Deployment and Adoption Strategy of Cloud Computing for Blended Learning in Higher Education Institutions in Sub-Saharan Africa

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ABSTRACT

Many higher education institutions in sub-Saharan Africa have been blending traditional face-to-face delivery with various Information and Communication Technologies (ICT) to meet the strong demand for higher education as well as to improve the quality of traditional campus programs. Despite the increased adoption of various forms of blended learning in the region, the cost of acquiring and managing ICT infrastructure remained to be the biggest challenge. While cloud computing can provide powerful computing at a fraction of the cost of traditional ICT infrastructure, its potential to enhance blended learning in higher education in sub-Saharan Africa is unexplored. This chapter proposes deployment and adoption strategy of cloud computing to enhance blended learning services in the region. This work contributes towards helping higher education in sub-Saharan Africa to understand cloud services and to make plans for successful migration of computing services into cloud.

INTRODUCTION

Over the past few years there has been a dramatic increase in the use of various Information and Communication Technologies (ICT) in higher education institutions in sub-Saharan Africa. Many institutions are integrating ICT into education as a way to meet the strong demand for higher education – a demand they simply cannot meet with traditional campus programs (Adkins,
Institutions have also been viewing ICT as a solution to cost reduction as well as improving the quality of teaching and learning in the region (Selim, 2007). The cost reduction is described in terms of the costs of classrooms and facilities, training, travel, printed materials, and labor (Bhuasiri, Xaymoungkhoun, Zo, Rho, & Ciganek, 2012).

In light of these benefits, it is not surprising that institutions and international agencies have been spending many thousands of dollars to pilot and implement various eLearning solutions in the region (Farrell & Isaacs, 2007). For example, the African Development Bank Group (AfDB) provided a grant of $15.6 million to African Virtual University (AVU) to build eLearning centers and train content developers at 31 partner institutions in the region (Adkins, 2013). Similarly, the Partnership of Higher Education Africa (PHEA) has given funding to seven institutions in Africa to implement various eLearning solutions (Hoosen & Butcher, 2012).

With these initiatives and many others, the integration of ICT with traditional face-to-face classroom has been increasing significantly in the past few years. According to Adkins (2013), the blended learning in the region has been growing at the rate of 15% per annum between 2011 and 2016. This is also evident from the number of Learning Management Systems (LMS) which have continued to be implemented in higher education in the region. For instance, 80% of higher education institutions in Tanzania were found to have installed various LMS with Moodle being the most popular (Munguatosha, Muyinda, & Lubega, 2011). Similarly, five institutions surveyed by Ssekakubo et al. (2011), six by Lwoga (2012), and seven institutions that participated in PHEA project were found to have installed various LMS (Hoosen & Butcher, 2012).

Similarly, 74 per cent of 447 respondents across 41 African countries said they were using various ICT to support teaching and learning; with 48 per cent using mobile phones, 36 per cent Shared Resource Computing, and 29 per cent desktop virtualization (Isaacs & Hollow, 2012). Additionally, a recent eLearning Africa conference 2013 report indicates that 83 per cent (out of 413 respondents) from 42 African countries were using laptops, 71 per cent mobile phones, and 67 per cent stand-alone computers to support teaching and learning (Isaacs, Hollow, Akoh, & Harper-Merrett, 2013). The majority of these institutions have been combining various ICT with traditional face-to-face delivery to create the so called “blended learning”.

Despite the adoption and penetration blended learning in higher education institutions in the region, several challenges exist. The majority of the challenges faced by these institutions are unique from developed countries (Bhuasiri et al., 2012). For instance, one of the main challenge is the cost of acquiring and maintaining ICT infrastructure to facilitate blended learning delivery (Lwoga, 2012; Ssekakubo et al., 2011; Tedre, Ngumbuke, & Kemppainen, 2010; Unwin et al., 2010). The cost of hardware, software and Internet in the region is still high and unaffordable to the majority of institutions. For example, one institution surveyed by Lwoga (2012) was paying 104 million TShs per year for Internet connection, while another institution surveyed by Tedre et al. (2010) was paying 4 million TShs (2140€ = 3100$) per month for a dedicated 704kb/128kb satellite connection for 300 computers.

In addition to the cost of the Internet connection, the ICT infrastructure is not reliable due to frequent power cuts and shortage of technical staff to provide maintenance to on-campus ICT infrastructure. According to Selim (2007), the success of blended learning depends on the availability of rich and reliable ICT infrastructure capable of providing the courses with the necessary tools to make the delivery process as smooth as possible.

In recognizing these challenges, several initiatives have been underway to overcome these challenges especially improving the Internet connectivity and increasing Internet bandwidth. The most recent initiatives are the three broadband
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submarine fiber-optic cables (SEACOM, EASSy, WACS). These broadband submarine fiber-optic cables promises to bring increased connectivity, leading to a spurt of broadband penetration to the region (Laverty, 2011). Despite these initiatives and many others, the potential of cloud computing is unexplored. Cloud computing can provide powerful computing solutions at a fraction of the cost of traditional ICT infrastructure required to implement blended learning (Laverty, 2011).

Cloud computing involves hosting ICT infrastructure, software applications, and other computing services into cloud servers and being accessed via the Internet. Institutions can only pay for services based on usage the same way as utility services, such as water, electricity, gas, and telephony (Buyya, Yeo, Venugopal, Broberg, & Brandic, 2009; Carroll, Merwe, & Kotzé, 2011). As a result, institutions will no longer be required to procure and host ICT infrastructure in their premises and therefore, reduce the cost associated with hardware purchase, software licensing and updating, electric power, cooling, and salaries for IT support staff (Carroll et al., 2011; Koch, Assuncao, & Netto, 2012; Mircea & Andreescu, 2011; Mokhtar, Ali, Al-Sharafi, & Aborujilah, 2013; Sultan, 2010).

Therefore, the appropriate adoption and implementation of cloud computing in higher education in the region will contribute significantly towards reducing ICT investment required to deliver blended learning. This chapter proposes deployment and adoption strategy of cloud computing to enhance blended learning services in the region. This work contributes towards helping higher education in sub-Saharan Africa to understand cloud services and to make plans for successful migration of computing services into cloud.

**BLENDED LEARNING IN HIGHER EDUCATION**

The adoption of blended learning in higher education institutions is becoming common as many institutions have continued to combine various ICT with face-to-face delivery (Porter, Graham, Spring, & Welch, 2014). The ICT environment involves the use of video conferencing, learning management systems, the Internet, and other related technologies (Kumar, 2012). Kumar (2012) added that, the majority of these institutions have chosen blended learning in order to take the best of both face-to-face delivery and eLearning based delivery. The ICT environment provides opportunities for students to learn and express themselves in the written form while face-to-face discussions enables them to have enthusiasm that are spontaneous and contagious (Garrison & Kanuka, 2004).

The adoption of blended learning also enables instructors to use variety of instructional techniques with available ICT to achieve effective learning outcome. More importantly, the blended learning can potentially enable institutions in the region to widen access to their courses through distance courses. With blended distance courses, learners have greater flexibility of studying anywhere, and anytime regardless of work commitments, or distance limitations (Kumar, 2012). As a result, even those learners described as “hard-to-reach” learners such as those located in rural areas can easily benefit from courses offered in these institutions without being required to attend physically at a given institution.

For instance, the University of Dar es Salaam in Tanzania has introduced three blended courses namely the Postgraduate Diploma in Education, the Postgraduate Diploma in Engineering Manage-
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ment, and Master degree in Engineering Management (Mtebe & Raphael, 2013). These courses are offered via regional centers located in Mwanza, Arusha, and Dar es Salaam. Several institutions in sub-Saharan Africa have also adopted the same mode of delivery.

Regardless of these benefits, the success of blended depends on many factors. Selim, (2007) identified four critical factors for successful implementation of blended learning in a given institution. These factors are ICT infrastructure, university support, learner characteristics, and instructor characteristics. Similarly, Bhuasiri et al. (2012) described learners’ characteristics, instructors’ characteristics, institution and service quality, infrastructure and system quality, course and information quality as the critical factors for implementing blended learning.

Another study conducted in higher education institutions in South Africa higher education revealed that the technological infrastructure, high cost of technology, instructional efforts, graduate competencies, and technology satisfaction as the factors that affect institutions from continuing to use the eLearning technologies in their institutions (Venter, Rensburg, & Davis, 2012). The findings from this study corroborate with the findings obtained by Lwoga (2014) in higher education institutions in Tanzania. Lwoga (2014) found infrastructure and system quality as the main determinants of blended learning implementation as they had direct impact on perceived usefulness and user satisfaction.

Combining the findings from these studies, and many others in the literature, it is clear that the reliability of ICT infrastructure as well as the costs required to implement it are the key determinants to the success of blended learning in higher education institutions in sub-Saharan Africa. However, the majority of institutions in the region are affected by regular power outages. Due to the frequent power cuts, many servers have been unavailable especially those hosted on-premises. Nonetheless, migrating the ICT infrastructure into the cloud will enable these services to be available 24/7 as cloud hosted servers are not affected by any power cuts.

Another main challenge that is well described in the literature is the lack of skilled technical staff to support to maintain various ICT infrastructure hosting blended learning services. These technical staff members do not have skills to perform various services such as the upgrading of software, virus protection, and performance maintenance of computer servers and associated accessories. According to Selim (2007), if the technical support is lacking, the blended learning will not succeed. Studies have shown that migrating blended learning services into the cloud will increase the reliability of blended services, but also, will reduce the costs for hiring in-house technical staff. The burden of hiring staff, and management of hardware with its accessories will be moved to cloud service provider.

In conclusion, the appropriate adoption and application of cloud computing in blended learning has the potential to reduce the costs of hardware and software that institutions must spend to run blended learning programs. It should be noted that early investigations into the cloud readiness of countries in the region has shown that there is the potential for growth of at least one form of the cloud technology in the future (Laverty, 2011).

CLOUD COMPUTING

The National Institute for Standards and Technology (NIST) defines cloud computing as “a model for enabling 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” (Mell & Grance,
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2011, p.2). The idea behind cloud computing is to enable clients (e.g., users, or institutions) to access computing resources via the Internet and pay per use as utilities; the same way users normally pay water, electricity and related services.

CLOUD COMPUTING SERVICE MODELS

The cloud computing is divided into three service models namely Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). SaaS means the software or applications run on cloud provider’s servers and users interact with it via the Internet (Mathew, 2012; Mokhtar et al., 2013). Google Apps such as Gmail and YouTube are typical examples of SaaS (Babar & Chauhan, 2011). For example, institutions can use Gmail for students and staff instead of institutional email system.

The PaaS enables users to access development platform and tools through APIs which support a specific set of programming languages (Babar & Chauhan, 2011). PaaS basically aims to help developers who want to create, test, and deploy software applications on provider’s servers via the Internet without installing them locally (Hosam, Tayeb, Alghatani, & El-seoud, 2013; Mokhtar et al., 2013). Google Application Engine, and Microsoft Azure are good examples of such platforms.

The third cloud computing service model is IaaS that enables users to manage processing, computing services, storage, networks, and are able to configure the cloud servers similar to the physical servers (Mell & Grance, 2011). This model enables users to get rid of problems of purchasing the latest technology, maintenance, upgrading of software and software licenses (Mokhtar et al., 2013).

CLOUD COMPUTING DEPLOYMENT MODELS

The cloud computing can be deployed in four different ways: private cloud, public cloud, community cloud, and hybrid cloud. A public cloud is where cloud infrastructure is made available to several clients and this infrastructure is owned by a cloud service provider (Carroll et al., 2011; Mokhtar et al., 2013). Companies such as Google, Amazon, Microsoft provides several public cloud services. The private cloud is where cloud infrastructure is operated solely for particular organization with services made available for internal users (Babar & Chauhan, 2011; Bansal, Singh, & Kumar, 2012). Normally, the private cloud is managed by an ICT department within an organization or commissioned to a service provider or a third party organization but all services are dedicated to that organization.

The community cloud deployment model enables organizations with shared interests to control and share cloud infrastructure (Carroll et al., 2011; Mokhtar et al., 2013). One amongst participating organizations may manage the infrastructure or it may be managed by a third party organization. The last type of cloud computing deployment is called hybrid cloud. This is a mix of two or more cloud models (Mokhtar et al., 2013). Normally, organizations that adopt private deployment model aims to expand its services by outsourcing services with less security and legal requirements to public cloud providers to create a hybrid cloud. For example, organization might use public cloud basic business applications such as email and their private cloud for storing sensitive data such as financial data (Bansal et al., 2012).
CLOUD COMPUTING IN HIGHER EDUCATION

The adoptions of cloud computing to embrace education is growing fast as many institutions have been migrating computing services into the cloud. This is further facilitated by existence of cloud service providers that provide cloud services for free or at a discount to educational institutions (Alshuwaier, Alshwaier, & Areshey, 2012; Bansal et al., 2012; Mokhtar et al., 2013). Typical examples of such cloud service providers are: Microsoft, Google, IBM, and Amazon. They have established special packages to provide institutions with access to ICT infrastructure, software, platforms, and other educational services hosted in their clouds.

For example, Google educational package consists of collection of web-based messaging (e.g., Gmail, Google Talk, and Google Calendar), productivity and collaboration tools (Google Docs: text files, spreadsheet, presentation, and form creation and sharing), Google Video, and Google sites. This package is offered at zero cost to unlimited number of users (Chandra & Malaya, 2012). The Microsoft package for education (called Live@edu) is also available at no cost (Chandra & Borah, 2012). The package consists of Microsoft Office, Windows Live SkyDrive, Windows Live Spaces, Microsoft SharedView Beta, Microsoft Outlook Live, Windows Live Messenger, and Windows Live Alerts.

The support and involvement of these companies in educational field has attracted dozens of institutions all over the world to adopt and use cloud services to enhance education. There are already several successfully deployments of cloud services in institutions such as in countries like United States, United Kingdom, Asia, and Africa. Some few examples of such institutions include North Carolina State University (Mokhtar et al., 2013), Colorado State University (Herrick, 2009), University of California in the United States (Sultan, 2010). Other institutions include Leeds Metropolitan University, the University of Glamorgan, the University of Aberdeen, and the University of Westminster in the United Kingdom.

Cloud services have also found its way in African institutions. Over 30 institutions across Africa partnered with Google to use Google cloud services (Obi, 2012). The partnership includes grants, technical, consulting, and training. These institutions include University of Pretoria, University of Ibadan, University of Mauritius, and University of Ghana. Some East African institutions that have partnered with Google are: National University of Rwanda, Kigali Institute for Education, Kigali Institute for Science and Technology, and the University of Nairobi (Wanjiku, 2009).

ADVANTAGES OF CLOUD COMPUTING IN EDUCATION

One of the biggest advantages of migrating eLearning services into the cloud is the reduction of cost associated with acquiring, managing, and maintaining ICT infrastructure. This cost reduction will be realized in three ways. First, institution will no longer incur expenses to procure computer servers needed to run blended learning. All computing services will be hosted in the cloud servers. The cost reduction has been demonstrated by Florida Atlantic University which reduced IT costs by at least U.S. $600,000 by migrating Blackboard LMS into the cloud (Chandra & Borah, 2012). Likewise, the Wake Community College reduced by nearly 50 percent of Total Cost of Ownership (TCO) through migrating traditional ICT infrastructure into the cloud (Rindos et al., 2009).

Second, the cost reduction can be realized as a result of reducing the number of IT support staff often employed to maintain ICT infrastructure in the campuses. The burden of hiring staff and management of hardware with its accessories will be moved to the cloud service provider. Similar benefits was demonstrated by the North Carolina State University which reduced the number of IT
staff from 15 to 3 employees with full working schedule by migrating its computing services into the cloud (Chandra & Borah, 2012).

Finally, the cost reduction can be realized due to pay-per-use cost structure offered by cloud computing providers. In the current situation, institutions are charged flat rates even if the computing services are not used. However, the majority of institutions require intensive computing services in a short period due to the structure of teaching semesters (Truong, Pham, Thoai, & Dustdar, 2012). When students are on vacation, computing services are normally not used. The pay-per-use payment mechanism will help institution to make significant savings due to the fact that institutions will pay for only services they have used similar ways as already done for other utilities such water, electricity, and other related services (Buyya et al., 2009).

Another biggest advantage of cloud computing is the provision of high computing facilities for research and teaching especially for science and mathematics. These facilities are expensive to procure, and therefore, the majority of institutions cannot afford them. According to Truong et al. (2012), due to financial constraints, investment for research facilities is normally prioritized after teaching facilities. Institutions can use already existing facilities such as Virtual Computing Lab (VCL) offered by cloud providers to support high performance computational facilities. For instance, University of Pretoria uses VCL from IBM to enable students access and use the next-generation medical research to test the development of drugs, which are expected to cure serious illnesses unique to Africa (Kshetri, 2010).

**CLOUD COMPUTING ADOPTION STRATEGY**

The capabilities and practices that can help in the adoption of the cloud computing into higher education are not yet defined (Nasir & Niazi, 2011). It should be noted that cloud computing adoption has an impact on accounting, security, compliance, project management, system support, work of end users, authority of the ICT department, ICT governance, ICT provisioning, ICT procurement, and ICT policies (Khajeh-hosseini, Greenwood, & Sommerville, 2010). Therefore, it is important for institutions to develop a strategy that will provide a smooth migration of blended learning services into the cloud. We have adopted and proposed a strategy suggested by Mircea and Andreescu (2011) which consists of five stages. The description of each stage is explained next.

1. **Developing the Knowledge Base about Cloud Computing:** The first step is to ensure that all people involved in the implementation of cloud computing are well informed about the benefits and risks, policies and the best usage practices of the technology. The knowledge about cloud computing can be gained through attending seminars, workshops as well as conducting discussions with the suppliers and consulting the most recent researches in the field.

2. **Institutional ICT Assessment:** The cloud computing strategy should take into account the institutional needs and the overall institutional strategy. Therefore, it is important to evaluate the needs, structure and usage of various IT services. This will help the institution to understand which data, services, processes and applications that may be migrated or need to be maintained within the institution.

3. **Experimenting the Cloud Computing Solutions:** The third stage is to experiment selected cloud computing solutions. This can be done gradually as pilot test projects, and thereafter scaling it to all users within the institution.

4. **Choosing the Cloud Computing Solution:** At this stage, institutions are required to conduct thorough evaluation to compare cloud
service providers’ capabilities, licensing mechanisms, and pricing models in order to make sustainable choices. The choice will also depend on cloud deployment options presented in section 6.

5. **Implementation and Management:** This stage involved the migration of computing services and data into the selected cloud solution. Mircea and Andreescu (2011) suggested that data migration should be performed while keeping balance between the data accuracy, migration speed, non-functioning time and minimum costs.

The cloud adoption strategy is shown in Figure 1.

**CLOUD COMPUTING DEPLOYMENT OPTIONS**

After selecting a suitable adoption strategy, the next step is to select deployment option. The selection of deployment option will vary from institution to institution depending on a number of factors such as the cost constraints, security and privacy requirements, number of users, competence of internal IT staff, and institutional policies.

Regardless of the deployment option, Mtebe and Raisamo (2014) proposed the following computing requirements for blended delivery:

- **Learning Management System (LMS):** This is the main system used to deliver course content and facilitate interaction between students and instructors and between students and course content.
- **Multimedia Software:** These are software used to develop multimedia enabled blended courses.
- **Student Laboratories:** These are labs to provide Internet access to blended learning students.
- **Course Content:** Learning resources integrated with audio, video, animation, and text to foster student learning.
- **Digital Libraries:** Repositories of journals, books, and other learning resources.

*Figure 1. Cloud strategy in Higher Education. Adapted from (Mircea & Andreescu, 2011)*
**Computer Server:** A computer server and a computer backup server with associated accessories.

**Other Services:** The ICT unit is also responsible for providing students and staff with software (e.g., email accounts, operating systems, productivity applications, malware detectors, and cleaners, and hardware (e.g., PCs, Servers, etc.).

These requirements can be deployed in various cloud models. In next sub section, we propose two deployment options that can be adapted to enhance blended learning in higher education in sub-Saharan Africa.

**PUBLIC CLOUD OPTION**

This is an option that can be adopted by small or new institutions that have limited budgets to procure computing infrastructures to run blended learning courses. This option enables institutions to host all necessary computing requirements into the cloud providers. As shown in Figure 2, mail servers, LMS servers, digital library, course content development tools, multimedia tools, and other tools will be accessed directly from cloud provider’s servers via Internet.

There are numerous companies that provide public cloud services. These companies include Microsoft, Google, IBM, Amazon, Salesforce.com, and HP Cloud Computing.

The main challenge of public computing option is security and privacy concerns on confidential and valuable data such as research results, students’ and employees’ records, and financial data (Mircea & Andreescu, 2011; Mokhtar et al., 2013). It is advisable that institutions migrate low risk computing services such as learning resources, timetable, emails and other learning activities into the cloud until they have developed enough capacity to deal with security issues.

**HYBRID CLOUD OPTION**

The hybrid deployment option is proposed for institutions that have already invested their own ICT infrastructure over the years and have enough
technical staff to manage such infrastructure. In the hybrid cloud, institutions will use the private cloud to host and control high sensitive data such as students’ academic records, financial systems, faculty records, and medical records. On the other hand, low risk data can be hosted in the public cloud. These include course notes, student projects, websites for faculty, and news and announcements. Figure 3 shows hybrid cloud option that can be adopted for higher education institutions in sub-Saharan Africa.

CONCLUSION AND RECOMMENDATIONS

Cloud computing technology is not a new concept in higher educational institutions in sub-Saharan Africa. Faculty members as well as students are already using various cloud services for personal purposes. For example, majority of social networking applications such as Facebook, Twitter, YouTube, and Flickr are based on cloud platforms (Babar & Chauhan, 2011). Services from Google cloud services such as Gmail, GoogleDrive, YouTube are widely used by students and faculty members. Therefore, migrating existing blended services into the cloud will not be something new to institution community. In fact, students and staff expect to gain the same benefits in academic activities through these cloud services as they do in their day-to-day activities. In order to benefit from these technologies, the following are recommended:

First, institutions should develop and/or update policies that increase ICT infrastructure and increase availability of cloud computing tools (Laverty, 2011). The majority of these polices are those related to regulatory compliance and payments mechanisms. These policies were developed when technologies such as cloud computing was not in place.

Second, institutions should improve the reliability and speed of the Internet. Cloud computing is an Internet based service, obviously, if the bandwidth is insufficient it will be very difficult.
to deliver educational services (Laisheng & Zhengxia, 2011). The majority of higher education institutions in sub Saharan Africa are faced with low Internet speed. For example, in a study conducted by Mtebe and Raisamo (2014b) in Tanzania found that 82% of 11 surveyed institutions had Internet speed between 7Mbps and 20Mbps. Similar situation can be observed in many institutions in the region. Some eLearning solutions such as cloud services, video based learning resources will not benefit many users in the region, as they require good Internet speed.

Third, many institutions in the region do not have cloud computing experts for both technology and regulatory compliance (laws, data compliance, tax & payment, etc.). These institutions should equip their staff members with skills and competence with various aspects of cloud computing adoption and implementation.

REFERENCES


Deployment and Adoption Strategy of Cloud Computing for Blended Learning


**KEY TERMS AND DEFINITIONS**

**Blended Learning:** A combination of face-to-face delivery with a certain eLearning technology. The combination can be face-to-face delivery with the learning management system where students’ access learning resources via the system with some selected face-to-face teaching. The similar combination can be between face-to-face teaching with video conferencing technologies.

**Cloud Service Provider:** This is a company that offers customers with computing services such as storage or software services available via the Internet. Typical examples of such companies include the Amazon, HP, and Google.

**Elearning Technologies:** Any technology that can facilitate students learning such as video conferencing, Internet, web based systems and the likes.

**Higher Education Institutions:** These are institutions that offer post secondary courses including universities and non-universities.

**ICT Infrastructure:** Include computer hardware (servers and related workstations), network connectivity with accessories, and all necessary equipment.

**Learning Management System:** A web based system used by institutions to provide students with access to learning resources and other learning resources. The systems have communication tools such as discussion forums, chat and whiteboards.

**Sub-Saharan Africa:** This is an area that lies south of the Sahara Desert of the African continent. All countries that are located in this region are termed as sub-Saharan African countries.