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Cloud Services in Libraries for Efficient Information Delivery

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Writing on the importance of internet stated that student offering correspondence course in Africa have the benefit of the use of e mail and World Wide Web to embark on studies online. Consequently, time and distance is no longer a barrier to research because at any time of the day, contact can be made to gather the needed information from anywhere in any part of the world. Given the many different cloud services and capabilities of the public cloud, there has been some confusion between cloud computing and major uses, such as web hosting. While the public cloud is often used for web hosting, the two are quite different. A cloud service has three distinct characteristics that differentiate it from traditional web hosting. Users can access large amounts of computing power on demand. It is typically sold by the minute or the hour. It is elastic -- users can have as much or as little of a service as they want at any given time. The service is fully managed by the provider -- the consumer needs nothing but a personal computer and internet access. Significant innovations in virtualization and distributed computing, as well as improved access to high-speed internet, have accelerated interest in cloud computing. Nigeria is linked to the internet hence it is possible for Nigerian researchers to access up to date information from the net to make their research, journal articles, conference/ workshop/ seminar papers, technical reports, scientific findings known worldwide. The cloud service market has no shortage of providers.

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INTRODUCTION

According to Chai (2022) Cloud computing is a general term for anything that involves delivering hosted services over the internet. These services are divided into three main categories or types of cloud computing: infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS). Tella…et al. (2007) in Okello-Obur and Ikoja-Odongo (2010) affirmed that the students' ability to find and retrieve information effectively is a transferable skill useful for their future life as well as enabling the positive and successful use of the electronic resources while at school.

A cloud can be private or public. A public cloud sells services to anyone on the internet. A private cloud is a proprietary network or a data center that supplies hosted services to a limited number of people, with certain access and permissions settings. Private or public, the goal of cloud computing is to provide easy, scalable access to computing resources and IT services.

Cloud infrastructure involves the hardware and software components required for proper implementation of a cloud computing model. Cloud computing can also be thought of as utility computing or on-demand computing.

The name *cloud computing* was inspired by the cloud

symbol that's often used to represent the internet in flowcharts and diagrams.

How does cloud computing work?

Cloud computing works by enabling client devices to access data and cloud applications over the internet from remote physical servers, databases and computers. For proper management, Nworu and Enwereuzor (2006) pointed out that the application of basic information technology and system to meet the expectation of modern users, whose focus have turned world class, has become imperative.   In essence, any university that wants to be relevant and up to date in this information age must be ICT-friendly. An internet network connection links the front end, which includes the accessing client device, browser, network and cloud software applications, with the back end, which consists of databases, servers and computers. The back end functions as a repository, storing data that is accessed by the front end.

Communications between the front and back ends are managed by a central server. The central server relies on protocols to facilitate the exchange of data. The central server uses both software and middleware to manage connectivity between different client devices and cloud servers. Typically, there is a dedicated server for each individual application or workload.

Cloud computing relies heavily on virtualization and automation technologies. Virtualization enables the easy abstraction and provisioning of services and underlying cloud systems into logical entities that users can request and utilize. Automation and accompanying orchestration capabilities provide users with a high degree of self-service to provision resources, connect services and deploy workloads without direct intervention from the cloud provider's IT staff (Chai 2022).

Types of cloud computing services

Cloud computing can be separated into three general service delivery categories or forms of cloud computing:

1.   **Infrastructure as a service (IaaS)** is a type of cloud computing service that offers essential compute, storage, and networking resources on demand, on a pay-as-you-go basis. IaaS providers, such as Amazon Web Services (AWS), supply a virtual server instance and storage, as well as application programming interfaces (APIs) that let users migrate workloads to a virtual machine (VM). Users have an allocated storage capacity and can start, stop, access and configure the VM and storage as desired. IaaS providers offer small, medium, large, extra-large, and memory- or compute-optimized

instances, in addition to enabling customization of instances, for various workload needs. The IaaS cloud model is closest to a remote data center for business users.

2.   **Platform as a service (PaaS):** In the PaaS model, cloud providers host development tools on their infrastructures. Users access these tools over the internet using APIs, web portals or gateway software. PaaS is used for general software development, and many PaaS providers host the software after it's developed. Common PaaS products include Salesforce's Lightning Platform, AWS Elastic Beanstalk and Google App Engine.

3.   **Software as a service (SaaS)** is a cloud-based software delivery model in which the cloud provider develops and maintains cloud application software, provides automatic software updates, and makes software available to its customers via the internet on a pay-as-you-go basis**.** SaaS is a distribution model that delivers software applications over the internet; these applications are often called *web services*. Users can access SaaS applications and services from any location using a computer or mobile device that has internet access. In the SaaS model, users gain access to application software and databases. One common example of a SaaS application is Microsoft 365 for productivity and email services in Libraries for students' research.

Cloud computing deployment models

Private cloud services are delivered from a business's data center to internal users. With a private cloud, an organization builds and maintains its own underlying cloud infrastructure. This model offers the versatility and convenience of the cloud, while preserving the management, control and security common to local data centers. Internal users might or might not be billed for services through IT chargeback. Common private cloud technologies and vendors include VMware and OpenStack.

In the public cloud model, a third-party cloud service provider (CSP) delivers the cloud service over the internet. Public cloud services are sold on demand, typically by the minute or hour, though long-term commitments are available for many services. Customers only pay for the central processing unit cycles, storage or bandwidth they consume. Leading public CSPs include AWS, Microsoft Azure, IBM and Google Cloud Platform (GCP), as well as International Business Machine, and Oracle.

A hybrid cloud is a combination of public cloud services and an on-premises private cloud, with orchestration and automation between the two. Companies can run

mission-critical workloads or sensitive applications on the private cloud and use the public cloud to handle workload bursts or spikes in demand. The goal of a hybrid cloud is to create a unified, automated, scalable environment that takes advantage of all that a public cloud infrastructure can provide, while still maintaining control over mission-critical data.

In addition, organizations are increasingly embracing a multi-cloud model, or the use of multiple IaaS providers. This enables applications to migrate between different cloud providers or to even operate concurrently across two or more cloud providers.

Organizations adopt multi-cloud for various reasons. For example, they could do so to minimize the risk of a cloud service outage or to take advantage of more competitive pricing from a particular provider. Multi-cloud implementation and application development can be a challenge because of the differences between cloud providers' services and APIs.

Multi-cloud deployments should become easier, however, as providers' services and APIs converge and become more standardized through industry initiatives such as the Open Cloud Computing Interface.

A community cloud, which is shared by several organizations, supports a particular community that shares the same concerns -- e.g., the same mission, policy, security requirements and compliance considerations. A community cloud is either managed by these organizations or a third-party vendor and can be on or off premises.

Characteristics and advantages of cloud computing

Cloud computing has been around for several decades now, and today's cloud computing infrastructure demonstrates an array of characteristics that have brought meaningful benefits for businesses of all sizes. Some of the main characteristics of cloud computing are the following:

- **Self-service provisioning.** End users can spin up compute resources for almost any type of workload on demand. An end user can provision computing capabilities, such as server time and network storage, eliminating the traditional need for IT administrators to provision and manage compute resources.
- **Elasticity.** Companies can freely scale up as computing needs increase and scale down again as demands decrease. This eliminates the need for massive investments in local infrastructure, which might or might not remain active.
- **Pay per use.** Compute resources are measured at a granular level, enabling users to pay only for the resources and workloads they use.

- **Workload resilience.** CSPs often implement redundant resources to ensure resilient storage and to keep users' important workloads running -- often across multiple global regions.
- **Migration flexibility.** Organizations can move certain workloads to or from the cloud -- or to different cloud platforms -- as desired or automatically for better cost savings or to use new services as they emerge.
- **Broad network access.** A user can access cloud data or upload data to the cloud from anywhere with an internet connection using any device.
- **Multi-tenancy and resource pooling.** Multi-tenancy lets numerous customers share the same physical infrastructures or the same applications yet still retain privacy and security over their own data. With resource pooling, cloud providers service numerous customers from the same physical resources. The resource pools of the cloud providers should be large and flexible enough so they can service the requirements of multiple customers.

An overview of cloud features and characteristics

These characteristics support a variety of important benefits for modern business, including the following:

- **Cost management.** Using cloud infrastructure can reduce capital costs, as organizations don't have to spend massive amounts of money buying and maintaining equipment. This reduces their capital expenditure costs -- as they don't have to invest in hardware, facilities, utilities or building large data centers to accommodate their growing businesses. Additionally, companies don't need large IT teams to handle cloud data center operations because they can rely on the expertise of their cloud providers' teams. Cloud computing also cuts costs related to downtime. Since downtime rarely happens in cloud computing, companies don't have to spend time and money to fix any issues that might be related to downtime.
- **Data and workload mobility.** Storing information in the cloud means that users can access it from anywhere with any device with just an internet connection. That means users don't have to carry around USB drives, an external hard drive or multiple CDs to access their data. Users can access corporate data via smartphones and other mobile devices, enabling remote employees to stay up to date with co-workers and customers. End users can easily process, store, retrieve and recover resources in the cloud. In addition, cloud vendors provide all the upgrades and updates automatically, saving time and effort.

- **Business continuity and disaster recovery (BCDR).** All organizations worry about data loss. Storing data in the cloud guarantees that users can always access their data even if their devices, e.g., laptops or smartphones, are inoperable. With cloud-based services, organizations can quickly recover their data in the event of emergencies, such as natural disasters or power outages. This benefits BCDR and helps ensure that workloads and data are available even if the business suffers damage or disruption.

Disadvantages of cloud computing

Despite the clear upsides to relying on cloud services, cloud computing carries its own challenges for IT professionals:

- **Cloud security.** Security is often considered the greatest challenge facing cloud computing. When relying on the cloud, organizations risk data breaches, hacking of APIs and interfaces, compromised credentials and authentication issues. Furthermore, there is a lack of transparency regarding how and where sensitive information entrusted to the cloud provider is handled. Security demands careful attention to cloud configurations and business policy and practice.
- **Cost unpredictability.** Pay-as-you-go subscription plans for cloud use, along with scaling resources to accommodate fluctuating workload demands, can make it tough to define and predict final costs. Cloud costs are also frequently interdependent, with one cloud service often utilizing one or more other cloud services -- all of which appear in the recurring monthly bill. This can create additional unplanned cloud costs.
- **Lack of capability and expertise.** With cloud-supporting technologies rapidly advancing, organizations are struggling to keep up with the growing demand for tools and employees with the proper skill sets and knowledge needed to architect, deploy, and manage workloads and data in a cloud.
- **IT governance.** The emphasis on do-it-yourself capability in cloud computing can make IT governance difficult, as there is no control over provisioning, deprovisioning and management of infrastructure operations. This can make it challenging to properly manage risks and security, IT compliance and data quality.
- **Compliance with industry laws.** When transferring data from on-premises local storage into cloud storage, it can be difficult to manage compliance with industry regulations through a third party. It's important to know where data and workloads are

actually hosted in order to maintain regulatory compliance and proper business governance.
- **Management of multiple clouds. Every cloud is different, so** multi-cloud deployments can disjoint efforts to address more general cloud computing challenges.
- **Cloud performance.** Performance -- such as latency -- is largely beyond the control of the organization contracting cloud services with a provider. Network and provider outages can interfere with productivity and disrupt business processes if organizations are not prepared with contingency plans.
- **Building a private cloud.** Architecting, building and managing private clouds -- whether for its own purpose or for a hybrid cloud goal -- can be a daunting task for IT departments and staff.
- **Cloud migration.** The process of moving applications and other data to a cloud infrastructure often causes complications. Migration projects frequently take longer than anticipated and go over budget. The issue of workload and data repatriation -- moving from the cloud back to a local data center -- is often overlooked until unforeseen cost or performance problems arise.
- **Vendor lock-in.** Often, switching between cloud providers can cause significant issues. This includes technical incompatibilities, legal and regulatory limitations and substantial costs incurred from sizable data migrations.

Cloud computing examples and use cases in Libraries

Cloud computing has evolved and diversified into a wide array of offerings and capabilities designed to suit almost any conceivable library needs. Examples of cloud computing capabilities and diversity include the following:

- **Google Docs, Microsoft 365.** Users can access Google Docs and Microsoft 365 through the internet. Users can be more productive because they can access work presentations and spreadsheets stored in the cloud at anytime from anywhere on any device.
- **Email, Calendar, Skype, WhatsApp.** Emails, calendars, Skype and WhatsApp take advantage of the cloud's ability to provide users with access to data remotely so they can access their personal data on any device, whenever and wherever they want.
- **Zoom.** Zoom is a cloud-based software platform for video and audio conferencing that records meetings and saves them to the cloud, enabling users to access them anywhere and at any time. Another common communication and collaboration platform is Microsoft Teams.

- **AWS Lambda.** Lambda enables developers to run code for applications or back-end services without having to provision or manage servers. The pay-as-you-go model constantly scales with an organization to accommodate real-time changes in data usage and data storage. Other major cloud providers also support serverless_computing capabilities, such as Google Cloud Functions and Azure Functions.

So, how is the cloud actually used? The myriad services and capabilities found in modern public clouds have been applied across countless use cases, such as the following:

- **Testing and development.** Ready-made, tailored environments can expedite timelines and milestones.
- **Production workload hosting.** Organizations are using the public cloud to host live production workloads. This requires careful design and architecture of cloud resources and services needed to create an adequate operational environment for the workload and its required level of resilience.
- **Big data analytics.** Remote data centers through cloud storage are flexible and scalable and can provide valuable data-driven insights. Major cloud providers offer services tailored to big data projects, such as Amazon EMR and Google Cloud Dataproc.
- **IaaS.** IaaS enables companies to host IT infrastructures and access compute, storage and network capabilities in a scalable manner. Pay-as-you-go subscription models can help companies save on upfront IT costs.
- **PaaS.** PaaS can help companies develop, run and manage applications in an easier and more flexible way, at a lower cost than maintaining a platform on premises. PaaS services can also increase development speed for applications and enables higher-level programming.
- **Hybrid cloud.** Organizations have the option to use the appropriate cloud -- private or public -- for different workloads and applications to optimize cost and efficiency according to the circumstance.
- **Multi-cloud.** Using multiple different cloud services from separate cloud providers can help subscribers find the best cloud service fit for diverse workloads with specific requirements.
- **Storage.** Large amounts of data can be stored remotely and accessed easily. Clients only have to pay for storage that they actually use.
- **Cloud disaster recovery (Cloud DR)** is a combination of strategies and services intended to back up data, applications and other resources to public cloud or dedicated service providers**.** Cloud offers faster recovery than traditional on-premises

DR. Furthermore, it is offered at lower costs.
- **Data backup.** Cloud backup solutions are generally easier to use. Users do not have to worry about availability and capacity, and the cloud provider manages data security.

Cloud computing vs. traditional web hosting

On the same note, Okiki and Asiru (2011) writing on the importance of internet stated that student offering correspondence course in Africa have the benefit of the use of e mail and world wide web to embark on postgraduate studies on line. Consequently, time and distance is no longer a barrier to research because at any time of the day, contact can be made to gather the needed information from anywhere in any part of the world.

Given the many different services and capabilities of the public cloud, there has been some confusion between cloud computing and major uses, such as web hosting. While the public cloud is often used for web hosting, the two are quite different. A cloud service has three distinct characteristics that differentiate it from traditional web hosting:

1.   Users can access large amounts of computing power on demand. It is typically sold by the minute or the hour.
2.   It is elastic -- users can have as much or as little of a service as they want at any given time.
3.   The service is fully managed by the provider -- the consumer needs nothing but a personal computer and internet access. Significant innovations in virtualization and distributed computing, as well as improved access to high-speed internet, have accelerated interest in cloud computing.

Cloud computing service providers

Nigeria is linked to the internet hence it is possible for Nigerian researchers to access up to date information from the net to make their research, journal articles, conference/ workshop/ seminar papers, technical reports, scientific findings known worldwide (Abidoye and Afolabi,2001). The cloud service market has no shortage of providers. The three largest public CSPs that have established themselves as dominant fixtures in the industry are the following:

- Amazon Web Services (AWS)
- Google Cloud Platform (GCP)
- Microsoft Azure

Other major Cloud Computing Service Providers include the following:

- Apple
- Citrix
- IBM
- Oracle
- Virtual Machineware(VMware)
- Systems Applications and Products (SAP)

When considering a cloud service vendor, certain considerations should be taken. First, the actual suite of services can vary between providers, and business users must select a provider that offers services -- such as big data analytics or artificial intelligence (AI) services -- that support the intended use case.

Though cloud services typically rely on a pay-per-use model, different providers often have variations in their pricing plans to consider. Furthermore, if the cloud provider will be storing sensitive data, physical location of the provider's servers should also be considered.

Naturally, reliability and security should be top priorities. A provider's service-level agreement should specify a level of service uptime that is satisfactory to client business needs. When considering different cloud vendors, close attention should be given to what technologies and configuration settings are used to secure sensitive information.

Cloud computing security

Security remains a primary concern for businesses contemplating cloud adoption -- especially public cloud adoption. Public CSPs share their underlying hardware infrastructure between numerous customers, as the public cloud is a multi-tenant environment. This environment demands significant isolation between logical compute resources. At the same time, access to public cloud storage and compute resources is guarded by account login credentials. Kumar and Kaur (2005) in Nwokedi and Amkpa (2011) affirmed that internet provides scientists, lecturers and students access to un-traditional sources of information at any points of the globe. Thus, access to current literature for research work has been made easier through the use of internet connectivity. The current information revolution and the increasing impact of information and communication technology have gone a long way in modernizing the process of teaching, learning and research in most universities. Postgraduate studies are basically dwelling on research and the report of the research is given for further research. Also, different publications are made available through the internet. Some libraries have their digital collections in the internet which can easily be accessed by users. This has made it possible to have access to vast amount of resources such as dissertations, books, articles etc. All published and uploaded in the internet (Ezeani, 2010).

Many organizations bound by complex regulatory obligations and governance standards are still hesitant to place data or workloads in the public cloud for fear of outages, loss or theft. However, this resistance is fading, as logical isolation has proven reliable and the addition of data encryption and various identity and access management tools have improved security within the public cloud.

Ultimately, the responsibility for establishing and maintaining a secure cloud environment falls to the individual business user that is responsible for building the workload's architecture -- the combination of cloud resources and services in which the workload runs -- and implementing the security features that the cloud provider offers.

History of cloud computing

The history and evolution of cloud computing date back to the 1950s and 1960s. In the 1950s, companies started to use large mainframe computers, but it was too expensive to buy a computer for each user. So, during the late 1950s and early 1960s, a process called time sharing was developed to make more efficient use of expensive processor time on the central mainframe.

Time sharing enabled users to access numerous instances of computing mainframes simultaneously, maximizing processing power and minimizing downtime. This idea represents the first use of shared computing resources, the foundation of modern cloud computing.

The origins of delivering computing resources using a global network are, for the most part, rooted in 1969 when American computer scientist J.C.R. Licklider helped create the Advanced Research Projects Agency Network, the so-called precursor to the internet. Licklider's goal was to connect computers across the globe in a way that would enable users to access programs and information from any location.

In the 1970s, cloud computing began taking a more tangible shape with the introduction of the first VMs, enabling users to run more than one computing system within a single physical setup. The functionality of these VMs led to the concept of virtualization, which had a major influence on the progress of cloud computing.

In the 1970s and 1980s, Microsoft, Apple and IBM developed technologies that enhanced the cloud environment and advanced the use of the cloud server and server hosting. Then, in 1999, Sales force became the first company to deliver business applications from a website.

In 2006, Amazon launched AWS, providing such services as computing and storage in the cloud.

Following suit, the other major tech players, including Microsoft and Google, subsequently launched their own cloud offerings to compete with AWS.

Prospects of cloud computing and emerging technologies in Libraries

Over 30% of enterprise IT decision-makers identified public cloud as their top priority in 2019, according to the Right Scale 2019 State of the Cloud Report. Still, enterprise adoption of the public cloud, especially for mission-critical applications, hasn't been happening as quickly as many experts predicted.

Today, however, library organizations are more likely to migrate mission-critical workloads to public clouds. One of the reasons for this shift is that library executives who want to ensure that their companies can compete in the new world of digital transformation are demanding the public cloud.

CONCLUSION

Library leaders are also looking to the public cloud to take advantage of its elasticity, modernize internal computer systems, and empower critical business units and their DevOps teams. Additionally, cloud providers, such as IBM and VMware, are concentrating on meeting the needs of enterprise IT, in part by removing the barriers to public cloud adoption that caused IT decision-makers to shy away from fully embracing the public cloud previously.

Generally, when contemplating cloud adoption, many enterprises have been mainly focused on new cloud-native applications -- that is, designing and building applications specifically intended to use cloud services. They haven't been willing to move their most mission-critical apps into the public cloud. However, these enterprises are now beginning to realize that the cloud is ready for the enterprise if they select the right cloud platforms, i.e., those that have a history of serving the needs of the enterprise. Cloud providers are locked in ongoing competition for cloud market share, so the public cloud continues to evolve, expand and diversify its range of services. This has led public IaaS providers to offer far more than common compute and storage instances.

For example, serverless, or event-driven, computing is a cloud service that executes specific functions, such as image processing and database updates. Traditional cloud deployments require users to establish a compute instance and load code into that instance. Then, the user decides how long to run -- and pay for -- that instance. With serverless computing, developers simply create

code, and the cloud provider loads and executes that code in response to real-world events so users don't have to worry about the server or instance aspect of the cloud deployment. Users only pay for the number of transactions that the function executes. AWS Lambda, Google Cloud Functions and Azure Functions are examples of serverless computing services. Public cloud computing also lends itself well to big data processing, which demands enormous compute resources for relatively short durations. Cloud providers have responded with big data services, including Google BigQuery for large-scale data warehousing and Microsoft Azure Data Lake Analytics for processing huge data sets.

Another crop of emerging cloud technologies and services relates to AI and machine learning. These technologies provide a range of cloud-based, ready-to-use AI and machine learning services for client needs. Amazon Machine Learning, Amazon Lex, Amazon Polly, Google Cloud Machine Learning Engine and Google Cloud Speech API are examples of these services.

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