,000. Out of this population we were interested in conducting our study in ICT departments of each selected institution; therefore we estimated the population to be 200. We also considered other parameters like confidential interval of 95% and a confidential interval of plus/minus 5.

3.4 Sampling and Sample size

A sample is defined as the number of entities or objects in a subset of a population selected for analysis. There are various approached to obtaining and determining the sample size to use in research. These may include using a census for population that is small, imitating a sample size of other studies, using published tables, or applying formulae to compute a sample size. Kothari, (2004) points out that an optimum sample is one which fulfills the requirement of efficiency, representativeness, reliability and flexibility.

This study will use purposive sampling whereby the sample size will be selected using predefined criteria. The reason for this is that, the researcher will be looking for the people who are most likely to be involved in advising the top management on technology trends and might also be involved in decision related to cloud computing adoption in their respective universities. The advantage of using this technique is that it ensures intensive study of the selected items and also ensures proper representation of the universe when the investigation has full knowledge of the composition of the universe and is free of bias (Karuna 2011).

To determine the sample size of the study we used the following formula adopted by Smith (2013).

$$n= ((Z\text{-score})^2 * StdDev*(1-StdDev))/(Margin\ of\ error)^2$$

Where:

n=desired sample size

Z-score = confidential level

Standard deviation = variance of expected responses which is 0.5

Margin of error = confidential interval +/-5%

$n= ((1.96)^2*.5(.5)/ (.05)^2$

= 384.16

= 385 persons

Based on the calculated sample size we adopted another formula recommended by Mugenda O. & Mugenda A., (1999).

nf= n/1+(n/N)

Where: nf= desired sample when population is less than 10,000

n= desired sample when population is greater than 10,000

N=estimated population size

Therefore:

nf= 385/ 1+(385/200) = 132 persons

3.5 Data collection methods

Questionnaires were used to collect first hand data from the selected university ICT staffs. The questionnaire method presents more advantage than interview because it's free from researcher's bias (Kothari 2004). Respondents who were not approachable were able to respond. Questionnaires were administered through the internet using googleforms.com. Semi structured interviews were also used in this study as a follow up, to help the researcher get detailed information on phenomenon under investigation that cannot be investigated using questionnaires. Semi-structured interviews consist of key questions that help to define the areas to be explored and allow the researcher to get more detailed response (Gill et al. 2008). Interviews are used to explore the views, experiences, belief and /or motivation of individuals on specific matters. We chose interviews because

of its ability to generate detailed data where less is not known and could not be captured through the questionnaires. Secondary sources were also used to collect data; these include published statistics, journals and any other relevant material.

3.6 Data Analysis

Data analysis is the process of systematically applying statistical and/or logical techniques to describe and illustrate, condense and recap and evaluate data. In this study we had quantitative and qualitative data to be analyzed. Quantitative data collected using online questionnaires was analyzed using descriptive analysis and presented through bar charts and pie charts. Thematic analysis was used to analyze qualitative data obtained through interviews whereby field notes were categorized into themes as we tried to answer the research questions. We choose this tool to help us organize and analyze unstructured data; by classifying, examine relationships in the data and combine analysis modeling which in return will help us identify trends and make conclusions.

3.7 Reliability and Validity Considerations

To ensure the data was in line with the objectives of the study, some reliability and validity tests were employed and considered. This helped to ensure that necessary measures were in place to provide accurate results of the study.

3.7.1 Reliability considerations

This is the degree to which measurement techniques can be depended upon to secure consistent results upon repeated application. This was emphasized during questionnaire development. To test whether our questions would generate consistent and accurate results as intended, we conducted a pilot survey with the same sample respondents. This helped us to get an insight of the result and we were able to fine tune the questionnaires before the actual survey. We were also able to seal loop hole in the data collection tool where by we were able to block a respondent from filling the questionnaire more than once.

3.7.2 Validity Considerations

Validity indicates how well an instrument measures what is it purports to measure. To ensure that the data we collected using online questionnaires was valid, we did a follow up interview with the department heads of each institution. We also marked some critical questions as 'required' to make sure we get detailed data as possible.

3.8 Limitations of Research Methodology

During pilot test survey, most of the respondents in each department refused to answer more than three questionnaires sighting duplication of information. This made us to reduce our sample size to 24 respondents of the total 132. Another limitation we encountered was delay of online responses which led us to make hardcopies questionnaires which we delivered to respective respondents. These responses were later filled online for analysis.

3.9 The Proposed Migration framework

Requirements

The functional and non functional requirements presented in this section aim to provide decision support for an application data layer migration to the cloud as proposed by strauch et al., (2013a).

Functional requirements(FR)

a) Independence from database platform: the methodology should support both relational database management systems as discussed by Codd (1970) and NoSQL data stores as discussed by Sabalage and Fowler (2012) that have emerged recently.

b) Support of data stores and data services: the methodology should be able to support migration for both fine and course-grained types of interactions i.e. through SQL and service API respectively.

c) On-premise and off-premise: the methodology should be able to support data stores and data services that are either hosted on-premise and off-premise, using either cloud or non-cloud technologies.

d) Management and configuration: any tool supporting this methodology should be able to provide management and configuration capabilities for data stores, data services, and migration projects, e.g. registration for new data store including its configuration such as database schemas, database system end points URL. Must also support new migration projects.

e) Support various migration scenarios: Data migration depends on the context and the concrete use cases e.g. backup, archiving or cloud bursting, the methodology should be able to support various migration scenarios.

f) Support for incompatibility identification and resolution: the methodology has to incorporated the specification of functional and non-functional requirements of database layer for the both source database layer used before migration and target data store or service. For example any incompatibility between SQL versions supported by different data services must be identified and guidance provided on how to overcome them.

Non-functional requirements (NFR)

a) Security – any tool using the methodology should be able to support necessary authorization, authentication, integrity and confidentiality of source of data store during export and import. And should also enforce user wide security policies when required.

b) Reusability – the methodology should be reusable with respect to integration into methodology of migration of the whole database as the one proposed by Varia (2012).

c) Extensibility – methodology should be extensible to incorporate further aspects that impacts the data migration to the cloud, such as regulations compliance.

3.9.1 Strauch Migration Framework discussed

The step by step methodology that we present in chapter five refines and adapts the migration framework Strauch et al. (2014) so as to address the identified requirements. Taking into consideration Strauch et al. (2014) their methodology addresses all the requirements discussed above. However, it is designed to support applications' data layer to cloud rather than the whole databases. It is also a migration tool specific methodology in that, the methodology was designed to fit specific tool which makes it insecure when it comes to data migration as the user may not know whether some data is visible to other users. This is due to the fact that the user of the methodology has no access to the source code of the tool therefore hard to customize it to users' requirements. Therefore it fails to satisfy a major requirement that we mentioned (NFR_a).

In addition, the methodology is designed with an assumption that all errors and conflicts can be identified before and during migration, therefore testing phase is not required. Another assumption is that all applications can be refactored therefore no need of testing or tuning before or after migration. In other words it is not clear whether after using this methodology the user will achieve optimum performance and if not, no guidelines are given on how to solve the problem. It is also not clear how to deal with applications that cannot be refactored during migration and/or when the user want to migrate part of the database without migrating the application that uses the database.

Since we are concerned with moving database to cloud and offering it as a service, we drop replace this phase with testing and tuning phase, where migration is implemented, tested and tuned in preparation for going live. Phases three and four of the strauch et al. methodology are not seperable because before the user to select target data store or data service they must consider the source data store or service, understand its compatibility and incompatibility nature for them to select a target data store that will be friendly with the source data store, therefore we merge these two phases in our proposed framework.

3.10 Framework Realization

Our literature review did not result in a method that is specially for evaluating migration methodologies, so we sought for a tool that would help us realize the propose framework. To achieve this, we used a dummy MySQL database to fully migrate it to Google cloud. We choose public cloud because it was the most adopted cloud model in Kenyan universities.

We did not find any tool that could fully support our framework, therefore we settled to use a data migration assistant tool found on http://www.cloud-data-migration.com/ because it was the only tool that supported some aspects of the framework. Cloud data migration assistant is a free automated online tool that was designed to support migrating application's data layer to cloud; therefore it was not meant for migrating whole or part of enterprise database to the cloud.

CHAPTER FOUR

DATA COLLECTION AND ANALYSIS

4.1 Introduction

This section presents an account of the research findings gathered from both questionnaires and interviews. The questionnaires were aimed at addressing the research objectives while the semi structured interview questions were used to provide insight into the research objectives as well as validate the credibility of the findings gathered from the questionnaires.

4.2 Analysis of the Questionnaires

In order to know the extent of cloud computing in Kenyan universities questionnaires were administered through online survey using Google forms. The questionnaires targeted selected four universities ICT department employees, five from each university. Since ICT department has sub-departments, two questionnaires were administered to software development department, two to network management department and one to support department. 18 responses were received which represented 90% of the sample size, two did not consent to take the survey. The research objectives below were addressed using this sample size.

The researcher wanted to know the size of the institutions under study; this was to assist in tracking trend of adoption of cloud computing in different universities and make informed conclusion. The figure (Fig. 4.0) below shows the response on size of institution under study.

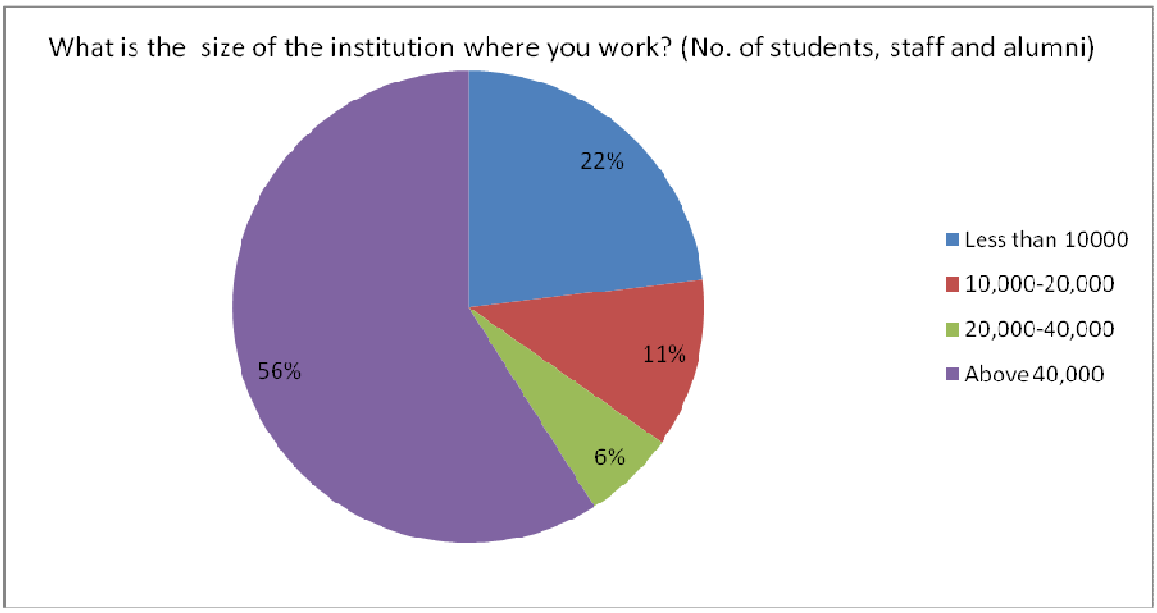

Fig. 4.0 Size of Institution

Research objective 1: To investigate the state of art of cloud computing in Kenyan universities. In order to achieve this goal, a number of questions were asked and the survey revealed that 100% of the respondents were aware of cloud computing and they were using it in their institutions. 56% said their institutions have adopted public cloud, while 39% said their institutions have adopted hybrid cloud model; that is a combination of private and public cloud models. 5% did not know which cloud model was being used in their institutions. Figure 4.1 below shows the responses on cloud models currently being used.

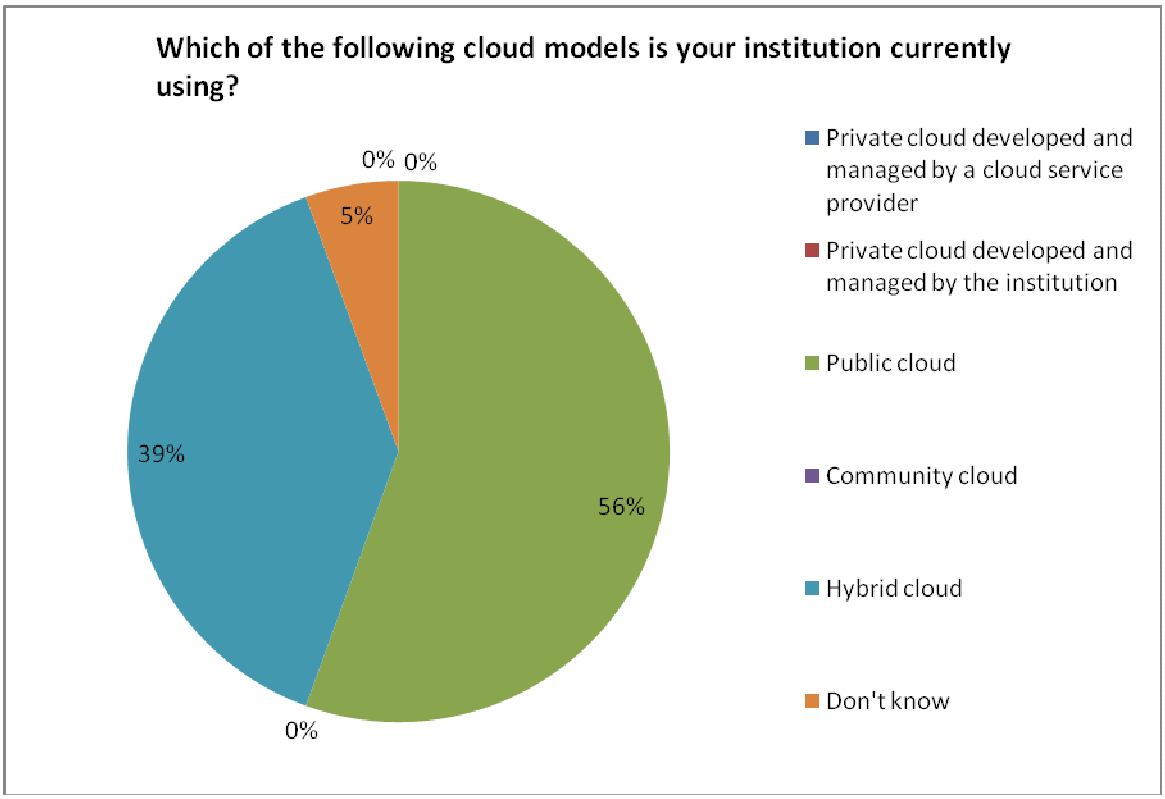

Figure 4.1 Responses on cloud models currently being used

Student emails and staff emails emerged to be the most adopted cloud service in HE with 100% respondents indicating that they have moved these services to cloud. 50% said they have adopted hardware infrastructure, while the rest said they have no plans of adopting this service in the near future. 33% said they have adopted a cloud based learning management system, while 77% said they have no plans of adopting it in the near future. 33% have plans to adopted backup and storage facility while 77% said they have no consideration of adopting the service in the near future as depicted in figure 4.2 below.

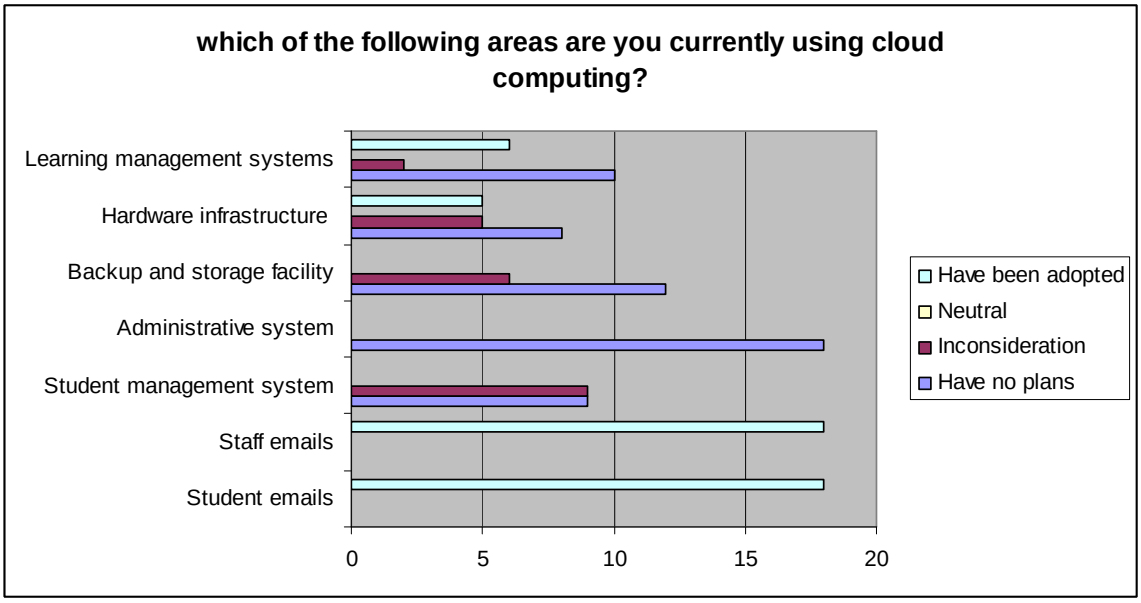

Fig 4.2: Areas cloud computing have been adopted

The researcher wanted to know the motivating factors towards adopting cloud computing in HE. In order to achieve this, respondents were benefits of cloud computing and some other known factors were used as motivating factors. When asked about the motivating factors, 100% of the respondents said their institutions adopted CC inorder to reduce IT cost, while 89% said getting access to cutting edge resources at a reduced cost was also their motivating factors. 28% agreed that management support was a motivating factor in adopting cloud computing in their institutions. Reduced implementation risk rated very important by 5% of the respondents, 61% said they were neutral while 22% said it was an important factor. 72% said that lack of in-house technical expertise was not an important factor for motivation to adopt of cloud computing, while 22% indicated neutral only 5% of the respondent thought it was an important factor. 61% of the respondents thought that management support was an important factor that have contributed to the adoption of cloud computing, 22% said they were neutral, 5% thought it was not important while 11% said it was an important factor. The figure (Fig. 4.3) below shows the responses on motivating factors to adoption of cloud computing in HE.

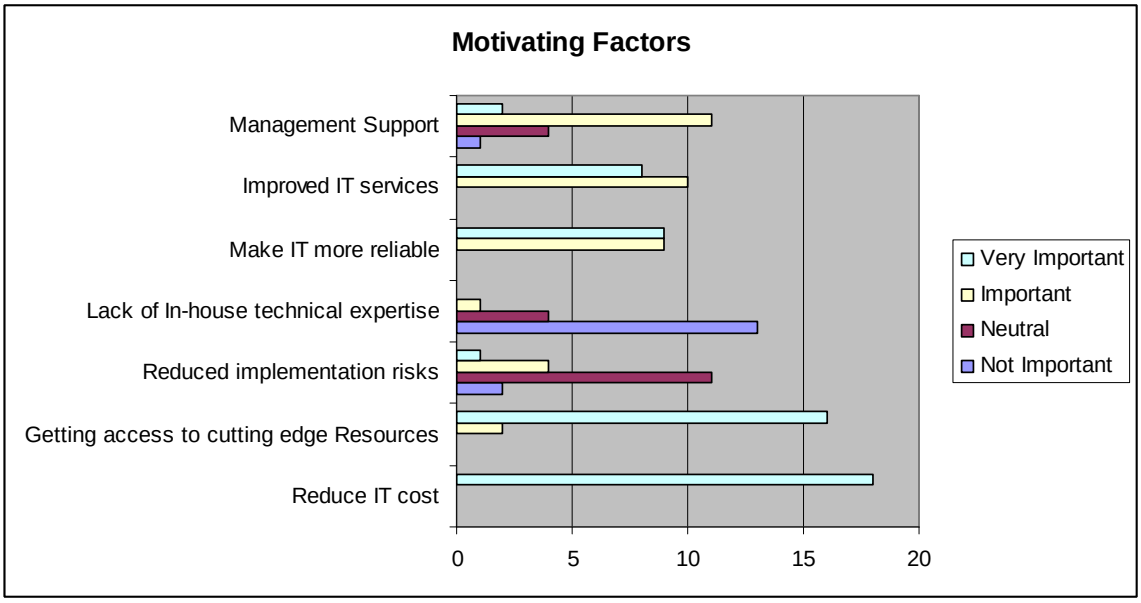

Fig. 4.3 Motivating factors to adoption of cloud computing in HE

To know whether respondents encounter hindrances during cloud computing adoption decision implementation, we asked them to indicated either 'yes' or 'no' to the question. If "Yes', they were to list the de-motivating factors that they may have encountered during decision making.

It emerged that, data security and privacy concerns is the most de-motivating factor of adopting cloud computing with 67% responses supporting, 22% said that inadequate knowledge about cloud computing was also a de-motivating factor, with 17% indicating that bandwidth limitations contribute to reluctance of adopting cloud computing. Another factor that contribute to reluctance to consider cloud computing are reliability concerns according to 11% of the respondents. 38% of the respondents said that budget constraints was hindering their cloud adoption, while 4% indicated that lack of mature cloud solutions was also a contributing factor to reluctance in adopting cloud computing as shown in figure 4.5 below.

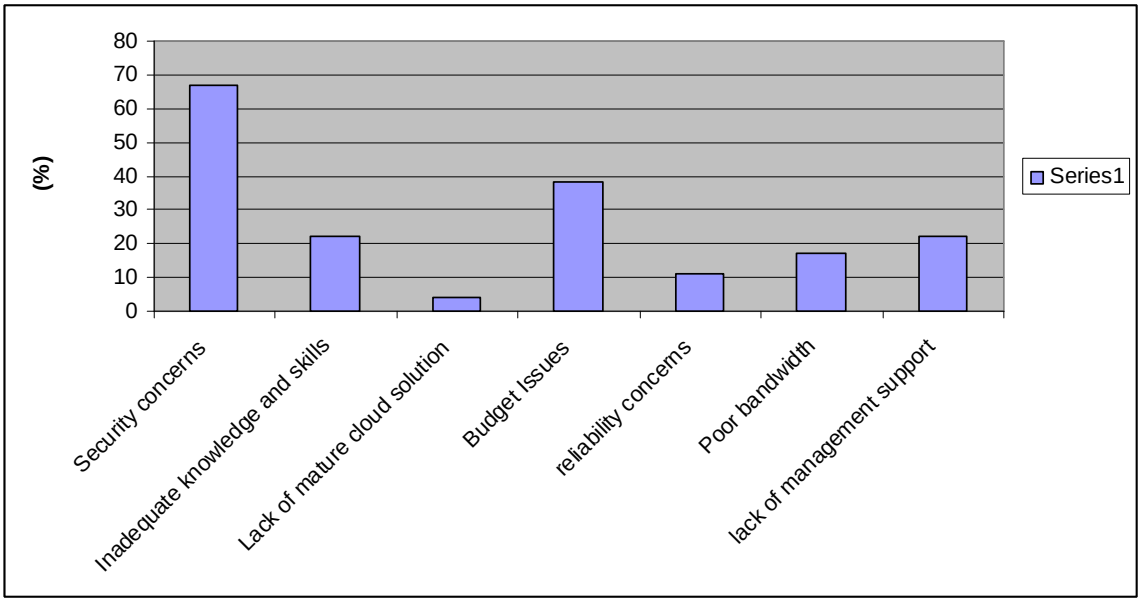

Fig. 4.5 De-motivating factors

Research objective 2: To assess universities' readiness to adopt cloud computing services. To achieve this objective several questions were asked and the survey revealed that 22.2% of the respondents said that they have a strong knowledge of cloud computing and IT infrastructure management and they can manage it themselves without needing support from a service provider. 39% agreed that they have advanced skills and technical knowledge of cloud management and IT infrastructure while 39% also said they have basic knowlegde and understanding. No respondent agreed that they are weak in cloud computing and IT infrastructure management as shown in figure (Fig 4.6) below.

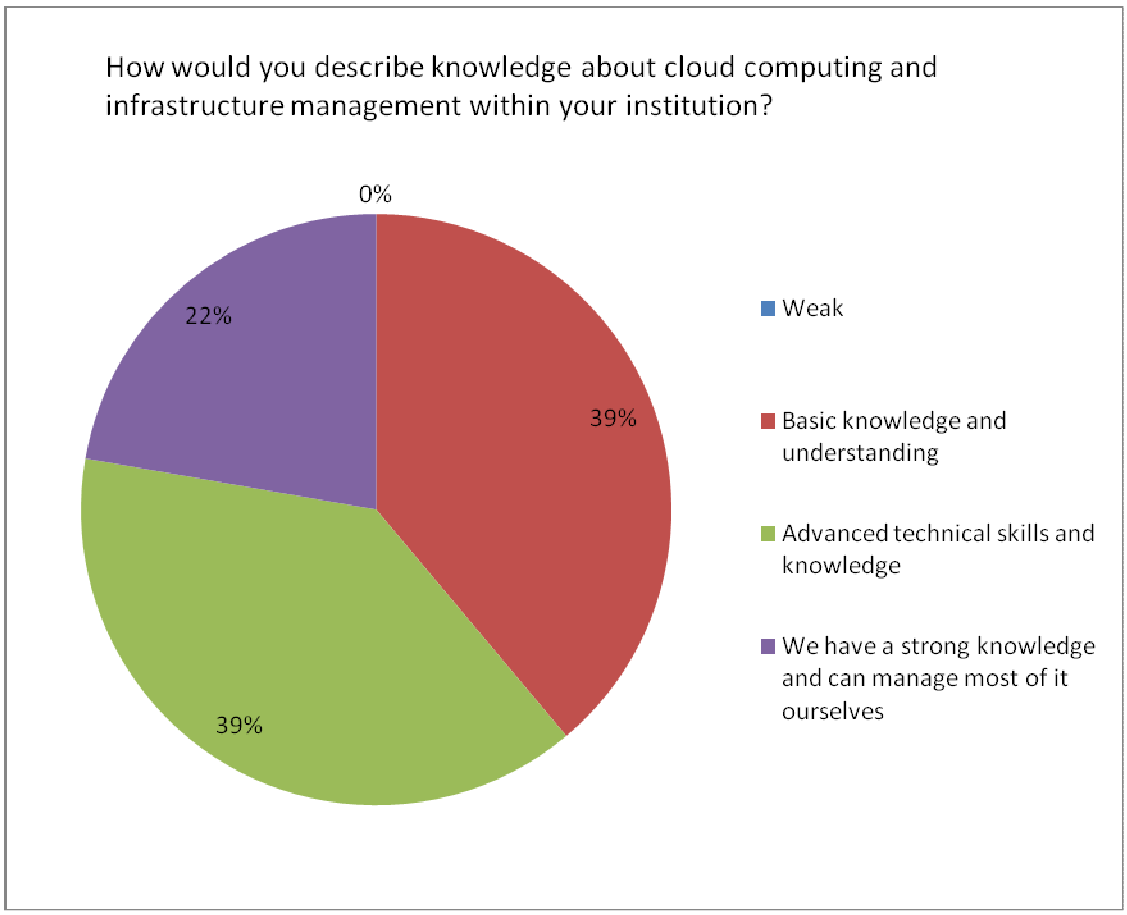

Fig 4.6: Response on knowledge about cloud computing and IT infrastructure management

The research revealed that most institutions need to predict rapid growth and expand their infrastructure in the next three years which is represented by 56% in the figure (Fig 4.7) below. 44% said they need to be able to expand their infrastructure. No respondents opted for decreasing and constant growth therefore no need to expand.

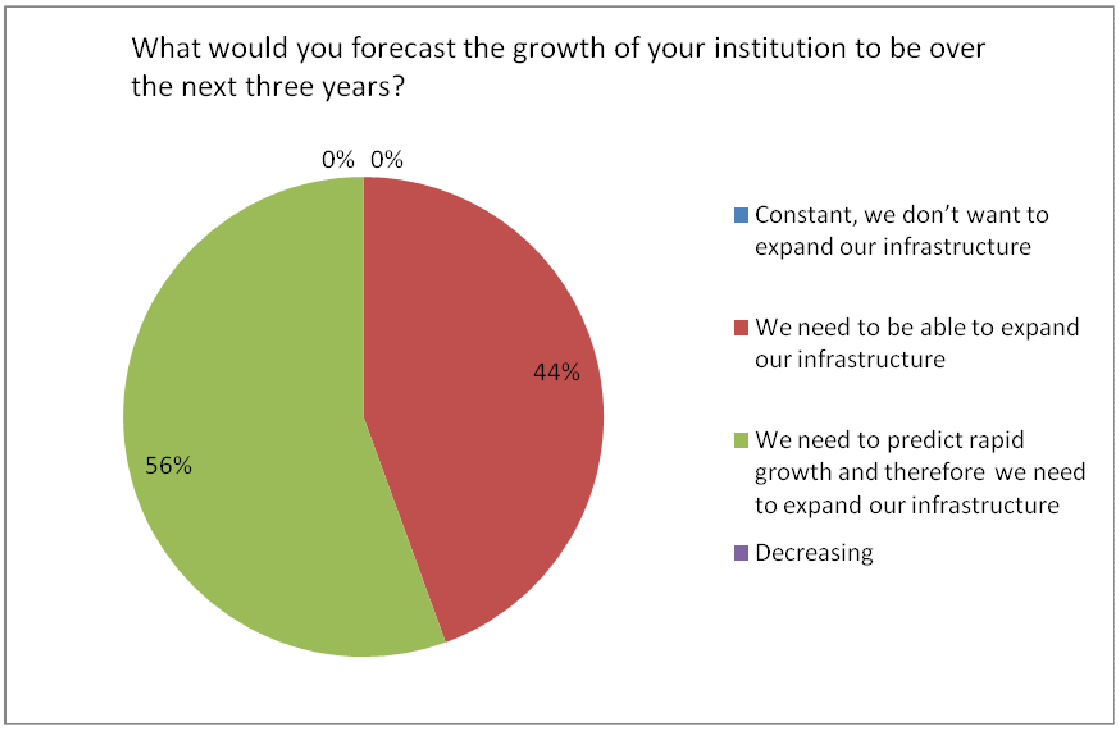

Fig 4.7: Response on growth forecast in the next three years

The research also revealed that most universities have a bandwidth of between 100Mbps to 1Gbps which is represented by 50% in the figure (Fig 4.8) below. Followed by a bandwidth of between 10Mbps to 100Mbps which is represented by 39% of the respondents, while 11% represnts above 1 Gbps; no respondents opted for 10 Mbps and below.

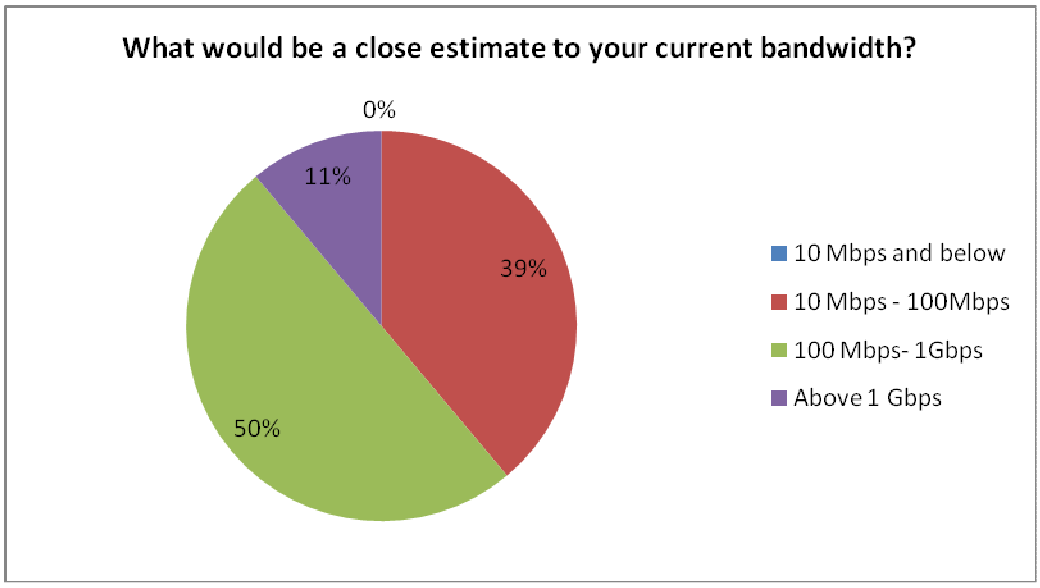

Fig 4.8 Response on current bandwidth estimates

Most respondents agreed that their servers encounter increased work loads during some periods of the year represented by 78% of the respondents as shown in the figure (Fig 4.9) below. Only 22% said their servers do not encounter increased work loads.

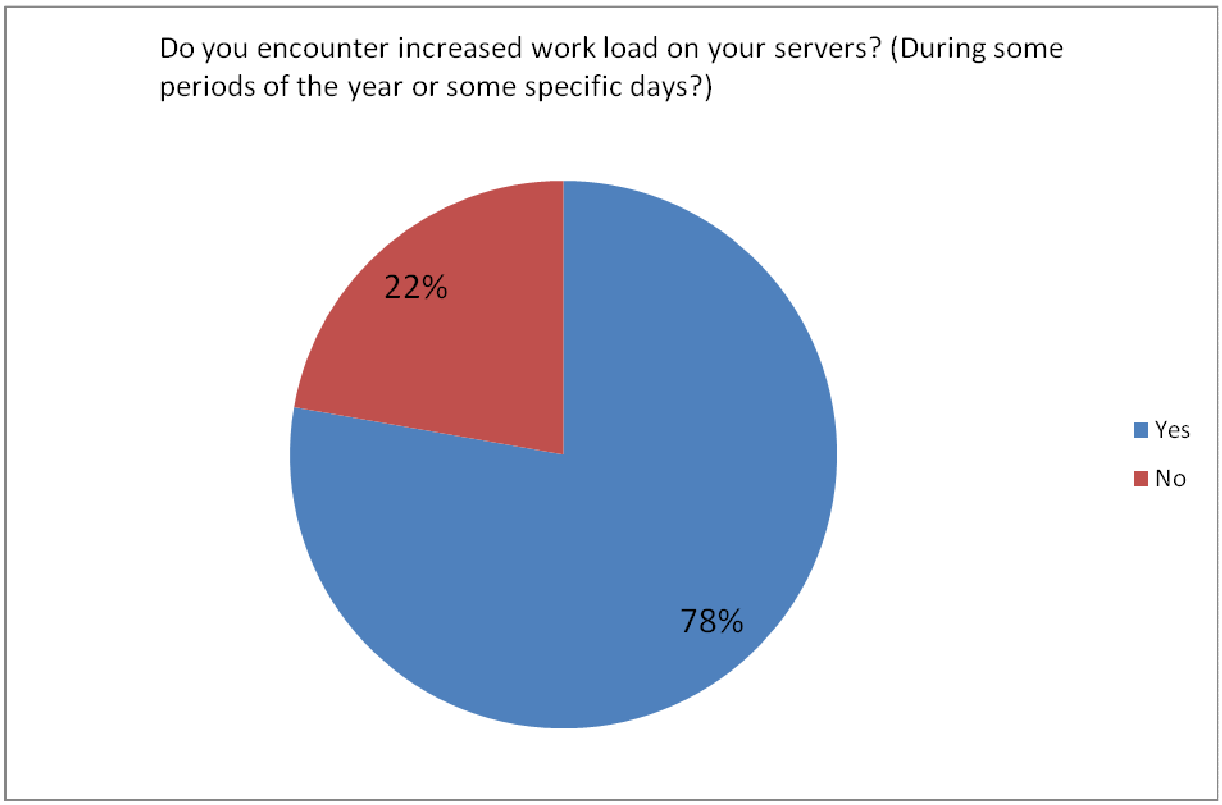

Fig 4.9 Response on increased server workload

We also wanted to know migration timelines set by the institutions, 40% of the respondents said they are not sure when they plan to migrate to cloud while 27% indicated that they plan to migrate in the next one year. 20% said they plan to migrate within five years; 7% said that they plan to migrate in the next 18 months while 7% said that they intend to migrate in the next three years as shown in figure (Fig. 4.10) below.

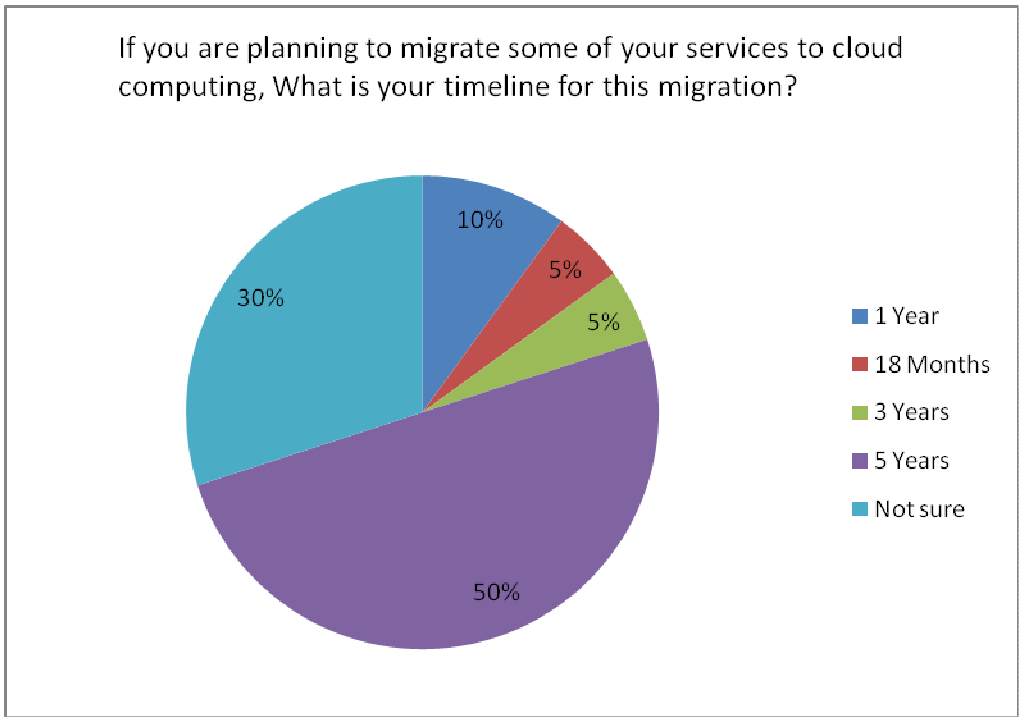

Fig. 4.10: Responses on migration timelines

4.3 Qualitative Data Analysis - Interview

We sent an individual email to four participants describing what the study entails, plus an invitation letter asking for a suitable date and time for the interview to take place. The approval of invitation and consent were sent back through email to the researcher. We sent a confirmation email to the three participants who agreed to be interviewed; one did not consent. The interviews were conducted in the month of June 2015. The interview was done face to face as this method was considered more convinient. The interview lasted for approximately fifteen to twenty minutes for each participant, and the discussions were based on the research objectives. The table below shows the respondents interviewed, size of their institution and their position.

Table 4.0 Respondents of interview

Respondent	Size of institution	Position
Respondent A	Above 40,000	Director of ICT department
Respondent B	Above 40,000	Chairman ICT department
Respondent C	10,000 - 20,000	Chairman ICT department

4.3.1 Steps used to analyse qualitative data

We conducted semi structured interviews whereby an interview guide was used. We had the same set of questions for each respondent. The data was collected in form of notes, which was later organized in terms of research objectives, other pattern of ideas that were not answering immediate research objectives were also marked for further analysis to know how they relate with the objectives.

We coded the data into themes that described issues highlighted in the research conceptual framework and other factors that emerged from the data. The table 4.1 below shows the list of themes and corresponding responses for each.

Table 4.1 Thematic analysis showing the codes that were used

Themes	**Responses**
Adoption	Most agreed they currently using CC to offer a variety of services including student and staff emails… Majority said they have adopted hybrid cloud model…
Knowledge	Majority agreed they have advanced knowledge and skills in CC and IT infrastructure management….

Relative advantage	All respondents agreed that they considered CC because the technology is almost 100% reliable, cost effective in terms of cutting expediture…..
Hindrance	Budget constraints was the major hindrance to achieve this goal. The recent global espionage and lack of national CC strategy….
Management support	With the help of the management, majority said they have a five year working cloud strategy to help them….
Innovative	Majority said that they are looking into implementing the cutting edge cloud services solutions in the near future…
Infrastructure	The majority said they have sufficient bandwidth, data center with generators in place for power backup…..

4.3.2 Summary of the Findings

The findings showed that the concept of cloud computing is well understood in many institutions but in some institutions the concept is still at its infancy. It also emerged that most institutions are currently using cloud computing in their institutions, with respondents saying they have moved their staff and student emails to cloud. Respondent A and B added that they have already implemented infrastructure as a service to reduce cost of buying and maintaing institutions' infrastrucutre. Hybrid cloud model emerged to be the most adopted model with few having adopted public cloud model.

Relative advantage of cloud computing technology emerged to be the reason why institutions are adopting and implementing cloud technology such as reduced cost of IT, reliability, improved IT services. On the other hand, the findings showed that budget constraints, security concerns were major demotivators of adopting and implementing cloud computing technology in institutes of higher learning. Lack of national cloud computing strategy was also metioned as a hinderance to adoption and implementation of cloud

computing. Although it was not supported by many respondents it was inline with this study's literature review.

The findings showed that management support is key in adopting and implementing cloud computing in HEIs in that many institutions had already incorporated cloud computing to their mission objectives. Respondent A and B agreed they have already formulated and five year cloud strategy which is currently being implemented. With this strategy in place, the respondents said they are in search of cutting edge cloud computing services solution for their institutions. However, respondent C said their management have no plans to implement cutting edge cloud solutions.

It also emerged that most institutions have invested in building well equipped data centers with power backup systems and have efficient bandwidth to support cloud services. The findings showed that big institutions (with a population of above 40000), were more innovative than other small institutions, in that the respondents from these institutions seemed more motivated to look for cutting edge cloud solutions and they also had great confidence in cloud computing technology.

4.4 Discussion of findings

The research sought to design a migration process framework to database as a service for a Kenyan university. To achieve this the researcher had to evaluate the state of art of cloud computing in HE and assess the readiness to adopting the technology. This was achieved quantitatively by use of online survey and qualitatively with interviews. The findings of both research are discussed below in relation to research objectives and literature reviewed.

4.5.1 Discussion of findings

Research objective 1: To evaluate the state of art of cloud compting in kenyan HE.

The survey revealed that cloud computing is understood in all institutions under study and are currently using it. The most adopted model is public cloud model followed by hybrid cloud model, other models were not being used. This corresponds to the results obtained from qualitative research (majority of the respondent agreed cloud computing is the next

technology that will of great help to HE, that CC is understood in their institutions and they agreed they are using cloud computing in their institutions).

Among the services that have been migrated to cloud the survey revealed that most institutions have migrated student and staff emails to cloud. This corresponds to the qualitative research (All respondents agreed they have migrated student and staff emails to google cloud except respondent A who said they have not considered migrating staff emails to public cloud citing security concerns as the major reason). Other services that have been adopted by some of the institutions are infrastructure as a service; this corresponds to qualitative research (respondent A and B agreed they have adopted infrastructure as a service) ,11% said they said they have adopted backup and storage facility and learning management system but this differ with qualitative research in that no respondent said that they have migrated backup and storage facility and learming management system.

The survey revealed that institutions are motivated to adopt cloud computing due to perceived relative advantage. Reduce IT cost was indicated as the most important factor for adopting cloud technology, with reduced implementation risks being rated as not a very important motivator. It also emerged that management support was an important motivator when it comes to adopting cloud technology in these institutions. This corresponded with qualitative research where all respondents agreed that cloud computing is an attractive venture for HE due to its advantages and that management support was the key to adoption of cutting edge technologies in HEIs.

However, survey revealed that data security and privacy concerns and budget constraints were the major hinderance of adoption of cloud computing in higher education institutions in Kenya with most respondents supporting it; this was supported by interview survey that revealed security as the most demotivating factor citing how recent global espionage is affecting cloud computing migration decision making negatively and that lack of finances has hindered implementation of institutions' cloud strategy. The findings revealed that though some HE have laid out five year cloud strageties, it would be hard to achieve it within the stupilated time frame due to budget constraints.

Reliability concerns and bandwidth limitations was also cited to be demotivating factors; this differed from interview survey where cloud computing was rated to be very reliable and current bandwidth good enough to support cloud computing services.

Research objective 2: To assess Kenyan universities to adopt cloud computing services. The findings revealed that most institutions ICT departments have strong knowledge of cloud computing and IT infrastructure management and they are able to manage it without needing support from service providers. Findings from interview survey supported this fact that these institutions already are running their private cloud. The survey revealed that all institutions need to predict rapid growth and therefore expand their infrastructure. The survey revealed that most institutions have sufficient bandwith to support cloud based services which corresponds to interview findings.

Also, the findings revealed that most institutions' servers encounter increased workloads during specific days with 78% respondents, which was supported by interview survey with respondents agreeing they need to adopt better technology to solve this problem. The findings revealed that most institutions have plans to migrate more services to cloud and have set migration timeline. This was supported by interview survey findings where most respondents agreed that they have set cloud strategy for the next five years. Interview survey also revealed that there is no migration process in place to help see the migration process run successfully.

CHAPTER FIVE

THE MIGRATION FRAMEWORK

5.0 Introduction

In this section we discuss each step of the proposed migration framework and evaluation results.

5.1 Migration framework

As discussed earlier in chapter two, we introduce a step by step methodology for migration of database layer to cloud. To address the identifeid deficienceis, we propose a vendor and database technology independent step-by-step methodology which refines and adapts one discussed above. The diagram 12 below shows our six step methodology

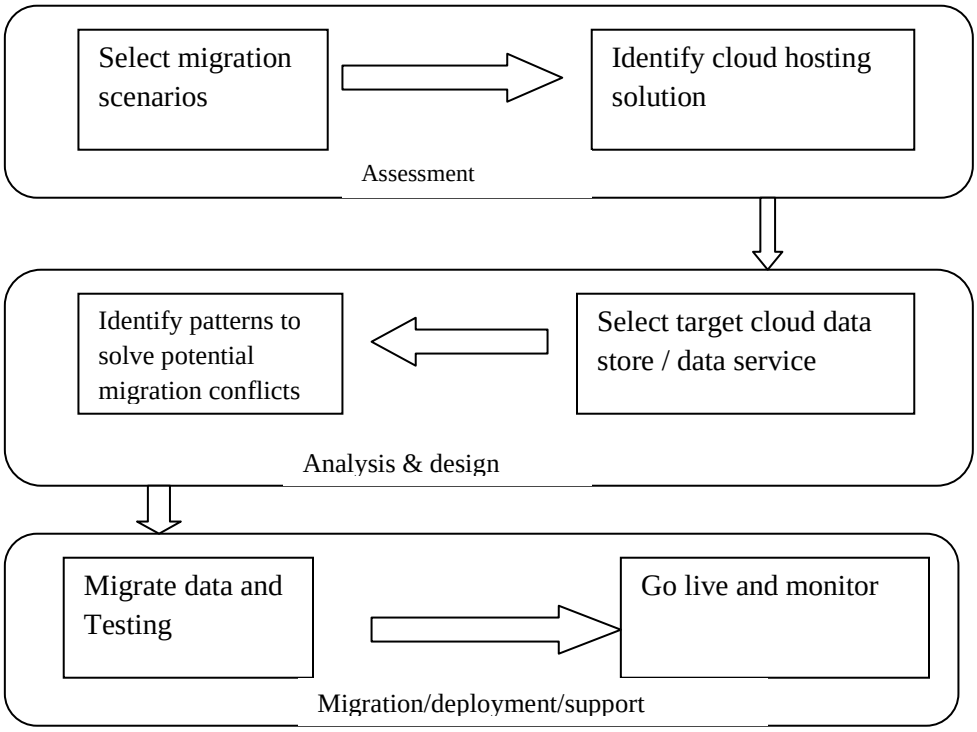

Fig 12: The Proposed database as a service migration framework

5.2 The steps of the migration framework are explained

For this framework to be realized, we sought for a cloud data migration tool that could help us achieve our goal. We found an online automated cloud data migration assistant tool from www.cloud-data-migration.com, which we used to migrate dummy MySQL database to Google SQL cloud.

The tool allows you to create an account into their portal then describe the project(s) you want to undertake. The figure 13 below shows the tool's homepage

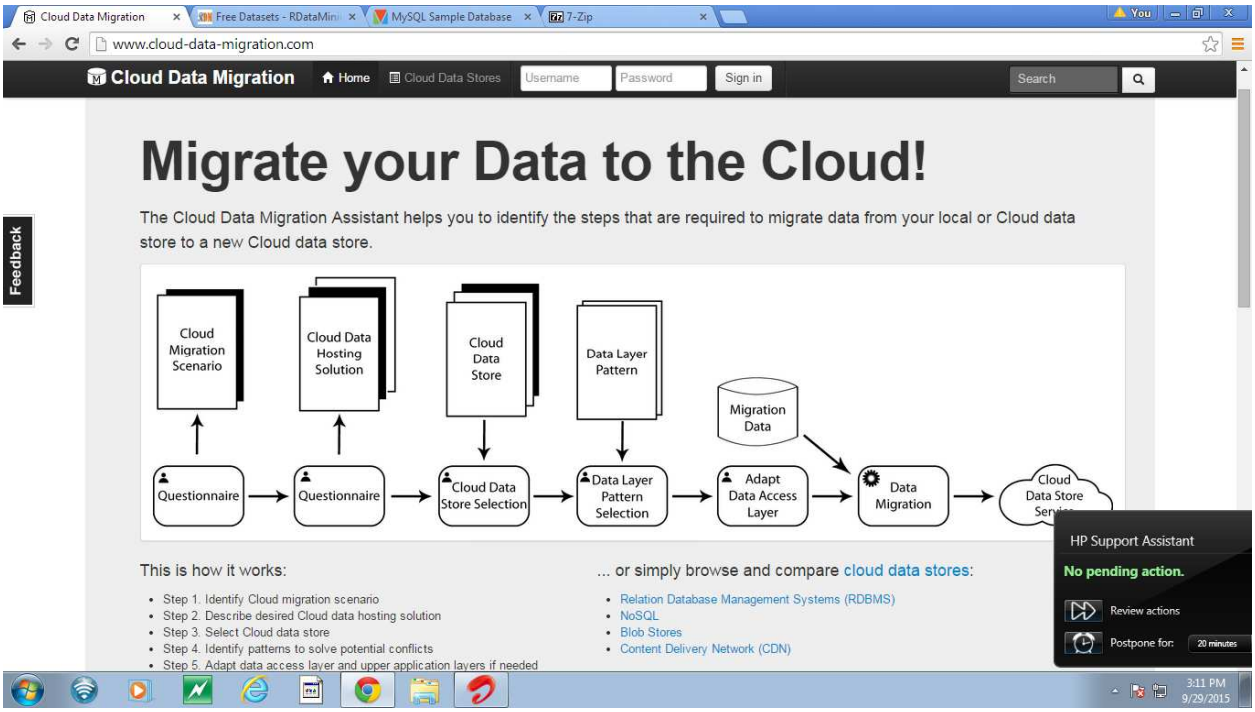

Fig 13: cloud data migration assistant tool

Step 1: Select Migration Scenario

The first step is selection migration scenario, where the user choose cloud migration scenarios that will fit their requirements i.e. cloud bursting, geographical replication, sharding, working on data copy *(FR_f)* etc. These migration scenarios cover both migration directions between on-premise and off-premise (FR_a).; it also helps the user to formulate a migration strategy by considering migration properties such as live or non live, complete or

partial migration, temporary or permanent migration. At this point any conflict between selected migration scenario and migration strategy should be solved.

Step 2: Identify cloud data hosting solution

This is focuses on the specification of functional and non-functional requirements with respect to target data store or data services. Therefore we derive an initial set of properties grouped in different categories based on Paul, (2009) criteria of good database design and some categories provided by cloud providers such as Microsoft, Amazon etc. The table below shows the categories and the properties we consider. These categories cover both relational and non relational databases.

Table 4.2 Set of categories and properties for specification of requirements of cloud hosting solution

Category	Properties	Available options
Scalability	Degree of automation	Manual, automated
	Type	Horizontal/vertical
	Degree	Virtually unlimited/limited
	Time to launch new instance	
Security	Storage encryption	Yes/No
	Transfer encryption	Yes/No
	Firewall	Yes/No
	Authentication	Yes/No
	Authorization	Yes/No
	Integrity	Yes/No

	Confidentiality	Yes/No Yes/No
Availability	Replication Replication type Replication method Replication location Automatic failover Degree	Yes/No Master-slave, master-master Synchronous, Asynchronous Same data center, different data center Yes/No 99.9%, 99.999%
Storage	Storage type	RDBMS or NoSQL
Interoperability	Migration deployment and support Data portability Data exchange format	Yes/No None, import, export XML, JSON, proprietary

Step 3: Select target cloud data store or data service

This is done by mapping the properties of cloud data hosting solution specified in previous step to the set of available data stores and data services that have been categorized according to the same functional and non-functional properties. Implementation of this step requires data stores and data services to be previously specified according to the set of functional and non-functional properties either directly by cloud provider or by the user of this methodology. To solve any potential migration conflicts, source of data store or service should be described *(FR_h).*

Step 4: Identify patterns to solve potential migration conflicts

Data migration to cloud comes along with many challenges as incompatibilities with database previously used or accidental disclosing of sensitive data. Incompatibilities may lead to inconsistencies between functionality of an existing traditional database layer and characteristics of an equivalent cloud data hosting solution. In this phase, conflicts are identified by checking the compatibility properties of the target data store selected in step 3 with the properties of the source data store or data service used before migration *(FR_h)*. These patterns include confidentiality patterns, replication patterns etc.

Step 5: Migrate data and Testing

This stage entails reassessing all other phases to ensure that all the requirements are met; institutional data access and security constraints are well implemented *(NFR_a)*. It also entails configuration of the connections to the source and target data stores or service. Source data store or service and target data store or services are synchronized.

Step 6: Going Live and Monitoring

This phase involves full migration implementation and going live. Monitoring is done to ensure that the target environment meets the users' requirements. The cloud data migration tool used in this study offers basic monitoring parameters. Guidelines required in this phase are determined by the cloud provider chosen by the user. For private cloud we propose that the user should set their guidelines guided by their requirements.

5.3 Framework realization

In this section we present how the proposed framework was realized and challenges encountered during this process. We used an online cloud data migration assistance tool describe above. This is an automated data migration tool that offers user control of his/her data in the sense that it offers most of the facilities needed during migration depending on which migration scenario you select. The tool also offers choices of the important data security concepts and constraints.

In the first phase we choose cloud burst migration scenario where data is moved temporarily to the cloud to deal with high traffic situations. After the peak is over and local data sources are big enough to handle the traffic, the data is moved back. In step two we selected properties like security, interoperability, storage types, maintenance services i.e. monitoring and performance measuring parameters.

We selected Google cloud SQL public cloud because it provides most of properties we selected and described in the previous phase. We also selected confidential pattern to solve any data confidential conflicts between source data store and target data store. The tool automatically configures the all the selected items and gives a summary of your choices, this helped us to make changes to solve any identified problem. The actual migration depended on Google Cloud SQL set procedures; therefore we configured the database to be migrated using Google set procedures, for final migration.

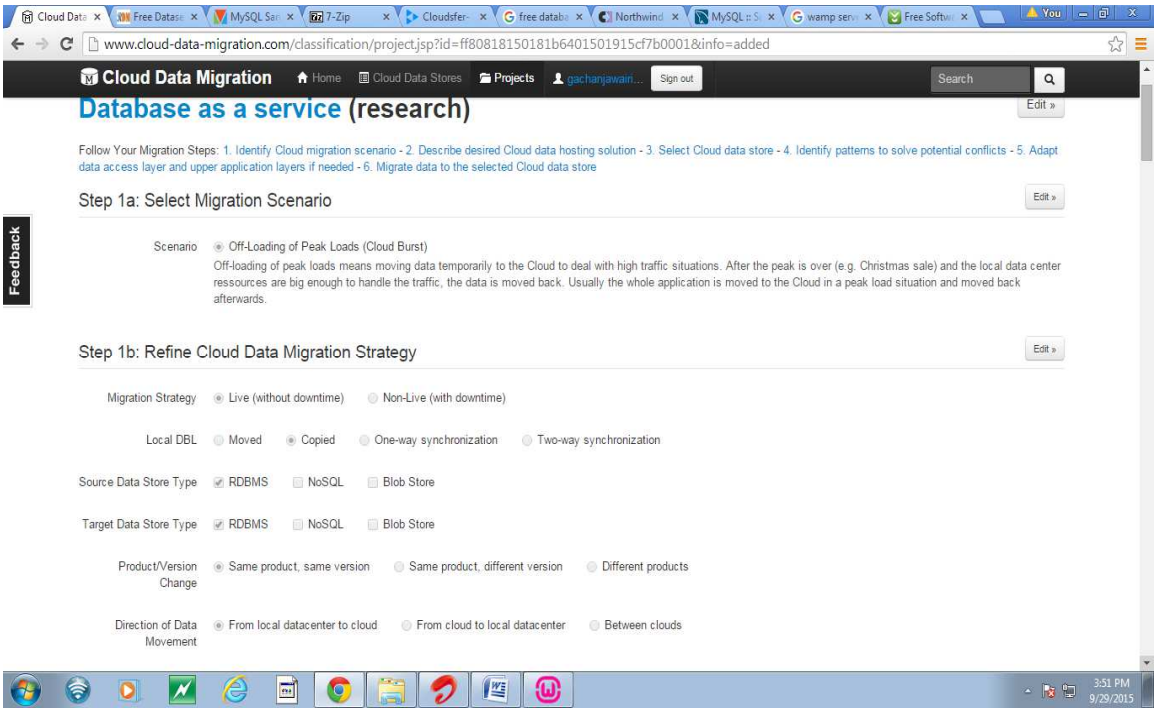

Fig. 14 Migration process

5.3.1 Challenges encountered during migration

Our framework 5th phase required we first implement the data migration and test it before going live. Using cloud data migration assistant tool it was not possible to implement this phase since the tool does not supported it. Also the final phase of the proposed migration was not implemented fully using the tool because performance and monitoring parameters are set during 2nd and 3rd phases.

We selected a public cloud model and target data to implement our migration. We noted that not all security and privacy considerations we has selected were supported by public cloud providers, therefore we conclude that for better data security and privacy results, a private cloud should be considered rather than a public cloud.

Since the tool we used was designed to migrate database layer of an application, we observe that it is not the best for migrating the whole database to cloud. We did not get any other free migration tool that could support database migration to cloud, therefore propose further study on a tool that can support the proposed framework fully. We also suggest further work on the last two phases specifically on database testing and monitoring.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

In this section we will briefly discuss the research conclusion, recommendations, contribution to knowledge and future work.

6.2 Conclusion

Overall, cloud computing is no longer a hype but a technology that is set to change the way HEs operations are implemented. Colleges and universities around the world are discussing, planning for and using cloud computing and services driven by the opportunities it promises to offer.

Summary of conclusions addressing the research questions

1. **What are the factors that influence adoption of cloud computing in Kenyan Higher Education Institutes?**

   Cloud computing is very a promising technology that offer a variety of advantages. The research shows that HEIs in Kenya are attracted to cloud computing by it offerings. 100% of the respondent felt that cloud computing reduces IT cost that is reduced cost of buying new licenses, maintenance etc. Other factors that positively influence adoption of CC are getting access to cutting edge IT resources at low cost, make IT more reliable and to improve IT services. With less budget allocated to ICT departments, CC offers an alternative to costly on premise services.

   On the other hand, HEIs face a number of hindrances in making decision on adoption of CC. The study revealed that security concern is the biggest issue when it comes to adoption of cloud computing with 67% respondents saying it affects the way adoption decisions are made. The study concludes that for

better data and security terms, institution should consider either private or hybrid cloud models for their data hosting.

Other issues that arose were budget constraints, inadequate knowledge and skills, lack of management support and bandwidth issues. To make the right decision, motivating factors must over ride de-motivating factors and this requires institutions' management to be innovative to be able to take the risk and in turn rip from the technology. The research indicated that some institutions are taking the risk.

2. **Are Kenyan universities ready to adopt database as a service?**

   The study shows that the more innovative an institution is, the more it is likely to adopt cutting edge cloud solutions such as database as a service. The study revealed that universities with a population of over 40000 were more ready and willing to adopt and implement best cloud solutions than ones with less population; therefore we can conclude and say that 'big' universities are ready to adopt database as a service.

3. **What cloud database migration framework exists and can they be used to migrate an institutions database to cloud?**

   There are several cloud migration frameworks that exist; both vendor-technology dependent and vendor-technology dependent frameworks. All of these frameworks are for migrating enterprise applications or application data to cloud. Vendor-technology dependent frameworks are offered by cloud service providers like Oracle, Amazon etc. and are for migrating to their cloud services. The study reveals that they cannot be used in a university setting for data privacy and security reasons. The existing vendor-technology independent framework deals with migrating application data to cloud, therefore there is no database as a service migration framework that exists since it does not take into consideration the performance and optimization

The proposed framework that is built on an existing application data migration framework will be used for migrating databases to private clouds. It is a vendor and technology independent framework that well fits in a university setting because an institution can be able to customize it to fit its cloud requirements. The framework will play a great role in standardizing cloud database migration and hence support cloud maturity.

There have been a lot of efforts in recent years to make cloud technology mature with National Institute of Standard and Technology (NIST) proposing cloud service models and delivery models. Other individuals have proposed various ways of making migration of cloud data more secure and effective in their effort to standardize cloud technology. We expect our framework to prove useful in this effort and also provide a secure process of migrating institutional database to cloud.

We expect that the framework will help create confidence in HEIs when it comes to migrating database to cloud since it ensures that institutional security constraints on data are observed during migration. We also expect that if an institution adopts cloud technology, they would get an opportunity to be the next cloud service provider to industries and business therefore generating more revenue. This will also help in creating the much required capacity of cloud technology experts in Kenya.

Additionally, a key element of further work is to developing a cloud data migration tool that would support the proposed framework fully. Other further work is to test our framework through a real life case study and also identifying improvements on the framework especially in ensuring that applications are self adaptive.

6.3 Recommendation

Following the outcome of the research, the following recommendations are put forth to boost growth of cloud computing in Kenyan universities.

1. Allocation of more funds to implement institutions' cloud strategy not only to serve their constituents better but also to become cloud service providers to business and other institutions of higher learning.

2. The government should come up with an education cloud strategy and other policies that will safeguard information in the cloud; this can be done through a body like Kenya Education Network (KENET) which can help in laying out cloud computing adoption standards for HEIs, research on best cloud solutions suitable for HEIs in Kenya. The study revealed that lack of a national cloud strategy have hindered adoption of cloud computing in the sense that there is no formal platform that can be used as a pillar for building an institutional cloud strategy. In other words, a national education cloud strategy will create confidence that cloud technology is mature.

3. Institutions should venture in developing private/community cloud owned and operated by the institution, where they will have full control of institution's data and security controls.

6.4 Contribution to knowledge

The findings showed that cloud computing will be the next generation computing model in Kenyan universities; that most universities have adopted cloud computing and have plans to adopt significant cloud solutions in the near future as discussed in chapter four.

The proposed migration framework will contribute a great extent in standardizing cloud computing technology; this will increase maturity of cloud computing technology and hence increased adoption of cloud computing in institutes of higher learning in Kenya.

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APPENDICES

ASSESSING READINESS FOR ADOPTION OF DATABASE AS A SERVICE IN KENYAN UNIVERSITIES

I am a Msc student at University of Nairobi, school of computing and Informatics conducting a survey on state of art of cloud computing in Kenyan Universities. The purpose of this survey is to collect data that will be used to assess the readiness of adopting cloud computing in Kenyan Universities. It is a baseline survey towards developing a migration framework to cloud computing services i.e. Database as a service.
The information collected will be treated confidentially and will be used for academic purposes only.

Thank you for taking your time to participate in this survey.

* Required

1. What is the size of the institution in which you are working (No. of students and staff)? *

- o ☐ less than 10,000
- o ☐ 10,000 - 20,000
- o ☐ 20,000-40,000
- o ☐ Above 40,000

2. What is the type of the institution in which you are working? *

- o ☐ Public
- o ☐ Private

3. How well understood is the concept of cloud computing at your institution? *

- o ☐ We know what cloud computing means, we are already using it in my institution
- o ☐ We know what cloud computing means, BUT we are not currently using it in my institution.
- o ☐ We have heard of the term cloud computing, but we are not sure what it means.
- o ☐ Never heard of the term cloud computing, no idea what it means.

4. Which of the following cloud models is your institution currently using? *

- o ☐ Private cloud developed and managed by cloud service provider
- o ☐ Private cloud developed and managed by the university
- o ☐ Public cloud
- o ☐ Community cloud
- o ☐ Hybrid cloud
- o ☐ Don't know

5. Which of the following areas have you adopted cloud computing in your institution? *

	No plans to be adopted in the near future	In consideration to be adopted in the near future	Neutral	Have been Adoption
Student Management (Administration, Registration, Enrollment, Alumni)	☐	☐	☐	☐
Student Emails	☐	☐	☐	☐
Staff Emails	☐	☐	☐	☐
Administrative Systems(HR, Payroll, Asset Management etc.)	☐	☐	☐	☐
Backup and Storage facility	☐	☐	☐	☐
Hardware Infrastructure	☐	☐	☐	☐
Learning Management system	☐	☐	☐	☐

6. Which of the following factors may have influenced your decision to adopt cloud computing in your institution? *

Pick an area for which you are currently using cloud computing

	Not very important	Neutral	Important	Very Important
Reduce IT cost	☐	☐	☐	☐
Get access to cutting edge IT resources	☐	☐	☐	☐
Reduce implementation risks	☐	☐	☐	☐

	Not very important	Neutral	Important	Very Important
Lack of in-house technical expertise	☐	☐	☐	☐
Make IT more reliable	☐	☐	☐	☐
Improve IT services	☐	☐	☐	☐
Management support	☐	☐	☐	☐

7. Have you encountered any problem that may have contributed to your reluctance to consider cloud computing? *

(Pick an area you have not adopted Cloud computing)

7b. If YES , List down the problems you may have encountered in the space provided below

8. Do you encounter occasional increased workloads on your servers? (during some periods of the year or on some specific days) *

- o ☐ Yes
- o ☐ No

9. What would be a close estimate to your current Internet bandwidth? *

- o ☐ 10 Mbps and below
- o ☐ 10 -100 Mbps
- o ☐ 100 Mbps – 1 Gbps
- o ☐ Above 1 Gbps

10. What would you forecast the growth of your institution to be over the next 3 years? *

- o ☐ Constant, we don't plan to expand our infrastructure

- o ☐ We need to be able to expand our infrastructure
- o ☐ We need to predict rapid growth and, therefore we need to expand our infrastructure
- o ☐ Decreasing

11. How would you describe knowledge about cloud computing and IT-Infrastructure management within your institution? *

- o ☐ Weak
- o ☐ Basic knowledge and understanding
- o ☐ Advanced technical skills and knowledge
- o ☐ We have a strong knowledge and can manage most of it ourselves

12. If you are planning to migrate to cloud computing, what is your timeline for this migration? *

- o ☐ 1 year
- o ☐ 18 months
- o ☐ 3 years
- o ☐ 5 years
- o ☐ Not Sure