Use of Cloud Computing Technologies for Library Services Delivery: A Survey of Librarians in University Libraries in Africa

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Article Info	ABSTRACT
	Objective: The aim of the study was to investigate the use of cloud computing technologies for library services delivery by librarians in university libraries in Africa. **Methods**: Online survey method was adopted to collect qualitative data from 315 librarians working in 67 university libraries in English speaking countries in Africa. **Results**: The study found that YouTube, Google Drive, OPAC, Google Form, Gmail, and Google Scholar are the most mentioned Cloud Computing (CC) technologies used by the librarians in university libraries in Africa. The study also revealed that the librarians use CC technologies to store and share files, for sharing videos related to library orientations/other video contents, to collaborate with other librarians for research projects, to survey users' level of satisfaction with library services, online document editing services, and provision of virtual/online reference services. The majority of the librarians mentioned lack of fund, no security and privacy of data, irregular staff training and development, and lack of CC knowledge and awareness as challenges associated with adoption of CC technologies in universities in Africa. Solutions to security of data threats in the cloud environment are offered in the study. **Conclusion**: The findings will contribute by aiding the providers and potential adopters to devise context specific strategies for the penetration of cloud services and sound adoption decisions (ADs), respectively. Findings of the study will provide a better understanding and application of CC to advance the provision of library services to users of academic libraries in the African continent.

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Introduction

One of the prominent information and communication technologies that are currently supporting and improving library services and functions is cloud computing (CC). Badwai and Kayed (2015 p.136) support this by maintaining that "information and communication technology (ICT) development has brought a dramatic change in every sector and libraries are not an exception to it". Libraries adopt CC to advance library services such as making use of CC to allow patrons to have remote access to the library collection.

Cloud computing can be defined as a technology that relies on the transfer of processing and storage space of a computer to the so-called cloud that is accessed via the internet (Elshite, 2013). In cloud computing environment, processes and applications run in the cloud and does not require processing power or hard disk space like the traditional desktop software (Elshite, 2013). Cloud computing has emerged as a big benefit for libraries, giving libraries multiple ways to link their resources to cloud computing (Mahajan & Gulati, 2017). Cloud computing offers an application service framework that can integrate all libraries' digital information resources and process distributed digital resources, information integration, and reconfiguration to better meet user library services needs where the digital book services have become an academic hub for disseminating and processing modern human knowledge (Lijuan, 2020). Cloud computing is the result of advancements in various technologies, including the Internet, hardware, systems management and distributed computing (Buyya et al., 2011).

Presently, academic libraries are using new and emerging technologies such as cloud computing, social media, and others to expand services. Most of academic libraries are using cloud computing to enhance services thereby adding more value to their services and making it attractive to the users and focusing on maximizing the effectiveness of shared resources for libraries to deliver (Mishra, 2016; Mate, 2016). Cloud computing is a combination of computer and internet usage that can build a consolidated data with many libraries. With cloud computing, the delivery of different library services through the internet becomes a possibility (Mate, 2016). Cloud computing offers many interesting possibilities for libraries that may help to reduce technology costs and increase capacity reliability and performance for some type of automation activities. It has large potential for libraries as it enables them to put more content into the cloud (Neethu & Vanaja, 2017). Cloud computing provides higher learning institutions with the opportunity to utilize external providers and on demand services that are highly scalable (Armbrust et al., 2009) and accessible via internet. The attributes promoted in cloud computing are optimal resource utilization, elasticity, pay per use and multi-tenancy among many other attributes (Agarwal & Agarwal, 2011).

Cloud storage is the library's latest technology, where the end-user can conveniently access the library at remote locations. In cloud computing, the storage capacity can be adjusted according to the needs of the library, since the storage is controlled by the service provider. It is on this note that many academic libraries are now struggling to adopt cloud computing. However, using or implementing this technology makes library face too many issues like security, data privacy. Cloud computing helps LIS professionals build an ecosystem to make library services convenient for their users (Muhammad, 2019). Srinivas (2017) reported that we need to adopt cloud computing due to knowledge explosion, difficulties accessing information, saving user and staff time, resource sharing and resource management issues, and cost-effectiveness.

Studies have found that readiness for cloud adoption is low in developing countries despite its benefits and solution to challenges such as electricity consumption, capital investment and network provision, and so on (de Bruin & Floridi, 2016; Arkorful, 2019). Considering the lack of financial resources and budget weakness, there is an increasing need to take advantage of cloud computing applications in the field of libraries to improve services. Even though, there might be a number of libraries using cloud computing, only few studies have been conducted on cloud adoption in university libraries in Africa. It is with this backdrop that this study seeks to gain an in-depth insight into how librarians in university libraries in Africa adopt cloud technologies. To achieve this, the study will be guided by the following research questions.

Research Questions

RQ1: What type of cloud computing technologies are being used by the librarians in Africa?

RQ2: What is the level of the librarians' computer literacy skills to use CC technologies?

RQ3: What is the purpose librarians in Africa use cloud computing technologies?

RQ4: What are the challenges librarians in Africa experience in adopting cloud computing technologies?

Literature Review

Adoption of cloud computing technologies by librarians in libraries

Now cloud storage has become one of the most convenient and efficient methods to store data online. In cloud storing, the user, rather than saving the data at local storage or hard disk, stores data somewhere at the remote location, which can be accessed using internet service (Sharma et al., 2021). There are various cloud storage service providers who sell storage services for different ranges. Njoku and Ken-Agbiriogu (2021) investigated awareness and use of cloud computing; its implications by libraries in selected academic libraries in Imo State, Nigeria. The study revealed that there is certain level of awareness on cloud computing technologies and

models in the libraries studied. It was also discovered that cloud computing technology were used by libraries in the institutions studied, and economy of resource cost effectiveness and file sharing are some of the major positive implications of librarians' adoption cloud computing technologies. However, security and privacy, multiple taxation were also identified as major negative implications of cloud computing adoption by the librarians in discharging their functions in the libraries. Arkorful (2019) also studied cloud computing adoption in public and private universities in Sub-Saharan Africa and reported that despite the potential benefits that are associated with cloud computing which includes reduction of total costs of acquisition or ownership of hardware, software and skilled resources, the adoption level of cloud services is still very low in higher institutions of learning in Africa due to security issues, especially trust issues which remain a major concern over cloud solutions.

An exploratory study by Noa (2015) focused on factors influencing the application of CC by librarians. The study found that the behavioural goal to adopt CC was impacted by personal innovativeness and perceived ease of use. Similarly, Amponsah et al. (2016) determined factors influencing CC adoption in a developing country of Ghana. The findings discover that habit, facilitating condition, price value and performance expectancy were positive significant factors influencing the implementation of CC in Ghana. Yaseen, et al (2022) assessed the factors that influence cloud computing adoption among small and medium- sized businesses (SMEs) in Jordan. The results indicate that seven factors significantly affect cloud computing adoption among SMEs. Among these factors, cost reduction was found to be the strongest predictor, while the weakest predictor was firm size. The study by Sharma et al. (2021) highlighted security risks, cost, relative advantage (RA), complexity, compatibility, competitive pressure and top management support as the most discussed factors on cloud computing adoption literature globally. Sharma et al. (2021)'s study further revealed that benefits such as scalability, virtualization and other perceived benefits act as primary motivators towards adoption in developing nations.

Yuvarej (2013) enlisted some benefits of cloud computing to librarians which include high computing power, location and device independency, high scalability, less maintenance, less indulgence, unlimited storage capacity, diverse support, faster deployment, etc. With cloud computing optimization of resources and services are ensured in libraries (Yuvarej, 2013). These benefits have positive implication to library services and growths. Idhalama and Fidelis, (2020) investigated the perception and attitude of librarians towards cloud computing in the University of Dar es Salaam library and found that librarians at the University of Dar es Salaam are aware of cloud computing technologies; they have positive perception about it. Tella. Ukwoma and Kayode (2020) examined through the modification of two models the factors that determine cloud computing adoption for web-based services in academic libraries in Nigeria. The findings

revealed correlations among facilitating condition, perceived benefits, user-friendliness, and perceived ease of use, perceived security, ease of maintenance, perceived flexibility, perceived reliability, and increased performance/productivity and adoption of cloud computing for web-based services. Perceived security and reliability were reported to exert the most significant influence on adoption.

A survey conducted in 2014 to evaluate ICT usage in European union households revealed that 21% of the population aged between 16-74 have used CC technologies to store personal documents, photos, videos, and audio files, where more than 80% of this usage is utilized for photos saving and sharing. Additionally, over a quarter of the users were sharing and storing their personal information but unaware that they are using CC technologies (Seybert & Reinecke, 2014). Bhardwaj (2018) points out that libraries will revive and sustain their importance by integrating cloud computing technologies, which will make them part of the Internet of Things (IoT) experience that will soon rule every educational sector's activities. Yuvaraj (2013) explored the librarians' curiosity in CC adoption within libraries of Indian Central Universities and identified applications and services of CC applied for library services and discloses that libraries deeply depend on CC applications which include PaaS such as google applications to improve the quality of library services. Different studies have shown the SaaS model heavily used in libraries. Tritt and Kendrick (2014) conducted an exploratory study to assess the use of CC tools by librarians. The results indicate high use of SaaS tools that include cloud file sharing and storage such as Gmail and google drive. SaaS tools that can be accessed via web browser interface for daily duties include Google Drive, Microsoft OneDrive, and Dropbox for storage and features that include synchronized data, and backup copying of files in cloud-based storage. For instance, Hoy (2012) asserts that many library patrons are already using cloud products such as Gmail, Google Docs and bibliographic management tools for their daily needs.

Library services that can be rendered using cloud computing technologies

The use of CC in libraries requires ICT infrastructures that include network facilities, software and hardware such as remote servers virtualized on the cloud to allow access for a variety of services. Dar and Ravindran (2018) postulate that "CC provides a large number of services in a virtualized manner to reduce the server upgrade and high cost of administration". These ICT infrastructures are grouped into three models, which includes "Infrastructure as a Service (IaaS), Software as a Service (SaaS), and Platform as a Service (PaaS) on computing machines that are remotely accessible through Internet" (Wada, 2018). The study by Swapna and Biradar (2017) reported that libraries are shifting their services to the cloud with the help of networking and other facilities; they are able to access both their existing applications and documents from anywhere and anytime.

According to Luo (2013), virtual reference services and research guides can be provided in libraries through software such as LibChat, QuestionPoint and LibGuides which are all hosted on the cloud. Neethu and Vanaja (2017) explored the concepts amongst the academic libraries on CC and its conditions with libraries. From their exploration, they observe that libraries are shifting towards and taking advantages of cloud-based services more especially in digital libraries. Scale (2010) puts forth his view that cloud computing is currently enabling librarians to shift from the paradigm of ownership and maintenance of resources towards the provision of access to information maintained and controlled by others. However, cloud-based services are not entirely plug and play and libraries using cloud computing services need to worry about local bandwidth, hardware clients (PCs) and software configuration (Prince, 2012). Konganurmath and Shekar (2014) state that "libraries are interested in SaaS services for daily routine work". The old-style library system is now being replaced by developments brought by CC. Several CC services such as Microsoft OneDrive offer space for storing files. CC does not only provide storage but also provide tools to share information and library collection.

Cloud computing offers a variety of services, such as storage and different modes of use (Leavitt, 2009). Most libraries are now using CC to host digital libraries and integrate library systems to create an incorporated presence on the web to provide users with local, national and global remote access (Suman & Singh, 2016). For instance, CC includes applications for online reference services, bibliographic management, and online cataloguing such as Worldcat, as well as digital storage for electronic sources (Mohammed, 2018).

Computing services brought by CC continually transform library services to be more convenient for users and addressing problems faced in libraries, problems such as library system breakdown. According to Sahu (2015), "CC allows libraries to render a variety of ICT services without much of a problem because service providers maintain servers and provide free upgrades and backup". By maintaining both the hardware and software reduces cost for libraries. CC offer real-time information sharing regardless of platforms or devices types, and reduce time and effort of applications and service maintenance and development (Bhattacherjee & Park, 2014; Park & Kim, 2014). CC storage becomes ubiquitous and is obtained consciously from cloud service providers such as Amazon, Google Drive, and Dropbox or even unconsciously from a local software such as Office Online, social networking channels, as well as wearable devices (Griffith, 2016). Kaur (2018) studied cloud computing and its use in libraries and reported that knowledge collection is the prime component in library cloud computing, others are supplying libraries with resource and information technology capabilities, e-resources sharing, database sharing sure as OPAC which offers online cataloging resources when uploaded to cloud.

Libraries worldwide have also started using cloud computing to handle e-resources usage, hosting web applications, cataloging online public access, managing digital libraries, hosting

various statistical tools and data sets, etc (Salam & Ali, 2020). This technology has provided an opportunity for libraries and a fear of data loss and involving massive costs in building infrastructure, leading to highly scalable, service-oriented architecture and many other things. The most remarkable benefit is online repositories and global access to services. Although implementation is bit costly, libraries move slowly towards cloud computing and are undoubtedly viewed in libraries as a boon in the digital age (Tripathi & Pandy, 2019). Cloud computing has the potential to remarkably enhance library staff productivity and can radically re-engineer and regenerate library operations that support the rendering of effective information services (Salam & Ali, 2020).

In the African continent, the uptake of newer technologies such as CC is lagging in most libraries. Adegbilero-Iwari and Hamzat (2017) conclude that in Nigeria and many other African developing countries, attention of librarians has been drawn to an important era of modern computing services. In South Africa, academic libraries as compared to public libraries compete on CC to show their presence on the web. This is because the higher education system has transformed after apartheid, and students are provided with advanced ICT which allow remote access to digital services (Nyahodza & Higgs, 2017).

Challenges associated with adopting cloud computing technologies

Ali (2021) examined cloud computing adoption efficiency and risks in Higher Education Institutions (HEIs) from several perceptions. The analysis emphases on the characteristics of CC service quality, which will add value to HEI stakeholder needs. The findings indicate that trust, protection and privacy are the main factors of non-adoption as stakeholders believe that cloud computing cannot completely ensure the sensitive information protection. Key factors for cloud adoption include strengthening student-teacher interactions through collaboration resources, and proposing cloud applications for mobile devices to access various learning materials virtually and secure off-campus email. According to Bhardwaj (2018) five facilities such as "internet service, thin client architecture, digital librarian, digital resources and wireless access point are considered requirements for cloud computing implementation". Mavodza (2012) reported that librarians in many developing countries are disadvantaged due to encountering connectivity challenges because funding cloud computing platforms or enhancing bandwidth are not always priorities in these regions as there are more immediately urgent problems for funders to deal with, such as hunger.

Arkorful (2019) conducted a study on some selected public and private universities in sub–Saharan Africa to determine the reason for the low cloud adoption by key stakeholders in higher institutions of learning. The study found that loss of control of data, availability, privacy, contractual issues, security, performance, data portability/migration issues, compliance issue,

data leakage/loss, lack of standards and lastly, legal issues are the main barriers to cloud computing adoption in institutions of higher learning. The study therefore recommended that cloud service providers should be transparent with their privacy policies with institutions of higher learning as this can influence cloud purchasing decisions. Secondly, there is the need for training IT personnel and to create awareness of the benefits of cloud computing to enable institutions of higher learning to adopt them to enhance their productivity. On their part, Alsmadi and Prybutok (2018)'s study confirmed that cloud security and privacy concerns does not significantly influence on information sharing and storage behavior. Rather, Peers influence was found a significant determinant of the behavior. The study supports that the CC technology is perceived as able to protect user information.

The study by Sharma et al. (2021) found complexity issues related to adoption of cloud computing as more critical in developing countries, as almost all studies have revealed its significance, indicating that ease of use encourages developing countries to adopt new technology/innovation. According to Wang et al. (2010) the main concerns on cloud adoption are mainly on "safe data management, reliable access control, weak systems monitoring and service availability". Due to this, there is imminent exposure to risks such as theft, leakage of sensitive data and loss of privacy in relation to adoption of cloud computing services (Wang et. al., 2010).

Muhammed et al. (2015) highlight major challenges in adoption of CC which include poor internet service, power supply, fear of hackers and insecurity. The study by Amponsah et al. (2016) determined factors influencing CC adoption in a developing country of Ghana and found that insignificant security, hedonic motivation, effort expectancy and social influence negatively influence CC application in Ghana. Jalamneh and Khder (2021) studied the challenges of implementing cloud computing in the Arab libraries environment and concludes that the main challenges lie in professionalism, training and technical challenges, such as the availability of applications and programs, storage capacity, huge volume of data, privacy and information security.

Abu-Saada (2013) summed up the following as challenges of adopting cloud computing technologies:

  - Security and privacy, since the files and information are stored in the third party, there are concerns about the security of information and privacy. There is no full guarantee not to get attacked by black hackers. For example, the question to ask which need to be considered in terms of security and privacy is, if your data host disappeared where will your data go? Therefore, it is better for the user to rely on the services of the most prestigious international companies, because they are unlikely to go bankrupt or theft.

- Dependency (loss of control): Cloud computing imposes full dependence on service providers for everything that concerns them because the cloud is a programmatically closed environment.

- Lack of flexibility: This service is still unable to provide all the needs of the user and often data loss occurs when updating systems and software for the cloud.

- Knowledge and integration: Using the cloud requires extensive technical knowledge and experience in dealing with software that may not be owned by some.

Sharma et al. (2021) review have revealed some critical technical and institutional challenges (such as standards and procedures in service level agreement (SLA), encryption of data over cloud) hampering the faster adoption of cloud services. Sharma et al. (2021) added that governmental involvement for framing the right policies with the regulatory frameworks is the need of developing nations.

Materials and Methods

The study covered all librarians practicing in university libraries in Africa. An online questionnaire was designed to collect data using open ended questions. The link to the questionnaire on Google form was forwarded to e-mail addresses of librarians working in the various university libraries in Africa. Their e-mail addresses were collected from the various university library websites. In order to raise the response rate, the respondents were reminded twice in an e-mail to respond to the survey in their e-mail box.

One major limitation for the study is the language barrier, as most of the Africa countries are French-speaking countries. The language barrier became a hindrance for the authors to collect data from those countries, for that reason, the study was limited to English-speaking countries only. Second, the researchers observed that many librarians do not check their e-mails regularly to enable them respond to a request to participate in an online survey; some of them do not have stable internet facilities, whereas others are reluctant to respond to an online questionnaire. These reasons lead to a low response rate which makes it difficult to generalize findings.

In total, 556 e-mails with the link to the questionnaire were sent out to librarians working in university libraries in English speaking countries in Africa. Collection for the study started October 2022 and ended December 2022. Out of the number, 315 librarians with response rate of 56.7 per cent in 67 universities in Africa responded to the survey. Full names of the universities and the number of respondents from each university library are given in Table 1.

The qualitative data was analyzed by using content analysis. Data obtained from –the CC technologies used, the purpose of using CC technologies, and challenges associated with adoption of CC technologies were prepared and organized, reviewed and explored, created initial

codes, combined into themes. The obtained themes were categorized according to the specific research questions. The results are presented using tables and charts.

Results

The demographic information of respondents is shown in Table 1.

Table 1. Names of universities and number of respondents that responded

S.N.	Name of university	Country	No. of Respondents
1	University of Nairobi	Kenya	3
2	Strathmore University	Kenya	4
3	Kenyatta university	Kenya	7
4	Dedan Kimathi University of Technology	Kenya	2
5	Bindura University of Science Education, Zimbabwe	Zimbabwe	6
6	National University of Science and Technology, Zimbabwe	Zimbabwe	3
7	University of Botswana	Botswana	7
8	Cairo university	Egypt	8
9	Aswan university	Egypt	4
10	American University in Cairo	Egypt	5
11	National University of Lesotho	Lesotho	7
12	Mbarara University of science and technology	Uganda	3
13	Kyambogo University	Uganda	6
14	Makerere University, Uganda	Uganda	2
15	Central University of Technology Free State Bloemfontein RSA, South Africa	South Africa	11
16	University of Johannesburg	South Africa	9
17	Stellenbosch university	South Africa	6
18	CPUT, South Africa	South Africa	7
19	University of the Free State	South Africa	9
20	Nelson Mandela University	South Africa	10
21	North-west university	South Africa	7
22	University of Witwatersrand	South Africa	6
23	University of Pretoria	South Africa	5
24	University of the Western Cape	South Africa	3
25	University of Johannesburg	South Africa	4
26	University of Kwa Zulu-Natal	South Africa	2
27	University of South Africa	South Africa	5
28	Rhodes University	South Africa	11
29	University of Namibia	Namibia	7
30	Namibia University of Science and Technology	Namibia	9
31	University of Ghana	Ghana	5
32	University of Mine and Technology, Tarkwa	Ghana	1
33	University for development Studies, Ghana	Ghana	2
34	Ashesi university	Ghana	5
35	University of Cape Coast	Ghana	9
36	University of Benin	Nigeria	1
37	Nnamdi Azikiwe University, Awka	Nigeria	3
38	American University of Nigeria, Yola	Nigeria	1
39	Federal University Otuoke	Nigeria	5
40	Federal University of Agriculture, Abeokuta	Nigeria	4

41	Kwara State University, Malete	Nigeria	**7**
42	Rivers State University of Science and Technology, Port Harcourt	**Nigeria**	**4**
43	Westley University, Ondo	Nigeria	**3**
44	Obafemi Awolowo University, Ile-ife	Nigeria	**6**
45	University of Africa, Toru-Orua	Nigeria	**8**
46	Enugu State University of Science and Technology	Nigeria	**10**
47	University of Agriculture, Makurdi	Nigeria	**1**
48	Ambrose Alli University, Ekpoma	Nigeria	**2**
49	Delta State University, Abraka	Nigeria	**6**
50	Federal University, Gusau	Nigeria	**3**
51	Bingham University, Karu	Nigeria	**3**
52	Usman Danfodiyo University, Sokoto	Nigeria	**5**
53	Umaru Musa Yar'adua University, Katsina	Nigeria	**4**
54	Augustine University, Ilara-Epe	Nigeria	**6**
55	Covenant University, Ota	Nigeria	**8**
56	Federal University of Petroleum Resources, Effurun	Nigeria	**1**
57	Bowen University, Iwo	Nigeria	**4**
58	Sudan University of Science and Technology	Sudan	**2**
59	Alzaeim Alazhari University, Sudan	Sudan	**3**
60	Shendi University, Sudan	Sudan	**4**
61	State University of Zanzibar, Tanzania	Tanzania	**2**
62	Mzumbe University, Tanzania	Tanzania	**5**
63	Sokoine University of Agriculture, Tanzania	Tanzania	**2**
64	Muhimbili university of Health and Allied Sciences	Tanzania	**5**
65	Makerere University	Uganda	**4**
66	Uganda Christian university	Uganda	**3**
67	Kampala International University	Uganda	**1**
			315

Demographic information of respondents

Staff designation

The respondents were asked to provide information about their current designations. The highest category of staff that responded to the survey are Assistant Librarians (90: 28.6%), followed by Information Specialists (76: 24.1%), and Senior Librarians (56: 17.8%) (see details in Table 2).

Table 2. Staff designation

Staff designation	No. of Respondents	(%)
University Librarian	5	1.6
Deputy University Librarian	21	6.7
Principal Librarian	25	7.9
Senior Librarian	56	17.8
Librarian II	42	13.3
Information Specialist	76	24.1
Assistant Librarian	90	28.6
Total	**315**	**100%**

Gender distribution of respondents

Out of the 315 respondents, 169 (53.7 per cent) indicated as females, while 146 (46.3 per cent) indicated as males.

Cloud computing technologies used by librarians in university libraries in Africa

The respondents were asked to mention some cloud computing technologies they use in their library in an open-ended question. The responses to this question were sorted and grouped into similar CC technologies. The results show that YouTube (287: 91%), Google Drive (279: 88.6%), OPAC (266: 84.5%), Google Form (262: 83.2%), Gmail (261: 82.9%), and Google Scholar (217: 68.9%) are the most mentioned CC technologies used by the librarians in university libraries in Africa (Table 3).

Table 3. Cloud computing technologies used by librarians in university libraries in Africa

CC technologies used	No. of Responses	(%)
YouTube	287	91
Google Drive	279	88.6
OPAC	266	84.5
Google Form	262	83.2
Gmail	261	82.9
Google Scholar	217	68.9
Dropbox	195	61.9
iCloud	152	48.3
OneDrive	149	47.3
Refworks	112	35.6
Amazon cloud	81	25.7

Level of computer literacy skills to use CC technologies

The reason for adding this question was because computer literacy skills are needed to effectively use CC technologies. For that reason, respondents were asked to rate their level of computer literacy skills to use CC technologies. Almost half (150: 47.6%) of the respondents rated their computer literacy skills to use CC to be very good, followed by those who rate their computer literacy skills to use CC technologies to be excellent (81: 25.7%) (Figure 1).
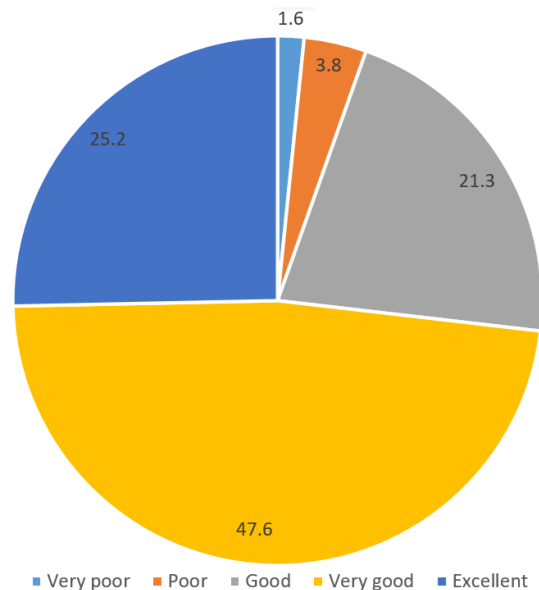
Figure 1. Level of computer literacy skills to use CC technologies

Purpose of using CC technologies by the librarians in Africa

Out of the 315 respondents, 267 responded to this question, whereas 48 skipped this question. The qualitative data collected were listed by topics and then the responses were finally grouped into similar categories and ranked in order.

The most commonly mentioned purpose of using CC technologies by the librarians is to store and share files, it was mentioned by 251 (94.0%) respondents. Closely followed by 229 (85.8%) who mentioned using CC technologies for sharing videos related to library orientations/other video contents, and 219 (82.0%) respondents mentioned using CC technologies to collaborate with other librarians for research projects (Details in Table 4).

Table 4. Purpose of using CC technologies by the librarians in Africa

Categories	No. of Responses	Order	%
Use to store and share files	251	1st	94.0
Sharing videos (library orientations/other video contents)	229	2nd	85.8%
To collaborate with other librarians for research projects	219	3rd	82.0%
Survey users level of satisfaction with library services	175	4th	65.5
Online document editing services	162	5th	60.7%
Provision of virtual/online reference	159	6th	59.6%
Information collection services	138	7th	51.7%
Use to download bibliographic descriptive records	112	8th	41.9%
Library awareness campaign services	101	9th	37.8%
For searching current publications	92	10th	34.5%
Library meetings and activities	81	11th	30.3%

Challenges associated with adoption of CC technologies

Respondents were asked to mention challenges encountered in adopting CC technologies. The majority (279: 88.6%) of the respondents mentioned no security and privacy of data to adopt CC technologies. The majority (278: 94.6%) also mentioned lack of CC knowledge and awareness, also 231 (73.3%) respondents mentioned lack of skills to use CC technology, and the majority (221: 70.2%) of the respondents also mentioned low internet connectivity as challenges to adopting CC technologies (details in Table 5).

Table 5. Challenges associated with adoption of CC technologies

Challenges	No of Responses	%
No security and privacy of data	279	88.6
Lack of CC knowledge and awareness	278	88.3
Lack of skills to use CC technology	231	73.3
Low internet connectivity	221	70.2
Irregular staff training and development	187	59.4

Discussion

Cloud computing technologies used by librarians in university libraries in Africa

Findings on the CC technologies used by the librarians revealed that YouTube, Google Drive, OPAC, Google Form, Gmail, and Google Scholar are the most mentioned CC technologies used by the librarians in university libraries in Africa. These findings are in line with the existing literature, especially the publication of Tritt and Kendrick (2014) who in their study observed that some libraries have jumped and are increasingly stepping into the realm of digital librarianship as well as platforms that extend information technology obtainable capabilities, and thus at length depends on using the cloud facilities.

Level of computer literacy skills to use CC technologies

Regarding computer literacy skills to use CC technologies, almost half of the respondents rated their computer literacy skills to use CC to be very good. This finding is in line with Wada (2015) who reported on library professionals' responsibilities in managing a digitized library in a CC environment, that knowledge for computer software and hardware is required to facilitate the application of CC in Libraries. Therefore, it can be deduced that computer literacy skills of librarians can help them to handle computer hardware and software in the CC environment. Neumann (2014) emphases that influence to adopt CC in libraries are massive and involve the librarians with advanced management knowledge and skills to escalate technological changes offered by CC. Even though there is a struggle to adopt CC in libraries, some libraries are actively adopting CC.

Purpose of using CC technologies by the librarians in Africa

The study revealed that the librarians use CC technologies to store and share files, for sharing videos related to library orientations/other video contents, to collaborate with other librarians for research projects, to survey users' level of satisfaction with library services, online document editing services, and provision of virtual/online reference services. These findings support the findings of Mohammed (2018), Salam and Ali (2020), and Adamou and Ntoka (2017). For example, Adamou and Ntoka (2017) examined the impact of digital equipment on academic libraries. The study found that e-mail and Open Public Access Catalogue (OPAC) were tools used more often by both librarians and library users. Email is used in libraries because it offers an instant messaging system which enables librarians to address library choirs, while OPAC allows remote access to the library catalogue. Cloud computing is considered one of the important Web applications that can be utilized in libraries based on their ability to create different forms of information vessels via the library site which allow users to share them. Sharing could be possible by using a ready-made model provided by cloud computing.

Challenges associated with adoption of CC technologies in libraries in Africa

No security and privacy of data

The majority of the librarians mentioned no security and privacy of data as challenges to adopting CC technologies. This finding is in line with the findings of Singh (2020) who also identified data security and privacy as drawback to using cloud storage. He explained that many cloud storage vendors lack data security and privacy fields, and there are many cases where the data from the cloud storage gets leaked. The study by Arkorful (2019) reported that despite the potential benefits that are associated with cloud computing which includes reduction of total costs of acquisition or ownership of hardware, software and skilled resources, the adoption level of cloud services is still very low in higher institutions of learning due to security issues, especially trust issues which remain a major concern over cloud solutions. On his part, Netshakhuma (2023) assessed cyber security at South African universities. The results from the comprehensive literature review revealed poor implementation and adherence of cyber security strategy and standards by employees and students; poor cyber security awareness relation to information communication technology (ICT) infrastructures and assets; and lack of strategy and framework to implement cyber security management. The study by Tella et al. (2020) also found that perceived security and reliability were reported to exert the most significant influence on adoption of CC tools. The study recommends that academic libraries in Nigeria should make sure that the security of the cloud computing they adopt is not compromised by the cloud providers.

Lack of CC knowledge and awareness

The majority of the librarians mentioned lack of CC knowledge and awareness as challenges to adopting CC technologies. This finding is in line with the literature. For example, Aliyu et al. (2019) analyzed the need for CC application in Nigerian academic libraries for improved delivery of services and reveal that librarians have little knowledge about CC and its unlimited benefits. Sudhier and Seena (2018) conducted a case study on library professionals' awareness and adoption of CC technologies in the university of Kerala. The study reveals that librarians had an inadequate idea about CC technology. Therefore, the study by Arkorful (2019) recommended that there is the need for training IT personnel and to create awareness of the benefits of cloud computing to enable institutions of higher learning to adopt them to enhance their productivity.

Lack of skills to use CC technology

The majority also mentioned lack of skills to use CC technology. Wada (2015) believes that ICT competencies could be attained via strong trainings and consistent use of the CC to any aspect of services provided in the libraries. Training librarians to enrich skills and knowledge on the use of new technologies is supported by a case study on an examination of CC amongst university lecturers in Zimbabwe by Musungwini, et al. (2016), which found that there were a knowledge gap and a need for workshops to enlighten the users' knowledge on the value of CC technology.

Low internet connectivity

Unstable or no internet connectivity was another most mentioned challenge that hinder use of CC technologies in the libraries in Africa. This finding supports previous findings by Singh (2020) who identified the following as drawbacks to using cloud storage. They are: Internet dependency and Expensive nature of cloud storages. He explained that without the internet, you cannot access your data while downloading the file from cloud storage. If there is an internet failure, it might corrupt the data which you were downloading. Concerning expensive nature of cloud storages, he added that most of the best cloud services are expensive; this is because they are specially designed for business purposes. If you go for a less expensive plan, you might have to compromise with some of the features. Lack of good internet connectivity and CC service providers inhibits the use of CC in libraries.

Solutions to security of data threats in the cloud environment

Libraries use cloud-based resources primarily to create digital libraries, social networking and knowledge communication without discarding the concerns about some cloud-related issues like privacy, protection, etc. One of the major tasks of LIS professionals in this digital era is to make cloud-based platforms a secure platform for delivering library services to users. Therefore, below are some measures to handle data security issues:

Data encryption

There are various ways through which the Apple and Google security threats can be mitigated. However, data encryption is the best practice of enhancing privacy and confidentiality as essentials of cloud computing (Jaatun, 2009). Encryption entails providing a specific key for data access. In the recent past, the use of Advanced Encryption Standard (AES) has helped in ensuring safety of data in transit (Jaatun, 2009). In this standard, symmetric and asymmetric data authentications are used. Unlike the public key cryptography, the asymmetric encryption involves generating two distinct keys which are meant for use by the data sender and the recipient (Jaatun, 2009). Jalamneh and Khder, (2021) and Alharthi, et al. (2015) reported that the evolving paradigm of CC tools and the security and privacy mechanisms offered by service providers presented accelerated and trusted mechanisms to assure information security and privacy such as identification and authentication, encryption, and privacy policy.

Digital signature

The well-liked Rivest Shamir Adelman (RSA) encryption can also play an important role in digital signature generation. In this process, data can be decrypted appropriately from cipher text through the use of signature verification (Jordan & Bruno, 2011). Through the generation of symmetric encryption keys, the RSA standard has particularly enabled the transmission of various multimedia contents over the Internet (Acquisti et al., 2010). This is because it ensures an uninterrupted exchange of private keys which are used in the access of data. The Voice over IP (VoIP) technology has specifically benefitted from the provision of digital signatures over the Internet platform (Acquisti et al., 2010).

Phishing detection

Phishing detection, widely deployed by Google, has helped in curbing the phishing attacks which lead to hacking of users' accounts (Oberheide, n.d). Google uses this security service through a number of anti-phishing tools which can detect the presence of a counterfeit websites. Fraudulent activities have decreased in Google's Apps Engine, since the phishing detection process has significantly been enhanced (Oberheide, n.d).

Preventing network intrusion

Network intrusion is the cause of various malicious activities over the cloud platform (Jordan & Bruno, 2011). However, there are various technologies which can be used in preventing this kind of intrusion. The Multiprotocol Label Switching (MPLS), Virtual Private Networks (VPNs) and Virtual Local-Area Networks (VLANs) are some of the best strategies that have been developed to avoid this problem (Jordan & Bruno, 2011).

Spam/content filtering

Spam filtering is mostly used for securing text contents, such as SMS and email messages. The filtering process enables in detecting the source of malicious information, through extracting the IP addresses of the senders (Oberheide, n.d). In some countries like China, the use of content filtering and blocking has enabled the security of web contents. This is done through deleting any content deemed inappropriate by the cyberspace authorities (Oberheide, n.d).

Conclusion

The study found that YouTube, Google Drive, OPAC, Google Form, Gmail, and Google Scholar are the most mentioned CC technologies used by the librarians in university libraries in Africa. The librarians use CC technologies to store and share files, for sharing videos related to library orientations/other video contents, to collaborate with other librarians for research projects, to survey users level of satisfaction with library services, online document editing services, and provision of virtual/online reference services. The majority of the librarians mentioned lack of fund, no security and privacy of data, irregular staff training and development, and lack of CC knowledge and awareness as challenges associated with adoption of CC technologies in universities in Africa.

It is seen that the use of cloud computing can improve services and operations and provide genuine advantages for libraries thereby enabling them to be competitive in the information changing and dynamic environment. There has been an abrupt change in the approach of library patrons to information accessibility and delivery that have actively moved into the virtual environment. Smart phones, mobile phones, tablets and laptops are everywhere now. Libraries therefore need to deliver resources and services in the virtual environment preferred by students, researchers, staff and faculty members, or they risk alienating users.

Author Contributions

Dime, I. A., and Okeji, C. C.: conceived and designed the study, reviewed the literature, collected the data, analysis and graphs, contributed to interpretation and manuscript preparation, literature review, writing manuscript, and proofreading. All authors have read and agreed to the published version of the manuscript.

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The authors declare no conflict of interest.

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