Higher Education Cloud Computing in Zimbabwe: Towards Understanding Trends of Adoption

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Abstract – **Cloud computing has gained attention in the field of Information Technology (IT). The technology has created new opportunities for many organisations worldwide. Organisations have adopted cloud computing due to its enormous economic benefits. Cloud computing can be used by the education sector as a computing solution required to deliver improved services to stakeholders. The majority of studies carried out are more biased towards business organisations. The educational sector has received little attention with regards to cloud computing technology. Therefore this study investigates the trends of adoption of cloud computing by Zimbabwe state universities. A sample of 5 IT directors was selected from 5 universities under study. In-depth interviews were used to uncover the trends of adoption of this cutting-edge technology. Literature was used to corroborate the findings. The encouraging factors and challenges confronting the extensive adoption and utilization of cloud services were also investigated. The results indicated that all the universities under study adopted cloud computing to a certain extent. The library services and anti-plagiarism systems were the major services adopted. The universities were though not fully enjoying the benefits of the technology due to bandwidth, security and privacy issues. The paper concludes by recommending strategies to mitigate the challenges being faced by universities.**

Keywords - Cloud computing; Cloud adoption; Zimbabwe state universities; Higher education.

I. INTRODUCTION

Universities in developing countries face problems in acquiring the right type of technologies in order to execute tasks in an efficient and effective way. Distance learning is often affected by software and hardware which is limited and sometimes non-existent. State owned universities also suffer from inadequate funding by the Government. To reduce technology-driven overheads, while at the same time improving end-user productivity, a subscription-based model that provides computing utilities is adopted by many institutions. Computing solutions that do not involve huge initial capital investments and that have minimal difficulties in maintaining complex IT infrastructure are being opted for by a number of organizations.

In order for universities to overcome their IT-related problems, cloud computing [1] is the solution they can implement. Cloud computing can help students communicate with lecturers within and outside universities [1]. Services, such as learning management systems, library management systems and document creation can be adopted at affordable costs [2][3]. According to Ding et al. [4], cloud computing technology can give support in online learning, virtual learning, distance learning and the assessment system in universities. Collaboration is facilitated and hardware, software and maintenance costs are reduced [5][6]. Virtual laboratories can be developed to improve students' academic performance through cloud computing.

The majority of research done in the field of cloud computing concentrated on business organisations and few studies have been done in the education sector [7][8][9]. Previous studies focused on the factors that influence the adoption of cloud computing in the education sector [5][10][11][12]. More empirical studies were called upon in the education sector by Hashin et al. [13]. Some state universities might have adopted cloud computing services in Zimbabwe, and there is need to investigate and understand cloud computing adoption trends, the reasons for adoption and the challenges faced by Zimbabwe state universities in the adoption and utilization process.

In Section II, the specific objectives of the paper will be presented, Section III will shade light on the actual data gathering techniques that were used for the study. Section IV will describe related work and justify the reasons for undertaking this study so as to contribute more to the knowledge in the field of cloud computing. Section V presents a discussion of the findings obtained. In Section VI, a summary of the findings is explained. Section VII gives an overall conclusion and recommendations for future research in the education sector in relation to cloud computing in Zimbabwe.

II. STUDY OBJECTIVES

The aim of this study is to investigate cloud computing adoption trends in the higher education sector in Zimbabwe. The study concentrates on the 5 selected state universities. To achieve the main goal, the following are the specific objectives of the study:
1. To determine the adopted cloud computing service by each university under study.

2. To identify the delivery and deployment models that are currently adopted by the universities.

3. To understand the major reasons for the adoption of cloud computing and challenges which hinder the utilization of this technology.

4. To assess the technological readiness of each university.

5. To recommend strategies to mitigate challenges faced by universities.

III. METHODOLOGY

The case study approach was used to understand the adoption trends in Zimbabwe state universities. Having a total of 10 provinces in Zimbabwe, 5 provinces were conveniently chosen for the study and 1 university was purposively chosen from each province. An IT director from each university was interviewed and literature was used to corroborate the findings. The inquiry was qualitative and a relatively small sample was purposefully selected [14]. The identity of the chosen IT directors who participated in the study was made anonymous so as to get more information pertaining to the adoption trends in state owned universities of Zimbabwe [15]. Appointments were made with the directors and, due to their tight schedules, face-to-face interviews were conducted with only 1 IT director and the rest were telephone interviews. Semi-structured questions were used in the interviewing process and also follow up interviews were conducted for clarity sake. All interviews were recorded with the consent of the interviewee and later on transcribed into a document.

IV. LITERATURE REVIEW

A. Cloud Computing

Cloud computing has received different definitive definitions from different researchers. No definition of cloud computing has been universally accepted, though the National Institute of Standards Technology (NIST) [16] definition is widely used since it offers a more detailed definition. In its broader sense, cloud computing is a model that offers IT services as computing utilities that are paid for per-use, and accessed through the Internet. The cloud has 5 essential characteristics, 3 service/ delivery models and 4 deployment models [16]. Fig. 1 depicts the essential characteristics of cloud computing.
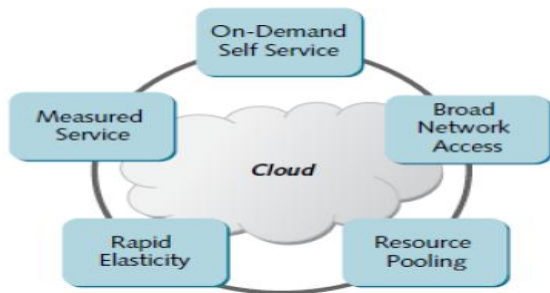

Fig. 1. Essential characteristics of cloud computing [16]

A consumer can access cloud services without support from the service provider (*on-demand self-service*), various devices with Internet capabilities can access the cloud services worldwide (*broad network access*), multiple users can access shared resources concurrently (*resource pooling*), services are flexible, they can expand or contract depending on the user's demands (*rapid elasticity*) and lastly consumers pay for the services they would have used (*measured service*) [16][17][18].

Cloud computing can be delivered using Software-as-a-Service (SaaS), Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service [16][17][19]. Software packages that can be accessed through the web browser yet they reside on someone's infrastructure fall under SaaS [18], computing power and hardware resources are delivered as a service to consumers under IaaS delivery model. In PaaS, a platform for designing, testing, debugging, deployment and implementation is offered to developers over the Internet [20].

B. Cloud computing in education

Universities provide the necessary education that allows the economy of every nation to grow, decrease disparities among citizens and greatly reduce poverty. For universities to carry out their educational activities, they need resources. The appropriate hardware and software required is scarce or sometimes non-existent and cloud computing can be the right computing solution to alleviate the IT-related problems [10]. Cloud computing therefore can be used in teaching and learning activities [21]. Distance learning, online learning and formative assessment systems in universities can be supported by this cutting-edge technology. Students can communicate with lecturers or their peers regarding educational issues through communication tools such as Google hosted students and academic staff electronic mails (emails) [1][4][22]. Students in rural areas can be engaged in the learning process as long as they have an Internet connection and a gadget with the capability to access the "mother" of all networks, thereby bridging the digital divide. Cloud computing can then be used as a tool that supports collaboration in the education sector. Learning management systems, library management systems and anti-plagiarism systems can also be supported by this technology [3][23][24]. The costs of acquiring appropriate software and hardware are therefore reduced, even the maintenance costs are minimised since a third party will be responsible for maintaining the outsourced hardware and software [5]. Students in the IT sector can develop, test, debug and deploy their applications over the Internet through the PaaS delivery model [20].

Previous studies indicate that the educational sector has few studies in cloud computing especially in resource constrained environments. In Zimbabwe, cloud computing has received few studies. The studies conducted concentrate on business organisations such as Small and Medium

Enterprises (SMEs). Very little has been done in the education sector, yet education is the pillar of every nation.

V. RESULTS AND DISCUSSION

A. University A

Results show that university A adopted cloud computing. The services adopted include Domain Name System (DNS) server, Google hosted students and staff electronic mails, electronic mail routing, anti-plagiarism system and library services (library management system, institutional repository and library management system backup). The IT director mentioned that the services were adopted due to the fact that the technology offers the service at any time and can be accessed through thick and thin clients over the Internet, the services open doors for advanced research and support offline usage. It can be noted that the delivery models that were adopted are SaaS and IaaS. The aforementioned library services, anti-plagiarism system and Google hosted staff and student electronic mails fall under SaaS. The library virtual server and the DNS server fall under IaaS. The university uses a hybrid deployment model, thus both the private and public model are used. The private model is used onsite and is used to service multi campuses of the university. Sensitive data of the university such as student records, registration details and student grades resides on an onsite server.

Since the cloud services are accessed through the Internet, it was rendered imperative to assess the technological readiness of the university. Stakeholders of the university that use cloud services were noted to have adequate Information and Communication Technology (ICT) equipment which included desktops, laptops, tablets and smart phones among other gadgets with Internet capabilities. Internet connectivity and its transmission speed was regarded as acceptable. A bandwidth of 750Mbps was found to be sufficient. The university uses optic fiber as a transmission medium and networking nodes are connected using a star topology, which is used as a backbone of the wireless network within the institution. It was also noted that the IT support staff was experienced and supported the users in an acceptable way. In terms of compatibility and complexity, the IT director highlighted that the technology is compatible with the technological infrastructure currently in place, the culture, work style and performance. The users of the services within the institution were said not to be aware that some services they are using are offsite.

Though the technology was adopted there were some challenges that hindered the extensive adoption and utilization of this technology. The issue of limited bandwidth, sanctions and Internet services were mentioned as some of the challenges. If the issue of bandwidth is not addressed then utilization of the technology will be impossible. Some services are not offered in Zimbabwe due to sanctions imposed on the country and lastly cloud services depend on the Internet and if there is no connection

then it will be difficult, if not impossible, to access the services. Economic sanctions limited trade and financial relations which crippled the Zimbabwean economy. The economic status of the country affected adversely the operations of the state owned universities. The monetary resources needed to support the innovation are scarce and some cloud services cannot be afforded by the state universities.

B. University B

University B adopted cloud computing technology; though not as many services as adopted by university A, the university managed to adopt the following services offered by the technological innovation: anti-plagiarism system and learning management system. The IT director vowed that though few services were adopted they were planning to adopt more cloud services but of interest the IT director did not have the knowledge on whether they had adopted cloud computing or not. The term cloud computing was still cloudy to the IT director. After in-depth interviews it was uncovered that the aforementioned services were actually adopted by the institution. It was noted that the delivery model adopted by university B was SaaS as evident by the anti-plagiarism and learning management system adopted. The hybrid deployment model was adopted by this institution, with the private cloud being used to store sensitive data while the public cloud being used to store less sensitive data. The major reasons for adopting the cloud services were reduced costs, infrastructure maintenance and reduced mobility.

It was noted that the ICT equipment with Internet capabilities existed in the institution. The Internet connectivity was deemed reliable and a bandwidth of 71Mbps was regarded sufficient since the institution has few users who consume the bandwidth. Optic fiber was used to connect the wired star network which works as the backbone of the wireless network. The IT director revealed that cloud computing was consistent with their culture, needs and past experience, and also users are embracing the technology without any difficulties. Limited bandwidth, security and reliable Internet connections were noted as challenges that hinder the adoption and utilization of the technological innovation fully.

C. University C

The library management system, institutional repository and the anti-plagiarism system are the services that the institution allowed a third party to host. The services fall under the SaaS delivery model. The institution uses the hybrid deployment model, as some services are hosted by a third party and some are hosted locally to service users in their geographically dispersed multi campuses. The adoption of the services was mainly due to reduced costs and transfer of the management to a third party. The IT director of this institution knew that some services were

hosted by a third party but the term cloud computing was still confusing and cloudy.

ICT equipment that is required to access cloud services is possessed by the stakeholders, a bandwidth of 220Mbps was adjudged sufficient and IT support staff was seen to be experienced. The institution has a hybrid topology and it uses fiber optic and UTP cables as transmission media. The IT director vowed that users were using the services without any complications and also the technology was compatible with their work style and culture which in turn improved performance. Resistance from other users who fear technology, limited bandwidth and capacity were seen to be challenges that hinder the institution to fully enjoy the benefits of the technological innovation.

D. University D

The institutional repository, international databases and an anti-plagiarism system are the services that are leased from the cloud service provider. The institution once adopted a learning management system but subsequently resorted to an in-house developed e-learning platform. The reason towards resorting to an in-house e-learning system was that leasing the system from a third party was more expensive than employing a full time specialist. The institution is also planning to adopt Google hosted student e-mails. The services adopted fall under the SaaS delivery model. The deployment model currently being used is the hybrid model; a private cloud is used to service the five (5) campuses of the institution. The technology was seen to be compatible with the existing infrastructure, norms and values, work style and performance. The users of the services do not face challenges in using them which means the technology is not complex.

ICT equipment which can connect to the Internet is available within the institution, a bandwidth of 65Mbps was said to be sufficient and the institution uses fiber optic as a medium for transmission. Internet dependency, limited bandwidth and lack of foreign currency were seen as major factors negatively affecting the effective utilization of the technology.

E. University E

University E adopted the following cloud services; web hosting, library services and an anti-plagiarism system. Lack of adequate resources and low costs forced the institution to adopt the cloud services. SaaS and PaaS delivery models were adopted whereby web hosting falls under PaaS and the remaining services fall under SaaS. A hybrid deployment model is used by the university, the private cloud is used to service the institution's multi campuses and that is where more sensitive data resides. The technology was adjudged compatible with the culture and work style and users were using its services easily.

In order to use the cloud services, the stakeholders have got a variety of ICT gadgets that can connect to the Internet. The institution uses optic fiber as a transmission medium.

The Internet can be accessed from both a wired and a wireless mode. The IT director revealed that the current bandwidth of 150Mbps was inadequate and the institution is planning to increase it. The issue of limited bandwidth was seen as a hindrance towards the utilization of cloud computing technology.

VI. SUMMARY OF FINDINGS

All the universities under study adopted cloud computing and the major services adopted included library services and anti-plagiarism systems. In support of this [3][23][24] state that the services that are mainly adopted by institutions of higher learning are library management systems and learning management systems. The findings of this research showed that learning management systems are not widely adopted by state owned universities in Zimbabwe. A single university adopted the learning management system but it is no longer using it. The universities under study adopted the SaaS delivery model. Organisations mainly adopt SaaS delivery model [25][26]. Organisations in Zimbabwe mainly adopted communication applications which fall under SaaS delivery model [27]. In a study conducted in Nigeria, it was found out that universities adopted IaaS, PaaS and SaaS with a proportion of 10%, 20% and 70% respectively [28]. It was realised that all universities adopted SaaS, university A added IaaS and university E also added PaaS.

The hybrid deployment model was adopted by all universities investigated in order to separate data. Business critical data and services are hosted on a private cloud and non-business critical data and applications are hosted on the public cloud. The result was supported by other scholars [17][29]. All universities were adjudged to be technologically ready, ICT equipment with Internet capabilities was seen to be available, the Internet was easily accessible through a wired and wireless mode and technical support was available to give support on the cloud service. A different view was reported by a study which realised that the accessibility and availability of the ICT infrastructure is not enough and sometimes does not exist in universities [30].

Universities adopted cloud services but they have not fully enjoyed the benefits brought by the technological innovation due to some challenges. Bandwidth is a major challenge. This was also reported in a study by [31]. Security and privacy are also issues that affect the full utilization of cloud computing. Universities lack trust of cloud services offered by the cloud as witnessed by the adoption of the hybrid deployment model. Universities also have problems with reliable Internet connections due to various problems like power shortages that affect the nation as a whole. Some applications also cannot run on the cloud and some services are not offered in Zimbabwe. Table 1 shows an overview of the key findings.

TABLE 1. OVERVIEW OF THE KEY FINDINGS

	University A	University B	University C	University D	University E
Adopted cloud computing?	YES	YES	YES	YES	YES
Services Adopted	DNS server, e-mail, e-mail routing, anti-plagiarism software, Library Management System, institutional repository, LMS backup	Learning Management System, anti-plagiarism software.	Library services, anti-plagiarism software.	Library services, institutional repository, international databases, anti-plagiarism software.	Web hosting, library services, anti-plagiarism software.
Delivery models adopted	SaaS and IaaS	SaaS	SaaS	SaaS	SaaS and PaaS
Deployments models adopted	Hybrid	Hybrid	Hybrid	Hybrid	Hybrid
Reasons for adoption	Virtual continuous operation, advanced research, offline usage.	Reduced costs, infrastructure maintenance and mobility	Affordable services, easy maintenance	Availability of services on time of need.	Lack of adequate resources, reduced costs
Gadgets available	Desktops, laptops, tablets, smart phones	Desktops, laptops mobile phones, PDAs	Laptops, desktops, smart phones, tablets	Desktops, laptops, tablets, smart phones	Desktops, laptops mobile phones, tablets
Bandwidth	750Mbps	71Mbps	220Mbps	65Mbps	150Mbps
Transmission medium used	Fiber optic	Fiber optic	Fiber optic and UTP	Fiber optic	Fiber optic
Network Topology	Star topology	Star topology	Hybrid topology	Star topology	Star and Ring topology
IT Support staff experience	Satisfactory	Satisfactory	Satisfactory	Satisfactory	Satisfactory
Relative advantage	Virtual continuous operation, Risk shifted to a third party, pay per use, increased production, access to latest version of software, sharing of limited resources.	Reduced costs, mobility, reduced workload.	Easy access to resources, easy management.	24-7 access to resources	Reduced costs, pay-per-use, sharing limited resources.
Challenges	Bandwidth, Sanctions and Technology affected by absence of Internet Services.	Bandwidth, Security, reliable Internet connections.	Resistance by staff members, lack of funds, bandwidth.	Absence of Internet services, misuse of the Internet, bandwidth, lack of funds.	Limited bandwidth , interfacing
Compatibility	Compatible	Compatible	Compatible	Compatible	Compatible
Complexity	Technology is easy to use.	Learning the technology usage is straightforward.	Technology is not complicated.	Technology is easy to use.	Technology is easy to understand and use.

VII. CONCLUSION, RECOMMENDATIONS AND FURTHER STUDY

It is evident that Zimbabwe state universities adopted cloud computing technology, but they are not fully utilizing the technology due to some challenges being faced. All universities currently adopted SaaS service model due to reduced initial investments, reduced maintenance costs, reduced licensing costs and availability of services at any given moment in time. The hybrid deployment model was adopted by the universities since they do not trust the cloud with their institutional data. It was established that the universities were technically ready since they possessed the ICT equipment which is used to access cloud computing services. It was also noted that some IT directors had little knowledge about cloud computing, they adopted the services without background information about the technology. Sometimes universities adopt cloud services without proper planning, thus adopting the technology without forecasting what the future holds. The stumbling blocks that emerged were security concerns, limited bandwidth and lack of reliable Internet connections. These challenges negatively affect the full utilization of cloud computing.

Based on the findings, it is recommended that before universities adopt cloud services, they should engage the end users of the services. The users should be aware of the impending developments so that they understand the concept and realise the importance of the technology, as well as the skills required to use the services. IT directors and decision makers should also be sent to conferences, seminars and workshops so that they gain the required knowledge of this emerging technology. Collaboration is critical among universities where knowledge about this technology can be shared. Since users login to access cloud services, they should be allocated the bandwidth to use so that they do not misuse the available bandwidth. Different fund raising projects should be undertaken by universities so that they sustain themselves to a certain level rather than relying on funds from the Government. Forming partnerships with organizations in developed countries can help in acquiring skills and raw materials for projects, IT students can build and sell computers to raise funds to sustain the university. Students can develop applications and test them using Google cloud which is a cost-effective technology that can be adopted by universities. To mitigate high bandwidth costs, universities can invest in Google University Access Program. Further study should seek to develop a cloud computing security model that would work between the universities and service providers in order to ensure a secure cloud and increase trust. A cloud computing adoption framework can also be developed so that universities follow a step by step approach in the adoption process.

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