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A Comparative Review of Cloud Computing Deployment Models for Academic Libraries

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Abstract

Cloud computing technology has evolved as a technology of great effect and impact that provides businesses with better enhancement in dealing with business. Academic libraries that is gradually adopting this technology are getting transformed in terms of their various digital service deliveries. Many academic libraries are not aware of the availability of different types of cloud deployment models, hence it is a pressing present challenge to many academic libraries as they have no idea of the multiple model to be selected from not to mention selecting the suitable model. This review examine the major cloud deployment models including: public, private, hybrid and community cloud, evaluate their benefits, limitations and evaluate their suitability for academic library operations. Key evaluation criteria considered include costs of deployment, security,

data privacy, control, scalability, ownership and maintenance. The analysis shows that each model provides very dissimilar benefits and limitations based on the various needs and capacity of institutions. Public cloud deployment model provides very high scalability with low cost of deployment but it gives limited control of data and infrastructure. Private cloud deployment on the other hand offers very high security, control and data privacy but requires high cost and technicalities. Hybrid cloud model combines the efforts of both public and private to achieve the collective benefits and the combined limitations though partly. The community cloud provides collaboration of resources thereby enhancing active sharing. In all, the review do not identify any one model as universally suitable, the choice depends on library requirements.

Keywords: Cloud Computing, Academic Libraries, Cloud Deployment Models, Library Operations, Private Cloud, Hybrid Cloud

1. Introduction

Cloud computing as a technology to individual and organizations of all sizes that provides cost effective flexible and scalable way to access and utilize technology resources with or without the need for extensive on-premises infrastructure is gradually adopted by Academic libraries in order to continue to thrive in the digital era and play a vital role in connecting individuals or information seekers to information and fostering human connections.

The recent technology trend in libraries and information centers is the use of Cloud Computing as a strategic tool to provide seamless library services with quality cost-effectively or economically. (Shivakrishna & Kumar, 2024) ^[26]. The services carried out by the academic libraries entails circulation services, cataloguing, classifying Services and reference services all of which are featured in an integrated Library Management Software and other important services like E-library services, Website and Institutional repository services. All of the services are required to operate on a technology where they can be effectively housed and manage for enhanced services. The technology capable of handling the need better is cloud computing technology.

1.1 Problem Statement

The awareness that demand for cloud computing has led to different types of cloud deployment models (Hiral & Nirali, 2021) ^[9], but according to Mabawonku *et al.*, (2024) ^[15] primary challenge among others in adopting cloud computing is the lack of awareness and understanding among library staff. It was identified by Krishnamurthy and Arali (2024) ^[14] that Lack of awareness and unwillingness attitude of librarians towards cloud computing is a major challenge in the libraries, while Muhammed (2019) ^[20] opined that librarians are not fully aware of the cloud computing technology, Hiral and Niral (2021) ^[9]

also identified the recent problem from another study as people do not know which cloud is suitable according to their requirements; they cannot choose the right cloud for their services among the different clouds managed by different cloud providers, these aforementioned issues in association with low adoption of cloud computing technology by the academic libraries demands that libraries get more awareness and understand the major cloud deployment models for effective deployment accordingly.

1.2 Aim and Objectives

This review aims to address this need by synthesizing the existing literature on cloud deployment models and evaluating their relevance to academic libraries. The scope of this review paper covers the description of deployment models, investigation of the major cloud computing deployment models and relevance to academic libraries. How each of the models can benefit the library various operations, putting into consideration, factors such as cost, security of data, scalability and control.

The specific objectives of this paper are:

1. To examine the major cloud deployment models to academic libraries.
2. To analyze the benefits and limitations of each deployment model to academic libraries.
3. To evaluate the suitability of each cloud deployment model for various academic library operations.

2. Cloud Computing and Academic Libraries

Cloud Computing is an on-demand access to computing resources – physical or virtual servers, data storage, networking capabilities, application development tools, software, AI-powered analytic platforms and more over the internet with pay-per-use pricing. (Susnjara & Smalley, 2025) [29].

A cloud service company which is an information technology business offers business scalable resources accessible on demand via a network consisting of cloud based computing, storage, platforms, and applications (Borra, 2024) [6]. Taking advantage of the services provided by the cloud technology can be accessed via business with the commercial cloud service providers or by privately owned cloud service as the case maybe which improve not only staying agile in a rapidly changing market world today but also reducing IT costs and improving operational efficiency whereby Libraries are also keeping up with this change for efficient service delivery. Adam (2023) [1] described Libraries as places where you can find anything you need and learn about any subject you are interested in. they are knowledge centers where you can learn from history to science to literature and more. Academic library is identified as one of the major types of libraries.

Academic libraries are known as libraries established in higher tertiary institutions such as universities, polytechnics, moo-technics, colleges of education, college of Agriculture, institutes of Technology and the like to play strategic role in complementing the vision and mission of their parent body (Bashorun *et al.*, 2020) [5].

In a study by Krishnamurthy and Arali (2024) [14] academic libraries have been using the cloud computing services such as online databases and large union catalogues for over a decade. He mentioned that while planning to use third party services one need to have thorough idea about the whole system and should search and find out the standard company

who has experience in handling such services. They identified service providers that can provide cloud services for library as Ex Libris, Duracloud and Polaris Library System. While also Sivankalai (2021) [28] pointed the key players in cloud computing platforms as: AWS Inc., Google Cloud and Microsoft Azure.

3. Applications of Cloud Computing in Academic Libraries

Wada (2018) [31] identified that the missions of library are now been fulfilled and manifested by the presence of cloud-based solutions due to its support and facilitation of online electronic resources and services provision. Cloud computing services covers many library management services, such as linking, circulation, acquisitions and dissemination (Sahu *et al.*, 2016; Mcmanus, 2016) [25, 17] in relation to Krishnamurthy and Arali (2024) [14] who identified related area of application of cloud technology in various forms of the library activities such as; Automation, Web hosting, Search services, storage and digital library services.

Automation: Where different commercial software or open source integrated library management software are now deployed on some of the cloud vendors.

Web hosting: Most of the libraries prefer to host their websites with third party service providers rather than hosting and maintaining their own servers due to dearth of required technical manpower to maintain the servers.

Search services: Using commercial or open source solutions libraries have already migrated key services such as OpenURL providers, and federated and pre-indexed search engines on the cloud.

Storage: The cloud computing has brought new services, which even offer space at no cost to store the files and documents. For example, cloud storage services such as Dropbox, Google Drive, Microsoft OneDrive, Amazon Cloud Drive and other initiatives offer storage space on the cloud to enable libraries and other organizations including individuals to store and share their documents.

Digital library services: DSpace, Greenstone, EPrints, Fedora Commons etc are some of the open source software for providing open access to scholarly resources which some libraries have deployed on the cloud technology for better and easy access.

4. Cloud Computing Deployment Models

Generally speaking, deployment is the process of making software available and ready for use. In cloud context, deployment is basically where the software is made available (Akhouri & Wasim, 2022) [2]. Cloudvisor defined cloud deployment models as how cloud services are delivered and managed. They determine how resources such as storage, computing power, and applications are allocated and accessed. (Kim *et al.*, 2014) in (Wada, 2018) [31] established a description of Cloud deployment model such that it is a platform of relationship between vendor and client based on agreement to access whole or part of the cloud technologies via Internet and in line with needs and demand of the users.

Cloud deployment model therefore, can then be defined as not just making computing resources available but where, who and how this resources are presented for use and managed.

Google Cloud which is one of the top cloud computing

provider (Sivankalai, 2021) ^[28], acclaim three different types of cloud deployment models that help deliver cloud computing services as public cloud, private cloud and hybrid cloud. The largest online programming learning website W3Schools (Mitharam, 2024) ^[18], also confirm there are three different kinds of deployment models: cloud-based as public, On-premises as private and Hybrid cloud. The study by (Wada, 2018) ^[31] identified that deployment model of cloud computing can be categorized into four, which are, private cloud, community cloud, public cloud and hybrid cloud. A study by (Hiral & Nirali, 2021) ^[9] identified six model out of which five are the main models; Private Cloud, Public Cloud, Hybrid Cloud, Community Cloud, Virtual Private Cloud. Inter-Cloud as the other which can be in two types: Federated Clouds and Multi-clouds.

While cloud computing continues to evolve, this paper will focus study on the identified models by the National Institute of Standards and Technology (NIST), consisting of Public, Private, Hybrid and Community Cloud.

4.1 Public cloud deployment model

The public cloud is the most commonly deployed model where cloud services are delivered via the internet by third party providers such as Google Cloud Platform (GCP), Amazon Web Services (AWS) and others. The basic characteristics of public cloud is that they are homogenous infrastructure, common policies, shared resources and multitenancy, leased infrastructure and economies of scale. (Okike & Omali, 2023) ^[22]. The study by Wada (2018) ^[31] stated that this cloud deployment model may be owned, managed, and operated by a business, academic, or government organization, or a combination of them and it usually exists on the premises of the cloud provider.

Benefits

1. No Infrastructure Management – the organization does not require any infrastructure management by in-house team to utilize the public cloud (Patil *et al.*, 2022) ^[24]. The cloud service providers fully fund and manage the entire infrastructure.
2. Cost – effectiveness: there are a couple of public cloud providers, which lead to competitive pricing among them. A study by Nworie *et al.* (2023) ^[21], opined funding challenge has been a big challenge right from the time of colonial government in Nigeria till date. He stated that the budget of academic libraries in the 21st century has risen high. At the moment, the best of any academic library in Nigeria in the 21st century is hybrid enabled, hosting a combination of print and electronic resources.
3. Cloud computing technology can be deployed to effectively utilize the little and inconsistent available fund provided in academic libraries considering the benefit of cost effectiveness provided by public cloud deployment model which also provide minimal investment advantage as the services used are charged as a pay-per-use base (Patil *et al.*, 2022) ^[24].

Limitation

1. Security & Privacy are major concern to cloud because moving to the commercial public cloud reduces the direct control over the systems that manages data and valuable applications deployed (Okike & Omali, 2023)

^[22]. Public cloud does not regulate data privacy and residency satisfaction.

2. Shared tenancy which is also known as shared resources potentially not only impact performance, but also could affect the policies and governance related to an organization's data security and integrity.
3. Internet Connectivity: Public Cloud requires a stable internet connection to function (Indraji & Satishkumar, 2025) ^[11]. The library would have to also invest in internet infrastructure in order to have smoother access to the public cloud deployed.
4. Service Provider Reliability: A technical service provider's capability is just as crucial as their cost. The reputation and sustainability of the service supplier should be the primary concerns. Public cloud deployment model require dependency on third party service providers for infrastructure and support (Indraji & Satishkumar, 2025) ^[11].

4.2 Private cloud deployment model

The private cloud model as the name suggests is the type that is used by one organization, not sharing with any organization. The infrastructure of this type can be self-managed by the organization or outsourced to third party but the distinctive feature is that it is used to service solely one organization (Anike & Otubelu, 2024) ^[4].

The private cloud deployment model is also called as the internal or corporate model. A private cloud belongs to a specific organization. While a third party (for example, a service provider) can host a private cloud server, most companies choose to keep the hardware in their local data Centre (Hiral & Nirali, 2021) ^[9].

A cloud service provider, Google Cloud identified types of private cloud as: On-premises private cloud, Virtual private cloud, Hosted private cloud and managed private cloud.

Benefits

1. Scalability: Private cloud model has a high tendency of attaining a high scalability as there are no other system tenants and depending on the institution available hardware infrastructure (Hiral & Nirali, 2021) ^[9].
2. Security & Privacy: The private cloud model has a very high security and ideal for corporate data. It offers a greater degree of security because it is private (Sivankalai, 2021) ^[28].
3. In-House Management: Some organizations prefer to manage their cloud infrastructure in-house, maintaining full control over data center operations, maintenance, and security protocols (Harness Team, 2024) ^[8].

Limitation

A study by Joshi (2025) ^[12] identified higher cost as a limitation of private cloud deployment model such that setting up and maintaining a private cloud requires significant upfront investment in hardware, software and potentially data center facilities. Ongoing operational costs are also higher compared to using a public cloud.

A study conducted by (Wu, *et al.*, 2014) ^[33] on the migration of digital library system to private cloud was faced with the following challenges which are possible limitation of private cloud deployment model. The challenges include the following: System Compatibility, Resource Allocation and Configurations.

4.3 Hybrid cloud deployment model

Hybrid clouds combine elements of both private and public clouds, allowing organizations to leverage the benefits of each deployment model combined (Harness Team, 2024) ^[8]. Academic libraries are starting to use hybrid cloud models, which blend private and public cloud services (Indraji & Satishkumar, 2025) ^[11].

Hybrid cloud model is made from combination of two or more than two clouds which may be public or private or community cloud in such a way that its environments appear as a single cloud with implementing standards in order to provide services.

Benefits

1. The main benefit of deploying hybrid cloud is that it provides the scalability and low costs of a public cloud without exposing mission critical applications and data to third party.
2. These approaches provide greater flexibility by enabling libraries to store sensitive data in private clouds and use public clouds for less important workloads. (Indraji & Satishkumar, 2025) ^[11].

Limitations

Vendor Lock-in: Choosing a cloud computing vendor often locking the business into using their proprietary applications or formats. For instance, it is not possible to insert a document created in another application into a Google Docs spreadsheet. Furthermore, a library needs to be able to add and/or subtract cloud computing users as necessary as its services grow or contracts (Krishnamurthy & Arali, 2024) ^[14].

4.4 Community cloud deployment model

A community cloud is a cloud infrastructure that allows a group of organizations in the same community to share the same computing resources, such as servers, data storage, etc, in order to save costs and improve efficiency (Singh, 2024) ^[27].

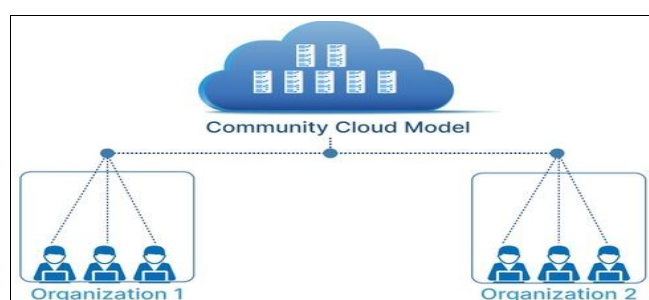


Fig 1: Community Cloud (Singh, 2024) ^[27]

Benefits

Here are some benefits of community cloud model as identified by (Kostic, 2024) ^[13]:

1. Cost efficiency: Sharing infrastructure reduces individual capital and operational expenditure. Organizations benefit from economies of scale in purchasing and maintaining hardware and software.
2. Flexibility and scalability: Community clouds ensure compatibility among each user, allowing them to modify properties according to their use cases. They are scalable in various aspects, such as hardware resources, services, and manpower.

3. Enhanced security and compliance: Tailored security measures address the specialized needs of a community, providing higher protection than generic solutions. Users also do not have to worry about the security concerns linked to public clouds because of the closed user group.
4. High availability and reliability: Community clouds secure your data by replicating data and applications in multiple secure locations to protect them from unforeseen circumstances. The cloud possesses redundant infrastructure to ensure data is available whenever and wherever you need it.
5. Convenience and control: Conflicts related to convenience and control does not arise in a community cloud. Democracy is a crucial factor, as all tenants share and own the infrastructure and make decisions collaboratively. This setup allows organizations to have their data closer to them while avoiding the complexities of a private cloud.

Limitation

1. Internet Connectivity: Constant internet connection is also required here since the model combine more than one cloud model.
2. Security in terms of data loss, leakage and system crash is guaranteed, since the account service is always monitored by the third party to avoid traffic hijacking and malicious insider (Hussaini *et al.*, 2017) ^[10].
3. An article by a software dealer who deals also in cloud services Patel (2022) ^[23] identified the following as the limitation of community cloud model:
 - (i) Because this model relies on finding companies with comparable criteria, it's still less popular than other deployment models.
 - (ii) Bandwidth and storage capacity might be an issue when numerous firms share the same resources.
 - (iii) You get excellent performance with limited scalability.

5. Suitability for Academic Library Operations

Determining the appropriate cloud deployment model for academic libraries is dependent on the level of support the deployment model has on various operations of the library, data protection, scalability provided and the available financial resources. A study by (Momoh & Folorunsho, 2019) ^[19] revealed the roles of libraries and librarians as Custodian of information such as providing access to electronic and physical materials, maintaining specialized knowledge of digital databases, evaluating and acquiring more and newer electronic materials. Also as Guardian of information, this entails educating patrons about the use of digital library services and providing virtual services to users.

Wani and Ayoub (2023) identified the major roles performed in the library to include: acquisition, cataloguing and classification, storage, retrieval, and service provision. Having spelt out the roles of academic libraries including librarians operations, it is therefore verified that academic libraries manage abundant of information which requires use of various digital services such as electronic resources management, institutional repositories, data curations and more. The choice of deployment model is therefore required to balance performance, security and cost-effectiveness.

Public cloud deployment is suitable for academic libraries

that prioritize both immediate affordability and scalability of computing resources upon deployment. Services including the library website, Online Public Access Catalogues (OPACs) and institutional repositories are found appropriately fitting in this model. Public cloud services eliminates the need for huge financial investment as cloud provider organizations get paid gradually for cloud services leading to cost effectiveness (Sivankalai, 2021) ^[28] and low infrastructure management as identified by (Patil *et al.*, 2022) ^[24]. The concerns driven by the benefits of this model are not limited to data privacy and limited control of resources such as the data, and other resources like the infrastructure.

Private cloud is suitable for academic libraries whose focus is centered more on security of data, privacy and control. Academic libraries that are more inclined to dealing with research information and data handling would consider prioritizing security more highly whereby privacy is not lacking to justify the level of the security. The longing for security and privacy brings about the need for data and machine control, depending on the level of control in demand by the library. This deployment model is appropriate for providing the aforementioned services, such that tools for institutional repository, integrated library systems, website and other library digital services can be hosted without using shared resources externally especially for confidential and sensitive resources.

Despite that this model tackles the issues of security and privacy with control that the public deployment model is mostly deficient of, some other difficulties arises from this model which is on the aspect of huge initial investment capital for setting up and managing the private cloud infrastructure not excluding the maintenance.

Hybrid cloud deployment model marries both the public and

private cloud bringing together the combination of the benefits whereby the weakness of one is settled by the challenge the other. This model is suitable for libraries whose concern is not limited to affordability alone but also care about control and security of data. The hybrid cloud models offer dynamic scaling of resources, pays- as- you-go costs and better compliance with industry standards by keeping critical data inside private environments. For instance, such mission- critical applications or sensitive information can be kept inside a private cloud. However, the public cloud can be used for less sensitive workloads, requiring greater scalability and higher processing power (Mahalingam & Mahalakshmi, 2026). The organization using the hybrid cloud can manage an internal private cloud for general usage and migrate the entire or a part of an application to the public cloud during the peak periods.

Community cloud deployment model is a more secured deployment model compared with the public cloud, but a less secured model compared with a private cloud. This model is better choice for academic libraries that longs to develop the idea of library consortia and interlibrary loan require relying on cooperative infrastructure where by other neighboring libraries having a shared goal form a network to share resources. For instance, universities in Malaysia have adopted community cloud models for increasing mobile learning and inter-institutional collaboration (Chhaya *et al.*, 2021) ^[7].

6. Comparative Analysis

The previous sections examined the features, benefits, limitations and suitability of the major cloud deployment model for academic libraries. Table 1 below shows the summary of the comparative suitability of each deployment model as revealed in the reviewed literature.

Table 1: Summary Comparative Analysis of Cloud Computing Deployment Models for Academic Libraries

Evaluation Benchmark	Public Cloud Model	Private Cloud Model	Hybrid Cloud Model	Community Cloud Model
Ownership	Third-party provider	The institution (single)	Shared (institution + cloud provider)	Consortium/shared institutions
Cost of Deployment	Low	High	Moderate	Moderate
Operational Cost	Low-Moderate	High	Moderate	Moderate
Control	Low	Very High	High	Moderate-High
Data Security	Moderate	Very High	High	High
Data Privacy	Low	Very High	High	High
Scalability	Very High	High (Conditional)	High	Moderate
Maintenance	Provider	Institution	Shared (institution and vendor)	Shared (institution and vendor)
Ease of Deployment	Easy	Difficult	Moderate	Moderate
Compliance	Moderate	Excellent	Excellent	High
Vendor Lock-in Risk	High	Low	Moderate	Low
Overall Suitability	Moderate	Very High	High	High

7. Conclusion

These models describe the major cloud deployment models into public, private, hybrid and community. The benefits and limitations of each model were identified along with their suitability to academic libraries.

No one deployment fits all dealings of the academic libraries as every institution operates based on their capability in terms of funding capacity, data privacy regulations, and size of services rendered. Therefore each academic library has unique constraints that determine the choice of cloud deployment model. Following the review of cloud computing deployment models, an area of attention for future research emerges. Mostly public cloud and a bit more of hybrid model are dominant in available cloud computing

literatures, considering this, future studies should concentrate specifically on the suitability and technical deployment of private cloud for academic libraries.

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