

Adoption of Cloud Computing for Education in Kenyan Universities: Challenges and Opportunities

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Abstract— Cloud computing is an emerging technology that provides numerous services that enables one to store files “in the cloud” and access them from anywhere as long as there is internet connectivity. Cloud computing services may include dropbox, icloud, GoogleDrive, GoogleDocs amongst others. Kenyan universities are expected to stay abreast with the long list of competing demands such as: deploying applications and delivering web-based student services at a rapidly increasing rate without proportionate increase in budget allocation; Maintaining a legacy IT infrastructure increasingly unable to support the growing number of personal devices such as tablets, smart phones, and laptops that students bring into the campus network among others. The aim of this study is to explore the potential of cloud computing in transforming the operations of both public and private universities in Kenya as it offers many opportunities such disaster recovery, business continuity, data consolidation, availability, confidentiality and data integrity. The study was conducted in selected public and private universities to analyze the strengths, weaknesses, opportunities and threats regarding adoption and use of cloud computing. Structured interviews, open and close ended questionnaires, observations and examination of educational reports was done. The study adopted a descriptive survey method to determine perceptions of adoption of cloud computing in universities. The findings showed that most universities deployed SaaS for learning management and student e-mails. However, the perception on cloud insecurity and lack of awareness remains a key challenge for potential users.

Key words: Adoption, Cloud computing, Universities, ICT.

I. INTRODUCTION

According to [1] Cloud computing is a new model based on grid computing, distributed computing, parallel computing and virtualization technologies. It is used for hosting resources and providing services to consumers. It offers a convenient, on-demand access to a centralized shared pool of computing resources that can be deployed with minimum management overheads and at the same time realize great efficiency.

The National Institute of Standards and Technology (NIST) defines cloud computing 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 rapidly be provisioned and released with minimal management effort or service provider interaction [8].

Cloud Computing providers rely on the Internet as the means of communication to deliver IT resources to their consumers on a pay-as-you-go basis. With this technology consumers can access resources directly through the internet, from anywhere any time without any technical or physical concerns [4]

1.1 Types of Clouds

According to [6] Cloud computing services fall into three separate categories or levels:-

- i) *Infrastructure as a service (IaaS)* - This is the lowest level and it provides virtualized servers, networks, storage, and system software. This level also permits many advantages to organizations and even has the potential to replace an entire data-center Law [7]. A

cloud-based IaaS provide an effective solution against the problem of the reliance on a single server by providing multiple entry points application programming interfaces (API) as a service platform that enables data storage and retrieval from multiple points. Therefore, a failure at one point could be overcome by redirecting the request to a different point [2]. Consumers can rent basic computing resources such as processors and storage, and use them to run their own operating systems and applications for example Amazon's Elastic Compute Cloud. Universities can use this infrastructure to run servers on virtual machines and scale up usage as required.

- ii) *Platform as a service (PaaS)* - This is the next level up and it enables customers to install their own applications using a platform specified by the service provider. An example here is the Google Apps Engine where developers can write and install applications. This level gives customers virtual servers to run existing applications, in addition new applications can be developed without the need for maintenance.
- iii) *Soft ware as a service (SaaS)* – This is the highest level of cloud computing and the most important in education. Data and applications are stored in the cloud and the users only require a web browser to access them. Examples are Google Apps for Education and Microsoft Live@edu which provide communication and office applications such as email and spreadsheets.

1.2 Deployment Models

The National Institute of Standards and Technology's (NIST) outlines four different models of cloud deployment:-

- i) *Public* - A public cloud includes services that are available to all members of the general public. Applications in public clouds are provided by third parties on the cloud's servers, storage systems, and networks [2].
- ii) *Community* - A community cloud is cloud is an infrastructure that is shared between several organizations with common concerns, such as

security, from a specific community. The cloud can be hosted and managed internally or by a third party cloud [2].

- iii) *Private* - A private cloud is a cloud infrastructure managed and hosted internally or externally by a third-party for a single organization. Private clouds are built for the exclusive use of one client, to have full control over their data, increase the level of security, and assure quality of service [2].
- iv) *Hybrid* – This model allows institutions to use a combination of the previously mentioned deployment models to run an application or system. For instance, a hybrid cloud can combine multiple public and private cloud models.

1.3 Key characteristics of cloud computing

According to [8] the following are the key characteristics of cloud computing:-

- i) *On-demand consumer access*: The consumer can access computing facilities, such as server time and network storage as need arise without interacting with the service providers.
- ii) *Broad access to network*: Computing facilities are available over a network that can be accessed through thick or thin clients such as smart phones, tablets, laptops, and desktop computers.
- iii) *Pooling of resources*: The service provider's resources are pooled using a multi-tenant model to balance the loading between multiple consumers. Different physical and virtual resources are dynamically assigned and reassigned to optimize services according to consumer demand.
- iv) *Flexible provision of services*: Services can be flexibly provisioned and released, automatically, to scale and adjust to the levels of demand. For the customer, the services available usually appear to be unlimited and can be accessed in any quantity at any time.
- v) *Measurement of services*: Cloud systems utilize a metering capability to automatically control and optimize the allocation of resources in accordance with the type of service such as storage, and data processing.

1.4 Benefits of Cloud Computing for Universities

i) Lower environmental impact

In some countries there are now “green” targets for reductions in power usage by organizations. Cloud computing enables universities to reduce their electricity consumption and optimize power usage over a group of customers.

ii) Concentration on core business

Another claimed advantage of cloud computing is that it will enable universities to concentrate on their core business of education, training and research. Computing services can be handled better by organizations with specific expertise and economies of scale.

iii) End user satisfaction

Cloud computing offers availability and a wide range of new applications. These applications contain the latest tools and features from innovative companies such as Microsoft and Google. Students can use office applications for free without having to purchase, install and can keep these applications up to date on their computers. Users do not have to worry about backing up or losing data as it is safely stored in the cloud with large storage capacity provided for free. Users are also able to access their data from any location or via a range of devices such as their mobile phone. Technologies such as HTML5 are increasingly allowing users to work offline when Internet access is intermittent.

1.5 Challenges of Cloud Computing for Universities

i) *Security and Privacy:* - This was the top most concern of most universities. The fact that cloud computing introduces a third party due to outsource essential services it is difficult to maintain data integrity and privacy.

ii) *Real Benefits:* – Most Universities are not convinced of the potential benefits of this technology. Their main concern is how to realize the full potential and make cloud part of their mainstream IT Portfolio. Universities need to be aware of the real benefits of cloud computing rather than the seeing the potential of cloud computing to add value. There should be indicators to compare availability,

performance versus recovery SLA, costs benefits and utilization.

iii) *Service Quality:* - Service quality is one of the crucial factors that the universities cite as a core value for not moving their business applications to cloud. They feel that the SLAs provided by the cloud providers today are not sufficient to guarantee the requirements for running a production applications on cloud especially related to the availability, performance and scalability. In most cases, enterprises get refunded for the amount of time the service was down. Without proper service quality guarantee universities are not ready to host their critical infrastructure in the cloud.

iv) *Performance / Insufficient responsiveness over network:* - Delivery of complex services through the network is clearly impossible if the network bandwidth is not adequate. Most of the universities do not have enough bandwidth and are waiting for improved bandwidth and lower costs before they consider moving into the cloud since many cloud applications are still too bandwidth intensive.

v) *Integration:* - Many applications have complex integration needs to connect to other cloud applications as well as other on-premise applications. These include integrating existing cloud applications with existing university systems and data structures. There is a need to connect the cloud application with the rest of the university systems in a simple, quick and cost effective way.

2. BACKGROUND

According to the Kenya Vision 2030 education and training is one of the social pillars required to provide skills required to steer Kenyans to the economic and social goals of the vision. In his study [9] reported that there has been a rapid expansion of programs in our universities today and they are endangered by various socio-economic circumstances such as globalization drive, which is forcing universities to transform in an effort to increase their capital base to counter the consistently decreasing capitation by the government. Universities and Colleges in Kenya are already experiencing

e-mail security challenges from the large student accounts that require dedicated servers and techies to guard against virus, worms, spam and other malware attacks," said Kevin Chege, a senior ICT officer at the Kenya Education Network (KENET), the ISP which brings together higher education institutions in the country [15].

While budgets and resources remain under pressure, the education sector finds itself confronted with the growing challenges presented by technology (in fact, this is both an opportunity and a challenge) as well as by fundamental changes in society. As a response to these pressures, the universities must change to become service oriented in order to optimize the efficiency and effectiveness of all operations and interactions with the main stakeholders [10]. As a result universities throughout the World have become highly dependent on information technology to run their operations while procuring and maintaining a wide range of hardware and software require substantial, ongoing investment expertise to maintain them. The economies of scale and other features of cloud computing are likely to result to an increasing shift away from institutionally-hosted services. These cloud services are provided using Internet technologies to and universities user communities can access them anywhere using web browsers.

3. RESEARCH QUESTIONS AND OBJECTIVES

3.1 Questions

- i) What is the extent of cloud computing adoption in Kenyan Universities
- ii) What are the technical requirements for cloud computing?
- iii) What is the impact of adopting cloud computing in e-learning?
- iv) How can the universities exploit the full potential of cloud computing?

3.2 Objectives

The study seeks to provide an understanding of how Kenyan universities are using cloud computing to enhance teaching and learning and provide recommendations on how these universities can optimize the potential of cloud computing.

To realize this goal, the study is guided by the following objectives:-

- i) To find out the current status of cloud computing adoption in Kenyan Universities
- ii) To determine if the universities have the right infrastructure and human expertise in place
- iii) To assess the impact of adopting cloud computing in Kenyan Universities
- iv) To find out what is hindering deployment of cloud computing in our universities
- v) Make recommendations on how to exploit the potential of cloud computing

4. LITERATURE REVIEW

Many universities have begun moving to the clouds by outsourcing their student email provision [13]. Email is an important and yet basic service that can be provided easily by third parties. Both Google and Microsoft offer email services for free to institutions of learning, this is part of the larger applications suites usually made available to students alongside email. Google Apps for Education and Microsoft Live@edu contain other communication tools such as instant messaging along contact management and calendar software. There are also document creation applications allowing the production of word processed documents, spreadsheet, presentations as well as websites.

Significant storage space for all types of documents is offered to users and they can continue to use it even when they leave the institution. Educational institutions are using lower level cloud services for data storage especially where data security is of lower concern such as open educational resources.

Another emerging use of cloud computing is hosting of learning Management Systems (LMSs) such as blackboard and Moodle. This is cost effective for institutions who cannot justify the costs of purchasing, maintaining and supporting infrastructure. Support and involvement of these companies in education has attracted many institutions all over the world to enhance learning. There are successful deployment of cloud services in US, UK, Asia and Africa institutions of learning. Some few examples of these institutions are North Carolina State University [1], Colorado State University [5],

University of California, and Washington State University [14]. In the UK we have Leeds Metropolitan University, the University of Glamorgan, the University of Aberdeen, and the University of Westminster, just to mention few.

In Africa over 30 institutions have partnered with Google to use Google cloud services [11] and these institutions include University of Pretoria (South Africa), University of Ibadan (Nigeria), University of Mauritius (Mauritius), and University of Ghana (Ghana). In East Africa, we have the University of Nairobi, United States International University, the Kenyan Methodist University, Makerere University Business School (MUBS), National University of Rwanda, the Kigali Institute for Education and the Kigali Institute for Science and Technology [15].

5. MATERIALS AND METHODS

This study adopted a descriptive survey aimed at investigating the perceptions towards cloud computing in universities today, establishing the cloud services deployed in these universities and to do a SWOT analysis of this technology. Descriptive survey is concerned with finding out the what, where and how of a phenomenon. This survey was chosen because it enabled the researchers to generalize the findings to a larger population that is the findings to the adoption of cloud computing by Universities in Kenya.

5.1 Scope and Sample size

The study was limited to Universities in Nairobi due to time constraints and also the fact that most universities are setting up campuses in Nairobi being the economic hub of East Africa. Ten Universities were identified based on the possibility that they were using cloud services.

5.2 Population Sampling

Data for the study was mainly drawn from interviews conducted on ICT officers and ICT Manager or ICT Directors. The target population comprised of ten universities located in Nairobi. They include five Public Universities namely: - University of Nairobi, Moi University – Nairobi Campus, Technical University of Kenya, Kenyatta University, Multimedia University and Jomo Kenyatta University of Agriculture and Technology. The five private universities include Strathmore University, United States

International University, Kenya Methodist University, Catholic University of Eastern Africa, Kenya college of Accountancy University, Africa Nazarene University and Mount Kenya University.

6. RESULTS

The researchers went out to interview the respective people in 12 universities mostly the ICT Directors or Managers, Deans or Directors of Schools, Information Security Managers and ICT officers because they are familiar with the needs of the universities and are likely to be involved in policy formation and implementation. To cater for unavailable respondents the interviews were conducted in 13 universities. Out of the 13 we were not able to get the respondents in 2 universities within the set time. 10 universities out of the 11 who participated were chosen for this study.

Category	Population	Interviewed	%
ICT Directors / Security Managers	10	10	100
Deans of Schools	13	10	77
IT Officers	15	13	87
TOTAL	38	33	

Table 1: People Interviewed

7. ANALYSIS

Cloud computing as an emerging trend which is still very new and a lot of sensitization on the potential and benefits of this technology needs to be done. Most of the universities interviewed were basically using SaaS for learning management systems and students’ emails. PaaS and IaaS were not very common in these universities. Some universities have deployed private clouds within their intranet to support research. In our study we noted some concerns amongst the interviewees and they include:-

- i) Privacy and security concerns especially for their data
- ii) Availability especially when no internet connection
- iii) The technology requires expertise to deploy

<p>STRENGTHS</p> <ul style="list-style-type: none"> - Reduces costs such as infrastructure, labour, licensing - Increased productivity by trying new ideas without investing on the technologies - Universities are able to scale up usage as required - Disaster recovery and business continuity plans - Environmental conservation due to reduction in carbon emissions - Increased competitiveness since universities are able to concentrate on their core business - Flexibility since cloud services can be accessed from anywhere - Pay as you go basis enabling universities to pay for only what they need 	<p>WEAKNESSES</p> <ul style="list-style-type: none"> - Internet dependent - Poor network infrastructures - Insufficient bandwidth to serve the user communities effectively - Lack of policy and legal frameworks on cloud computing - Lack of technical skills hindering deployment of this technology - Regulatory uncertainties since users are not able to influence the technical architecture
<p>OPPORTUNITIES</p> <ul style="list-style-type: none"> - Reliability - Fault tolerance since there is no single point of failure - State of art technologies - Universities are able to deploy virtualization services - Expose students to new technologies - Provide opportunities for supporting research 	<p>THREATS</p> <ul style="list-style-type: none"> - Data breaches - Data Loss - Account or service traffic hijacking - Insecure interfaces and APIs - Denial of Service - Internal attacks - Abuse of cloud services since there is no regulatory framework - Insufficient due diligence - Shared technology issues

iv) Threats - external factors that could jeopardize the project.

Table 2: SWOT Analysis.

7.1 A SWOT Analysis of Cloud Computing

A SWOT analysis examines four elements:

- i) Strengths - internal attributes and resources that support a successful outcome.
- ii) Weaknesses - internal attributes resources that work against a successful outcome.
- iii) Opportunities - external factors the project can capitalize on or use to its advantage.

8. CONCLUSIONS

Adoption of cloud computing for universities can go a long way in enhancing teaching and learning; however there are insecurity perceptions amongst potential users. A lot of sensitization on the available policy and legal frameworks should be done. Regulatory standards should also be put in place to regulate the cost and protect end users by ensuring

confidentiality and integrity of their data. Technical expertise is another challenge facing the universities and this call for

development of human capacity to equip them with the necessary skills and legal knowledge to ensure contracts are well formulated and managed. Cloud computing is an emerging trend and therefore most people do not understand the potential and benefits of this technology thus awareness should be enhanced to send accurate information to potential consumers.

Through adoption of cloud computing universities will be able to cut down on costs especially with the decreasing capitation from the government. Consequently the universities can leverage on the state of the art technologies and concentrate on their core business for increased productivity.

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