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Using the Technology Organization Environment Framework for Adoption and Implementation of Cloud Computing in Institutions of Higher Learning in Kenya

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----------**ABSTRACT**----------
Many Institutions of higher learning in developing countries are adopting and implementing cloud computing in their efforts to provide information technology support necessary for administrative, educational, and research activities. Cloud computing delivers on demand provisioning of IT resources on a pay per use basis. This study discusses the adoption and implementation of Cloud Computing using the TOE framework. To achieve the purpose of the study, a critical analysis of relevant literature was conducted. An overview of the institutions technological, environmental and organizational issues that need consideration is done and suggestions for adoption and implementation strategies made. The study concludes that the TOE Framework is appropriate for the technological adoption of cloud computing in institutions of higher learning.

Keywords: *Cloud computing, TOE framework, learning institutions, developing countries*

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I. Introduction

Computer technology has become widespread in Institutions of higher learning with increasing demand for access and use. Universities and colleges cannot function without ICT, which is ubiquitous for administration, communication, information gathering and research, and is rapidly becoming an indispensable tool for teaching and learning [1]. In Kenya, majority of the Institutions have developed ICT strategic plans to aid in ICT resource utilisation and ICT service delivery to support pedagogical objectives. ICT Services provided at majority of learning institutions include, MIS, e-Learning, Network construction and management, Internet, Intranet and email, Computer Equipment Maintenance, User Support, digital library data and research databases[2] In order to overcome challenges of inability to adequately provide ICT services as a result of lacking adequate resources such as small classrooms, staffing cuts, shortage of qualified ICT personnel, qualified teachers and constantly changing standards, many institutions are turning to cloud computing. Cloud computing can be used to enable educational institutions to actually make use of the global internet resources for data storage and data analysis [3]. According to [4], Cloud computing presents a significant advancement in the delivery of information technology and services as it is capable of enhancing collaboration, agility, scaling, and availability. It also provides potential for cost reduction through optimized and efficient computing. Thus, Cloud Computing offers compelling advantages in cost, speed and efficiency by providing on-demand access to a shared pool of computing resources in a self-service, dynamically scaled and metered manner. The cloud is a valuable tool that can be used to improve ICT service delivery for institutions of higher learning and also accessibility to quality education at minimal costs [5].

The idea behind cloud computing from an institutions point of view is that instead of having the software and data stored locally on servers within institutions, they can all be stored on Internet servers, "in the clouds," and accessed as a service on the Internet. As a consequence users do not have to worry about storage capacity, memory, endless hardware purchases and upgrades [6]. Cloud Computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the data centres that provide those services [3]. The NIST Definition of Cloud Computing identified cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources e.g., networks, servers, storage, applications, and services that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three service models, and four deployment models [7]. This paper adopts NIST definition.

Kenya, like many other developing countries is characterized by many Institutions of higher learning not having access to adequate resources for research and teaching activities and lecturers have high teaching workloads. Information Technology services, such as machines and educational software applications, in most universities are required intensively only in a short period, due to the structure of teaching semesters, while other Information Technology services such as email and storage services are required in a regular basis. Both these types of Information Technology services can be offered by cloud computing [8].

II. Objective

The objective of this study is to investigate cloud computing adoption and implementation issues and formulate suggestions for cloud adoption strategies for effective utilization of cloud resources for learning institutions in Kenya.

III. Methodology

The research was exploratory in nature and used a literature search to study related works and have a comparison of different environments of cloud computing to identify issues that need consideration for effective adoption and implementation of cloud computing in institutions of higher learning. According to [9] the objective of exploratory research is to gain familiarity with a phenomenon or to achieve new insights into it.

IV. Characteristics of cloud computing

The characteristics of cloud computing include on-demand self service, broad network access, resource pooling, rapid elasticity and measured service. On-demand self service means that institutions can request and manage their own computing resources. Broad network access allows services to be offered over the Internet or private networks. Pooled resources means that customers draw from a pool of computing resources, usually in remote data centres. Services can be scaled larger or smaller; and use of a service is measured and customers are billed accordingly [10].

Cloud Computing Framework

According to [7], the Service Models of Cloud Computing are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). [12]observed that the three models are foundations upon which universities can implement cloud computing, and are described as follows:

Software as a Service (SaaS): The applications are hosted by a cloud service provider and made available to customers over a network, typically the Internet. The applications are accessible from various client devices through either a thin client interface, such as a web browser, or a program interface [13]

Platform as a Service (PaaS): Is the capability provided to the consumer to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment [3].

Infrastructure as a Service (IaaS): Is the capability provided to the consumer to process, store and network so that the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components such as host firewalls [3].

Deployment of cloud services:

Cloud services are typically made available via a private cloud, community cloud, public cloud or hybrid cloud. 1) Public cloud: Is available via the Internet for public use, and can be free or subscription pricing for individuals or organizations 2) Private cloud: Is a dedicated cloud for exclusive use by a specific organization or enterprise. It is sometimes called an enterprise cloud and can be on-premise or off-premise hosted by a third-party provider 3) Community cloud: Is shared by various organizations in support of a specific community and it can be either off-premise or on-premise 4) Hybrid cloud: Is a mix of the specified cloud models cited above, or the use of technologies selected for their cloud capabilities integrated into traditional data centres [4].

The inter-relationships and the necessary connections of the NIST cloud computing characteristics and models were specified by Jerry Bishop, the Chief Information Officer at Chippewa Valley Technical College in Wisconsin. These clearly show the five characteristics, the service models, and the deployment models and how they interrelate and work together in a model of cloud computing [11]. These interrelationships with the characteristics, service and deployment models are shown in figure 1 below.

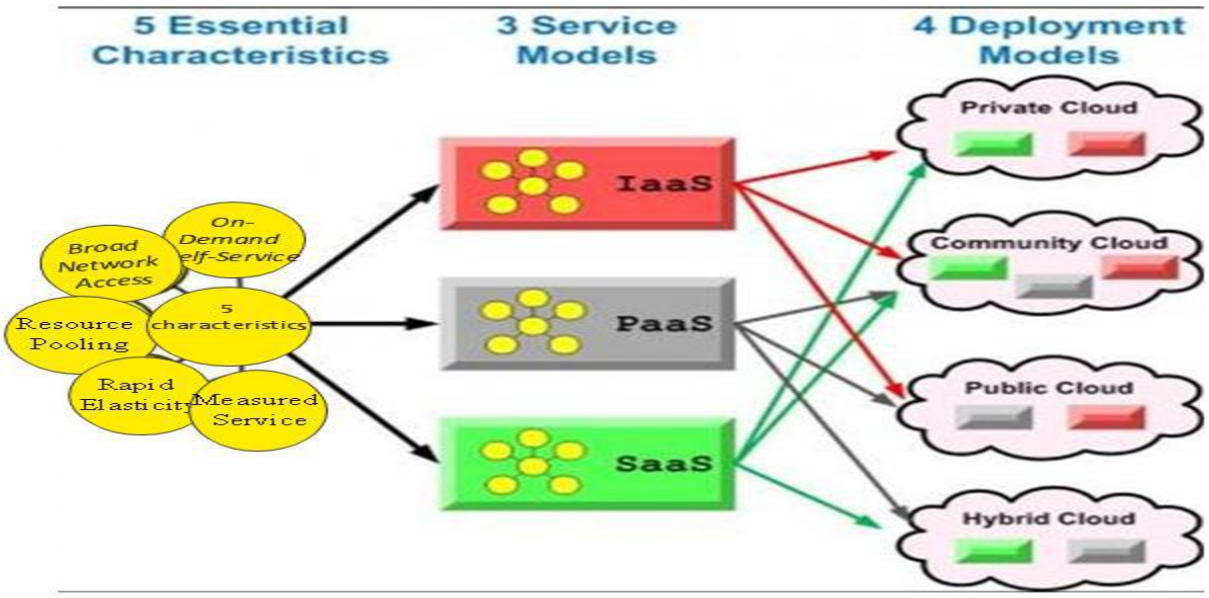

Figure 1: The interrelationships - characteristics, Service and Deployment Models (Source: http://blog.thehigheredcio.com/2011/02/23/cloud-definition-model/)

V. Theoretical Foundation

This study was anchored on the theoretic framework of Technology Organization Environment (TOE). The Technology Organization Environment Theoretical framework developed by [14] identifies three aspects of an organization that influence technological adoption; the environmental context, the organization context, and the technological context. This section examines relevant literature on the three dimensions of TOE in synthesizing adoption and implementation issues of cloud computing in order to suggest strategies that can be useful for institutions of higher learning in Kenya as well as other developing countries.

Technological context

The technological dimension comprises both the internal and external technologies relevant to the Institution [15]. According to [16], for institutions of higher learning in Kenya, the technology context includes factors of cost and technology competence. The technology resources available internally in these institutions are a reflection of the technology competence and for the case of Kenya these comprise the ICT technical infrastructure, ICT competent employees, internet connections and bandwidth. An institutions technical competence is a strong enabler for adoption of Information Technologies as it forms a basis upon which such initiatives are built [17]. In their study [12] observed that for institutions to implement cloud computing, they need to have computers with adequate physical memory, processors and middleware, and the computing infrastructure need to be integrated with tools which hasten the process of learning like set up of campus network architectures and web based technologies. Since cloud computing is internet based, there is need for adequate internet connections at the institutions and sufficient bandwidth in order to deliver educational services [18]. [19] noted that developing countries need to invest in capacity building especially on long term and short term training in various aspects of cloud computing in order to have cloud computing experts for both technology and regulatory compliance for example compliance to laws relating to data, tax and payment. The external technologies comprise factors such as availability of cloud service providers, internet service providers, power supplies and security.

Organizational context

The organizational context comprises an institution's innovativeness, top management support, organizational culture, the quality of human resource, and size [14] [21]. Organizational culture is associated with the organization's sense of identity, its core values, it's primary ways of working and a set of shared assumptions [22]. In the case of institutions of learning, a school's culture encompasses the vision, plans, norms and values that are shared by school members [23]. Top management support manifests itself in supportive leadership. School leadership has an impact on the implementation of innovations by teachers and administrative staff through its influence on participation in decision-making, reducing feelings of uncertainty and promoting professional developments [24]. School culture has a mediating role in adoption of technologies, and the

innovativeness of a school can be linked to how ready a school is to adopt Information Technology [25]. [22] Observed that the institutions readiness for adoption of an innovation is dependent on technical skills, and therefore a strong IT staff equipped high technical skills and interpersonal skills, will enable an effective partnership between IT and other functions dependent on IT at such institutions. According to [15], Firm size has been consistently recognized as an adoption facilitator. Thus, with regard to adoption of Cloud Computing, larger institutions have several advantages over small institutions. Larger institutions (1) tend to have more slack resources to facilitate adoption; (2) are more likely to achieve economies of scale, an important concern due to the substantial investment required for IT projects; (3) are more capable of bearing the high risk associated with early stage investment in IT projects; and (4) possess more power to urge partners to adopt technology.

Environmental context

The environmental context comprises factors of institutions surroundings, consisting of stakeholders such as sponsors, the government, the community, and competitive pressure. These can influence how an institution interprets the need for innovation, its ability to acquire the resources for pursuing innovation, and its capability for actually deploying [26]. Government regulations can force resources to be allocated for compliance. For example the Kenyan Government, through the ministries of Education, Science and Technology and Information and Communication Technology, developed several policy and strategy documents to guide the integration of ICT in education (National ICT Policy, 2006; Sessional Paper No. 1 of 2005 and Kenya Education Sector Support Program, 2005-2010). These have created awareness on the place of ICT in education, and possibly favoured allocation of resources [27]. In terms of competitive pressure, institutions are likely to come under pressure to go online and adopt Cloud Computing because other institutions have adopted it. The Kenya Governments policy for institutions to provide continuing education and e-learning is also a source of such pressure, since this form of learning can easily be delivered through cloud services. As competition for better delivery of learning increases, institutions may feel the need to adopt Cloud Computing technologies more extensively to gain competitive advantage [17].

VI. Adoption and Implementation issues

The adoption and implementation of cloud solutions has been on the increase with many institutions of higher learning in developing countries adopting the cloud computing offerings. For Institutions without adequate computing resources this is a viable solution and is facilitated by existence of cloud service providers who provide cloud services for free or at discounted rates to educational institutions [28]. Examples of such cloud service providers are: Google, IBM, and Microsoft, all of whom have special packages aimed at providing institutions with access to ICT infrastructure, software, platforms, and other educational services hosted in their clouds. The Google educational package for example has web-based collaborative tools e.g., Gmail, Hangouts, and Google Calendar and productivity tools such as Google Docs consisting of text files, spreadsheet, presentation packages, and form creation and sharing [19]. Thus, Cloud Computing has found its way in many institutions in developing countries, and as a result several institutions have started adopting various cloud services to reduce ICT investment costs as well as making teaching and learning more efficient [19]. According to [19], over 30 institutions across Africa have entered into partnerships which include grants, technical support, consulting, and training with Google to use Google cloud services. These institutions include University of Pretoria (South Africa), University of Ibadan (Nigeria), University of Mauritius (Mauritius), and University of Ghana (Ghana), National University of Rwanda and the University of Nairobi, United States International University, the Kenyan Methodist University, and the Makerere University Business School (MUBS). However, despite the economic potential of the computing models and other models of shared services, valid concerns remain for leaders of institutions deliberating particulars of their institution's involvement in the cloud. A number of primary concerns have been articulated by institutions [20]. In order to address these concerns, issues that must be addressed for successful adoption and implementation of cloud computing for institutions of higher learning in Kenya as well as other developing countries include:

Cloud Computing Expertise

Cloud computing aims at reducing administrative efforts from non-IT people, consequently expertise in cloud computing is required for technologies such as virtualization, cloud APIs, and web services and for regulatory compliance e.g. laws, data compliance, tax and payments There is need for continuous capacity planning and building in institutions since this expertise can be a strong enabler in utilizing public cloud offerings for institutions in developing countries [8]

Availability Internet bandwidth

The institutions in developing countries need to develop their ICT infrastructure and have in place adequate internet connections, adequate bandwidth, and stable power supply [8]. Cloud computing services are availed over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms e.g. mobile phones, tablets, laptops and workstations [29]

Financial resources for metered payments

According to [8], Cost analysis from existing clouds indicates that it is still quite expensive for educational institutions in developing countries, compared with their income, in their efforts to utilize clouds. Popular payment methods accepted by many public cloud providers are done electronically, which could be a problem in developing countries, where the use of credit cards and online banking is still limited and banking systems are not well developed. There are also strict regulations on making overseas payments in some of the developing countries. Since such limitations of payment system may hinder the adoption of public cloud in academic institutions, there is need for such institutions developing to set clear business objectives and adoption principles to help them overcome such obstacles [30], [8].

Information Security Concerns and Compliance

[20] States that among the key challenges for cloud computing are security issues, such as security of the facility where data is stored; security of data transport; and reliability of the provider, its service track record, and its business bona fides. Adoption and implementation strategies selected for educational institutions in developing countries therefore must address Information Security and Compliance concerns at all levels e.g., network, host, application, and data levels can be achieved and how applications security is moved to Cloud Computing [32]

Service and Infrastructure Readiness

[30] stated that most cloud service providers do not have the track record on which institutions can build the necessary trust in order to shift their existing services without either great deliberation or a very compelling benefit. Service provider attributes only come with time, reputation, and experience. Compounding these challenges, most IT departments in institutions of higher learning are not themselves highly skilled in managing risk and service performance in third parties. [30] asserts that lack of confidence in the cloud stems from: 1)Poor or nonexistent service level agreements 2) Inadequate risk management 3) ROI justification, management of change orders, and vendor lock-in 4) Market immaturity 5) Management issues

[11] observed that, the visual interrelationships in Figure 1 explain different configurations available for institutions in cloud-based strategies, and institutions should ideally begin with one service model, such as SaaS and a Public Cloud deployment model as a pilot, and then slowly scale if the pilot proves successful, and it is also possible to use several deployment models to support one or more service models, as indicated by the various red, green, and grey arrows depending again on the institutional needs and costs

VII. Adoption and Implementation Strategies

Migrating towards cloud needs a well defined strategy that supports Cloud Computing capabilities. In order to have success, the cloud strategy must take into account the real needs of the institution and be aligned with the institutions strategy [31]. In their researches related to the transition to Cloud Computing and the experience of universities using it [31] suggested a migrating strategy towards cloud, based on the following five stages: a) Developing the knowledge base about Cloud Computing; by participating at seminaries, conferences, discussions with the suppliers and consulting the most recent researches in the field. b) Evaluating the present stage of the university from the point of view of the IT needs, structure and usage; by understanding the university IT infrastructure, the data, services, processes and applications that may be migrated or need to be maintained within the university, so as to observe the security policy. c) Experimenting the Cloud Computing solutions; the transition to cloud may be achieved gradually, starting from testing a pilot project in cloud and then externalizing the applications chosen for cloud. d) Choosing the Cloud Computing solution; by identifying the data and applications, functions and main processes within the university and evaluating these elements according to criteria, such as mission, importance within the university, sensitivity, confidentiality, integrity, availability, in order to determine the candidate elements for cloud. e) Implementation and management of the Cloud Computing solution. These stages are illustrated by Figure 2.

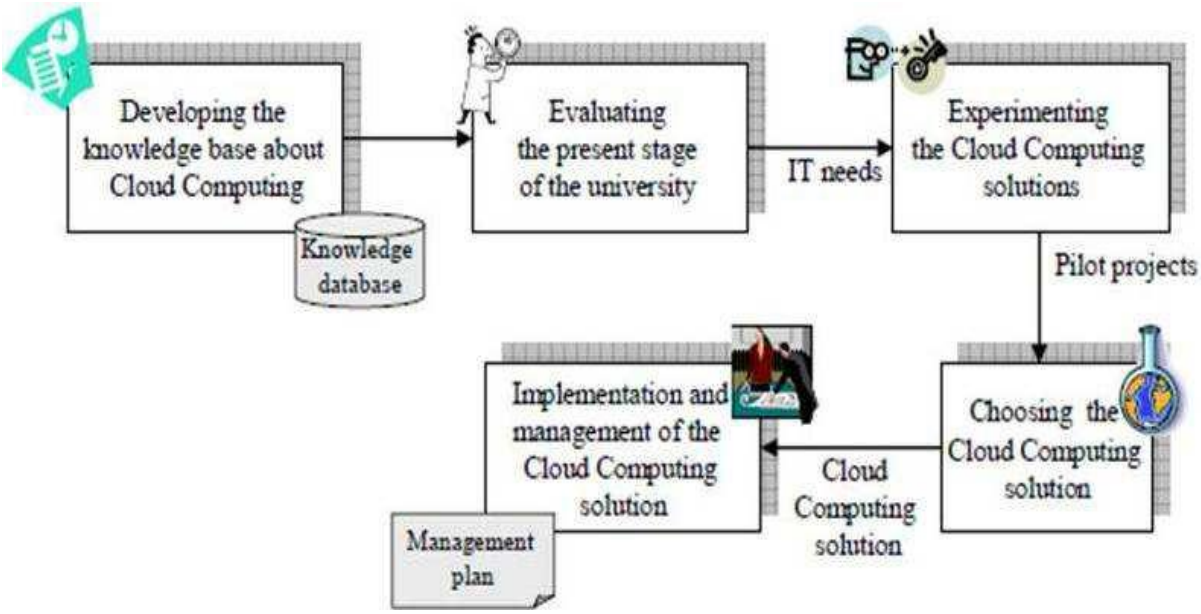

Figure 2: Cloud Strategy in Higher Education (Adapted from [31]).

VIII. Conclusion and Recommendations

This study is a step towards providing information on an appropriate framework that may be used in helping institutions adopt and utilize cloud services. The study considered adoption and implementation issues, and strategies that may be used by institutions of higher learning to adopt cloud computing. The Technology Organization Framework can be used to guide leaders of learning Institutions on the specific aspects of their institutions that need improvement in order to achieve the technological adoption of cloud computing. The study recommends further studies that will help determine the usefulness of combining the TOE framework with other existing theories on technology adoption.

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