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Cover Page Footnote

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Research Paper

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ABSTRACT

The cost of acquiring, managing, and maintaining ICT infrastructure is one of the main factors that hinder educational institutions in Sub-Saharan countries to adopt and implement eLearning. Recently, cloud computing has emerged as a new computing paradigm for delivering cost effective computing services that can be used to harness eLearning. However, the adoption of cloud computing in higher education in Sub-Saharan countries is very low. Although there are many factors that may influence educational institutions to adopt cloud services, cost effectiveness is often a key factor. Far too little is known on how much the use of cloud computing can be cost effective in delivering eLearning services. This paper compares the cost of hosting eLearning services between on-premise and cloud-hosted approaches in higher education, taking Tanzania as a case study. The study found that institutions can significantly reduce the cost of eLearning implementation by adopting a cloud-hosted approach. The findings of this study serve as a base for educational institutions seeking cost effective alternatives to implement eLearning in developing countries.

Keywords

Cloud computing; eLearning; ICT infrastructure; Sub-Sahara Africa.

INTRODUCTION

In recent years, there has been an increasing interest from Higher Education Institutions (HEIs) in Sub-Saharan countries to utilize the potential of Information and Communication Technologies (ICT) to meet diversified needs of contemporary learners, improve the quality of education, and to widen participation of education. By the end of 2006, 47 percent of 54 tertiary institutions from 27 African countries have installed educational technologies in their institutions (Gakio, 2006). Similarly, a recent study conducted by Isaacs & Hollow (2012) found that, 52 percent of 447 respondents African institutions were using eLearning systems.

However, one of the main factors that hinders institutions in Sub-Saharan countries to integrate ICT in education is the cost of acquiring, managing, and maintaining ICT infrastructure (Lwoga, 2012; Unwin et al., 2010). For example, the cost of deploying eLearning System at the University of Education, Winneba, in Ghana was estimated to be $20 a year per student with a minimum of 15,000 students in 2008 (Unwin et al., 2010). Nonetheless, studies show that cloud computing can potentially complement eLearning systems by alleviating investment costs needed to implement eLearning in Sub-Saharan countries.

Cloud computing involves "hosting applications on servers and delivering software and services via the internet" (Kshetri, 2010, p.2), and pay for services based on usage (Carroll, Merwe, & Kotzé, 2011). By adopting cloud services, institutions will no longer be required to procure and host ICT infrastructure in their premises to implement eLearning solutions. All ICT infrastructure, software, and eLearning services will be hosted in cloud provider servers. Students and instructors will access these services via the Internet. This approach will reduce costs associated with hardware purchase, software licensing, electric power, cooling, and salaries for IT support staff (Carroll et al., 2011; Mokhtar, Ali, Al-Sharafi, & Aborujilah, 2013; Sultan, 2010).

However, the adoption of cloud services in educational institutions in Sub-Saharan countries like Tanzania is very low; in fact, it is at an infant stage (Kshetri, 2010). Previous studies described lack of awareness on benefits of cloud computing (Bansal, Singh, & Kumar, 2012; Kshetri, 2010; Singh & Hemalatha, 2012), security concerns, bandwidth, and institutions management rules (Mokhtar et al., 2013) are among of the factors causing low adoption of cloud computing in education. While these hindrance factors cannot be ignored, the decision to migrate eLearning services into the cloud will also depend on institutions' awareness on cost effectiveness of cloud services.

So far, however, there are few studies that have compared the cost of hosting eLearning services into the cloud versus on-campus to help institutions to make decisions based on the cost effectiveness approach. This work contributes towards this goal, by comparing the cost of hosting eLearning services between on-premise and a cloud-based approach, based on Tanzania as a case study. The main research question addressed by this paper is:

> *How cost effective is it to host cloud-based eLearning services as compared to an on-premise approach in the context of Sub-Saharan countries?*

The findings of this study are expected to serve as a basis for educational institutions seeking cost effective alternatives to implement eLearning in developing countries.

CLOUD COMPUTING IN EDUCATION

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, 2011, p.2). Generally, cloud computing is divided into three main service layers: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). SaaS means the software or application runs on cloud servers and users interact with it via Internet (Mokhtar et al., 2013). Therefore, users do not need to install software applications in their local servers or computers.

Likewise, PaaS provides an environment for developers to create, test, and deploy software applications on cloud servers via the Internet (Mokhtar et al., 2013). This service layer enables developers to access development platform and tools through APIs which support a specific set of programming languages (Babar & Chauhan, 2011). On the other hand, IaaS enables users to manage processing, computing services, storage, networks, and are able to configure the cloud servers similar to the ordinary physical servers (Mell & Grance, 2011). The IaaS enables users to get rid of problems of purchasing the latest technology, maintenance, upgrading of software and payment of software licenses (Mokhtar et al., 2013).

In terms of deployment, 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 and resources are made available to several customers and this infrastructure is owned by a cloud service provider (Carroll et al., 2011; Mokhtar et al., 2013). Private cloud is where cloud infrastructure is operated solely for a particular organization (Babar & Chauhan, 2011; Bansal et al., 2012). Such infrastructure may be managed by the same organization or commissioned to a service provider or a third party organization, but all services are dedicated to that organization.

On the other hand, a community cloud is where the cloud infrastructure is controlled and shared by several organizations with common interests, such as with agreed and common mission, policy, security requirements, and compliance considerations (Carroll et al., 2011; Mokhtar et al., 2013). The community cloud infrastructure can be managed by these organizations or commissioned to the cloud provider. The last type of cloud computing deployment is the so-called hybrid cloud. This is a mix between two or more of the previous types (Mokhtar et al., 2013). Normally, organizations that adopt a private cloud aim to expand its services by outsourcing services with fewer security and legal requirements in a public cloud 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 personnel data (Bansal et al., 2012).

Essentially, the cloud computing industry has been growing very fast recently. For instance, the cloud service market ranged between $46.3 billion reported in 2008 to $148.8 billion and is predicted to grow to $150 billion by 2014, and $222.5 billion market by 2015 (Carroll et al., 2011). Accordingly, several IT companies have already dedicated a large cluster of several hundred computers to support educational institutions to adopt cloud computing by providing several cloud services for free or at a discounted rate (Bansal et al., 2012; Mokhtar et al., 2013). Typical examples of such companies are: Microsoft, Google, IBM, and Amazon. They have established cloud packages that provide educational institutions access to ICT infrastructure, software, platforms, and other educational services hosted in their cloud.

For example, the Google educational package consists of a 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 (secure and private video sharing – 10GB free), and Google sites. Furthermore, Google provides access to APIs to integrate Google Apps with existing IT systems. Similarly, Microsoft have introduced the Live@edu suite for educational institutions at no cost (Chandra & Borah, 2012). The Live@edu suite consists of Office Live Workspace, Windows Live SkyDrive, Windows Live Spaces, Microsoft SharedView Beta, Microsoft Outlook Live, Windows Live Messenger, and Windows Live Alerts.

In addition, IBM have established "IBM Cloud Academy" that provide access to a Virtual Computing Lab (VCL) solution that enables institutions to access and use free software and host their applications in their cloud infrastructure. Naturally, the support and involvement of these companies in the educational field has attracted dozens of institutions all over the world to embrace cloud services in teaching and learning.

In the USA, for example, the University of California, Washington State University (Sultan, 2010), and North Carolina State University (Chandra & Borah, 2012; Mokhtar et al., 2013) are examples of institutions that have adopted cloud services in their educational activities. In Africa, the University of Pretoria, South Africa adopted cloud services from IBM to enable students to 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). Likewise, Microsoft supported Ethiopian institutions to run Microsoft's Azure cloud platform as well as rolling out 250,000 laptops to school teachers (Sultan, 2010). The adoption of cloud computing services enabled these institutions to significantly reduce the cost of ICT investments as well as making teaching and learning more efficient.

Similarly, some of East African educational institutions have partnered with Google to use various cloud computing services. These institutions include the National University of Rwanda, the Kigali Institute for Education, the Kigali Institute for Science and Technology, and the University of Nairobi (Wanjiku, 2009). Other institutions include the United States International University, the Kenyan Methodist University, and the University of Mauritius.

Naturally, many African institutions are expected to adopt cloud services in the near future. Diffusion of cloud services comes at the right time as many institutions are rolling out eLearning initiatives to cope with increased student demand as well as improving the quality of education. Cloud computing can potentially complement eLearning by alleviating investment costs needed to implement eLearning in Africa. Even small sized institutions or institutions which do not have staff with adequate IT skills, or with small budgets, can still implement eLearning through cloud services (Bansal et al., 2012; Mokhtar et al., 2013).

METHODOLOGY

In order to compare the cost required to host eLearning services in the cloud versus on-premise, we started by establishing computing resources required to implement eLearning for a typical institution in developing countries. The established computing resources were grouped into two distinct architectures: cloud-based architecture and on-premise-based architecture.

Moreover, the study adopted the Total Cost of Ownership (TCO) method to compute the cost of implementing eLearning using cloud-based architecture, and on-premise-based architecture, each separately. The TCO is a widely used method to compute the real costs (capital cost and cost of operating the IT infrastructure) associated with owning and managing an ICT infrastructure in a given organization (Li, Li, Liu, Qiu, & Wang, 2009).

Using TCO approach, the Total cost can be obtained as follows:

Total cost = Up-front costs + Operational cost

The two TCOs, cloud-based architecture and on-premise-based architecture, were then compared. The study also made some assumptions in order to compare architectures with almost similar resources. These assumptions are:

- The TCO calculations are based on 36 months (3 years), which is considered the standard life of a computing infrastructure
- The cost estimates are based on prices in Tanzania
- Institutions use open source eLearning system. Moodle LMS is used as a reference point as the main eLearning system
- Institutions adopt a public cloud architecture
- The cloud prices are based on monthly estimates of 730 hours (number of hours for one month) of service
- The minimum requirements for a server that is capable of hosting Moodle LMS used in this study is based on the specifications:
    - Server Memory (RAM): 15GB
    - Number of Servers: 1 with four virtual cores
    - Number of Red Hat Servers: 1
    - Monthly Hours of Service: 730 (hours for a month)
    - Outgoing bandwidth: 30
    - Hard drive: at least 800GB.

COMPUTING RESOURCES AND ARCHITECTURES

Computing resources

The following are computing resources required to implement eLearning for a typical institution in developing countries:

- **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. Several LMS exist, however, Moodle LMS is among the popular LMS in Africa (Isaacs & Hollow, 2012).
- **Multimedia software:** These are software used to develop multimedia enhanced courses. They are also used to integrate animations, video, and audio into course content in order to make courses more interactive.

- **Student laboratories:** Many institutions in Sub-Saharan countries that run eLearning programs have computer laboratories or public access labs to provide Internet access to distant or blended learning students.
- **Course content:** The majority of eLearning courses are enhanced with multimedia elements such as audio, video, animation, and text to foster student learning.
- **Digital libraries:** They are used to access journals, books, and other learning resources.
- **ICT infrastructure:** ICT infrastructure consists of a computer server and a computer backup server with associated accessories. Normally, these servers reside in IT Support Unit.
- **Other services:** The IT unit is also responsible for providing students and staff with software (e.g., email accounts, operating systems, productivity applications, malware detectors, and cleaners, etc.) and hardware (e.g., PCs, Servers, etc.).

On-premise based architecture

Figure 1 shows an on-premise based architecture for eLearning implementation in a typical institution in a developing country. Normally, the eLearning & IT Services Support Unit provides support to students and instructors on both pedagogy and technical support to instructors and students during eLearning implementation. All computing resources are normally centralized and managed by the eLearning and IT Services Support Unit.

Figure 1: Simplified structure of the users of eLearning & IT Services in a typical university

Cloud-based architecture

In the cloud-based architecture, the majority of computing resources will be hosted in the cloud as shown in Figure 2. All users will access computing resources directly from the cloud. For instance, instructional designers and course developers can use services available in the cloud to develop courses using software via SaaS. Similarly, students and instructors will access learning resources and other eLearning services hosted in the cloud-based servers via SaaS. Any other software required by students and instructors will be hosted in SaaS and made available online.

Under this architecture, IaaS will replace most of the existing ICT infrastructure such as servers that host LMS, Web mail, Back up Servers, and related network configurations. In fact, due to elasticity offered by cloud computing, any additional disk space, if needed, will be executed immediately through virtual servers.

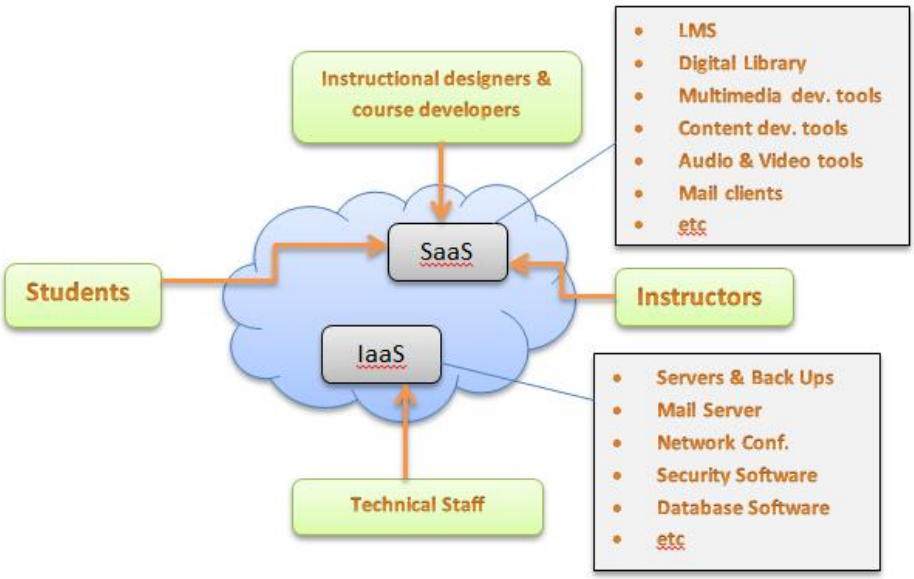

Figure 2: Proposed an eLearning- cloud based architecture

THE COST ANALYSIS

Using Total Cost of Ownership (TCO) approach, the costs were divided into two main categories: *up-front costs*, and *operational cost (recurrent or monthly costs).*

Therefore,

Total cost = Up-front costs + Operational cost

Up-front costs

- ***Server Hardware:*** Cost of the computer server that hosts LMS and other learning services. These costs will include the backup server.
- ***Software Cost:*** Cost caused by licenses institutions need to pay for using various software. These software include: Operating System, LMS, Anti-virus, Content development software, and multimedia integration software.
- ***Auxiliary Server Equipment:*** Cost related to Uninterrupted Power supply (UPS), Network Interface Card (NIC), and switches and cables which are used to attach physical servers to the network.

Operational Costs

- ***Support and Maintenance Cost****:* The costs related to maintenance of hardware and software used to run the eLearning systems. Some important activities under this category include software upgrading, virus protection, disk management, and performance maintenance (Li et al., 2009).
- ***Hosting Costs***: Cost for hosting software and other applications via Internet or in the cloud.
- ***Cooling and Power Consumption***: The cost related to cooling systems and electricity consumption by ACs, computer hardware, and related devices.

The cost analysis for on-premise-based hosting

Up-front costs

- **Server Hardware:** The minimum specifications of computer server capable of hosting Moodle LMS was sent to five computer companies in Dar es Salaam to request proforma invoice. Two companies responded as follows:
    - Computer Connections Ltd (Computertz, 2013) quoted a Dell PowerEdge R520 Server with its accessories for US $6,689.00.
    - Computer Center (Tz) Ltd (CCTz, 2013) quoted a HP ProLiant DL380p E5-2609 Gen8 Special Server with its accessories for US $9,100.52.

For simplicity, we took an average of the two prices to get the price of one computer server: Therefore, the price of computer server capable of hosting Moodle LMS is **US $7,894.50**.

- **Auxiliary Server Equipment**
    - **Uninterrupted Power supply (UPS):** The specifications of the UPS are: UPS System, Smart UPS(R), Power Rating 1000 VA, Watts 640, Voltage 120, Hz 47-63, Voltage Output 120. The indicted price is **US $1,036** per unit (Grainger, 2013)
    - **Other Auxiliary Equipment:** The costs of equipment such as Network Interface Card (NIC), switches, and cables have been estimated to **US $2,000.**

Table 1 provides a summary of upfront cost of hosting eLearning on-premise.

Direct/Indirect Cost Item	Quantity	Total (US$)	Remarks
Server Hardware & OS	1	7,894.50	Pre-Installed OS
Backup Server Hardware & OS	1	7,894.50	Pre-Installed OS
Uninterrupted Power supply (UPS)	2	2,072	Two UPSs
Auxiliary Server Equipment	1	2,000	
LMS		NIL	OSS
Content development Software	1	5,580	
Multimedia integration tools	1	NIL	OSS
Total		25,441	

Table 1: Upfront Cost

- **Software Cost**
    - **Content Development Software**: The proposed content development software for this study is Lectora Inspire software. The cost for the licensed software for two users with end user support is **US $5,580** (https://store.lectora.com/).
    - **Moodle LMS:** This is open source software and is available for free.

- **Multimedia integration tools:** The study assumes institutions will use open source tools to integrate multimedia (animation, audio, and video) into courses using free and open sources tools.

Operational Costs

- **Support and Maintenance Cost**: This is calculated based on the salaries of technical staff employed at the institution. At minimum, institutions need two technical staff to manage and maintain Moodle LMS. The government of Tanzania salary scale for a graduate of computer science or related field is approximately US $500 per months. Therefore, for two staff in a period of 3 years, the institutions will incur a total of US $36,000.
- **Hosting Costs**: The cost of hosting 3,000MB is US $25 per months at University Computing Center (http://ucc.co.tz/services/web.php). Therefore, for hosting a server of 800GB is estimated to be US $60 per month. In other words, hosting Moodle LMS server will cost the institutions a total of US $2,160 for 36 months.
- **Cooling and Power Consumption:** For simplicity, the cost of electricity consumption by ACs, computer hardware, and related devices for eLearning system at a given institution is estimated to be US $100 per month. Therefore, for 36 months the institution will incur a total of US $3,600. Table 2 provides a summary of operational costs for hosting eLearning on-premise.

Direct/Indirect Cost Item	Monthly cost (US$)	Total (US$)
Support and Maintenance Cost (based on salaries of two staff for 36 months)	1,000	36,000
Hosting Costs	60	2,160
Cooling systems and power consumption	100	3,600
Total		**$41,760**

Table 2: Operational costs

The cost analysis for cloud-based hosting

Up-front costs

- **Server Hardware:** Institutions will not be required to procure computer servers.
- **Auxiliary Server Equipment:** Since Moodle LMS will be hosted in the cloud, institutions will not be required to procure auxiliary equipment.
- **Software Cost**
  - **Content Development Software**: Institution will incur the same cost of procuring this software.

- **Moodle LMS:** This is open source software and is available for free.
- **Multimedia integration tools:** The same open source tools will be used for on-premises hosting.

Operational Costs

- **Support and Maintenance Cost**: Included in the Service Level Agreements (SLA) in the monthly charges.
- **Cooling and Power Consumption:** By hosting eLearning services in the cloud, institutions will not incur any cost related to electricity consumption by ACs, computer hardware, and related devices for eLearning system.
- **Hosting Costs**: To obtain the cost estimate of hosting eLearning services in the cloud, several cost estimation tools exists. However, this study adopted a tool developed by Mian, Martin, Zulkernine, and Vazquez-Poletti, (2012) which is relevant to this study. Additionally, the study excluded the penalty incurred in a given time-unit (hour), which is not significant for this study. The formula for calculating costs for hosting eLearning services in the cloud becomes:

$$Cost\$(C) = Compute\$(C) + Storage\$(C) + Network\$(C)$$

Moreover, this study uses similar server specifications used for on-campus hosting. The costs of cloud services of three companies Amazon, HP, and Google are compared using the formula above. Explanations on costs for each company on computing services are explained here under:

Using Amazon cloud service

Amazon offers two cloud services: Elastic Computing Cloud service (EC2), and Elastic Block Store (EBS). EC2 charges each hour an instance is running, and it offers instances with different compute power and memory (Kondo, Javadi, Malecot, Cappello, & Anderson, 2009). The EC2 pricing options for running an instance are shown in Table 3.

Instance Type	**Cost/hour (USD)**
Small	0.080
Medium	0.160
Large	0.320
Extra Large	0.640

Table 3: Pricing for Standard On-Demand Instances (Asia Pacific-Singapore)

The Moodle LMS server specification (assumed for this study), 15MB RAM, with 4 virtual cores running in Linux operating system falls under Extra Large instance type. Therefore, the cost of running this instance in Amazon EC2 will be 0.640 x 730 (total number of hours for the whole month) of service. The cost of running Moodle LMS instance for one month becomes 0.640 x 730 =US $467.20. In terms of network transfer, Amazon charges US $0.190 per GB per month of data up to 10 TB (see Table 4). In other words, to transfer 1TB of data will cost the institution a total of US $194.56 (1024 x $0.190 per GB).

Similarly the data transfer from Amazon EC2 to internet is shown in Table 4 (Amazon, 2013).

Transfer Type	**Cost/GB-Month (USD)**
First 1 GB	0.000
Up to 10 TB	0.190
Next 40 TB	0.150

Table 4: Pricing for Data Transfer (Asia Pacific-Singapore)

For storage, Amazon provides reliable and persistent storage with high IO performance through EBS. EBS charges per GB of storage and per million IO transactions. Table 5 shows pricing for EBS standard volumes. Since our Moodle LMS server has a size of 800 GB, the cost of storing courses and other learning resources in the cloud per month under Amazon EBS will be 0.11 x 800=US $88 per month.

Resource	**Rate (USD)**
Storage	0.11 / GB-Month
IO request	0.11 / million

Table 5: Pricing for EBS Standard volumes (Asia Pacific-Singapore)

Generally, the cost of hosting eLearning services using Amazon cloud service will be US $749.76 as shown below:

Cost$(C) = Compute$(C) + Storage$(C) + Network$(C),

Cost$(C) = US $467.2 + US $88+ US $194.56,

Cost$(C) = **US $749.76.**

Using Google Cloud service

Google offers several pricing options for hosting instances in their cloud (Google, 2013). The Moodle LMS server specifications fall under n1-standard-4-d instance type, which is charged $0.530 per hour for US hosting. Therefore, the cost of running Moodle LMS instance for one month will be 0.530 x 730 = US $386.90.

Additionally, Google charges US $0.10 GB per month for storage space. In this case, the Moodle LMS server of 800GB will cost US $0.10 x 800 GB = US $80 per month. Similarly, Google charges network transfer at a rate of US $0.12/per GB up to 1TB. Therefore, the network transfer will cost US $122.88 for 1TB (1024GB x 0.12).

In total, the cost of hosting eLearning services using the Google cloud service per month will be US $589.78 as shown in the breakdown below:

Cost$(C) = Compute$(C) + Storage$(C) + Network$(C),

Cost$(C) = US $386.9+ US $80+ US $122.88,

Cost$(C) = **US $589.78.**

Using HP Cloud service

HP charges US $0.56/hr which is equivalent to US $408.80 per month for an instance to execute into an HP cloud running Linux operating system (HP, 2013). In terms of storage, the HP cloud service charges US $0.10 per GB per month with US $0.10 per million requests (see Table 6). Therefore, the cost of storing 800 GB of Moodle LMS server in the cloud will be 800 GB x US $0.10 per GB per month=US $80 per month.

Resource	**Rate (USD)**
Storage	0.10 / GB-Month
IO request	0.10 / million

Table 6: Pricing for Standard Pricing of HP Block Storage

Moreover, HP cloud service charges US $0.12 per GB per month of network transfer of up to 10 TB metered for non-CDN bandwidth usage. Therefore, for 1TB (1024GB) of network transfer for learning resources and activities in Moodle LMS will cost the institution a total of US $122.88 (1024 X 0.12) per month.

Hence, if the institution opts to host eLearning services into the HP cloud, the cost will be as follows:

Cost$(C) = Compute$(C) + Storage$(C) + Network$(C),

Cost$(C) = US $408.80 + US $80 + US $122.88,

Cost$(C) = **US $611.68 per month.**

From the analysis above, out of three companies offering cloud services, Google Cloud service is the cheapest. This study will use the lowest cost of cloud services from Google to compare with on-premise hosting.

Cost comparison of cloud-hosted versus on-premises hosted approach

In this sub-section, the cost of hosting eLearning services on-premises is compared with that of hosting in the cloud. Table 7, provides a comparison of upfront cost-based on the cost analysis provided in section 5. From this table, upfront cost for hosting eLearning services on-campus is approximately US $25,441, while that of cloud based hosting is US $5,580.

Similarly, Table 8 shows a comparison of operational cost for hosting eLearning services in the cloud with that of on-campus hosting. Based on this table, total operational cost for hosting eLearning services in the cloud for 36 months is approximately US $21,232.08, and that of hosting on-campus is approximately US $41,760.

From the analysis on table 7 and 8,

a) Total cost for On-Premise hosting:

Total cost= Up-front costs + Operational cost,

Total cost= **US $25,441**+ **US $41,760,**

Total cost=**US $67,201.**

Direct/Indirect Cost Item	QTY	On-premises (US$)	On Cloud (US$)	Remarks
Server Hardware & OS	1	7,894.5	NIL	Pre-Installed OS
Backup Server Hardware & OS	1	7,894.5	NIL	Pre-Installed OS
Uninterrupted Power Supply (UPS)	2	2,072	NIL	Two UPSs
Auxiliary Server Equipment	1	2,000	NIL	
LMS		NIL	NIL	Open source software
Content Development Software	1	5,580	5,580	
Multimedia integration tools	1	NIL	NIL	Open source software
Total		$25,441	$5,580	

Table 7: Upfront Cost

Direct/Indirect Cost Item	Monthly cost (US$)	On-premises (US$)	On Cloud (US$)
Support and Maintenance Cost (based on salaries of two staff for 36 months)	1,000	36,000	NIL
Hosting Costs	60	2,160	21,232.08
Cooling systems and power consumption	100	3,600	NIL
Total		$41,760	$21,232.08

Table 8: Operational costs

b) Total cost for On Cloud hosting:

Total cost= Up-front costs + Operational cost,

Total cost= **US $5,580**+ **US $21,232.08,**

Total cost=**US $26,812.08.**

c) Savings obtained by hosting eLearning services in the cloud:

Savings= Total cost for On-premises hosting- Total cost for On Cloud hosting,

Savings= **US $67,201- US $26,812.08,**

Savings=**US $40,388.92.**

DISCUSSION

The study set out to compare the cost of hosting eLearning services on-premise and in the cloud, taking Tanzania as a case study. Generally, the study has shown that institutions can reduce the significant cost of running eLearning courses by hosting eLearning services into the cloud. More specifically, the study has found that institutions can save approximately US $40,388.92 in 3 years by hosting Moodle LMS and its services in the cloud.

The findings of this study are consistent with a study conducted by Chandra and Borah (2012). Chandra and Borah compared TCO for replacing five computers by migrating all its services into the cloud. The study found the savings per user per month were $942.60 whereas the savings for replacing office PCs by migrating its services into cloud were $33.05. Chandra and Borah (2012) furher noted that Florida Atlantic University reduced ICT costs by at least US $600,000 by migrating the Blackboard LMS and its services into the cloud. Similarly, Wake Community College witnessed annual ICT costs dropp from $1.04 million to $570,000 annually (nearly 50 percent) by migrating IT services in the cloud.

Moreover, the cost analysis of this study assumed institutions are going to pay all necessary costs for hosting their eLearning services into the cloud. Nonetheless, as mentioned in previous sections, many companies such as Google, IBM, and Microsoft provide cloud computing at a discounted price for educational institutions. Therefore, institutions can reduce substantial amounts of investments by subscribing to educational packages offered by these companies.

However, like many new innovations and new technologies, the adoption of cloud computing in eLearning faces some challenges that need to be addressed. One of the main challenges is limited bandwidth in Sub-Saharan countries. 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). Other challenges include lack the of eLearning and ICT policies that were developed, taking into account the complexity of cloud computing, and the lack of cloud computing experts for both technology and regulatory compliance (laws, data compliance, tax & payment, etc.) in Sub-Saharan countries (Mtebe, 2013).

RECOMMENDATIONS FOR FUTURE RESEARCH

This study has a number of important limitations that need to be considered. First, the prices used in this study were based on monthly estimates of 730 hours (for the whole month) of service. However, in many institutions ICT services are required intensively only in a short period due to the structure of teaching semesters (Truong, Pham, Thoai, & Dustdar, 2012). This means, when students are on vacation, most of computing services are normally not used (Mtebe, 2013). The cost of hosting eLearning services will go down once an exact number of hours is established as many cloud providers' costs are elastic.

Second, the cost comparison proposed in this study assumed institutions will adopt the public cloud architecture. In fact, some institutions may opt for private clouds in order to host highly sensitive data such as students' academic records, financial systems, medical records, and similar information. In such situations, a new cost analysis will be needed, taking into account the private cloud architecture. Finally, the study did not consider other charges such as the cost of migration from existing infrastructure into the cloud, the cost of using a public IP address, and the cost associated with learning how to use cloud computing. These charges were not considered significant and would not change the conclusion of this study.

CONCLUSION

This study has shown that adopting cloud computing in eLearning is cost effective compared to hosting eLearning services in institutional premises. The findings of this study are expected to serve as a base for educational institutions seeking cost effective alternatives to implement eLearning in developing countries. Moreover, cloud-based approach provides several other advantages besides reducing cost. This approach will increase the reliability of eLearning services as most on-premises hosted servers suffer from unreliable power supply. It can also provide high computing facilities for research and teaching, especially for simulations, the analysis of computation models, and similar research.

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