

**LEVERAGING CLOUD COMPUTING FOR ENHANCED LIBRARY SERVICES AND
EFFICIENT INFORMATION DELIVERY IN THE DIGITAL AGE**

By

OKIKE, BENEDICT O. I

and

OMALI, THERESA O.

Abstract

Cloud computing offers libraries an opportunity to proactively restructure their service delivery and provide efficient information resources to their patrons. This paper explores the role of cloud computing in transforming library services to meet the demands of the digital age. The paper examines various cloud computing services, including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS), and discusses their benefits and characteristics. Furthermore, it explores different cloud deployment models, such as public, private, community, and hybrid clouds, and highlights their respective advantages. The researchers emphasize that cloud computing can empower libraries to share distributed resources, provide real-time information access, and participate in a network of libraries, thereby enhancing collaboration and resource utilization. Additionally, the paper discusses the potential benefits of cloud-based applications in education, business, data storage, entertainment, and other areas. It outlines how cloud computing enables libraries to store, manage, and distribute information resources effectively, facilitating information discovery, sharing, and collaboration. The advantages of cloud computing in terms of cost savings, flexibility, scalability, and accessibility are also highlighted. Finally, the paper addresses potential challenges and problems that libraries may encounter when implementing cloud-based services. Overall, the study underscores the transformative potential of cloud computing for libraries and suggests means to enhance library services in the digital age using cloud technology-enabled solutions.

Keywords: Cloud Computing, Cloud Computing in Libraries, Library Services, Information delivery, Digital Library.

Introduction

In this digital age, libraries need to be smart in their service delivery in order to meet the demands of her users. Aligning on the need for libraries to be smart in their service delivery,

Irenea, Tijani & Bakare (2018) opined that libraries have to be proactive, re-strategize and restructure its mode of service delivery as to meet the information needs of their 21st century clientele. Pal (2014) opined that digital library is a development-oriented hardware and software integration platform which through a technical and product integration that has a kind of digitization. It also provides the platform for effective service delivery. According to Agbo & Anozie (2017) digital era is a period that is characterized by evolution in Information and Communication Technology (ICT).

Cloud computing is a new concept for delivery of application software through internet instead of installing and running the same on a user's computer. Cloud as it applies to information technology is offering remote access to any work-related data. Cloud computing is the on-demand availability of computer system resources, especially data storage and computing power, without direct active management of the user. Cloud computing in Joshi (2015) perspective is a kind of computing technology which facilitates in sharing the resources and services over the internet rather than having these services and resources on local servers/nodes or personal devices. National Institute of Standards and Technology (NIST) (2011) defined Cloud computing as "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction."

Cloud computing is one pathway to bring about significant benefits and create a better future for the society. According to Makori (2015), cloud computing has brought new innovative

ways of empowering the creation, diffusion, utilization and sharing of information, knowledge and intellectual records in organizational libraries, while reducing management related issues. When information is needed on the real time basis, cloud computing ensures it is gotten fast and appropriate (Onwubiko, Okorie & Onu, 2021).

In a related term, cloud computing and its architecture will encourage libraries and their users to participate in a network and community of libraries by enabling them to reuse information and socialize around information (Kamila, 2013). It also provides people the way to share distributed resources and services that belong to different organizations, establishments, libraries and sites via the internet in open environment (Zhu, 2012). Onwubiko, Okorie & Onu, (2021), suggests that it will transform the way systems are built and services delivered, providing libraries with an opportunity to extend their impact to clients and the society at large. This implies that libraries will be able to provide as more efficient information resources as possible especially on real time to her patrons.

The paper highlighted some of the cloud library services that can enhance efficient information delivery in this digital age as well as suggested means of enhancing library services in the 21st century using cloud technology-enabled services. It further suggested some of the problems that can be encountered in using cloud in the delivery of library services.

Cloud Computing Services

Cloud computing services has opened up much more new ways of providing services which are provided in different ways by vendors. It is worth noting that cloud computing customers do not own the physical infrastructure rather they rent the usage from a third-party provider. They

use resources as a service for performing a task and pay only for what they are utilizing. When information technology (IT) organization and vendors provide services to their clients they are in turn utilized by clients on pay-per –use basis. Clients can then access these services provided by vendors using a web-browser. An ideal cloud computing platform should be efficient in its use of resources, scalable, elastic, self-managing, highly available and accessible and inter-operable and portable. The services provided by vendors can be classified in three models that actually depict how services are being provided to the clients, these are

- **Infrastructure as a Service (IaaS):** This model is responsible for providing virtualized computing resources and network resources. IaaS users assemble their own virtual cluster on which they are responsible for installing, maintaining and executing their own virtual cluster on their own software stack. According to Nazir et. al (2020), the user manages the application, data, runtime, middleware and operating system while the vendor manages the virtualization, servers, storage and networking.

In other words, the user may have control over some selected network components as mentioned above but not the cloud infrastructure. The IaaS user can request to handle some operations of the virtual server such as operation systems and its applications. Mohammed & Zeebarec (2021), highlighted some of the characteristics of IaaS as follows

- a) infrastructure services are distributed between host and user
- b) changes are permitted to the service
- c) cost varies in relation to services rendered
- d) model price for the utility provided

e) multiple users are required

f) the services provided are self-service and supply is automatic

IaaS uses different tools for virtualizing and converting physical resources to logical resources that can be provisioned and published to clients as needed. In as much as IaaS provides virtual machines, but it cannot provide elastic computing by itself, where services scale up and down to meet user demand.

- **Platform as a Service (PaaS):** PaaS supplies all the resources required to build applications and services completely by using internet without having to download or install software. PaaS services include application design, development and hosting. Other services include collaboration, web service integration, database integration, security, scaling etc. PaaS leverages dynamic provisioning and multi-tenancy. In summary the user manages the application and data while the vendor manages the runtime, middleware, operating system, virtualization, servers, storage and networking (Nazir et. al 2020).

Users don't have to worry about purchasing hardware and software or hire experts for management of the software and hardware, it provides flexibility in installing software on system, scalability is another advantage of the PaaS. A downfall of the PaaS is the lack of interoperability and portability among providers.

- **Software as a Service (SaaS):** SaaS is the model in which an application is hosted as a service to customers who access it via the internet. It provides us the facility of using different software application, operating system and resources without the need of installing them on your own machine, upgrading and buying licensees. In SaaS we have

application, platform and infrastructure all together. The vendor manages everything which includes the application, data, runtime, middleware, operating system, virtualization, servers, storage and networking (Nazir et. al 2020).

Examples of SaaS are Google Applications, Micro Office365, and Salesforce (CRM Software). Some characteristics, according to Mohammed & Zeebareec (2021), are as follows

- a) users can access the services provided at all times
- b) vendors of this service can host their applications in third party premises
- c) services are available over internet connections through web interfaces

In all these services SaaS suites end users, PaaS suites application developers while IaaS suites network architects.

Cloud Computing and its Applications

Cloud service providers developed applications for users to easily access cloud services with quality of service (QoS) because cloud application plays an important role in service delivery of cloud organization (Nazir et. al, 2020). Cloud computing offers several applications in various fields like education, business, data storage, entertainment, management, social networking and arts, this comes in different forms depending on how it is deployed. According to Koutsogiannis, Mamatas & Tsaoussidis (2018), the deployment models are dependent on the infrastructure of the network. There are four primary cloud deployment models:

Public Cloud: Public clouds are owned by cloud service providers who charge for the use of cloud resources. The basic characteristics of public cloud is that they are homogeneous infrastructure, common policies, shared resources and multi-tenancy, leased or rented

infrastructure and economies of scale. Public clouds also have faster implementation times and are the most scalable option. For small to medium enterprises (SME), public cloud use may be the only affordable option. Public clouds are commonly used for workloads such as collaboration, human resources (HR), and customer relation management (CRM). Amazon's AWS, Microsoft's Azure, Google cloud platform and Rackspace are all public clouds.

Private Cloud: This cloud infrastructure belongs to and is operated by only one organization. Their characteristic is that it is heterogeneous infrastructure; customized policies, dedicated resources, In-house infrastructure and End-to-end control. Private clouds can provide the automation, provisioning, and deployment orchestration benefits associated with cloud computing while still retaining visibility and control over data. They are also well suited to meet high security, availability, and serviceability requirements related to compliance as well as instances in which data must remain within a certain geographic domain (Borovick & Mehra, 2011).

Community Cloud: This cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns for instance mission, security requirements, policy, and compliance considerations. It may be managed by the organizations themselves or by a third party and may exist either on premise or off premise. Using a community cloud allows organizations to benefit from excess capacity within the community rather than having to possibly expand their own data centers to cover occasional excess demand (Kathleen & Rahman, 2011).

Hybrid Cloud: In hybrid cloud, the infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by

standardized or proprietary technology that enables data and application portability. According to Kathleen & Rahman (2011), there are multiple scenarios where the utilization of hybrid clouds is more beneficial than a purely private or public implementation. They state that “compliance requirements may require strict controls over data security, but may allow leveraging a SaaS application from a public cloud to process data held in a private cloud; occasional excess demand may require temporary use of capacity from the public cloud, for example seasonal demand for a retailer; or as a disaster recovery option, storing a backup of a server image on a virtual private cloud in case of a disaster for quick conversion to a hot site”. Conclusively, hybrid clouds can offer the flexibility to rapidly change deployments in order to meet changing business needs.

Role of Cloud Computing in Efficient Library and Information Service Delivery

Libraries of today are not the same as they were decades ago. Libraries are constantly evolving for an effective information delivery while her user thinks, learns, reads, and sees things differently. This has changed the role of libraries in managing e-resources and there is increased need for information as well. Horsfall (2020) is of the opinion that information professionals are not only knowledge managers but also service providers to promote effective library and information service delivery in the digital age. Irenea, Tijani & Bakare (2018) opined that switching services to the cloud environments or running services alongside the traditional library routine will afford the libraries the opportunities to revolutionize service delivery in present-day libraries.

Cloud based services offer libraries new ways to serve users by adapting to work in a digital focused world. Generally, libraries acquire, manage, organize, store and distribute

information resources to her users at a given time. Prasad and Ghosh (2019) noted that cloud computing is a new trend in library which can create the new workforce needed by what they call “smart librarians” due to the fact it offers the opportunity for co-operative platform for libraries to build on. Suman & Singh (2016) asserts that cloud computing helps libraries to maintain the recorded data, private and delicate data and also help by showing their presence on the web.

On libraries showing their presence on the web through cloud computing, the operations and library services can be enhanced through sharing of document to large audience all at the same time, providing current awareness service to all patrons with ease, through creation of union catalogue and giving users access to their collection on one platform, sharing of information resources, information discovery and searching, conducting information literacy and orientation courses, study materials can be stored in different formats such as text, portable document formats (PDF), audios and videos. Kayode, Tella & Akande (2020) is of the opinion that the advancement in Information Communication Technologies (ICTs) and the emergence of web-based technologies have resulted to change in the way information is delivered especially web-based information services delivery in academic libraries.

Information delivery in Cloud Computing World

Internet has become the primary platform for libraries to build and deliver information resources and services. Moreso, the internet has made it easier to access data in these modern times with increase in availability of web enabled devices like smartphones, tablets, laptops and personal computers. The advantages of moving a library to the world of cloud computing is enormous. Most importantly file sharing is the primary benefit of cloud computing where the

library can use, save and store her large collections with multiple formats and also have a back-up facility where necessary. This helps to reduce the cost of managing and maintaining IT system for running a library. Libraries can use cloud resources of its service providers instead of spending funds for procuring costly systems and equipment. When connected to the internet librarians can access the stored files from any compactible device and there will be no need of large internal storage system while its users can access its resources from any part of the world with the required credentials. Libraries adopting cloud-based resources and services will thereby increase reach, foster efficiency in service delivery, create more opportunities for collaboration, reduce need for inhouse technical expertise, save costs, and improve services with faster access to the latest IT functionality (Irenea, Tijani & Bakare, 2018).

According to Tyagi, Passi & Baberwal (2015), services of cloud computing may be applied in areas like building digital library, searching library data, library automation, search services, website hosting, searching scholarly content, file storage and building community power in such that information seekers on a global level connect to one another which led to more intellectual conversations along with innovative ideas may be shared and implemented in a powerful approach. Enefu, Gbaje & Aduku (2015) suggested that cloud computing can transform the way information systems are built and services delivered which provides library with an opportunity to extend its impact to its users anywhere anytime. Similarly, Gandotra, Tyagi & Tiwari (2019), states that libraries are shifting their services with the attachment of cloud and networking with the facilities to access these services anywhere and anytime. They further note that cloud computing plays a major role in library management in areas like building digital

library/repositories, searching library data, building community power, library automation and house-keeping activities and library website hosting.

Additionally, Kumar (2017) asserted that application of cloud computing technologies in libraries can be beneficial in different ways, such as cost saving, flexibility and innovation, user centric, openness, transparency, availability of resources at all times and creating and collaborating with other participating libraries. To corroborate further on the benefits of applying cloud computing technology in the library, Gandotra et.al (2019) enumerates things like saving cost, easy on installation and maintenance where libraries need not to worry about constant server updates and other computing issues, highly automated in such that the library staff need not have to worry about keeping the software up-to-date., shared resources and better mobility where the staff and the users of the library can connect to the library servers from any place, rather than having to remain present at their desks by having a PC and internet access in as much as there might be concern of security and privacy. Mosenia et.al (2017) noted that the need for data protection increased in recent years due to numerous attacks on different computers and this is where the cloud plays a very important role in securing the digital world.

Shortcomings of Cloud Computing in Library Services

Although its benefits are quite enormous, security and privacy are still a major concern to its wide acceptability. Prasanth (2012) opined that Cloud service providers (CSPs) are separate administrative entities, so moving to the commercial public cloud reduces the direct control over the systems that manage their confident data and valuable applications. In this case, the paper went further to suggest that CSPs' infrastructure and management capacities are much more

powerful and reliable than those of personal computing devices, that makes cloud platform to face both internal and external security and privacy threats.

According to Dumka, Memoria & Ashok (2019), there are few common security and privacy issues specifically associated with running cloud applications such as data security and authenticity issues, application security issues, virtualization security issues. Furthermore, Nazir et. al 2020 enumerates security threats in cloud computing as insecure interface, unauthorized access, data leakage, malicious attack and denial of service attack. To corroborate this, Dutt (2015) notes that cloud computing like any other technology has its shortcomings which include; privacy and security of data, network connectivity and bandwidth, providers' supreme power, limited flexibility, cost and lack of technical know how. Additionally, Kumar (2017) suggests that dependency on internet, downtime, limited control and flexibility, cloud computing platform dependencies and cloud computing costs are some of the shortcomings associated with cloud computing.

According to Panetta (2017), major challenges identified in its study on cloud computing include insufficient budget, lack of resources, poor ICT infrastructure, inadequate Internet connectivity, lack of management support, constant breakdown of hardware among others.

The results of the study by Kayode, Tella & Akande (2020), imply that lack of in-house expert, unreliable and epileptic power supply, lack of resources, poor ICT infrastructure, constant breakdown of hardware, inadequate Internet connectivity are all significant challenges facing cloud computing adoption for Web-based service delivery in academic libraries in Kwara State.

Mishra (2016) identified challenges of cloud computing as insufficient budget, lack of resources,

poor ICT infrastructure, inadequate Internet connectivity, lack of management support, constant breakdown of hardware among other things.

Recommendation

1. **Embrace cloud computing:** Libraries should actively consider adopting cloud computing technologies and services to enhance their information delivery capabilities. They should assess their specific needs and choose the appropriate cloud deployment model (public, private, community, or hybrid) that aligns with their requirements.
2. **Develop cloud-based applications:** Libraries should explore the development of cloud-based applications that provide seamless access to information resources, enable collaboration among users, and offer innovative services. These applications should be user-centric, flexible, and adaptable to the evolving needs of library patrons.
3. **Ensure data security and privacy:** Libraries must prioritize data security and privacy when migrating to cloud-based systems. They should carefully select reputable cloud service providers that offer robust security measures and compliance with relevant regulations. Additionally, libraries should implement strong access controls, data encryption, and regular backups to safeguard sensitive information.
4. **Foster collaboration and resource sharing:** Cloud computing enables libraries to collaborate with other institutions and share resources, fostering a sense of community and expanding access to a wider range of information. Libraries should actively participate in collaborative networks, consortia, and digital repositories to maximize the benefits of cloud-based resource sharing.

5. Provide training and support: Libraries should invest in training programs to equip staff members with the necessary skills and knowledge to effectively utilize cloud computing technologies. Adequate training and support will ensure smooth adoption and integration of cloud-based systems into library operations.
6. Monitor emerging trends: Libraries should stay abreast of emerging trends and developments in cloud computing and related technologies. This will enable them to leverage new innovations and adapt their services accordingly, staying at the forefront of information delivery in the digital age.
7. Ensuring safe web access: These include setting a strong password, ensuring antivirus, antispyware and firewall software are installed, and ensuring that their operating system and web browser(s) are always updated with the latest security patches.

Conclusion

By embracing cloud computing and leveraging its potential, libraries can transform their service delivery, provide more efficient access to information resources, and better meet the evolving needs of their users in the 21st century. Cloud computing can be applied in all the services in library which implies a service-oriented architecture, reduced information technology overhead for the end user, great flexibility, reduced total cost of ownership, on demand services thereby lowering the total costs of managing library collections and exchanging the both library users experience and library staff workflows.

Cloud computing offers libraries new opportunities to enhance their information delivery services. By leveraging cloud-based resources and services, libraries can increase their reach, improve efficiency, foster collaboration, and provide faster access to the latest IT functionality.

The paper discusses how cloud computing can facilitate tasks such as building digital libraries, searching library data, automating library processes, hosting library websites, and creating a community of information seekers. Cloud computing will benefit the library in different ways and support more innovations. In this case libraries can now pay full attention on gathering library resources rather than paying attention on the technical aspects. With cloud-based applications, libraries are on the path to enhance their services very effectively and efficiently.

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