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Open Source Systems and Digital Library Services in Nigeria: A Review

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Abstract

The provision of refined information to patrons in the shortest possible time, as guaranteed by Digital Library, is cardinal to academic libraries. This has led to the emergence of Digital Library services in Nigerian academic libraries as a natural consequence of evolution of Information and Communication Technology (ICT) applications in librarianship. This study discusses the challenges faced by Digital Library services in Nigeria and how the capabilities of Open Source Systems can be harnessed toward overcoming such challenges.

Keywords

Digital Library Services, Open Source Systems, OpenStack, Dspace, Koha

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1. Introduction

With the advent of computer and internet, there has been a paradigm shift from manual library services to automated library services. This enables academic libraries to better achieve their chief goal of rendering information to the intended users at the shortest possible time. From Library Automation to Digital Library systems; several technologies, both propriety and open source, have been developed to enhance Digital Library services. Academic libraries in Nigeria are not left out in harnessing the potentials presented by this trend to add value to the library services available to their patrons. [1, 4, 8, 10, 19] record the existence of Digital Library services in some Nigerian tertiary institutions for enhanced information delivery. This study discusses the challenges faced by Digital Library services' provision and how the use of open source technologies can improve Digital Library services in Nigerian academic libraries.

2. Open Source Systems

Open Source Systems are software systems built upon the concept of Open Source. [26] describes the term "open source" as: *"something people can modify and share because its design is publicly accessible."* Open source software refers to software with their source code available to the public at no charge [9]. [12] describing source code in the context of open source stated: *"Source code is the code written by computer programmers to be "translated" by compilers to "instruct" a computer to carry out certain functions and actions. It's the part of the software that a surface-level user never sees. By altering a program's source code, programmers can improve, fix, modify, or add on to it as they please"*. The focus of open source is to empower the users with liberty to freely redistribute the software, access the source code, make modifications to produce derived works, etc., while maintaining technology independence and the integrity of the authors' source code, and with no

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discrimination to any category of users [24].

The availability of source code of open source software at the public domain and the freedom given to the user community result to higher flexibility, better quality and rapid response to security issues through collaborative contributions. These differentiate them from propriety systems that hide source code from the users as a trade secrete [12], despite the fees paid by the users to access them; and freeware that present the software to the users free of charge but still deny them access to the source code [17]. For software to be considered completely open, it must respect users' freedom to run, modify the source codes and redistribute the software without being charged by the original authors or license owners. The benefits of open source software can potentially reduce costs; give users more control and increase software performance [5].

3. Digital Library Services

[13] defined Digital Library as: *"Organized collection of resources, mechanisms for browsing and searching, distributed network environments, and sets of services objectified to meet users' needs"*. [27] delineates Digital Library as: *"The networked collections of digital text, documents, images, sounds, scientific data, and software that are the core of today's internet and tomorrow's universally accessible digital repositories of all human knowledge"*. [8] describes Digital Libraries as: *"libraries in which all information resources are available in computer process through which acquisition, storage, preservation, retrieval and dissemination of resources are carried out using digital technologies"*. Digital Library is often refers to as Electronic Library (e-library) according to [2], which is termed by [3] as: *"a collection of services and information objects that support users of the library in dealing with information objects and the organization and presentation of those objects which are available directly or indirectly via electronic/digital means"*.

Consequently, Digital Library services may be referred to as services emanating from the application of Information and Communication Technology (ICT) in librarianship which include services derived from the automation of library housekeeping operations (acquisition, collection development, classification, cataloguing, serial control and preservation); and new services such as repository and internet services that enrich information delivery. The automation of housekeeping operations is geared toward an enhanced management and administration of library physical resources (print materials) that give raise to user oriented services such Online Public Access Catalogue (OPAC). Repositories facilitate storage of large volume of digital materials for easy access and distribution to patrons, which may be online or offline.

4. Challenges Of Digital Library Services in Nigeria

Despite the realizations of Digital Library projects in Nigerian Academic Libraries, [8] identify certain challenges undermining the services of Digital Libraries in some examined tertiary institutions in Nigeria. Some of these challenges are discussed in the subsequent sections.

4.1. Licensing, Ownership and Cost

[8] remarked that licensing in a digital environment is confusing, problematic and very costly. This is because in the proprietary sense, ownership of resources such as software belongs to the vendor that develops the software.

Access to client organization is only granted through licensing for software component(s) of concern over a period of time. The period of access is usually extended through license renewal inform of annual subscriptions. Failure to meet up with subscription deadline may result to partial or total denial of access to Library Management System that facilitates Library Automation, causing critical obstruction to the availability of Digital Library services. Moreover, an attempt by the client organization to migrate to a new vendor's product after the subscription period elapse potentially result to loss of critical data.

Furthermore, subscriptions to Proprietary Library Systems are usually accompanied by access to online electronic resources such as e-books and e-journals, which may be terminated at the expiration of such subscriptions. Therefore, availability of electronic resources is restricted to the proprietary library system subscriptions unless additional electronic resources are separately subscribed for at spare cost. This led to insufficient electronic resources in some academic libraries in Nigeria, as was the case with Federal University of Petroleum Resources (FUPPRE) Library [16].

4.2. Abuse of Digital Library Technology

Electronic libraries are implemented over traditional network architecture that usually employ peer-to-peer communication model, making it highly difficult to actualize automated/centralized control of patron access to the computerized library services. Users' abuse of Digital Library technology, either consciously or unconsciously, is capable of exposing the system to some security threats which may affect the availability of the digital services on the network. These security threats may be initiated due to patrons accessing malicious sites online via the E-Library

infrastructure, where check mating patrons' access to websites with malicious contents on the internet remains a herculean task.

The situation becomes more complicated in a circumstance where wireless technologies are deployed for clients' systems to access the digital services, as clients may be at liberty to conduct wrong browsing for online betting, pornography, music downloads and so on, at the expense of legitimate courses defined by the library authorities. An effective option for arresting this ugly situation such as the use of Active Directory Services requires valid licenses and procurement of server machines that come at extra cost.

5. Analysis and Significance of Open Source Systems in Digital Library Services in Nigeria

In our study on how the identified challenges of can be addressed, we recognize three kind of systems that need to be implemented using open source technologies. These systems are Library Automation Systems, Repository Systems and Infrastructure System.

5.1. Library Automation System

Library Automation System (LAS) facilitates the computerization of traditional library housekeeping operations over a computer network using specialized software that guarantee speedy access to library information. LAS improve library productivity by reducing the workload on library staff in rendering information services. This study presents Koha Library Software as a suitable open source technology for implementation of Library Automation Systems

5.1.1. Overview of Koha

Koha Library Software is the world's first free and open source library system designed for library automation. It is a fully featured, scalable library management system. Its development is sponsored by libraries of varying sizes, volunteers, and support companies worldwide [15]. It was originally written by Katipo Communications Limited in New Zealand, and first deployed for Horowhenua Library Trust in January of year 2000 [25].

It is made up of three major sub systems namely: Web Server, Database Server and Search Engine. The web server is built on apache [16], with interfaces developed using standard web technologies such as CSS, XHTML and JavaScript; making it to be platform independent [14]. The search engine is based upon Zebra indexing that increase the speed of searches [7], and facilitate enhanced catalogue display capable of using contents from Google, Amazon, Open Library, LibraryThing, and Syndetics [14]. The database server works with MySQL as a preferable option [7]. The primary host operating systems for Koha Installation are UNIX-based such as Linux. However, it has been practically proven that Koha still work on Microsoft Operating Systems with the aid of application-based hypervisor such as VMware.

Koha is branded with modules for both basic and advance options that include acquisitions, circulation, cataloguing, serials management, authorities, flexible reporting, label printing, multi-format notices and offline circulation for when Internet access is not available. It is Multilingual, supporting about 47 languages of the world [20]; and compliant to several library standards and protocols such as UNIMARC, MARC 21, SRU/SW, z39.50, SIP/NCIP, SIP2; ensuring interoperability between Koha and other systems and technologies, while supporting existing workflows and tools [14]. Koha has support for barcode technology and possess user interfaces that are highly configurable.

5.1.2. Justification of Koha for Library Automation System Implementation

The evolution of koha over a long period of time has enable it to integrate ideal functionalities required for Library Automation. Its adoption in Nigerian academic libraries guarantees continuous access of Librarian to the Library Automation System without fear of cessation or drop in quality of the automated services rendered to patrons.

5.2. Repository System

Library Repository Systems are software systems that aid the actualization of digital repositories. A digital repository is a mechanism for storing and managing digital contents in order to support learning, research and administrative processes [28]. [11] defined a digital repository as *"Set of interrelated electronic documents, stored in files or database, usually classified in categories and other criteria, that stores knowledge useful to an enterprise or other organization"*. The focus of digital repository is on management and preservation of digital assets of a library. This study acknowledged Dspace Library Software as an apposite open source technology for implementation of digital repositories.

5.2.1. Overview of Dspace

Dspace is an Open Source dynamic digital repository system developed in collaboration between Massachusetts Institute of Technology (MIT) and Hewlett-Packard (HP) Company. The system is based on an information model built around the idea of organizational "Communities" [29]. Released in year 2002, Dspace design, according to [32] was aimed at:

"the capture, management, preservation and redistribution of digital scholarly research materials in a variety of formats, for a variety of purposes".

According to [30], Dspace enables an organization to *"capture and describe digital material using a submission workflow module, or a variety of programmatic ingest options; distribute an organization's digital assets over the web through a search and retrieval system; preserve digital assets over the long term"*.

Dspace is built on a database system that support the use of Open Source PostgreSQL and proprietary Oracle Database [30]; and a web server made up of Apache and Tomcat [18]. It is designed upon a data model that reflects the structure of the organization for ease of representation. The deployment of Dspace is achievable over both Unix-based and Microsoft Operating Systems.

Dspace renders online access to an organization digital asset through its support for Full-text search, OpenURL, and ability to store multiple file types in bitstream format. It offers fine-grained Metadata management options to the library administrators while maintaining a persistent identifier for each stored item for guaranteed continuous access to the item by web users. Dspace ensures digital preservation through a checksum mechanism.

Dspace guarantee data security by enforcing high level access control with enhanced user management system that categorized repository users into E-Persons and groups upon which subscriptions can be made to gain access to the digital contents.

One of the most remarkable features of Dspace is its support for Open Archives Initiative (OAI) via the use of OAI Protocol for Metadata Harvesting (OAI-PMH). The goal of OAI is the development and promotion of interoperability standards that facilitate efficient distribution of digital contents to increase the accessibility to scholarly communications. The OAI strives to make its standards and central technological framework to be independent of the types of digital contents offered and the economic mechanism surrounding such contents [23].

[22] described the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) as *"an application-independent interoperability framework based on metadata harvesting"*. Repositories referred to as data providers expose structured metadata about a particular resource via the OAI-PMH to other repositories referred to as service providers. The service providers harvest the exposed metadata through OAI-PMH service requests to build valued-added services for library clients. A client application (harvester) at the service provider end issues OAI-PMH requests to a repository (data provider) which returned the response in form of metadata in a specific metadata format (record). These metadata are disseminated by means of a standard entity called item. Upon the receipt of the responses of the requests made, the library client(s) at the service provider's end can seamlessly access the resource(s) in question. Dspace exposes Dublin Core metadata to take part in the OAI-PMH communication process.

5.2.2. Justification of Dspace for Repository System Implementation

The inherent capability of Dspace to discover metadata about resources from large number of repositories over the web, and presenting such resources for direct use of library users via a single point of access, projects it as ideal library software to address the identified problem of insufficient electronic resources in Nigerian academic libraries.

5.3. Infrastructure System

Infrastructure systems are software systems that facilitate the underlying structure or architecture upon which other systems are developed or installed. Infrastructure software aid the deployment, management and administration of Information Technology (IT) infrastructure such as network, storage and computing facilities as well as database systems. OpenStalk is identified by this study as an appropriate open source system for driving the IT infrastructure in academic libraries.

5.3.1. Overview of OpenStack

OpenStack is an open source cloud manager developed by United States NASA (National Aeronautics and Space Administration) and Rackspace in 2010, as a collection of projects aggregated into single software over a distributed architecture. These projects form the service components of OpenStack. Each component can be deployed individually or in combination with other component(s) to provision infrastructure services supporting an organization process or structure, without necessarily bringing up a full cloud environment. The role(s) played by each component can be assigned to a single or a group of machines which can either be physical or virtual, due to the clustering capability of OpenStack.

OpenStack has nine major components viz: Horizon, Keystone, Glance, Neutron, Nova, Cinder, Swift, Ceilometer and Heat. Horizon often refer to as dashboard, provides an easy-to-use web interface through which other components of OpenStack can be configured and managed. Glance is the image manager of OpenStack that serve as a registry for pre-built disk images to boot from when launching an instance. This remarkably reduces the time and efforts taken to provision infrastructure services.

At the core of OpenStack is Nova. Nova is the instance manager that administers computing resources, SSH (Secure Shell) key pairs and floating Internet Protocol (IP) addresses essential to launch an instance. Ceilometer is the telemetry component of OpenStack that measured the used resources for proper planning, while heat manages the orchestration of multiple instances launched to work together.

Keystone is the Identity Management component for OpenStack that handle catalogue services, authentication and policy management. Keystone registers tenants and users with associated roles in a central database against which authentication are made when establishing an OpenStack connection. A tenant is a grouping of object where an object can be a user, an instance or a network [6]. A user may be a person, system or service [31]. A role refers to what an object can do within OpenStack environment. In the context of information centre such as Digital libraries, patrons can be categorized into various groups of objects (tenants) with associated roles as a direct reflection of security policies defining rights and privileges of patrons. Networks can also be classified in this manner base on the level of trust accorded to each network in order to disallow malicious traffic. This provides a fine-grained infrastructure layer approach toward mitigating the identified abuse of Digital library technology.

Neutron is the Software-Defined Networking (SDN) management component of OpenStack that support both virtual and physical network operations. A Software-Defined Networking is a design concept that separates the data plane from control plane so that each plane can evolve independently. SDN provides programmable interfaces that permit the modification of behaviour of network forwarding devices at the data plane, employing a central software-based controller, to meet varying organizational needs. Neutron can be projected to proactively filter out traffic from suspected malicious network destinations either private or public – internet, by manually configuring Access Control Lists (ACL's) to deny requests from application layer protocols of concern; or reactively by interfacing high level network application systems such as Intrusion Detection Systems with the programmable interface(s) for automated network security. The flexibility in network security offered by neutron compliments security deliverables offered by keystone toward combating abuse of digital library technology at the infrastructure layer.

Cinder and Swift are storage managers in OpenStack. Cinder handles block storage which provide a virtual storage system that attaches virtual disks directly to an instance. Block storage persists after an instance to which it is attached is terminated. Swift provides an Application Programming Interface (API) based object storage system. In swift, file operations are handled by means of API calls. It is a very simple storage system aimed at storing and retrieving files' contents with minimal overhead to the operating system while interacting with the storage server [6].

OpenStack scale horizontally, and provide high availability of infrastructure services when configured with Pacemaker. Pacemaker has the ability to move services from node to node within a pacemaker cluster; and monitor the nodes to ascertain whether action needs to be taken to recuperate a specific resource or even one of the entire nodes. Horizontal scaling implies adding extra servers as the need arises without necessarily replacing the existing server with larger and more specialised ones [6].

OpenStack is hardware independent; therefore, it can be installed on commodity hardware such as regular personal computers, as well as high computing servers, according to organizational needs. This makes OpenStack suitable in setting up IT infrastructure for information centres of various sizes.

5.3.2. Justification of OpenStack for Infrastructure System Implementation

OpenStack offered a cost-effective, fine-grained infrastructure layer security to combat abuse of Digital library technology, with friendly web-based management tools and reduced time for infrastructure services provisioning. This makes it an ideal system to drive academic library infrastructure.

6. Conclusion

The assumption that Open Source Systems are primitive in addressing varying information technological needs of client organizations are mythical, as they have proved themselves reliable due to age-long evolution of their constituent components through active collaborative efforts of user communities.

In the provisioning of infrastructure services, OpenStack has proven to be a suitable system due to its horizontal scalability, high availability and hardware independence. The Keystone component of OpenStack can be configured for centralized patron management and automated security policy implementation. This provide an effective infrastructure layer approach to mitigating abuse of Digital library technology. This approach is further enhanced by the capabilities of Neutron to proactively or reactively mitigate network based attacks.

The combination of Koha and Dspace for the implementation of Library Automation and Repository Systems respectively, proffers an effective solution toward overcoming the

challenges associated with software licensing, ownership and cost in Nigerian academic library. The intrinsic capability of Dspace to discover metadata about resources from numerous repositories over the internet, while presenting such resources for direct use of library users via a single point of access; offers a practical solution to the problem of insufficient electronic resources in Nigerian academic libraries.

This study recommend the organization of awareness programs by relevant government agencies and stakeholders to sensitize librarians and decision makers in Nigerian academic libraries on the significance of Open Source Systems toward improving the quality of Digital library services.

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