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The Significance of Cloud Computing in the Healthcare Industry

Velmer Magaya[1], Monika Gondo[2]

Student, M Tech. Cloud Computing, Harare Institute of Technology
velmerm2[at]gmail.com

[2]Chairperson, Department of Software Engineering, Harare Institute of Technology
mgondo[at]hit.ac.zw

Abstract: ***Daily, a large amount of healthcare data is produced. The information is crucial for making decisions and providing patients with the best care. Real-time data collection, storage, and interchange between healthcare institutions are made possible using cloud computing, which is a practical and affordable solution. High throughput and high-volume storage are two characteristics of cloud infrastructure that are crucial for effective data processing of big patient populations. One of the main issues with employing cloud-based healthcare services is security and privacy. For healthcare organizations to use the cloud infrastructure, electronic medical records are a requirement. Healthcare data should be transferred from the conventional paper-based format to the electronic one to keep up with the rapid improvements in information technology and the use of cloud-based services. This essay aims to examine the significance of implementing cloud computing in the healthcare sector, the distribution and deployment methods that can be used, the advantages and disadvantages of cloud computing, as well as potential applications and system examples.***

Keywords: Cloud Computing, Healthcare System, Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS)

1. Introduction

The IT sector has traditionally employed cloud computing for data backup, software development and testing, and disaster recovery, to name a few. With the development of technology, cloud providers have created a variety of solutions that are targeted to particular industries, including healthcare, smart transportation, retail, marketing, and education. These sectors are utilizing cloud technology to benefit from it. In healthcare industry, cloud computing entails the implementation of remote server access through the internet to store, manage and process healthcare data. This provides a more flexible solution for healthcare stakeholders to remotely access servers where the data is hosted. This is not possible in a situation where on-site data centers are established for hosting data on personal computers. With the advent of the Electronic Medical Record (EMR) mandate, medical companies have embraced cloud-based solutions to store and secure their patient records.

Healthcare cloud computing is becoming more and more popular, especially in the wake of the COVID-19 pandemic. According to www.businesswire.com, the global computing market for the healthcare industry is anticipated to reach approximately $25.54 billion by 2024 and $89 billion by 2027, demonstrating the importance of this sector. For the healthcare sector to offer the best patient-centered experience, cloud computing is currently a requirement. With a predicted 32% increase by 2027, Infrastructure as a Service (IaaS), a cloud computing architecture, is currently the cloud service with the greatest growth.

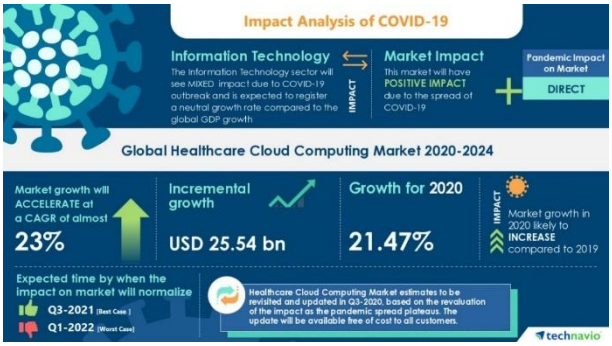

Figure 1

Figure 2

Every aspect of healthcare during the pandemic was dependent on the use of cloud computing, and each medical facility has benefited from IT infrastructures in addition to the doctors and nurses that provided care. Sharing medical records is facilitated and made safer in the healthcare industry by cloud computing. It streamlines back-end processes and even makes it easier to build and maintain

health applications, boosting productivity and cutting expenses. Using machine learning's natural language processing abilities, it is utilized to run crucial applications, cull, analyze, and extract crucial information from mountains of unstructured data, including doctor and lab notes. Readings from radiologists are also examined in the cloud.

The marriage of cloud computing and healthcare has a huge potential to improve a variety of healthcare-related functions, including telehealth and virtual care, medication adherence, drug anti-theft and counterfeiting measures, resource inefficiency, and uniformity of medical records, according to information gathered by the healthcare division of Renesas Electronics Corporation, a Tokyo-based company.

When a patient presents with chest symptoms and a headache, cloud-based analysis can be useful for uncovering patient information that might otherwise remain concealed. Using their expertise, the doctor would make a diagnosis and note all the important information. Only the primary diagnosis would be displayed on the patient's chat, and the cloud would offer other details on the patient, including previous visits and any treatments they may have received. However, skepticism persists, with many claiming worries because they are hesitant to disclose sensitive information with an outside provider. As operations shift to cloud-based servers and software, hospitals and other healthcare organizations are employing less internal IT employees.

Types of Cloud Computing in Healthcare

There are two view-point classifications.

1) **Distribution Model**
   a) Software as a Service (SaaS)
   b) Infrastructure as a Service (IaaS)
   c) Platform as a Service (Paas)

2) **Deployment Model**
   a) Community
   b) Private
   c) Public
   d) Hybrid

Distribution Model

SaaS (Software as a Service)

Program as a service (SaaS) is a licensing model where users can access the software via a subscription and the software is hosted on external servers rather than internal ones. Users log onto SaaS using a username and password and access it through a web browser. Instead than needing to install the software on each user's computer, they can access via the internet. Using its own servers, databases, networking, and computing capabilities, a software provider will host the application and accompanying data. Any computer or other device with a network connection will be able to use the application.

Applications and services offered as a service (SaaS) use a multi-tenant model in which a single instance of the SaaS is operating on the host servers and is used to serve each subscribed user or cloud tenant. The cloud service provider will handle upkeep, upgrades, and bug fixes more quickly, easily, and effectively. By maintaining the one shared instance, engineers can make any changes that are required for all clients.

Advantages

- **Flexible payments –** Instead of buying the software to install or the hardware to support it, customers subscribe to a SaaS product. Many firms can practice better and more reliable budgeting when prices are transformed into recurrent expenses. In order to stop the recurring fees, users can also cancel the service at any moment.
- **Scalable usage –** High vertical scalability provided by SaaS gives users the flexibility to acquire more or fewer services or features as needed.
- **Automatic Updates –** SaaS providers automatically manage upgrades and patches, which eases the workload on internal IT staff.
- **Accessibility and persistence –** Applications can be modified and integrated with other corporate software.

Disadvantages

a) **Issues beyond customer control** – Situations like service interruptions, unwelcome changes to service offerings, or security breaches can all have an impact on how customers use a service. Customers should be aware of and ensure compliance with the SLA of the service provider.

b) **Difficulty switching vendors** – When a customer switches vendors, a significant amount of data must be migrated. Transferring customer data between various cloud providers can be made more difficult by some suppliers' use of proprietary technologies and data types. Because of this, a customer could find it difficult to switch service providers, a situation known as vendor lock-in.

c) **Security** – concerns include:
   - Data privacy
   - Encryption and key management
   - Security monitoring
   - Incident response

d) **Customers lose control of versioning** – If the supplier adopts a new version, they may distribute it to all clients whether or not they desire the latest version. Organizations might need to allocate more time and training resources for this.

e) **IaaS (Infrastructure as a Service)**
   Over the internet, IaaS offers virtualized computer resources. The service provider oversees the management of networking resources, servers, storage, and load balancers. Through online virtual machines, they deliver them to their clients' businesses. IaaS does away with the requirement that each firm maintain its IT infrastructure.

   Advantages
   - **Shared Infrastructure –** IaaS allows multiple users to share the same physical infrastructure
   - **Web access to resources –** Users can access resources over the internet.
   - **Pay-as-per-use model** – IaaS provides service where users are required to pay for what they have used

- **On-demand scalability** – Users will not worry about software upgrade and troubleshooting issues related to hardware components.

Disadvantages

- **Security** – providers are not able to provide 100% security
- **Maintenance and Upgrade** – Providers can maintain the software but do not upgrade the software for the organizations
- **Interoperability Issues** – Migrating a VM from one IaaS provider to the other is very difficult and customers may face vendor lock-in problem.

f) PaaS (Platform as a Service)

In this type of cloud computing, a third party provides the application software platform. Developers and programmers are the primary target market for PaaS, which enables users to create, run, and manage their own applications without having to create and maintain the underlying infrastructure or platform. PaaS can be used with on-premises hardware or in the cloud. When a service provider manages an offering, the hardware and software are hosted on their own infrastructure, and the platform is then provided to the client as an integrated service over the internet.

Advantages

- **Simplicity and convenience for users** – Customers make recurring payments, which frees businesses from the capital costs associated with owning and operating their own hardware and software. The internal IT team no longer has to be responsible for supplying, managing, and updating tools thanks to PaaS.
- **Compute and Storage infrastructure –** The platform provides storage and computing facilities. Additionally, there are services for test editing, version control, compilation, and testing that aid developers in producing new software rapidly and effectively. Teams have the opportunity to interact and work together on this platform regardless of their physical location.
- **Hidden underlying structure –** from programmers and users generally. The architecture of the model is similar to serverless computing. The cloud service provider oversees distribution resources as well as server management and operation.

Disadvantages

- **Service availability** – Customers are impacted if there is a service outage or other disturbance on the provider's end, and this can lead to expensive productivity lapses.
- **Vendor lock-in** – Many of the services and data cannot be easily transferred by users from one PaaS platform to another. When choosing a supplier, customers must consider the financial risks of service outages and vendor lock-in.
- **Internal changes to a PaaS product –** Users may have difficulty and disruption from changes such as ending support for a programming language, delivering a different set of development tools, or terminating specific platform components.

Deployment Models

Community

Community model is a distributed system that is created by integrating the services of different clouds to address the specific needs of the community, industry, or business. The model allows systems and services to be accessible by a group of organizations.The infrastructure could be shared between the organization which has shared concerns and it is generally managed by a third party/vendor who hosts it at the vendor's data center. The public cloud model makes resources such as storage and applications available to the public over the world wide web.

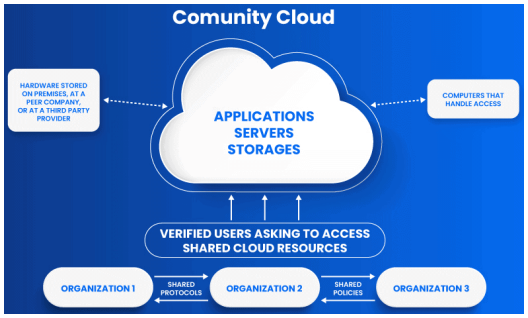

Figure 3: Community Cloud

Advantages

- Enables users to do collaborative work on the cloud
- Cost effective because multiple organizations share the cloud
- Suitable model for collaboration and data sharing
- Offers collaborative space that allows clients to enhance their efficiency

Disadvantages

- Challenges due to restricted bandwidth and storage capacity
- Not very popular and widely adopted model
- Security and segmentation are challenging to maintain

Private

This model is also called internal cloud and it means the ability to access systems and services within a given border or organization. The cloud platform is implemented in a cloud-based secure environment that is protected by powerful firewalls and under the supervision of the organization's IT department. The private cloud offers bigger opportunities that help meet specific organization requirements in customization.

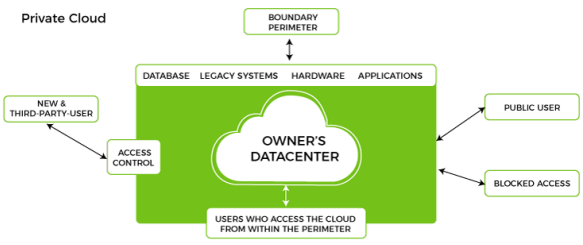

Figure 4

Characteristics of Private cloud:

1) it has a non-uniformly designed infrastructure
2) Low risk of data leaks
3) Provides end-to-end control
4) Internal infrastructure to manage resources easily

Advantages

- **Data Privacy –** Only authorized personnel get access to corporate data
- **Security** – better access and higher level of security if there is segmentation of resources within the same infrastructure
- **Supports Legacy Systems –** This model supports legacy systems that cannot access public cloud

Disadvantages

- **Expensive** – Investment will be larger as compared to public clous. The costs will include payment for hardware, software, staff resources and training
- **Fixed Flexibility** – the selected hardware make you scale in a certain direction
- **High Maintenance –** High maintenance costs because it is managed in-house

Public Cloud

Public Cloud is open to the public. This setup is ideal for organizations with fluctuating and growing demands and businesses with low-security concerns. A cloud service provider will offer networking, computing, virtualization, and storage accessible through the internet. Configuration is quick and simple, and it is a perfect delivery model for development and testing teams.

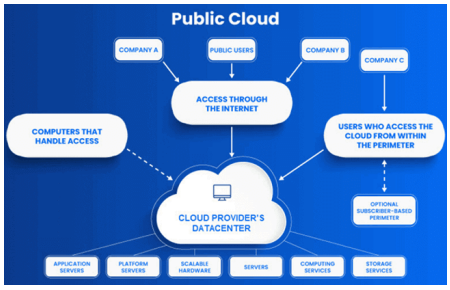

Figure 5: Public Cloud Architecture

Characteristics of A Public Cloud

- Uniformly designed infrastructure
- Work on a pay-as-you-go basis
- Economies of scale
- SLA guarantees that all users have a fair share with no priority
- Being a multitenancy structure, data is highly likely to be leaked

Advantages

- **No hardware setup –** public cloud providers fully fund the entire infrastructure therefore hardware installation is not required
- **Minimal Investment –** it is a pay-per-use service which makes it ideal for businesses that require immediate access to resources
- **No infrastructure Management –** There will be no need for an in-house team.

Disadvantages

- **License restrictions –** Usage limit on the available resources
- **Data Security and Privacy –** Vulnerable to Cyber attacks since it is an open to all service, it may not be fully protected.
- **Reliability Issues** - Malfunctions and outages will frequently occur because the same server network is accessible to a wide range of users

Hybrid

Hybrid cloud combines public and private clouds. This means that a company uses the public cloud but owns on-premises systems and provides a connection between the two. They work as one system which is beneficial for transition onto the public cloud over an extended period. Hybrid cloud may be preferred by companies that cannot operate solely in the public cloud because of security concerns or data protection requirements. They select Hybrid cloud to combine the requirements with the benefits of a cloud and it enables on-premises applications with sensitive data to run alongside public cloud applications.

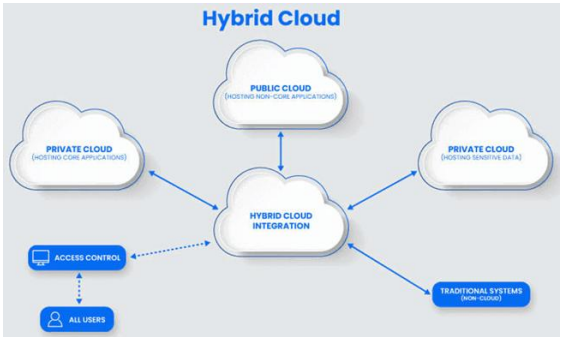

Figure 6: Hybrid Cloud

Characteristics of Private Cloud

- Provides better security and privacy
- Offers improved scalability
- Cost-effective cloud deployment model
- Simplifies data and application portability

Advantages

- **Flexibility and control –** Businesses with more flexibility can design personalized solutions that meet their needs
- **Cost –** Clouds provide scalability so the customer will be responsible for paying for the extra capacity if they require it.

Disadvantages

- **Difficult to manage** - The structure is complex because it is a combination of both public and private cloud
- **Slow data transmission –** Latency occurs because data transmission occurs through public cloud

Advantages of Adopting Cloud Computing In Healthcare

a) **Affordable solution for storing Healthcare Data**
Massive amount of digital data is produced every year, and these include laboratory tests, insurance claims, EMRs and prescriptions. Cloud technology helps by

handling that data efficiently. Cloud based analytical tools can use more data and change it into meaningful information.

b) Growth of Telemedicine
Cloud-based applications and tele-health systems help share healthcare data, offer patient health insurance during treatment, prevention and recovery and enhance availability. Many applications feature more enhanced functions like virtual analysis of medicine consumption or doctor's appointments through video conferencing.

c) Improved Patient Experience
Doctors ensure better patient involvement by providing real-time access to lab test reports, medical information and doctors noted using cloud technologies. This helps patients maintain their health more precisely and with better knowledge. Because of cloud computing, patients will not go through unwanted tests or extra prescriptions.

d) Enhanced Collaboration
Cloud technologies in healthcare improves collaboration. Patients nolonger require individual medical records while visiting a doctor because of EMR in the loud. Doctors can share data and check previous consultations with other healthcare professionals. This saves time for doctors and patients and aids in more precise diagnosis and treatment.

e) Interoperability
a. This involves creating data integrations through the healthcare system, regardless of the source of data storage. Cloud solutions make patients' information accessible for flexible distribution and getting insights to facilitate healthcare delivery. Medical professionals can access patients' medical data collected from numerous sources, distribute it among primary stakeholders and deliver on-time protocols.

Risks of Cloud Computing In Healthcare

Restricted Ecosystem
To enjoy the benefits of this technology, healthcare organizations need to use artificial Intelligence, the internet of things and Data Management technologies.

Lack of Experts
There are a few software developers in the healthcare software domain to carry the expertise for integrating new technologies in the industry. It is difficult to find cloud professionals in the health domain.

Security Challenges
A company's data share on the server with other companied and remote systems to individualize them may fail. This causes a situation where healthcare agencies fail to adopt cloud solutions.

Issues in adopting technologies
By moving from a legacy framework to cloud technologies, there is need for transformation of the whole task management process. Healthcare agencies need to teach everybody how it would be helpful in their day-to-day tasks.

Applications of Cloud Computing in Healthcare

E-health and Telemedicine
E-health is the electronic delivery of healthcare services over the internet. The cloud enables collaboration and input from various medical specialists on challenging medical problems like teleradiology and telesurgery. Patients living anywhere in the world can receive the appropriate clinical care thanks to e-health. For improved doctor-to-doctor and doctor-to-patient communication and engagement, telemedicine programs leverage cloud computing as an ICT infrastructure.

Drug Discovery
Drug recovery requires many computing resources for the discovery of different compounds from billions of chemical structures. IaaS is especially useful in simplifying this process.

Healthcare information systems
Healthcare management information systems are developed, tested, and deployed with the aid of cloud computing to improve patient care, handle human resources, improve querying services, and handle invoicing and finances. Cloud computing facilitates cross-platform interoperability, quick, collaborative development, and greater system integration with other healthcare systems.

Personal Health Records
Another use is access to personal health records (PHR) and electronic health records (HER). Users of PHR cloud-based programs can share data and quickly access and administer the PHR database. The apps' cutting-edge sharing features provide users complete control over data that is shared.

Clinical Decision Support System (CDSS)
This cutting-edge method gives recommendations on the patient record analysis based on the expertise and conduct of a medical expert. The system is used to diagnose illnesses and recommend treatment. Better patient care is provided by these systems. In addition, cellphones and fitness trackers now measure blood pressure, diabetes, and heart rate thanks to technological advancements. The usage of cloud-based technology allows for real-time diagnosis, patient data sharing, and timely medical advice from doctors.

Cloud based Digital libraries
Medical professionals and students can access material on demand through cloud libraries to stay current on the most recent studies. In order to comprehend the advancements in the healthcare sector and enhance their professional practices, physicians can also acquire essential information.

Cloud Computing in Healthcare Examples

Myphrmachines Systems
The Eindhoven University of Technology used the cloud to create this system. Through specialized software, users can share and analyze PHR data as well as access the PHR database. The system is built to give various users access with greater flexibility while also providing excellent security. Because the system deletes copies of the data after a given amount of time, patients who use it can simply communicate specific healthcare data with their doctors

without worrying about data misuse. No third party has access to the patient data that they do not want to disclose because it is safe in the system.

Cloud-Based Telemedicine

In this Australian project, telemedicine, e-appointments, e-prescriptions, and e-consulting were made possible by using cloud computing. Patients could communicate with doctors online to discuss health-related matters. This method makes it simpler for physicians and medical professionals to access patients' medical files, records, and test results. Through body sensor networks, this cloud-based technology also offered information on the patients' physiological status.

Microsoft Healthvault

Patients can store, manage, and share their PHR using this cloud-based PHR management system. They don't require any additional equipment or software because they can easily import their healthcare data from various medical devices into the healthvault.

2. Conclusion

Cloud computing systems provide various benefits, including cost or time savings, conveniences, scalability, and improved researcher cooperation. The healthcare sector is significantly impacted by cloud computing since it lowers healthcare costs, enhances patient communication, and raises the standard of care. According to the most recent reports, many medical firms are considering using cloud solutions. Security or a lack of technological resources are the main obstacles. Organizations are willing to invest in this since the advantages exceed the disadvantages.

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