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Use of Cloud Computing Prototypes and Facilities for Library Operations in Federal University Libraries in Nigeria

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Abstract

This study examined the use of cloud computing prototypes and facilities for library operations in federal university libraries in Nigeria. Specifically, the study sought to determine the types of cloud computing prototypes applied in federal university libraries in Nigeria; and identify the types of cloud-based services subscribed to by the libraries. The study adopted a survey research design. The population comprised 2,900 librarians from 43 federal university libraries in Nigeria, while a sample of 360 respondents, consisting of 354 librarians and 6 heads of ICT units, was selected. Data were collected using a structured questionnaire and analysed using frequency counts, percentages, mean and standard deviation with Statistical Package for the Social Sciences (SPSS) version 25. The findings revealed that the libraries applied Public and Private Cloud Computing models, as well as Infrastructure as a Service (IaaS), Software as a Service (SaaS), Platform as a Service (PaaS), and Hosting as a Service (HaaS). Community and Hybrid Cloud models were not applied. The study further found widespread utilisation of GSM, Facebook, WhatsApp, Telegram, Instagram, Twitter, Gmail, Yahoo Mail, Hotmail and Google Docs, while selected libraries adopted C-band, Ka-band, Ku-band and fibre-optic connectivity. The study concluded that cloud computing is increasingly supporting communication, collaboration, information access and library service delivery in federal university libraries. It recommends increased investment in cloud infrastructure, reliable internet connectivity, cybersecurity and continuous ICT training for librarians, alongside greater integration of cloud-based resources to support remote and user-centred library services.

Keywords: Cloud-Based Services, Cloud Computing, Federal University Libraries, Information and Communication Technology (ICT), Library Service Delivery.

Introduction

Cloud computing has emerged as an important technological development that provides flexible, scalable, and cost-effective access to computing resources and services over the internet. In university libraries, cloud computing models and services can support various operations, including information storage, resource sharing, library automation, digital collections, and access to electronic resources. Federal university libraries in Nigeria are increasingly exploring these technologies to improve service delivery, enhance efficiency, and meet the changing information needs of students, researchers, and academic staff. Therefore, examining the use of cloud computing models and services for library operations is important for understanding their adoption, applications, benefits, and challenges within federal university libraries in Nigeria.

Cloud computing is not an entirely new technological concept; rather, it represents a new approach to computing in which computing resources and services are delivered through the internet. It involves the integration of servers, networks, applications, storage facilities, and other computing resources within a shared virtual environment commonly referred to as the "cloud." According to Okwoli (2016), cloud computing provides users with access to computing resources and services through network-based platforms without requiring such resources to be

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physically installed or maintained on individual computers. This approach has increasingly transformed the way information resources and technological services are provided and managed in libraries.

Cloud computing can be broadly classified into different service and deployment models. The major deployment models include public, private, community, and hybrid clouds. The public cloud provides services to users through infrastructure owned and managed by external service providers, while a private cloud is designed for the exclusive use of a particular organization. A community cloud serves organizations with similar interests or requirements, whereas a hybrid cloud combines two or more cloud environments to provide greater flexibility and resource sharing (Okwoli, 2019).

In the library environment, cloud computing has become increasingly relevant because libraries have traditionally relied on network-based services for accessing and sharing information resources. Online databases, union catalogues, institutional repositories, electronic mail services, and web-based library management systems are examples of services that demonstrate the application of cloud-based technologies in library operations. Okwoli (2020) noted that the adoption of cloud computing can enhance library services by improving accessibility, resource sharing, collaboration, storage, and the management of electronic information resources.

Cloud computing services are generally categorized into three major models: Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Software as a Service (SaaS) enables libraries to access software applications provided by a cloud service provider through the internet, usually with a web browser. This model reduces the need for libraries to install, update, and maintain software applications locally. Examples of services that can be accessed through this model include web-based email, online databases, social media platforms, and other hosted library applications (Okwoli, 2016).

Platform as a Service (PaaS) provides libraries and other organizations with a cloud-based platform on which they can develop, deploy, and manage their own applications. The service provider manages the underlying infrastructure, while the library or institution can configure and customize applications according to its specific requirements. In the library context, PaaS can support the development of library portals, institutional applications, digital library systems, and other web-based information services (Okwoli, 2019).

Infrastructure as a Service (IaaS) provides access to fundamental computing resources such as virtual servers, storage, networks, processing capacity, and other infrastructure through the internet. Under this model, the cloud service provider is responsible for maintaining the physical infrastructure, while the library uses the computing resources according to its requirements. IaaS can therefore support services such as data storage, institutional repositories, file servers, network infrastructure, virtual servers, and data-centre facilities (Okwoli, 2020).

Cloud computing provides libraries with opportunities to improve the delivery of information services, facilitate resource sharing, reduce some of the costs associated with maintaining local computing infrastructure, and provide users with convenient access to electronic resources. Its application in libraries therefore represents an important development in the provision and management of modern information services.

Statement of the Problem

Despite the growing adoption of cloud computing in academic libraries, university libraries continue to face challenges in selecting, implementing, and managing appropriate cloud computing deployment models, including public, private, community, and hybrid clouds. Security and privacy concerns remain major barriers, particularly regarding data confidentiality, integrity, unauthorized access, cyber-attacks, data breaches, and institutional control over information resources.

In Nigeria, inadequate technological infrastructure further constrains effective cloud computing adoption. Challenges such as poor internet connectivity, limited bandwidth, unreliable electricity, inadequate hardware and networking facilities, shortage of skilled ICT personnel, and insufficient institutional support may limit libraries' capacity to implement and manage cloud-based services effectively. Although cloud computing offers significant opportunities for improving library and information services through enhanced access to electronic resources, resource sharing, collaboration, digital storage, and remote service delivery, the availability of the technology does not automatically ensure effective utilisation. Factors such as users' awareness, technological competence, service reliability, accessibility, and security may influence the effectiveness of cloud-based library services.

The problem, therefore, is that some federal university libraries in Nigeria may lack sufficient knowledge, infrastructure, technical expertise, and institutional support to determine and effectively utilise appropriate cloud computing deployment models. This situation may limit the accessibility, reliability, and utilisation of electronic information resources. Consequently, there is a need to examine the adoption, utilisation, challenges, and effectiveness of cloud computing deployment models in federal university libraries in Nigeria, with a view to identifying strategies for improving cloud-based library and information services. It is against this background that the study seeks to identify the use of cloud computing prototypes and facilities for library operations in federal university libraries in Nigeria.

Objectives of the Study

1. determine the types of cloud computing prototypes applied in federal university libraries, Nigeria.
2. identify the types of cloud-based facilities subscribed to in federal university libraries, Nigeria.

Research Questions

The following research questions were formulated in pursuance of the study:

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1. What are the types of cloud computing prototypes applied in federal university libraries in Nigeria?
2. What are the types of cloud-based facilities subscribed to in federal university libraries in Nigeria?

Literature Review

Types of Cloud Computing Facilities Useful in Libraries

Cloud computing has created new opportunities for libraries to improve the delivery, accessibility, storage, and management of information resources and services. By utilizing cloud-based technologies, libraries can reduce dependence on locally hosted computing infrastructure while gaining access to scalable computing resources, applications, storage, and network services. Cloud computing can also support collaboration, resource sharing, remote access, and the delivery of library services to users irrespective of their physical location. Recent studies indicate that cloud computing is increasingly relevant to library operations and information service delivery, particularly in university libraries (Kong, 2020, Kumar, 2021, Okwoli, et al, 2020).

Cloud computing services are generally categorized into three principal service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). These models differ according to the level of computing resources and management responsibilities provided by the cloud service provider and the extent of control retained by the library or other user organization (Kumar, 2021; Hu et al., 2020).

Infrastructure as a Service (IaaS):

IaaS provides libraries with fundamental computing resources such as virtual servers, storage, processing capacity, and network resources through the internet. Under this model, the cloud provider owns and maintains the underlying physical infrastructure, while the library can provision and manage resources such as operating systems, applications, and storage according to its requirements. IaaS therefore enables libraries to obtain computing capacity without necessarily purchasing and maintaining extensive physical hardware. This can be useful for institutional repositories, digital library platforms, database hosting, storage of electronic resources, and other applications that require scalable computing infrastructure. NIST explains that IaaS allows users to provision processing, storage, networks, and other fundamental computing resources while the provider remains responsible for the underlying cloud infrastructure (Hu et al., 2020).

Platform as a Service (PaaS):

PaaS provides a cloud-based environment through which libraries and other organizations can develop, deploy, and manage applications without having to manage the underlying physical servers, operating systems, and networking infrastructure. The model is particularly useful where libraries need to develop or customize applications for specific information-service requirements. PaaS can support the development and deployment of library portals, digital library applications, institutional repositories, and other web-based information systems. Evidence from federal university libraries in South-East and South-South Nigeria indicates that PaaS applications such as FOLIO, Alma/Ex Libris, OCLC, Polaris, ProQuest, and EBSCO are being utilized in library and information service delivery (Awa, et al, 2022).

Software as a Service (SaaS):

SaaS provides users with ready-to-use software applications through the internet, usually through a web browser. In this model, the cloud provider is responsible for managing the application, operating system, servers, storage, and other underlying infrastructure, while the library accesses the application as a service. This reduces the need for libraries to install and maintain software locally and can facilitate continuous software updates and remote access. SaaS can therefore be applied to library management systems, electronic resource platforms, institutional repositories, discovery services, online databases, email services, and other web-based library applications. According to Hu et al. (2020), SaaS requires appropriate management of access to applications and associated cloud resources, making issues such as authentication, authorization, and access control important considerations for libraries adopting cloud-based applications. NIST Computer Security Resource Center

Function as a Service (FaaS):

FaaS is an increasingly important cloud-based computing approach associated with serverless computing. It enables organizations to execute individual functions or pieces of application code without having to manage the underlying servers and infrastructure directly. In a library environment, FaaS can potentially support specific automated functions such as processing metadata, sending notifications, transforming digital files, processing user requests, or integrating different library applications. Unlike IaaS, PaaS, and SaaS, however, FaaS is better regarded as a specialized cloud computing approach rather than one of the three principal service models established in the NIST cloud computing framework.

Hosting as a Service (HaaS):

Hosting services can also be relevant to libraries where software applications, databases, digital collections, or library management systems are hosted on remote infrastructure and accessed through the internet. Such arrangements can reduce the need for libraries to maintain local servers and can transfer some infrastructure maintenance responsibilities to the service provider. However, HaaS should be distinguished from the three standard cloud service models because it is not classified by NIST as one of the principal service models of cloud computing. The specific characteristics of a hosted service should therefore be examined to determine whether it falls within IaaS, PaaS, SaaS, or another cloud-based service arrangement.

The application of these cloud computing services has important implications for university libraries in Nigeria. Recent evidence shows that PaaS-based applications are already being used to support information service delivery in federal university libraries, while studies of Nigerian university libraries have also identified issues relating to awareness, adoption, institutional readiness, staff capacity, and other factors that can affect the effective deployment

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of cloud technologies (Awa et al., 2022; Idahosa & Eireyi-Edewede, 2023; Alabi, Omekwu, & Martins, 2024). Consequently, the adoption of cloud computing services in university libraries should not be viewed solely in terms of technological availability. Consideration should also be given to the specific information services required, the technological infrastructure available, the skills of library personnel, security and access-control requirements, institutional policies, and the capacity of the library to manage relationships with cloud service providers. These factors are important in determining how effectively IaaS, PaaS, SaaS, and other cloud-based approaches can contribute to the delivery and accessibility of library and information resources.

On Premises as a service (OaaS):

On Premises as a Service (OaaS) is a software require a library purchase a license or a copy of the software to use, it is generally greater protection. It allows libraries to pay on an as needed basis and effectively scale up or down depending on overall usage. Various services are provided through cloud computing and each service is significantly independent and connected to other services in a more virtually inclusive manner. The services are based on applications, data, runtime, middleware, operating system, virtualization, servers, storage, and networking (Okwoli, 2016). Similarly, he also described service cloud model as a system that promotes availability of resources and creates powerful distributed computing system with global reach and super computing capabilities. Other service models that are available for anybody to subscribe to such as computing as a service (CaaS), data as a service (DaaS), network as a service (NaaS) and human as a service (HuaaS). In the same view, Hu et al (2020) reports that they are nine (12) public cloud computing service models that can be benefited from. According to him, they are: Infrastructure as a service (IaaS), Platform as a service (PaaS), Software as a service (SaaS), Storage as a service (STaaS), Security as a service (SECaaS), Data as a service (DaaS), Database as a service (DBaaS), Test environment as a service (TEaaS), Desktop virtualization, API as a service (APIaaS), Backend as a service (BaaS), Infrastructure as a Service (IaaS), Education as a Service(EDaaS). Cloud computing services are based on the facts that every single service session can be distinctively provided on the network once connection is established. As explained by Okwoli (2019) cloud computing resources are available immediately as soon as the agreement with the service provider is executed. Under the utility model of service provision, users are charged only for what they use, for the memory, CPU, data transfer, I/O requests, storage space and so on. Usually, cloud services are based on the internet which are accessed, transported and used over the internet in user`s web browsers.

Cloud deployment prototypes

Mell & Grance (2017) in the NIST Definition of Cloud Computing define four deployment models for cloud computing: Private, Community, Public and Hybrid.

Public cloud: Public cloud is meant for general public use and open to all. This kind of deployment model of cloud computing is developed by any cloud computing agency and having own policy, value, and profit, costing, and charging model. Some popular public cloud services include Amazon EC2, S3, Google App Engine and Force.com. Okwoli, (2022) reported that public clouds (or external clouds) describe cloud computing in the traditional mainstream sense, where by resources are dynamically provisioned on a fine-grained, self-service basis over the Internet, via web applications or web services, from an off-site, third-party provider who shares resources and bills on a fine-grained, utility- computing basis". Public cloud is for general public use: individuals or libraries.

Private cloud: This kind of deployment model solely developed and managed by a single library or a third party regardless whether it is located in premise or off premise. There are several reasons behind the development of private cloud for library some key reasons include optimize utilization of existing in-house resources, security concerns including data privacy and trust also make private cloud an option for many firms, data transfer cost from local IT infrastructure to a public cloud is still rather considerable, library's always require full control over mission- critical activities that reside behind their firewalls and for research and teaching purposes.

Community cloud: shared cloud infrastructure among libraries is a community cloud, it can be managed by one or several libraries, or by a third party and housed on or off premises. Users may connect over a shared private network or over the Internet using a Virtual Private Network (VPN). The most famous social networking services viz. Twitter and Facebook which play a key role in building community cloud.

Hybrid cloud: Hybrid cloud combines internal and external clouds (public, private, and/or community). NIST (2018) defines a hybrid cloud as 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 cloud bursting for load balancing between clouds). Libraries use private cloud (local data center) to keep critical or sensitive information in-house. Libraries are shifting their services with the attachment of cloud and networking with the facilities to access these services anywhere and anytime.

Types of cloud based databases subscribed to by libraries.

Cloud computing has large potential for libraries. Libraries may put more and more content into the loud. Using cloud computing user would be able to browse a physical shelf of books, CDs or DVDs or choose to take out an item or scan a bar code into his mobile device. More frequent online catalogues are linked to consortium that share resources. However, with faster retrieval times for user's requests and local server space it could improve storage solutions for libraries. Online databases are more focused on scholarly books and articles, and provide more quick access to online databases and union catalogue. Online databases platform facilitates the discovery and sharing of scholarly content. Kaushik and Kumar (2017) cited Knimbus as a knowledge cloud which is dedicated to knowledge discovery and collaborative space for

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researchers and scholars. The following online databases are subscribe to or applied to:

Worldcat:
World cat another type of digital resources in the cloud, another example of cloud computing architecture drawing on the union catalogue infrastructure they have built up over the years. Missions of library are now being fulfilled and manifested by the presence of cloud-based solutions due to its support and facilitation of online electronic resources and services provision. Ultimately, cloud computing in libraries is demonstrated by the Online Computer Library Center WorldCat, which has been around for generations (Okwoli, 2016), where it is indicated that cloud computing is already playing a very large role for research libraries.

Library thing:
Library Thing is one of the sites that combine aspects of social networking and cloud computing originated by Tim Spalding. Library Thing offers services which are just like social networking site, authorizes people to contribute information and suggestion about books and allows them to interconnect globally to share interest.

Reed Elsevier:
Reed Elsevier is a service provider for scientific information working with hospitals to provide point in time information to medical technicians as they need the information.

Amazon and Google:
These are among the leading enterprises also providing solutions for libraries by having partnership between library automation vendors (Hu et al, 2020).

Kindle and mobile me services:
Kindle and Mobile Me services is an electronic book arena Amazon is providing some reading services with “Kindle”. If one has wireless connection, can purchase and read a rapidly growing list of books and periodicals from the Kindle, no matter for the location. With this service largest text can be downloaded in seconds. Another like service is “Mobile Me” provided by Apple computing.

SeerSuite:
Awa, et al (2022) explained that SeerSuite was developed as a result of extensive research and development with the goal of enabling efficient dissemination of scientific information and literature. SeerSuite refers to a collection of open source tools that provide the underlying application software for creating academic search engines and digital libraries such as CiteSeerX, to mention but a few.

DuraCloud-Duraspace:
A hosted service and open technology that help on line databases and end users to effectively utilize public cloud services. Built upon existing cloud services. It is providing cloud solution for digital library services. DuraCloud is a sister concern of Duraspace which is a collaboration of the DSpace Digital Library Software and Fedora Commons. Fedora Commons is a framework for digital repository, which offers complete solution for digital library with standard software and hardware solution. DuraCloud also provides open source code and the code needs to be installed on your machine.

Ex libris:
Ex Libris is built on various standard and contains number of features like compatibility with Unicode font, flexibility, migration of data, customization and so on. It is a well-known cloud service provider based in USA. It is providing cloud solution in the field of library with all the software and hardware support needed to provide services to the users. Ex-Libris is available for all type of libraries and for consortia.

Polaris library system:
Polaris library system is one of the cloud based library automation system available in the market. The company also provides standard acquisition and processing system. Also, with a Polaris ILS Client License, the library can integrate various PC and print management systems at no extra cost. The systems use number of well-known standards like MARC 21 for bibliographic data, XML, Z39.50 for information retrieval, Unicode etc. Thus, the libraries, especially small one may utilize cloud computing facility. Online informational services such as NCLive which provides ebooks, audiobooks, computer based training (CBT), journals and newspapers, information, and database searching can be better utilized through cloud computing (Okwoli, 2019).

Hinari:
Some of the on line databases are similar to those provided in physical libraries, but many are quite different. In part this is because the development of digital libraries (DLs) has historically been strongly influenced by the field of computer science Hu et al (2020) point out that the approaches to services taken by the fields of computer science and library and information science (LIS) differ considerably.

Methodology

The study adopted a survey research design. Survey research is appropriate for systematically collecting information from a defined population and describing existing conditions, practices, attitudes, relationships and trends. According to Mugenda and Mugenda (2019), survey research design is concerned with determining the what, how and why of existing relationships, attitudes, practices, processes, conditions and trends. The adoption of this design was considered appropriate because the study sought to examine the provision of library services to open and distance learners in federal university libraries in Nigeria.

The population of the study comprised 2,900 librarians drawn from 43 federal university libraries in Nigeria. From this population, a sample of 354 librarians and 6 heads of ICT units, giving a total sample size of 360 respondents, was selected for the study. The sample was determined based on the number of librarians and heads of ICT units available in the university libraries covered by the study.

A structured questionnaire served as the principal instrument for data collection. The questionnaire was designed to obtain relevant

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information from the respondents on the provision, accessibility and utilisation of library services for open and distance learners, as well as the technological and institutional factors influencing service delivery.

For data analysis, the responses obtained were coded and analysed using the Statistical Package for the Social Sciences (SPSS), version 25. Descriptive statistical techniques, including frequency counts, simple percentages, mean and standard deviation, were employed to summarise and interpret the data. The use of these statistical measures enabled the researcher to present the characteristics of the respondents and the study variables in a clear and systematic manner. Details in Table 1

Table 1: Sample Population Table:

S/No	Name of Library/ Institution	Head of ICT units	Librarians
1	National Open University of Nigeria Library, Abuja.	1	**13**
2	Kenneth Dikke Library, University of Ibadan.	1	**67**
3	Ramat Library, University of Maiduguri.	1	**49**
4	John Harris Library, University of Benin, Edo State.	1	**51**
5	Nnamdi Azikiwe Library, UNN Nsukka.	1	**24**
6	Kashim Ibrahim Library, A B U Zaria.	1	**156**
	Total	**6**	
	Grand Total	**6 + 354 =360**	

Source: Through visitation and phone calls (November, 2027)

Presentation of the Achieved Objectives

Objective One. Determine the types of cloud computing prototypes applied in federal university libraries, Nigeria

Table 2 shows the responses of ICT heads on cloud computing prototypes applied in their various libraries. Details in table 2:

Table 2: Cloud computing prototypes applied in federal university libraries

SNO	Cloud computing prototypes	Federal University Libraries in Nigeria					
		NOUN	**UI**	**UNN**	**UNIMAID**	**UNIBEN**	**ABU**
	Service Models						
1	Public Cloud computing model	√	√	√	√	√	√
2	Private Cloud computing model	√	√	√	√	√	√
3	Community Cloud computing model	X	X	X	X	X	X
4	Hybrid Cloud computing model	X	X	X	X	X	X
	Deployment Models						
1.	Infrastructures as a Service (IaaS)	√	√	√	√	√	√
2.	Software as a Service (SaaS)	√	√	√	√	√	√
3.	Platform as a Service (PaaS)	√	√	√	√	√	√
4.	Security as a Service (SaaS)	√	X	X	X	X	X
5.	Human as a Service (HuaaS)	X	X	X	X	X	X
6.	Network as a Service (NaaS	√	X	X	√	X	X
7.	Database as a Service (DaaS	√	√	√	X	√	√
8.	Desktop Computer as a Service (DCaaS	X	X	X	X	X	X
9.	Hosting as a Service (HaaS)	√	√	√	√	√	√
10.	Function as a Service (FaaS)	X	X	X	X	X	X

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11.	On-premise as a Service (OaaS	X	X	X	X	X	X
12.	Storage as a Service (SaaS)	√	X	√	X	X	X
13.	Communication as a Service (CaaS)	X	X	X	X	X	X
14.	Monitoring as a Service (MaaS	X	X	X	X	X	X
15.	Anything as a Service (XaaS)	X	X	X	X	X	X

Source: Fieldwork, 2020; **Key: Applied (A), Not Applied (NA)**

Table 2 shows that the federal university libraries under study adopted some cloud computing models, while others were not applied. With respect to service models, all six libraries NOUN, UI, UNN, UNIMAID, UNIBEN and ABU applied both Public Cloud and Private Cloud models, whereas Community Cloud and Hybrid Cloud models were not applied by any of the libraries. For the deployment/service models, Infrastructure as a Service (IaaS), Software as a Service (SaaS), Platform as a Service (PaaS), and Hosting as a Service (HaaS) were applied across all six libraries. Security as a Service was applied only by NOUN, while Network as a Service (NaaS) was applied by NOUN and UNIMAID. Database as a Service (DaaS) was applied by NOUN, UI, UNN, UNIBEN and ABU, but not by UNIMAID. Similarly, Storage as a Service was applied by NOUN, UNN and UNIMAID. However, Human as a Service (HuaaS), Desktop Computer as a Service (DCaaS), Function as a Service (FaaS), On-premise as a Service (OaaS), Communication as a Service (CaaS), Monitoring as a Service (MaaS), and Anything as a Service (XaaS) were not applied by any of the six libraries. Overall, the findings indicate that cloud adoption was concentrated on basic and commonly available cloud services, particularly public/private cloud, IaaS, SaaS, PaaS and HaaS, while more specialised cloud models remained largely unexplored.

Objective Two. Identify the Types of Cloud-based Facilities subscribed to in Federal University Libraries, Nigeria

Table 3: The respondents were requested to indicate the cloud based facilities subscribed to in their libraries and their response were summarized in Table 3:

Table 3: Cloud-based facility subscribed to in federal university libraries

S/No	Cloud Computing Facility/Resource	**Federal University Libraries in Nigeria**					
		NOUN	UI	UNN	UNIMAID	UNIBEN	**ABU**
1)	*Internet Service*						
2)	C-band	√	X	X	X	X	**X**
3)	Ka-band	X	x	X	X	√	**X**
4)	Ku-band	X	x	√	X	X	**X**
5)	Global System for Mobile Communication (GSM)	√	√	√	√	√	√
6)	Fibre-Optic	X	X	√	X	X	√
	Social Media						
7) `	Facebook	√	√	√	√	√	√
8)	Whatsapp	√	√	√	√	√	√
9)	Telegram	√	√	√	√	√	√
10)	Instagram	√	√	√	√	√	√
11)	Twitter	√	√	√	√	√	√
	Messenger Apps (Emails)						
12)	Google mail (gmail)	√	√	√	√	√	√
13)	Yahoo mail	√	√	√	√	√	√
14)	Hotmail	√	√	√	√	√	√
	Word-Processing						

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15)	Microsoft Word Online	X	X	X	X	X	**X**
16)	Google Docs	√	√	√	√	√	√
17)	Zoho Writer	X	X	X	X	X	**X**

Source: Fieldwork, 2026; **Key:** Subscribed **(S),** Not Subscribed **(NS)**

Table 3 presents the cloud-based facilities subscribed to by the selected federal university libraries in Nigeria. The findings show that Global System for Mobile Communication (GSM) was subscribed to by all six libraries (NOUN, UI, UNN, UNIMAID, UNIBEN and ABU), while C-band was subscribed to only by NOUN, Ka-band only by UNIBEN, Ku-band only by UNN, and Fibre-Optic by UNN and ABU. With respect to social media services, all six university libraries subscribed to or utilised Facebook, WhatsApp, Telegram, Instagram and Twitter, indicating widespread adoption of social-media platforms for library communication and service delivery. Similarly, all the libraries subscribed to the three identified email/messaging services, namely Gmail, Yahoo Mail and Hotmail. Regarding cloud-based word-processing services, Google Docs was subscribed to by all six libraries, whereas Microsoft Word Online and Zoho Writer were not subscribed to by any of the libraries. Overall, the findings indicate that the university libraries had adopted a range of cloud-based services, with particularly widespread use of GSM, social-media platforms, email services and Google Docs, while specialised internet connectivity options and some online word-processing applications had limited or no adoption.

Findings and Discussions

The findings on the first research question revealed that federal university libraries in Nigeria have adopted selected cloud computing prototypes to enhance library operations and service delivery. As shown in Table 2, all the libraries studied applied Public Cloud and Private Cloud Computing prototypes, as well as Infrastructure as a Service (IaaS), Software as a Service (SaaS), Platform as a Service (PaaS), and Hosting as a Service (HaaS). This finding is consistent with Okwoli (2016), who identified SaaS, IaaS and PaaS as important cloud computing models through which organisations can access computing resources and software services. The adoption of these prototypes enables university libraries to reduce dependence on locally maintained infrastructure, improve access to electronic resources and support more flexible and efficient service delivery. It also creates opportunities for the deployment of cloud-enabled library resources and systems such as ProQuest, EBSCOhost, WorldCat, DSpace and Ex Libris, thereby transforming the library into a more networked and remotely accessible information environment.

The findings on the second research question further revealed that federal university libraries subscribed to and utilised a range of cloud-based facilities, including internet connectivity, social-media platforms, electronic mail and online productivity applications. All the libraries utilised GSM, Facebook, WhatsApp, Telegram, Instagram, Twitter, Gmail, Yahoo Mail, Hotmail and Google Docs, while selected institutions used C-band, Ka-band, Ku-band and fibre-optic connectivity. The finding agrees with Hu et al (2020), who noted that online services facilitate information dissemination, professional interaction, knowledge sharing and information transfer. The widespread adoption of these services indicates that cloud technologies have become important tools for communication, collaboration and information delivery in Nigerian university libraries. Their effective utilisation can improve librarians' work routines, expand access to information resources and enable more responsive services to users. Thus, cloud computing represents not merely a technological innovation but an important mechanism for transforming academic libraries into accessible, collaborative, efficient and user-centred information environments.

Conclusion

The findings indicate that federal university libraries in Nigeria have adopted a range of cloud computing facility prototypes, particularly the Public Cloud and Private Cloud models. The libraries also utilised major cloud computing service models, including Infrastructure as a Service (IaaS), Software as a Service (SaaS), and Platform as a Service (PaaS), to support library operations and enhance service delivery. Furthermore, the findings revealed that the libraries subscribed to and utilised various cloud-based online databases, including ScienceDirect (Elsevier), ProQuest, and the Directory of Open Access Journals (DOAJ), among others. In addition, cloud-based library automation applications such as the Koha Online Catalogue, as well as online cataloguing standards and formats, including the Online Computer Library Center (OCLC) and Machine-Readable Cataloguing (MARC21), were utilised. These findings demonstrate the growing adoption of cloud technologies by federal university libraries in Nigeria to facilitate resource discovery, information access, library automation and more efficient delivery of services to users.

Recommendations

1. **Federal university libraries in Nigeria should strengthen and expand their adoption of cloud computing technologies.** Library management should invest in appropriate cloud prototypes and services, particularly IaaS, SaaS and PaaS, as well as cloud-based databases, library automation systems and digital information platforms. This should be accompanied by adequate funding, reliable internet connectivity, electricity supply, cybersecurity measures and regular training of librarians to ensure effective utilisation of these technologies.

2. **Federal university libraries should promote wider integration of cloud-based facilities for remote and user-centred library service delivery.** Libraries should integrate platforms such as Koha, ScienceDirect,

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ProQuest, DOAJ and other relevant electronic resources into a unified digital library environment that allows users to access information resources and library services remotely. Librarians should also receive continuous ICT and digital-literacy training to enable them to provide effective support and maximise the benefits of cloud computing for teaching, learning and research.

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