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REVITALIZING LIBRARY SERVICES IN THE DIGITAL ERA BY HARNESSING CLOUD COMPUTING TO OPTIMIZE INFORMATION DELIVERY

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Abstract
This paper explores how cloud computing revolutionizes library services to meet the needs of today's digital landscape. Libraries face the challenge of providing services that align with 21st-century users. Cloud computing enables libraries to reshape service delivery and offer efficient information resources. Various cloud computing services, such as IaaS, PaaS, and SaaS, are examined, highlighting their benefits and characteristics. Different cloud deployment models (public, private, community, hybrid) are explored, emphasizing their advantages. Cloud computing empowers libraries to share distributed resources, provide real-time information access, and foster collaboration among a network of libraries, enhancing resource utilization. The potential benefits of cloud-based applications in education, business, data storage, and entertainment are discussed. Cloud computing enables effective storage, management, and distribution of information resources, facilitating information discovery, sharing, and collaboration. The advantages of cloud computing, including cost savings, flexibility, scalability, and accessibility, are highlighted. Potential challenges and issues during implementation are addressed. This study emphasizes the transformative potential of cloud computing for libraries, proposing strategies to enhance library services in the digital age with cloud technology.

Keywords: *Cloud computing, library services, information delivery and digital age*

Introduction

In today's digital age, libraries face the challenge of adapting their services to

meet the evolving needs of 21st-century users. According to Eiriemiokhale and Amzat, (2022) the proliferation of digital information and the increasing reliance on technology, libraries must leverage innovative solutions to ensure efficient and effective delivery of information resources. Libraries have long been regarded as information hubs, providing access to a wide range of resources and services. However, the rapid advancements in technology and the changing information-seeking behaviours of users necessitate a revaluation of traditional library services. The digital age brings forth new expectations, where users demand instant access to information, personalized experiences, and seamless connectivity (Dwivedi et al, 2021). The digital age has drastically changed the way people interact with technology, leading to higher expectations. People now expect to be able to access information quickly and easily, as well as have personalized experiences tailored to their preferences and interests.

Cloud computing offers libraries an opportunity to proactively reshape their service delivery and cater to these evolving user needs. Ohia (2015) noted that leveraging cloud-based solutions, libraries can efficiently store, manage, and deliver information resources, allowing users to access them anytime and anywhere. Cloud computing provides the scalability and flexibility required to accommodate the growing volume of digital content and the increasing number of users. Various cloud computing services, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) (Ohia, 2015), play a vital role in enabling libraries to enhance their services. IaaS allows libraries to offload the burden of infrastructure management and storage, freeing up resources for other critical tasks. PaaS provides a platform for developing and deploying library-specific applications and services, facilitating customization and innovation. SaaS offers libraries access to a wide range of pre-built software solutions, enabling efficient management of library operations and user interfaces (Wada, 2018).

Different cloud deployment models, such as public, private, community, and hybrid clouds, offer libraries options for hosting their services and data. Public clouds provide cost-effective solutions by leveraging shared infrastructure, while private clouds offer enhanced control and security. Community clouds allow libraries to collaborate and share resources with similar institutions, promoting resource optimization. Hybrid clouds combine different deployment models to meet specific needs, providing a balance between cost efficiency and security.

Libraries can empower themselves to share distributed resources by harnessing cloud computing, grant real-time information access, and foster

collaboration among a network of libraries. This collaborative approach enhances resource utilization, expands the scope of available resources, and enables libraries to provide a comprehensive and diverse collection of information materials to their users (Ashikuzzaman, 2018). Moreover, cloud-based applications have demonstrated significant potential benefits across various domains. In education, cloud computing enables libraries to support e-learning initiatives, facilitate remote access to educational resources, and promote collaborative research and learning. Cloud-based solutions facilitate knowledge sharing, document management, and remote access to resources. Cloud storage options provide secure and scalable data storage, reducing the burden on local infrastructure. Cloud-based entertainment platforms offer convenient access to media content, enhancing user experiences. This paper therefore explores the transformative potential of cloud computing in revolutionizing library services and meeting the demands of the digital landscape. Specifically, the paper cover cloud computing services such as IaaS, PaaS, and SaaS, cloud deployment models, expanding horizons, advantages of cloud computing, overcoming challenges, transforming libraries and application of cloud computing in libraries

Cloud Computing Services: exploring IaaS, PaaS, and SaaS

Libraries can revitalize their services in the digital era by harnessing cloud computing. Hence, they can optimize information delivery, enhance operational efficiency, reduce costs, and improve service quality. Cloud-based systems empower libraries to adapt to changing demands, provide tailored user experiences, and facilitate seamless collaboration (Suman, et al, 2023). The benefits of cloud computing extend beyond libraries, reaching various industries and sectors, including small and medium-scale enterprises (SMEs), which can leverage its advantages for efficient data management and protection against unauthorized access. Popular cloud service providers, such as Microsoft Azure, Amazon Web Services (AWS), and Google Cloud, offer a wide array of cloud computing services.

Infrastructure-as-a-service (IaaS): Under IaaS, organization subscribe to shared IT infrastructures such as servers (physical or virtualized), network infrastructures (switches, routers, & firewalls) or storage systems hosted in a cloud service provider's data centre such as Azure, AWS, Google data centres. Here, infrastructures are leased or provisioned on a pay-as-you-use (PAYU) or on-demand basis, giving organizations the flexibility to only deploy infrastructure that they need at the time. Organisations only need client PCs (workstations), LAN and internet connectivity through which users can access provisioned

infrastructures in the cloud.

Platform-as-a-service (PaaS): Under PaaS, organization access operating systems platforms such as Windows, UNIX, LINUX, IOS, database management systems (e.g., MSSQL, MySQL, Oracle, Sybase), Development Environment and DevOps tools (e.g., MSDN, Git, Jenkins) Web servers (e.g., Apache, TomCat, IIS), to host their applications without having to put anything on premise or worry about provisioning the services. This saves organisations cost to purchase those application or system software licenses, which are expensive but can only pay for platforms or tools that they need or use on demand.

Software-as-a-service (SaaS): SaaS provides the business owner the flexibility of using avalanche of end-user software or applications available in cloud providers' software store. For example, access to various Microsoft applications in their Office 365 platform (MS Office applications -Word, Excel, PowerPoint, Access, Frontpage, Outlook, Visio, etc.), collaboration tools such as Microsoft Team (for chat and conferencing), Skype for Business, Yammer (MS Social Media platform); Workflow tools such as MS SharePoint; Customer Relationship Management (CRM) tool like MS Dynamics 365 CRM; Cloud storage platform like OneDrive; Development Tool like MSDN, GitHub, Microsoft Azure DevOps, among other. For Google platform, software such as Gmail, GoogleDrive, Google Cloud APIs (e.g., Google Map, Firebase, OAUTH2, Recaptcha, 2FA), Google Developer, Google Webmaster tool, among others.

Cloud Deployment Models

When adopting cloud computing solutions, organizations have several deployment models to consider. These models according to Messina (2021) include public, private, community, and hybrid clouds.

1. Public Cloud: Public clouds are owned and operated by third-party cloud service providers, who make their resources available to multiple organizations and individuals over the internet. These resources, such as storage, virtual machines, and applications, are shared among multiple users on a pay-as-you-go basis. Public clouds offer scalability, cost-efficiency, and flexibility, as organizations can easily scale their resources up or down based on demand. However, organizations must consider data security and privacy concerns when entrusting their data to third-party providers.
2. Private Cloud: Private clouds are dedicated cloud infrastructures that are exclusively used by a single organization. These clouds can be managed and

maintained internally by the organization or by a third-party provider. It provides greater control, security, and customization options compared to public clouds. Private cloud ensures that data remains within the organization's boundaries. However, private clouds may require significant upfront investments and ongoing maintenance costs.

3. Community Cloud: Community clouds are shared infrastructures that serve a specific community of organizations with similar requirements, such as government agencies, educational institutions, or research organizations. In a community cloud, multiple organizations pool their resources to achieve cost savings, enhanced collaboration, and shared infrastructure. It offers more customization and control than public clouds, while still providing cost-sharing benefits. However, organizations must ensure effective governance and address potential conflicts of interest among community members.
4. Hybrid Cloud: Hybrid clouds combine elements of public and private clouds, allowing organizations to integrate and orchestrate resources across multiple cloud environments. In a hybrid cloud model, organizations can utilize public cloud services for non-sensitive or non-critical workloads while retaining sensitive data or critical applications in a private cloud. This flexibility enables organizations to optimize their infrastructure, balance costs, and address varying workload requirements. However, managing and integrating multiple cloud environments can pose challenges in terms of data synchronization, security, and interoperability.

Application of Cloud Computing in Libraries

Modern libraries embrace cutting-edge IT infrastructure and services, including AI, cloud computing, and blockchain technology, to better cater to their communities (Suman & Patel, 2021). The introduction of cloud computing has paved the way for exciting opportunities in delivering top-notch library services to patrons. This technology provides a plethora of services that libraries can utilize to economize on technology expenses, enhance their record-keeping and organizational structure, boost productivity and efficiency, and automate processes. According to Suman, Patel and Vijesh (2023) the following are some illustrations of how libraries and other information centres are harnessing cloud computing: cloud-based digital libraries and repositories, library automation, web hosting and cloud hosting services, data storage, cloud OPAC, library community, digital preservation and archiving services, searching scholarly literature, OCLC WorldCat service.

In digital era, the majority of libraries are embracing automation to

streamline their routine tasks. Initially, library automation was managed through locally hosted servers using a diverse range of Integrated Library Management Software (ILMS), which could be either commercial or open-source solutions (Olatunji, Farouq & Idris, 2018). A significant portion of the library's budget was allocated to software licensing, hardware procurement, and yearly maintenance fees. The responsibility for maintaining the entire system rested on the shoulders of the library staff. However, cloud service providers have stepped forward to offer hosting services for these library automation processes on the cloud. According to Quintel and York (2023), this shift to cloud-based solutions liberates libraries from the need to invest in hardware, software licenses, maintenance, and data backup, among other expenses. Cloud OPAC (Online Public Access Catalogue) and cloud ILMS exemplify the cloud-based library automation trend. Additionally, services such as Ex-libris and Polaris are available as cloud-based alternatives for library automation software. This transition to cloud-based solutions offers libraries a more efficient and cost-effective way to manage their operations and resources.

Website hosting is an essential aspect of managing digital or web-based resources. There are distinct differences between hosting the website on a traditional server and hosting it in the cloud. Traditional hosting requires payment for a fixed amount of server space, whereas cloud hosting keeps data stored in cyberspace. With cloud hosting, customers are charged based on the resources they actually utilize, rather than a predetermined storage space (Osborne, 2020). Given the advantages of cloud hosting, many institutions, including libraries, are considering hosting their websites outside their local servers. Tyagi, et al (2015) agreed that websites gain popularity and attract significant traffic, their resource requirements may grow rapidly, much like a thriving library.

This advancement has greatly benefited the research community, making information retrieval and academic literature searches much simpler. Duraspace, through open-source repositories like DSpace and Fedora Commons, plays a crucial role in promoting the sharing of intellectual materials among libraries. Also, Knimbus, a cloud-based research platform, offers researchers and subject-matter experts a collaborative space to learn from and contribute to the study of academic literature. Fakir, et al (2020) noted that using Knimbus, researchers can interact and exchange information, facilitating the labelling, sharing, and discussions of millions of eBooks, journal articles, patents, and other documents within the research community.

Cloud OPAC (Online Public Access Catalogue) is becoming increasingly

prevalent among libraries worldwide. Instead of hosting the library catalogue solely on local servers, cloud-based solutions offer a more user-friendly and convenient way for patrons to access and retrieve resources. Incorporating cloud technology into the OPAC streamlines the entire process, making it more efficient and scalable. Libraries can optimize their services, providing a seamless experience for users without the limitations of relying solely on local servers.

Cloud computing can play a pivotal role in fostering community strength. Libraries can utilize this technology to forge connections among LIS professionals and individuals seeking information on a global scale. Through cloud-based platforms such as Facebook, Twitter, WhatsApp, and others, libraries can create an inclusive and cooperative environment where they openly share resources, services, innovative ideas, and engage in intellectual discussions with the broader library community.

Digital preservation and archiving services streamline the time-consuming process of digitization, minimizing unnecessary repetition. Libraries can preserve their digital collections for the benefit of future generations. One such service is DuraCloud, open-source software developed by DuraSpace, which provides cloud-based support for digital preservation. With DuraCloud, libraries can efficiently migrate their valuable information to the cloud, ensuring safe storage across multiple service providers. Dutt (2015) noted that beyond archiving and preserving data, cloud solutions offer advantages like online backup, easy media access, and seamless online sharing.

Cloud storage services offer a secure and convenient solution for library professionals and staff to preserve and manage their digital documents, records, and files. By storing data in the cloud, libraries can safeguard valuable information from physical loss and damage, reducing the need for physical storage media like hard drives and flash drives (Onwubiko, Okorie & Onu, 2021). Leading cloud storage providers like Google Drive, Microsoft OneDrive, Dropbox, among others, offer reliable and cost-effective options for libraries to benefit from unlimited cloud storage.

The OCLC WorldCat service stands out as a leading cloud-based platform for exploring library data. It greatly enhances the online visibility of libraries and their collections. Operating under the umbrella of OCLC (Online Computer Library Center), the service offers an array of cloud-based library management solutions through its WorldShare Management Services (WMS) (Adams, *et al.* 2017). With WorldShare Management Services, libraries can seamlessly integrate all aspects of their print and electronic resource management workflows, spanning selection, acquisition, circulation, cataloguing, serials control, remote

database searches, and more.

Overcoming Challenges: Implementation Issues in Cloud-Based Library Services

While cloud-based library services offer numerous advantages, their successful implementation can be accompanied by certain challenges. Some common implementation issues that libraries may encounter when adopting cloud-based services and suggests strategies to overcome them.

1. Data Security and Privacy Concerns: One of the primary concerns when transitioning to cloud-based library services is ensuring the security and privacy of sensitive user data. Libraries need to assess the security measures implemented by cloud service providers, including data encryption, access controls, and compliance with industry standards. To address these concerns, libraries should thoroughly evaluate the security practices and certifications of potential cloud vendors. Additionally, implementing data encryption, strict access controls, and regular security audits on the library's end can provide an added layer of protection (Mishra, Alzoubi, Gill, & Anwar, 2022).
2. Vendor Selection and Vendor Lock-In: Choosing the right cloud service provider is crucial for successful implementation. Libraries should carefully evaluate potential vendors based on their reliability, track record, security measures, scalability, and customer support. Libraries should also consider the possibility of vendor lock-in, where migrating away from a specific cloud provider may be challenging or costly. To mitigate this risk, libraries should ensure proper data portability by adopting open standards, establishing clear contractual agreements, and regularly reviewing the vendor's performance and compatibility with emerging technologies (Abioye, et al, 2021).
3. Connectivity and Network Dependence: Reliable and robust internet connectivity is essential for accessing and utilizing cloud-based library services. Libraries need to assess their network infrastructure and bandwidth requirements to ensure seamless access and performance. In cases where network connectivity is limited or unreliable, libraries may consider hybrid solutions, utilizing a combination of local infrastructure and cloud services.
4. Staff Training and Skill Development: The successful adoption of cloud-based library services requires staff members to be proficient in working with the new technologies and tools. Libraries should invest in staff training programs to enhance their knowledge and skills related to cloud computing,

data management, and security protocols.

5. Data Migration and Integration: Moving existing data and systems to the cloud can present challenges in terms of data migration and integration. Libraries should carefully plan and execute the migration process, ensuring data integrity, compatibility, and minimal disruption to services. Collaborating with cloud service providers, libraries can develop a migration strategy that includes data validation, testing, and incremental transfers. Additionally, libraries should consider the integration of cloud-based systems with existing library management systems or other software applications to ensure seamless workflows and interoperability.
6. Service Reliability and Downtime Mitigation: While cloud services generally offer high availability, occasional downtime can occur. Libraries should assess the service level agreements (SLAs) provided by cloud vendors, particularly in terms of uptime guarantees and disaster recovery plans. Libraries can minimize the impact of downtime by implementing backup systems, maintaining local copies of critical data, and establishing redundancy measures.

Transforming Libraries: Enhancing Services in the Digital Age with Cloud Technology

Cloud technology has emerged as a powerful tool that enables libraries to enhance their services, optimize resource utilization, and provide seamless access to information and resources. According to Wada (2018) and Suman, et al (2023) cloud technology is transforming libraries and facilitating their evolution in the digital age as follow:

1. **Efficient Resource Management:** Cloud technology allows libraries to store and manage their collections, databases, and digital resources on remote servers, eliminating the need for extensive local infrastructure. By leveraging cloud-based platforms and applications, libraries can streamline resource management processes, including cataloguing, metadata creation, and content curation. Cloud-based systems provide centralized and scalable storage solutions, enabling libraries to efficiently organize, preserve, and share their resources with users across various locations.
2. **Enhanced Accessibility and User Experience:** Cloud technology enables libraries to deliver information and resources to users anytime, anywhere, on any device with internet access. Cloud-based platforms provide seamless access to digital collections, e-books, journals, and multimedia materials, breaking down geographical barriers and expanding the reach of library services.

3. **Collaboration and Knowledge Sharing:** Cloud-based collaboration tools empower libraries to foster collaboration and knowledge sharing among library staff, researchers, and users. Cloud platforms facilitate real-time collaboration, allowing multiple users to work on documents, projects, and research initiatives simultaneously. Through cloud-based document sharing, virtual meeting spaces, and project management applications, libraries can facilitate teamwork, improve communication, and promote information exchange within and across institutions.
4. **Data Preservation and Disaster Recovery:** Cloud technology plays a vital role in data preservation and disaster recovery for libraries. Cloud storage offers secure and redundant data backup solutions, ensuring the preservation and accessibility of valuable library resources in the event of hardware failures, natural disasters, or other unforeseen circumstances. Cloud-based disaster recovery mechanisms enable libraries to restore critical data and services quickly, minimizing downtime and ensuring continuous access to resources.
5. **Scalability and Cost Efficiency:** Cloud technology provides libraries with the scalability to meet fluctuating demands and optimize resource allocation. Libraries can scale their computing resources up or down based on usage patterns, avoiding the need for extensive hardware investments or underutilization of infrastructure. Cloud services operate on a pay-as-you-go model, allowing libraries to optimize costs by paying only for the resources they utilize. This cost efficiency enables libraries, especially smaller institutions with limited budgets, to access advanced technologies, expand collections, and enhance user services.
6. **Innovation and Future Adaptability:** Cloud technology enables libraries to stay at the forefront of innovation and adapt to future technological advancements. By leveraging cloud-based platforms and services, libraries can easily integrate emerging technologies, such as artificial intelligence, machine learning, and data analytics, into their operations. Cloud-based infrastructure and services provide a foundation for libraries to explore and implement new service models, such as personalized recommendations, virtual reality experiences, and data-driven decision-making.

Conclusion

Cloud computing has emerged as a transformative tool for libraries in the digital era, offering advantages such as optimized resource utilization, improved services, and adaptability. Cloud technology facilitates efficient collection and database management, scalable storage, collaboration among staff and users, and enhanced accessibility. The cost-effectiveness, flexibility, and accessibility of

cloud systems empower libraries to overhaul their operations, eliminating the need for extensive local infrastructure. While challenges like data security, vendor selection, and staff training arise during implementation, proactive strategies can overcome these barriers. Cloud computing's ongoing impact on libraries includes integration with emerging technologies, user experience enhancement, and innovative services, ensuring libraries remain leaders in the digital revolution, providing top-notch personalized services and accessibility.

Suggestions/Way Forward

To revitalize library services in the digital era, a strategic integration of cloud computing can be a powerful approach to optimize information delivery. This involves a comprehensive plan that includes several key steps such as:

1. **Needs Assessment and Planning:** There is need for needs assessment and planning by assessing the specific needs and goals of the library and determining how cloud computing can address existing challenges and enhance user experiences. A clear roadmap outlining the implementation process, from data migration to staff training need to also be designed.
2. **Vendor Selection and Partnerships:** Libraries need to choose reputable cloud service providers that align with the library's requirements and security standards and establishing strong partnerships with vendors to ensure ongoing support, updates, and scalability as the library's needs evolve.
3. **Data Migration and Management:** Implement a well-structured data migration strategy to seamlessly transition existing digital resources and collections to the cloud.
4. **Security Measures:** Address data security concerns by implementing robust encryption, access controls, and authentication mechanisms. Regularly update security protocols to stay ahead of emerging threats and vulnerabilities.
5. **Resource Optimization:** Leverage the scalability of cloud computing to efficiently manage resources. Allocate computing power, storage, and bandwidth dynamically based on demand, eliminating the need for over-provisioning.

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