Cloud Computing Model for Virtual Libraries Implementation in Nigerian Tertiary Institutions

Abdulwaheed A. Yusuf, Anderson I. Orobor, and Atanda S. Sambo

***Abstract*— Virtual library facilitates improved information services delivery that support qualitative learning and research in tertiary institutions. However, shortage of skilled manpower to manage and maintain existing ICT Infrastructure and erratic power supply to power the ICT equipment are identified as part of the challenges militating against virtual libraries implementation in Nigerian tertiary institutions. These have made it practically difficult for its effective maintenance and required utility throughput. This situation is further worsened by the increasing need for ubiquitous availability of electronic library services to patrons as an inherent characteristic of virtual libraries, resulting to prohibitive establishment and operational cost for the tertiary institutions to meet up. This study tends to address the identified problems by harnessing the benefits presented by open source and cloud computing technologies for the development and management of virtual library in Nigerian tertiary institutions. The model presented in this study is based on community cloud model that leverage open source platform as a service (PaaS) and software as a service (SaaS) model to provision and maintain virtual library services.**

***Keywords*—Open Source, Cloud Computing, Virtual Library, Tertiary Institutions.**

I. Introduction

The end of the twentieth century witnessed recent advancements in Information and Communication Technology (ICT) that result to an information age which redefines how information is stored, organised, managed, rendered and accessed to serve the information need of the intended users. This trend has given rise to the concept of Virtual Library often referred to as "electronic library," "library without walls" and "digital library" according to [2]. [5] defined the term virtual library as: *"a national collection of digitized texts, distributed among institutions and accessible from anywhere at any time"*. [21] defined digital library as *"a library in which collections resources are stored in digital formats (as opposed to print, microform, or other media) and accessible by computers."* [7] states the characteristics of digital and virtual library as: *"access to information over a network, facilitate immediate and simultaneous access to information, they are interactive, i.e. support 2 ways communication with the users, they exist in multimedia format of text, video, graphics, sound and animation. Above all, it increases speed and effectiveness in finding information and to decrease mental effort put into each search of information in the net"*. An analysis of the synonyms, definitions and characteristics of virtual library presented suggests the deployment of digital library contents and automated library services over the internet as a requirement for fully harnessing its benefits.

Libraries in Nigeria tertiary institutions as the heart of the institution they serve, supporting research and learning, are not left out in harnessing the opportunities presented by this trend. [13] reveals the gradual computerisation of Nigerian libraries in the universities through commencement of digitisation and establishment of library information network with connectivity through the university campus network to the Internet. Besides, [1] stating the report of IT News Africa, revealed the successful establishment of digital libraries in three (3) Nigerian Universities by Mobile Telephone Network (MTN) Nigeria. These Universities include: the Ahmadu Bello University, Zaria, the University of Lagos and the University of Nigeria, Nsukka. [9] had earlier revealed the launching of some Virtual Library Initiatives for Nigerian Higher Institutions by the Federal Government of Nigeria. [3] report the deployment of XLIB Library Management System in Ozoro Polytechnic Library, an ongoing Digital Library Project at Oghara Polytechnic, and the presence of ICT facilities in Ogwashi-Uku Polytechnic library, all in Delta State.

However, [2] identified shortage of skilled manpower to manage and maintain the required ICT Infrastructure and erratic power supply as part of the challenges faced by Virtual Libraries implementation. These have made it practically difficult for Virtual Library in Nigerian Tertiary Institutions to be effectively maintained and its benefits fully harnessed. Coupled with the fact that virtual library is characterised by round the clock availability, these challenges posed a prohibitive cost to the libraries as against the limited available funds.

This study tends to address the identified problems by harnessing the benefits of open source software and cloud computing in the deployment and management of virtual library in Nigerian tertiary institutions based on community cloud approach. We presented a cloud virtual library concept capable of implementing open source library management system on an open source cloud computing platform. Hence, migrating the cost of deploying, managing

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Abdulwaheed A. Yusuf is with Information and Communication Department, Federal University of Petroleum Resources Effurun, Nigeria. phone: +2347065777156, email: yusuf.abdulwaheed@fupre.edu,ng

Anderson I. Orobor is with Information and Communication Department, Federal University of Petroleum Resources Effurun, Nigeria. email: orobor.anderson@fupre.edu.ng

Atanda S. Sambo, is with Library Department, Federal University of Petroleum Resources Effurun, Nigeria. email: sambo.atanda@fupre.edu.ng

and maintaining the ICT infrastructure involved in virtual library operation to the cloud provider (i.e government agencies). The only cost incurred by the consumers (i.e tertiary institutions) is based on cloud resources usage or/and cost of deploying and maintaining the ICT infrastructure responsible for internet connectivity at their respective campuses. The rationale for virtual library implementation on cloud computing and open source technologies is also discussed in this work.

II. RELATED LITERATURE

A. Cloud Computing

Cloud computing is a Service Oriented Architecture (SOA) which reduced information technology overhead for the end-user and provide great flexibility, reduced total cost of ownership, on-demand services and many other things [11]. Hence it delivered all IT related capability as services rather than product [20]. [22] defines cloud computing according to Forrester Research as: "*a standardized IT capability (services, software, or infrastructure) delivered via Internet technologies in a pay-per-use, self-service way*." More so, National Institute of Standards and Technology (NIST), United States Department of Commerce, giving an elaborated definition of cloud computing states in [16] that: "*Cloud computing is 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 is composed of five essential characteristics, three service models, and four deployment models*".

a. Essential Characteristics

1. On-demand self-service: A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider [16].

2. Broad network access: Capabilities are available 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 [16].

3. Resource pooling: The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand [16]. Such dynamic resource assignment capability provides much flexibility to infrastructure providers for managing their own resource usage and operating costs [23].

4. Rapid elasticity: Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time [16]. This allows service providers to acquire resources based on the current demand, which can considerably lower operating cost compared to the traditional model that provisions resources according to peak demand [23].

5. Measured Service: Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported. This provides transparency for both the provider and consumer of the utilized service [16].

b. Service Models

The general architecture of cloud computing is shown in Figure 1. It supports three service models which are described in details:

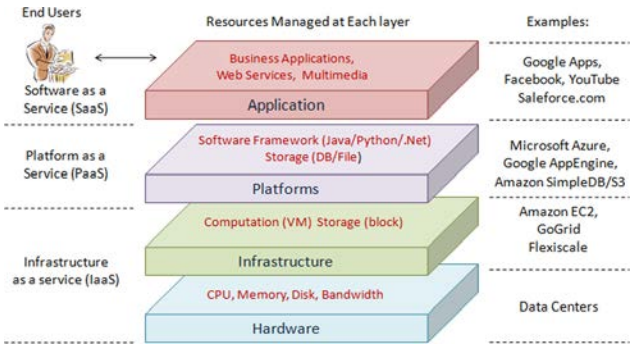

Figure 1. Cloud Computing Architecture (Zhang *et al*, 2010)

1. Software as a Service (SaaS): It deliver to user 'software' as a service over the Internet, eliminating the need to install and run the application on their own computers and simplifying maintenance and support [20]. The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based email), or a program interface. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings [16].

2. Platform as a Service (PaaS): It delivers to user a computing platform and/or solution stack as a service. It facilitates deployment of applications without the cost and complexity of buying and managing the underlying hardware and software layers [20]. The capability provided to the consumer is 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 [16]. PaaS provides operating system support and software development framework [23].

3. Infrastructure as a Service (IaaS): It delivers to user computer infrastructure, typically a platform virtualization environment, as a service. Rather than purchasing servers, software, data center space or network equipment, clients instead buy those resources as a fully outsourced service. It is an evolution of virtual private server offerings [20]. The capability provided to the consumer is to provision

processing, storage, networks, and other fundamental computing resources where 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 (e.g., host firewalls) [16]. IaaS is usually in terms of virtual machines [23].

c. Deployment Models

1. Private Cloud: The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises [16]. A private cloud offers the highest degree of control over performance, reliability and security [23].

2. Community Cloud: The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises [16]. This deployment model forms the basis of the model presented in this study, viewing Nigerian University Libraries as a community with the same or similar mission, security requirements, policy and compliance considerations.

3. Public Cloud: The cloud infrastructure is provisioned for the use of the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider. [16]. Public clouds offer several key benefits to service consumers, including no initial capital investment on infrastructure and shifting of risks to infrastructure providers [23].

4. Hybrid Cloud: The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds) [16]. Hybrid clouds offer more flexibility than both public and private clouds. Specifically, they provide tighter control and security over application data compared to public clouds, while still facilitating on-demand service expansion and contraction [23].

d. Benefits of Cloud Computing

1. Cost Savings: Cloud computing save cost by providing an economy of scale from the providers view, demand view and multi tenancy view [12]. The cloud provider can increase the degree of sharing to reduce operating cost, while the consumers does not need to use high powered and a high priced computers to access the cloud resources.

2. Increased Storage: Due to the rapid elastic nature of cloud computing, additional storage can be easily provisioned to support the increasing consumer's storage need with minimal human intervention (i.e automated). This makes the consumer feels they have access to unlimited storage facilities available on demand.

3. Flexibility: Cloud computing supports organisational agility as consumers can pool and release cloud resources at any time to satisfy their information technological needs.

4. Mobility: Since Cloud computing is characterised by broad network access over the Internet, cloud resources can be accessed anytime and anywhere. This projects cloud computing model to be a valid alternative to implement Bring-Your-Own-Device (BYOD) in learning.

5. Reduced Time for Implementation: Cloud computing provides near real-time automated process for implementing new IT initiative when they occur unlike the traditional way that might take weeks or months to achieve.

B. Open Source Software

The term Open Source is described as a development method for software that harnesses the power of distributed peer review and transparency of process. The promise of open source is better quality, higher reliability, more flexibility, lower cost and an end to predatory vendor lock-in [14]. Open source software are those whose source codes are available publicly without any charge [8]. Organisations and individuals can use open source software (OSS) for free, they can study its internal workings, and they can even fix it or modify it to make it suit their particular needs. These attributes make OSS an enticing technological choice for a company [19]. The benefits of open source software can potentially reduce costs; give users more control and increase software performance [4]. These have led to the adoption of open source software in the academic libraries.

C. Related Work

[15] discusses constraints and choices faced by information retrieval systems like CiteSeer (an application instance of SeerSuite) by exploring in detail aspects of placing CiteSeer into current cloud infrastructure offerings. Movement of well-chosen components of CiteSeer to the public cloud while hosting others locally is presented as a cost effective choice for its continued operations and growth. The researchers also propose an ad-hoc system to provide the same services provided by SeerSuite repository by virtualizing the storage system, which can be adopted for a more scalable, extensible and robust CiteSeer. However, open source technologies are not considered.

[10] propose a digital library platform based on cloud computing, which can offer unified service interface and provide personal service to different terminal users. The authors opined that the model can solve the problem of library resource storing and sharing effectively, and provide fast, safe, convenient and efficient services to users.

[18] discusses the benefits of cloud computing and its application in elibrary services in Nigeria, with more emphasis on cost reduction. However, a specific model that manifests those benefits was neither presented nor open source software for improved cost effectiveness in elibrary operation discussed.

III. PROPOSED MODEL DESIGN

The architecture of the proposed model is shown in figure 2. The design of the proposed model is a community cloud based on open source technologies. It shows the conceptualize service view separating the users and the

services. The hardware that houses the physical resources such as CPU, memory, disk and bandwidth, is virtualized with the aid of a hypervisor to create virtual machines on which the guest open source cloud operating systems (cloud manager) are installed. The cloud manager provisions the infrastructure supporting the cloud resources accessed by the cloud consumers. It provide tools used by the cloud provider for cloud deployment, management and orchestration. Some open source cloud managers include OpenStack, CloudStack, Eucalyptus, OpenNebula etc.

The model provision PaaS and SaaS for consumers. The PaaS exposes operating systems, software development framework, storage (DB/Files) such as Python, Java, PHP, MySQL, MongoDB, etc. that supports the deployment of customized library management system (LMS) to the consumers through the Representational State Transfer (REST) Application Programme Interface (API). The SaaS is characterised with instance(s) of open source LMS for implementing virtual library services. These LMS may include Greenstone Digital Library, KOHA, E-Prints, PhpMyLibrary, OpenBiblio, Avanti, DSpace, NewGenlib etc. which can be accessed through web interface. The IaaS is deployed for internal usage of the cloud provider to provision other cloud resources. It is not exposed to consumers' access.

The actors that interact with the system are described as follows:

1. Cloud Consumers: These are individual Nigerian tertiary institutions such as Universities, Polytechnics and Colleges of Education that subscribed as part of the community cloud members, accessing the PaaS and SaaS available on the cloud to satisfy their information needs. They can be further classified to three categories which are patrons (students and faculties) that are users of the virtual library services; the Liberians or Information Scientists that create, manage and maintain the virtual library services; and system developers with required programming or software engineering skills, who interacts with the PaaS through the REST API to deploy customized library management system that best satisfy the information needs of their respective institution.
2. Policy Makers: These are government agencies, interest groups, and private partners who are stakeholders responsible for policy formulation within the education, information science and technology sectors of the Nigerian economy. They work with the cloud providers to ensure the cloud system best meet consumers' need.
3. Cloud Providers: These are government ICT agencies, perhaps in collaboration with third party entities responsible for designing, developing, deploying and maintaining the overall cloud infrastructure.

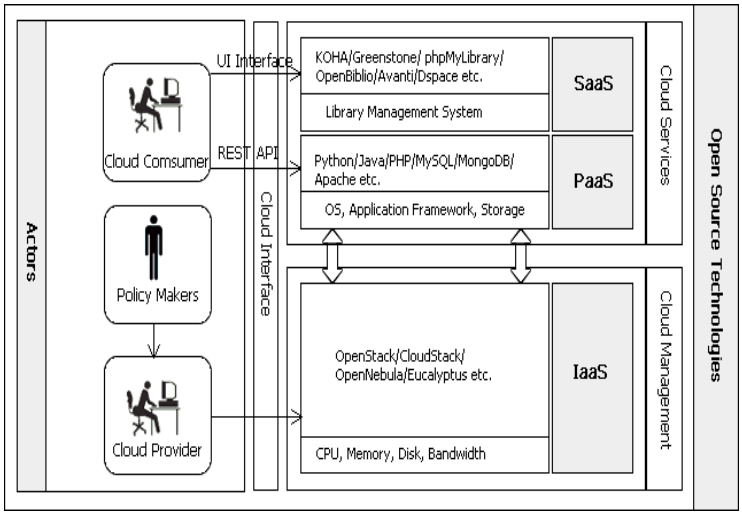

Figure 2. Architecture of the Proposed System

IV. Rationale for Open Source and Cloud Implementation of Virtual Library

[17] noted that libraries with small budgets always consider automation of housekeeping operations as a financial burden due to the high cost of commercial software. However, development of open source software is an effective way to automate library operations without undertaking substantial financial investment. Libraries are taking up open source software as a way to reduce the costs of expensive commercial products and as a viable alternative to the often expensive proprietary library automation systems.

Cloud computing is also an alternative for educational institutions which are especially under budget shortage in order to operate their information system effectively without spending any more capital for computers and network devices. Many technologies that were previously expensive or available are now becoming free with this new IT paradigm [6].

Leveraging on both technologies benefits, this study hence, presented a model not only capable of reducing the cost of implementing virtual library and its operational cost in Nigerian tertiary institutions, but also pave way for easy adoption of Bring-Your-Own-Device (BYOD) for patron access to the electronic library infrastructure, resulting to enhanced and effective learning process. The deployment of library management system as SaaS with generic considerations will eliminate the burden of skilled manpower on the library authorities within Nigerian tertiary institutions. The model also provision PaaS service to tertiary institutions with skilled manpower in ICT, to deploy customized library management application to satisfy some of their information needs that is not (properly) catered for by the generic library management system deployed as SaaS by the cloud provider.

V. Conclusion

The proposed model is for government funding and implementation. When implemented as a national IT policy strategy will offers huge cost saving in deploying, managing and maintaining virtual libraries across Nigerian tertiary institutions. The model also helps consolidate datacentres and aggregate library services existing in silos with

ubiquitous access to library resources. The study did not discuss sharing digital library contents among the cloud consumers, however, it is recommended for future research.

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