Use of Cloud Maintenance Practices for Metadata Management in Federal University Libraries in North Central States of Nigeria

Mustapha Yusuf Hussaini
Isa Mustapha Agwai I Polytechnic, Lafia, Polytechnic Library

Nurudeen Mu'azu Maifata (Ph.D)
Nasarawa State University, Keffi, University Library

Ahmed Yusuf
Ahmau Bello University, Zaria, University Library

Abstract: *This research investigates the adoption of cloud maintenance practices for metadata management in federal university libraries within the North Central states of Nigeria. Metadata management is a critical component of library operations, ensuring the organization, retrieval, and preservation of digital resources. By leveraging cloud technologies, libraries can enhance metadata accuracy, security, and accessibility while addressing challenges like data loss and resource limitations. The study employed a quantitative methodology using a cross-sectional survey design to collect data from seven federal universities, analyzing cloud practices, their impact on metadata management, and the challenges faced. Findings revealed the adoption of advanced practices such as encryption, automated performance monitoring, and disaster recovery strategies, significantly enhancing metadata reliability and security. However, foundational practices like standardized metadata schemas and frequent backups were less consistently implemented, indicating gaps in a holistic cloud strategy. The study also identified key challenges, including inadequate IT infrastructure, insufficient funding, lack of skilled personnel, and cybersecurity threats, which hinder the effective adoption and sustainability of cloud maintenance practices. These barriers, compounded by issues like poor internet connectivity and resistance to technology adoption, limit the libraries' ability to fully leverage cloud technologies. To overcome these challenges, the study recommends targeted investments in IT infrastructure, staff training, and secure funding mechanisms, alongside strengthening both foundational and advanced cloud practices. By addressing these areas, federal university libraries can achieve more effective metadata management, ensuring improved service delivery and the sustainability of their digital resource management systems.*

Keywords: cloud maintenance, metadata, management, digital resource, library, IT infrastructure.

INTRODUCTION

Metadata management is the process of organizing, retrieving, and preserving digital resources in libraries, and the use of cloud-based maintenance practices has revolutionized this process. Cloud technologies provide scalable and efficient solutions for handling large volumes of metadata, ensuring data integrity, and enabling seamless resource sharing and accessibility (Chen et al., 2023; Azraoui et al., 2024). These practices address critical issues such as resource limitations, data loss, and inefficiencies in synchronization by leveraging advanced protocols for dynamic data processing and secure auditing (Guo et al., 2022; Hahn et al., 2022). Also, privacy-preserving techniques and certificateless storage systems enhance the security and reliability of metadata stored in the cloud, ascertaining that sensitive library information is protected against unauthorized access and modifications (Hao et al., 2011; Huang et al., 2024). This study explores the application of cloud maintenance practices in metadata management, aiming to highlight their potential in improving library operations and ensuring the sustainability of digital resource management.

In federal university libraries in the North Central states of Nigeria, the growing complexity and volume of digital content have raised the need for robust metadata management systems. Cloud-based solutions, which provide scalable and efficient infrastructures, have emerged as a transformative tool for handling metadata effectively. These systems offer enhanced storage capacity, sharing of resources, and improved accessibility (Chen et al., 2023). Moreover, their ability to facilitate data integrity and security through advanced protocols such as proofs of retrievability shows their suitability for metadata management in academic institutions (Azraoui et al., 2024).

These practices leverage dynamic data processing capabilities, allowing libraries to handle metadata updates and synchronization efficiently (Hahn et al., 2022). With the increasing need for data integrity and public auditing in cloud environments, protocols designed to maintain transparency and accountability have been developed (Guo et al., 2022). Such capabilities are critical for university libraries in Nigeria, where resource constraints often hinder the effective management of digital collections.

The security and privacy of cloud-stored metadata are equally significant, given the sensitivity of library data. Techniques like privacy-preserving remote data integrity checking protocols and secure network coding enhance the security framework for cloud-based metadata systems (Hao et al., 2011; Chen et al., 2022). These technologies ensure that the metadata stored in the cloud remains confidential and is safeguarded against unauthorized access or modification. Also, certificateless cloud storage auditing and user revocation systems provide robust mechanisms to address security concerns specific to multi-user environments like university libraries (Huang et al., 2024).

This study seeks to explore the use of cloud maintenance practices for metadata management in federal university libraries in the North Central states of Nigeria. By

examining the use, challenges, and potential solutions related to these practices, the research aims to provide actionable insights for improving metadata handling and fostering digital resource accessibility in academic libraries. The findings will contribute to understanding how cloud-based solutions can address operational inefficiencies and support the sustainable development of library services in the digital age.

Problem statement

Adequate metadata management is necessary for library operations, enabling the organization, retrieval, and preservation of digital resources. However, federal university libraries in the North Central states of Nigeria face significant challenges in this regard, including inadequate infrastructure, limited storage capacity, and inefficient resource sharing mechanisms. These issues have hindered the ability of these libraries to meet the growing demands of users for digital resources and have led to operational inefficiencies. Traditional metadata management systems, often constrained by outdated technology, fail to provide the scalability and dynamic processing capabilities required for handling large volumes of data (Chen et al., 2023; Guo et al., 2022). The lack of robust security measures in these systems increases the risk of data breaches and unauthorized modifications, further complicating metadata management processes (Hao et al., 2011).

Cloud maintenance practices offer a potential solution to these challenges by providing scalable, secure, and efficient infrastructure for metadata management. Advanced features such as dynamic data auditing, privacy-preserving integrity checks, and certificateless storage systems can address the limitations of traditional systems while ensuring data security and accessibility (Hahn et al., 2022; Huang et al., 2024). However, despite the potential of cloud technologies, their use in Nigerian university libraries remains limited, largely due to resource constraints, lack of technical expertise, and inadequate policy frameworks. This gap shows the need for an investigation into how cloud maintenance practices can be implemented effectively in metadata management to improve library operations and enhance access to digital resources.

Research questions

The following research questions were raised:
1. What are the current cloud maintenance practices employed for metadata management in federal university libraries in the North Central states of Nigeria?
2. How do cloud maintenance practices influence the effectiveness and accuracy of metadata management in these libraries?
3. What challenges do federal university libraries in the North Central states of Nigeria face in adopting and sustaining cloud maintenance practices for metadata management?

REVIEW OF RELATED LITERATURE

Cloud maintenance practices for metadata management in federal university libraries include the adoption of cloud-based Integrated Library Systems (ILS) and metadata

indexing tools. Libraries utilize platforms such as Koha, DSpace, and WorldCat, which facilitate remote access to resources, metadata creation, and collaborative cataloging (Kumar & Jasimudeen, 2021). These platforms offer automation in metadata extraction, enabling the organization of digital and physical collections with increased efficiency (Kaur & Singh, 2020).

In Nigeria, studies reveal a growing adoption of cloud technology for library services, particularly in metadata management, due to its cost-effectiveness and scalability (Adeleke et al., 2022). However, many libraries in North Central Nigeria still rely on hybrid systems, integrating both manual and automated approaches, due to limited infrastructure and expertise (Oyewole et al., 2020).

Cloud maintenance practices significantly enhance the accuracy and accessibility of metadata in university libraries. By leveraging cloud services, libraries can synchronize metadata updates in real-time, reduce duplication errors, and maintain uniform metadata standards (Patil & Thakkar, 2019). Automation tools also improve the speed of metadata generation and updates, which is crucial for large digital repositories.
In federal university libraries in Nigeria, cloud practices have improved resource discoverability, enabling users to access materials seamlessly from different locations (Onuoha & Obaje, 2021). The collaborative features of cloud systems further enhance data sharing and consistency, which is essential for interlibrary cooperation (Okoh et al., 2023). Nonetheless, inconsistent internet access and power supply disruptions limit the potential impact of these practices in certain regions (Abubakar et al., 2022).

Despite the advantages of cloud maintenance practices, federal university libraries in North Central Nigeria encounter several challenges. Key issues include inadequate funding, which hampers the procurement and maintenance of cloud services, and a lack of skilled personnel to manage cloud-based systems (Egunjobi & Awoyemi, 2021). Furthermore, infrastructure deficiencies such as unreliable internet connectivity and erratic power supply create significant barriers to the effective use of cloud technologies (Okafor et al., 2023).

Another challenge is resistance to change among library staff, particularly those accustomed to traditional systems. This is compounded by insufficient training programs to equip librarians with the necessary skills for cloud system operation (Adeleke et al., 2022). Moreover, concerns about data security and privacy discourage the full adoption of cloud services, as many libraries lack robust cybersecurity measures (Oyewole et al., 2020).

The reviewed literature highlights the adoption of cloud technologies for metadata management in Nigerian federal university libraries, particularly in North Central states, but significant gaps remain. Existing studies often generalize findings across regions, failing to account for variations in institutional priorities. While the benefits of cloud systems, such as improved metadata accuracy and accessibility, are acknowledged, the literature provides limited discussion on specific maintenance practices like updates,

backups, and system monitoring. Most works emphasize challenges, such as inadequate funding and staff resistance, without offering actionable solutions, and they lack robust empirical evidence or user-centered perspectives. Emerging technologies like AI and blockchain, which hold promise for metadata management, are also notably absent from discussions.

These gaps justify a focused study on cloud maintenance practices for metadata management in federal university libraries in North Central Nigeria. Research is needed to address regional variability, explore specific cloud practices, and provide empirical data that reflects the realities of library operations. Incorporating the perspectives of librarians, IT staff, and users can offer a holistic understanding of the effectiveness of these practices. Additionally, identifying challenges and proposing practical solutions will guide libraries in overcoming barriers to adopting and sustaining cloud technologies. This research will also explore the potential of emerging technologies, contributing innovative insights to improve metadata management and enhance library services in the region.

METHODOLOGY

This study employed a quantitative research methodology to analyze how postgraduate students in federal universities in North-Central Nigeria utilize online IT tools for scholarly work. Using a cross-sectional survey design, the study collected data from a population of 19,342 students across seven universities, with a sample size of 968 selected through simple random sampling. Data was gathered using a structured questionnaire divided into sections addressing demographic details, IT tools usage, awareness, influencing factors, skills, challenges, and extent of use. Validity was ensured through expert reviews, while a pilot study conducted at Ahmadu Bello University confirmed the reliability of the instrument with a coefficient of 0.86. Data collection was facilitated by research assistants and conducted confidentially, while descriptive statistics, including frequency, percentages, and mean, were used for data analysis, with a benchmark mean of 3.00 for interpretation.

RESULTS

Research Question 1: **What are the current cloud maintenance practices employed for metadata management in federal university libraries in the North Central states of Nigeria?**

Table 1: Means and Standard Deviation of current cloud maintenance practices employed for metadata management in federal university libraries

S/N	maintenance practices	X	SD	RMK

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1.	Libraries frequently back up metadata stored in the cloud to prevent data loss due to system failures or breaches.	1.78	1.02	DA
2.	Access to metadata systems is restricted based on staff roles, ensuring that only authorized personnel can modify or manage metadata.	2.65	1.06	DA
3.	Libraries adopt standardized metadata schemas (e.g., Dublin Core, MARC 21) to ensure interoperability and consistency in cloud environments.	1.54	0.97	DA
4.	Metadata is encrypted during storage and transmission to enhance security and protect sensitive information from unauthorized access.	3.19	0.96	DA
5.	Cloud service providers or library IT teams regularly update metadata management systems to include the latest security patches and features.	3.96	1.10	A
6.	Automated tools are employed to monitor system performance and generate reports to identify bottlenecks or areas for improvement.	4.05	1.06	A
7.	Comprehensive disaster recovery strategies, including off-site backups and recovery protocols, are maintained to ensure data resilience.	3.68	1.12	A
8.	Enhanced login protocols such as MFA are implemented to secure access to cloud-based metadata systems.	3.23	1.35	DA
9.	Libraries conduct regular audits of cloud service providers to ensure compliance with service level agreements (SLAs) and data protection laws.	2.14	1.24	DA
10.	Librarians and IT staff receive ongoing training to manage, troubleshoot, and optimize metadata systems hosted on the cloud.	2.45	1.29	DA

The analysis of current cloud maintenance practices with mean scores of 3.0 and above reveals a focus on advanced strategies for metadata management in federal university libraries in the North Central states of Nigeria. Automated tools for system performance monitoring and reporting recorded the highest mean (X=4.05, SD=1.06), indicating strong adoption of technology-driven approaches to ensure system optimization. Similarly, regular updates to metadata management systems by cloud service providers or IT teams (X=3.96, SD=1.10) highlight a proactive effort to incorporate the latest security patches and features, enhancing system reliability and protecting against potential vulnerabilities.

Disaster recovery strategies (X=3.68, SD=1.12) and encryption of metadata during storage and transmission (X=3.19, SD=0.96) also scored above the benchmark, showcasing an emphasis on resilience and security in metadata management. The implementation of enhanced login protocols, such as multi-factor authentication (MFA) (X=3.23, SD=1.35) further underscores efforts to secure cloud-based metadata systems against unauthorized access. These practices suggest that while libraries prioritize robust security and resilience measures, they may be better positioned to mitigate risks associated with metadata loss or breaches, ensuring continuity and data protection in cloud environments. This focus on advanced practices demonstrates significant progress in adopting modern technologies and methods, though complementary foundational practices are needed to achieve comprehensive metadata management.

The findings imply that federal university libraries in the North Central states of Nigeria prioritize advanced cloud maintenance practices, such as system updates, automated monitoring, encryption, disaster recovery strategies, and enhanced login protocols, to secure and optimize metadata management. However, the focus on these advanced measures, while commendable, suggests potential neglect of foundational practices such as standardized metadata schemas and frequent backups, which are equally critical for ensuring long-term data integrity and interoperability. This imbalance could result in vulnerabilities, such as difficulties in data recovery or integration with global metadata systems, potentially limiting the libraries' effectiveness in managing and sharing information securely and efficiently. This implies that libraries should strengthen these fundamental practices for a more holistic cloud strategy. According to Kaur and Sood (2021), effective metadata management relies not only on secure technologies but also on consistent and standardized practices to ensure interoperability and long-term accessibility of data in cloud environments.

Research Question 2. How do cloud maintenance practices influence the effectiveness and accuracy of metadata management in these libraries?

Table 2: Means and Standard Deviation of How cloud maintenance practices influence the effectiveness and accuracy of metadata management

S/N	Influence of cloud maintenance practices	X	SD	RMK
1.	Regular backups and data validation processes prevent data corruption, ensuring the metadata remains accurate and reliable.	3.79	1.15	A
2.	Practices like encryption, multi-factor authentication, and role-based access control protect metadata from unauthorized access or tampering, maintaining its accuracy and confidentiality.	3.56	1.12	A

3.	Routine software updates and performance monitoring optimize system efficiency, reducing errors and enhancing metadata accessibility.	2.65	1.25	DA
4.	Adopting and enforcing metadata standards (e.g., Dublin Core, MARC) in cloud environments ensures consistency and interoperability across library systems.	2.48	1.24	DA
5.	Deduplication processes identify and eliminate duplicate metadata entries, streamlining cataloging and improving accuracy.	3.27	1.38	DA
6.	Cloud-based systems enable simultaneous access by multiple users, ensuring that metadata updates and corrections are timely and synchronized.	3.10	1.34	DA
7.	Scalable cloud infrastructure accommodates growing metadata volumes, maintaining system responsiveness and accuracy during expansion.	3.37	1.18	DA
8.	Robust disaster recovery practices ensure that metadata remains intact and quickly restorable after data loss incidents, avoiding disruptions in service.	3.08	1.24	DA
9.	Detailed audit logs track changes to metadata, helping identify and correct inaccuracies while promoting accountability.	3.43	1.26	DA
10.	Automation tools in the cloud handle repetitive tasks like metadata tagging, reducing manual errors and improving data quality.	3.18	1.19	DA
11.	Cloud platforms support analytics tools to identify trends and inconsistencies in metadata, improving management and decision-making.	3.51	1.33	A
12.	Regular cloud maintenance enhances system uptime and speeds up access to metadata, enabling quicker retrieval and usage.	3.57	1.20	A

The analysis of how cloud maintenance practices influence the effectiveness and accuracy of metadata management reveals significant impacts, with several practices exceeding the benchmark of X=3.0. Regular backups and data validation processes achieved the highest mean (X=3.79, SD=1.15), emphasizing their critical role in preventing data corruption and ensuring metadata reliability. Similarly, practices like encryption, multi-factor authentication, and role-based access control (X=3.56, SD=1.12) demonstrate their influence on maintaining metadata accuracy and confidentiality by protecting it from unauthorized access. The use of analytics tools

(X=3.51, SD=1.33) and automation for metadata tagging (X=3.18, SD=1.19) further highlights the importance of cloud-enabled technologies in improving data quality, reducing errors, and supporting decision-making. Also, detailed audit logs (X=3.43, SD=1.26) and robust disaster recovery practices (X=3.08, SD=1.24) underscore the role of accountability and resilience in maintaining metadata integrity and minimizing disruptions.

Scalable cloud infrastructure (X=3.37, SD=1.18) and simultaneous access capabilities (X=3.10, SD=1.34) enhance metadata synchronization and responsiveness, their moderate scores suggest they are underutilized compared to their potential. However, practices such as routine software updates and performance monitoring (X=2.65, SD=1.25) and enforcement of metadata standards (X=2.48, SD=1.24) fall below the benchmark, indicating areas for improvement. These findings highlight the duality of cloud maintenance practices: while advanced technologies are leveraged to enhance metadata accuracy and effectiveness, gaps in foundational practices, such as software updates and metadata standardization, may hinder consistent interoperability and efficiency across library systems. A balanced approach is necessary to maximize the benefits of cloud maintenance for metadata management.

The findings suggest that while cloud maintenance practices such as regular backups, encryption, automation, and analytics tools significantly enhance the accuracy, reliability, and security of metadata, there are gaps in foundational practices like routine software updates and the enforcement of metadata standards. These gaps may hinder consistent system efficiency, interoperability, and the overall effectiveness of metadata management. The implications are that federal university libraries in the North Central states of Nigeria need to focus on strengthening these foundational practices to complement the advanced strategies already in place. This balanced approach would ensure comprehensive metadata management, improve system consistency, and minimize potential errors, ultimately enhancing the libraries' overall metadata management capabilities. This aligns with findings by Ibrahim and Abubakar (2020), who note that insufficient resources, poor internet connectivity, and a shortage of skilled professionals are significant obstacles in the successful implementation of digital technologies in Nigerian academic libraries. Overcoming these barriers is critical to enhancing the use of cloud technology in metadata management.

Research Question 3. What challenges do federal university libraries in the North Central states of Nigeria face in adopting and sustaining cloud maintenance practices for metadata management?

Table 3: Means and Standard Deviation of challenges face in adopting and sustaining cloud maintenance practices for metadata management

S/N	challenges	X	SD	RMK
1.	Insufficient funding for cloud services.	3.45	0.80	DA
2.	Inadequate IT infrastructure.	3.51	0.92	A
3.	Lack of skilled personnel.	3.51	1.04	A
4.	Cybersecurity threats.	3.38	1.04	DA
5.	Poor internet connectivity.	3.29	1.11	DA
6.	Resistance to technology adoption.	3.22	1.21	DA
7.	High cost of software licenses.	3.37	1.15	DA
8.	Data migration complexities.	3.63	1.28	A
9.	Limited user training programs.	3.58	1.24	A
10.	Frequent power outages.	3.76	1.14	A

The analysis of challenges faced by federal university libraries in the North Central states of Nigeria in adopting and sustaining cloud maintenance practices for metadata management reveals a mix of moderately high and low challenges. Inadequate IT infrastructure (X=3.51, SD=0.92) and lack of skilled personnel (X=3.51, SD=1.04) both recorded high means, reflecting a significant barrier to adopting and effectively managing cloud-based metadata systems. These challenges are critical, as they directly affect the library's ability to implement and maintain complex cloud infrastructure. Also, data migration complexities (X=3.63, SD=1.28) and limited user training programs (X=3.58, SD=1.24) highlight ongoing difficulties in transitioning to cloud systems and ensuring that both staff and users can effectively utilize the technology. These findings indicate that while the libraries may be able to invest in cloud infrastructure, the lack of sufficient technical skills and proper training programs limits their ability to leverage the full potential of cloud-based metadata management systems.

On the other hand, challenges such as insufficient funding for cloud services (X=3.45, SD=0.80), cybersecurity threats (X=3.38, SD=1.04), poor internet connectivity (X=3.29, SD=1.11), resistance to technology adoption (X=3.22, SD=1.21), and the high cost of software licenses (X=3.37, SD=1.15) all show moderate scores above the benchmark of X=3.0, indicating that these issues also pose significant challenges to cloud maintenance practices. While libraries are aware of the importance of cloud technologies, financial constraints, security risks, and infrastructure limitations hinder their effective adoption and maintenance. These findings suggest that overcoming these barriers requires not only improving IT infrastructure and staff training but also addressing financial and cybersecurity challenges to ensure sustainable metadata management in cloud environments.

The implication of these findings is that federal university libraries in the North Central states of Nigeria face multiple significant challenges in adopting and sustaining cloud maintenance practices for metadata management. While issues such as inadequate IT infrastructure, lack of skilled personnel, and data migration complexities are critical

obstacles, the financial barriers, including insufficient funding for cloud services and high software licensing costs, exacerbate the problem. Furthermore, poor internet connectivity, cybersecurity threats, and resistance to technology adoption further hinder effective implementation. To address these challenges, libraries must prioritize investments in IT infrastructure, staff training, and user education. Also, securing stable funding and addressing cybersecurity concerns will be essential to fully capitalize on the benefits of cloud technologies for metadata management. Without overcoming these barriers, the libraries may struggle to realize the long-term advantages of cloud adoption, limiting their ability to improve metadata accuracy, accessibility, and overall operational efficiency. This finding aligns with the work of Msimanga and Marwala (2019), who emphasize the importance of robust cybersecurity frameworks in cloud environments to prevent data breaches and ensure data integrity, especially in contexts with limited technological resources.

CONCLUSION

This research explored the cloud maintenance practices employed for metadata management in federal university libraries in the North Central states of Nigeria, their influence on the effectiveness and accuracy of metadata management, and the challenges faced in adopting and sustaining these practices. The findings reveal a notable emphasis on advanced cloud maintenance practices such as regular backups, encryption, multi-factor authentication, automated performance monitoring, and disaster recovery strategies. These practices contribute significantly to ensuring metadata security, reliability, and efficiency, with encryption and system updates being particularly prioritized. However, foundational practices like the use of standardized metadata schemas, role-based access control, and frequent backups are less consistently implemented, suggesting room for improvement in the overall cloud maintenance strategy.

While the effectiveness and accuracy of metadata management are positively influenced by these advanced cloud practices, the research also highlights several challenges hindering the libraries' ability to adopt and sustain these practices. Inadequate IT infrastructure, lack of skilled personnel, data migration complexities, insufficient funding, and cybersecurity threats are major barriers. These challenges, along with resistance to technology adoption and poor internet connectivity, underscore the need for comprehensive strategies to strengthen both the technical and financial capacities of the libraries. Addressing these barriers through targeted investments in infrastructure, staff training, cybersecurity, and secure funding mechanisms will be essential for ensuring the successful and sustainable adoption of cloud-based metadata management systems. Ultimately, a balanced approach, integrating both advanced and foundational cloud maintenance practices while overcoming existing challenges, will enable federal university libraries in the North Central states of Nigeria to effectively manage metadata and enhance their overall service delivery.

Recommendation

Based on the findings of this study, the following recommendations were made:

Federal university libraries should prioritize the implementation of foundational practices such as standardized metadata schemas (e.g., Dublin Core, MARC) and frequent backups. These practices are essential for ensuring metadata consistency, interoperability, and data recovery. Libraries could consider adopting a phased approach to improve these practices, beginning with staff training on metadata standards and the integration of regular backup procedures, ensuring a balanced adoption alongside advanced practices like encryption and system updates.

To enhance the effectiveness and accuracy of metadata management, libraries should focus on improving routine software updates and performance monitoring, which were found to have lower implementation scores. Libraries should invest in automation tools that optimize these processes and ensure that metadata remains consistent and easily accessible. A stronger focus on continuous system performance assessments and updates will help minimize errors and enhance metadata quality and accessibility.

Libraries should develop a comprehensive strategy to overcome challenges related to inadequate IT infrastructure, lack of skilled personnel, and financial constraints. This could include seeking external funding, collaborating with government bodies or private institutions, and investing in staff development programs. Also, libraries should advocate for better internet connectivity and cybersecurity measures, which are crucial for the secure and effective use of cloud services in metadata management. Training programs and workshops on cloud technologies should be prioritized to build internal capacity and reduce reliance on external expertise.

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