Cloud Computing for Improving Healthcare System during COVID-19 Pandemic

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ABSTRACT:
Recently, cloud computing has emerged as one of the most promising technologies in the healthcare industry, particularly during the coronavirus (COVID-19) pandemic. In this pandemic, the volume of data generated from various sources is increasing which is needs novel technologies for data storage systems, and storage mechanisms. Cloud computing is considered an unsung hero in the healthcare context which provides new services in a simple, cost-efficient model. Furthermore, it can obtain the healthcare data from various sources, mixing, and evaluating the data in real-time, and allows physicians to access patient records at any place and anytime. During the COVID-19 pandemic, the request for online services has been growing which shifts working patterns towards working at home as a protective measure in order to prevent the virus. Since the development of cloud computing in healthcare is happening at fast rates, it has expected that a key part of the healthcare services into transfer onto the cloud to improve outcomes of healthcare service. However, health cloud applications may have security risks, raise the awareness of users about the threats when using unsecured devices may decrease these risks the present paper discusses the concept of cloud computing, its role in the healthcare system by highlighting the COVID-19 pandemic as well as its challenges in the healthcare system.

KEYWORDS: Coronavirus, Cloud-based applications, Healthcare, Security and Privacy, Telemedicine.

1. INTRODUCTION

Cloud computing, as one of the relatively new technologies, can have a great impact on the lives of people around the world and provides the availability of computing resources and services anytime and anywhere [1]. Until 2020, approximately 80% of companies have received cloud computing to improve the level of services [2]. The advantages of cloud computing contain easy management, cost reduction, flexibility, and uninterrupted services which features result in the increasing utilization of cloud computing in various business areas, especially in the healthcare domain [3], [4]. In recent years, cloud computing has been applied to monitor patient health as described in various studies [1], [3]–[5].

Since the development of cloud computing in healthcare is happening at fast rates, it has been expected that a key part of the healthcare services into transfer onto the cloud to improve outcomes of healthcare service [6]. Data management and analysis in the healthcare system are very important and need an appropriate application to provide good quality services for patients [7]. However, cloud computing may support these issues, the adoption rate in the healthcare system significantly remains low [8], [9]. The highest acceptance of cloud computing is in the retail industry, approximately 57%, whereas the healthcare system has been reported with 31% acceptance [4]. Microsoft HealthVault and Google Health applications are considered examples of cloud platforms for medical services [4].

One of the recent challenges for the health domain in all the world is coronavirus (COVID-19) which is associated with the global recession [10]. Instead, the industry that has emerged stronger than before is the cloud computing industry [10]. With the rapid spreading of COVID-19, the use of cloud computing might reduce the virus spread via providing online services which allow individuals to stay at home or at least reduce their mobility [11]. Cloud computing emerged as an unsung hero in the context of healthcare to enable the opportunity to provide new services in a cost-efficient fashion [12]. Therefore, the role of cloud computing in the healthcare system has been attractive in recent years.

The main objective of this study is to discuss the concept of cloud computing, its role in the healthcare system, and related challenges with the aim of

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highlighting the role of cloud computing in the COVID-19 crisis.

2. CLOUD COMPUTING

2.1. Definition

The term "Cloud Computing" described for the first time in 1996. Based on the definition of The National Institute of Standards and Technology (NIST), "Cloud Computing was considered as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources and can be rapidly provisioned and released with minimal management effort or service provider interaction"[13]. Several companies are applying this technology such as Amazon Web Service (AWS), Microsoft Azure, Google Cloud Platform, Oracle Cloud, and Rackspace [14]. Fig. 1 presents a correlation among applications, platforms, and infrastructure in cloud computing.

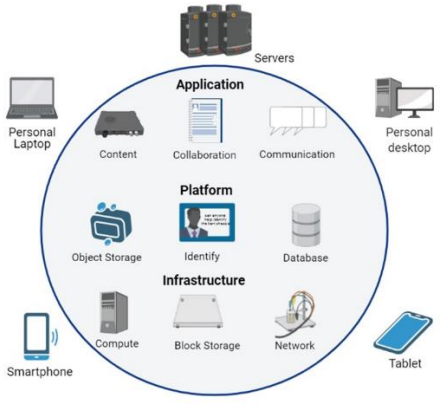

Fig 1. Overview of a correlation among applications, platforms, and infrastructure in cloud computing.

2.2. Cloud Service Models

Cloud computing provides three main service models, including:

Software as a Service (SaaS): It is considered as a software licensing and delivery model in which software is centrally hosted and is licensed on a subscription basis, as well as the user, can access it by means of a web browser. It is also known as "on-demand software". Several examples based on the SaaS cloud model include Google Docs (2019) as a document editing service, Dropbox (2019) as a file storage service, and Netflix (2019) as a video streaming service [15].

Platform as a Service (PaaS): Platform-as-a-Service (PaaS), as a business model in the cloud environment, provides a set of software and development tools on the provider's servers. PaaS applications are usually known as on-demand, and web-based. Google Apps is one of the well-known PaaS platforms, which helps developers to build and run their own applications over the platform. Furthermore, developers can store data and manage the server. PaaS service provides a flexible platform compared to the SaaS service [16].

Infrastructure as a Service (IaaS): Infrastructure as a Service, IaaS, is the lowest layer of the cloud service model. It delivers virtualized computing resources such as networks, storage, and processing through the internet. Examples based on IaaS providers include Amazon EC2 and Dropbox [14].

2.3. Cloud Deployment Model

One of the core components of cloud computing is the deployment model which consists of four types with specific features [17] and Table1 compares different models with each other.

a) Private cloud: Recently, presenting free storage and resource sharing in cloud is known as a great challenge. Therefore, many organizations prefer to use a separate cloud environment, exclusively. The term private cloud refers to a model used exclusively for one organization and has not been shared with other organizations; thus, it has high security. It can physically locate at the company's data center or can control by a third party. Cloud Stack and OpenStack are examples of open-source software used to form a private cloud.

b) Public cloud: The public cloud model, as the most commonly used cloud service, provide all facilities like software, hardware, and network bandwidth. It is considered as an economical cloud that is stand-alone, proprietary based, and off-site. This model plays an important role in the development and testing and developers often use public infrastructure order for development and testing purposes. Customer relationship management (CRM), messaging and office productivity are good examples of applications used in the public cloud.

c) Community cloud: This model is shared by some organizations and allows a particular community with common interests like mission, security requirements, policy, and compliance considerations. This model can be managed on-site, at a peer organization, or by a third party. It is more secure compared to the public cloud and less secure than the private cloud. Google's "Gov Cloud" is considered a sample of community clouds.

d) Hybrid cloud: The hybrid cloud model is known a composition of two or more cloud model which it exists due to mixed needs of an organization. However, the private and public parts of the hybrid cloud are bound together, they remain unique entities. The hybrid model delivers businesses with greater flexibility through moving workloads between cloud solutions. The other benefits of a Hybrid cloud include security scalability and cost-efficiency. The examples of providers are used hybrid cloud such as Amazon Web Services (AWS) and Microsoft Azure with an internal public cloud, as well as Google Cloud Platform (GCP) with an internal private cloud [16]

Table 1. A comparison of the different cloud deployment models.

No	Deployment model	Scope of services	Location	Security Levels
1	Public	General public and large industry groups	Off premise	Low
2	Private	Single organization	Off or on premise	High
3	Community	Organizations with same mission and policy	Off or on premise	High
4	Hybrid	Organizations and public	Off *and* on premise	Medium

3. Cloud Computing in the Healthcare System

Because of the change in the age structure of the world's population, the healthcare system seems to put pressure, in the future, which leads to an increase in demand for health services [6]. Furthermore, the unavailability of patient medical records, in any place and anytime, is one of the main limitations in healthcare service, particularly under emergency situations in which access to medical records is crucial [4].

Cloud computing provides an appropriate environment for supporting collaboration among medical workers, patients, and other involved parties [18]. It can be solved many problems in the healthcare domain such as storage capacity, saving cost, and optimizing resources [4]. Cloud computing is also related to improved availability, recovery, and transfer of medical data, as well as immediate access to medical records [19]. Yoo et al., succeeded to combine virtualization technology, and 400 virtual machines to construct a cloud computing in Bundang Hospital of Seoul National University (Korea) to manage and easy access to hospital data from mobile devices in the hospital [5]. On the other hand, hospitals are deal with large amounts of medical data which are to be recorded in a long term, even after the patient's treatment [20]. With respect to this issue, the use of cloud-based applications in healthcare can resolve the analysis challenge of large data amounts. These technological capabilities have been used to support patients suffering from diabetes, heart and skin diseases [21]. Nevertheless, cloud computing deals with challenges including security and privacy, confidentiality, and reliability, which increase concerns among patients and medical workers [22], [23]. One of the important services of cloud computing in the healthcare system is telemedicine discussed below.

3.1. Telemedicine as a Cloud Service

Telemedicine as also referred to as Telehealth includes real-time audio/video services that allow physicians and patients to connect for healthcare delivery [24]. According to the definition of the World Health Organization (WHO), "telemedicine denotes the delivery of healthcare over long distances for the exchange of evidence for diagnosis, treatment, as well as prevention of disease" [25]. Telemedicine can be used in several scopes such as a) oncology/radiology services (cancer diagnosis), b) Ophthalmology services (diabetes checks), and c) Obstetrical services (pregnancy monitoring) [7]. Other examples of telemedicine include patient consultations by videoconferencing, transmission and storage of medical image data, e-health services, patient monitoring of vital signs to improve chronic illnesses' management including heart failure, diabetes, and hypertension [26]. However, telemedicine applications have attained variable levels of success [27]. Karthikeyan and Sukanesh have suggested a cloud-based healthcare application that uses palm vein pattern in order to patient's identification and distributes an image processing tool, such as a DICOM (Digital Imaging and Communications in Medicine) viewer [28]. In another study, researchers survey the implementation of cloud-based telemedicine and demonstrated that the physician can easily access the patient's medical history, files, and test results [29]. Fig. 2 shows telemedicine systems that used new features of cloud computing.

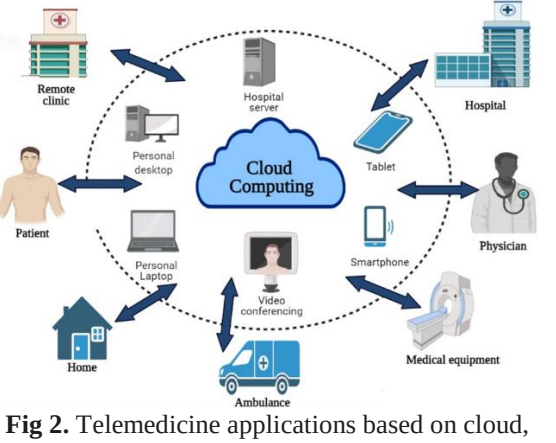

Fig 2. Telemedicine applications based on cloud, where individuals can be connected and achieve the advantage of the shared infrastructure via different means.

3.2. Cloud Computing and COVID-19

The COVID-19 pandemic as a global challenge has caused various problems in hospitals, where these are not able to accommodate many infected patients [3]. In order to reduce the spread of COVID-19, the use of cloud computing service is one of the best possible solutions [12]. So that the request for online services has been increasing consequently [30]. During COVID-19, the launch of virtual hospital HelloDoc23, and the Daktarbhai telemedicine platform, have both supported by a telehealth system [31]. Organizations can have drawn on cloud technologies to implement COVID-19-associated functionality in order to clinical processes such as monitoring, diagnostics, and consultations [32]. Pathao Health application as an online COVID-19 sign checker provides medical services via mobile and video consultations. Users can also obtain prescriptions and order medicines through this application.

The applications of cloud computing can help real-time monitoring of COVID-19 patients via data overviews from various sources, also support interactions between healthcare staff and patients at a distance, as well as help the development of operational management dashboards facilitating workforce, resource, and care planning [3], [33].

3.2.1. Major applications of Cloud Computing related of COVID-19

The cloud computing applications which may be useful during the COVID-19 pandemic are presented in Table 2. These applications help patients suffering the COVID-19 for better and early treatment via cloud computing services [3].

Table 2. Major applications of Cloud Computing during the COVID-19 pandemic.

No	Applications	Description
1	Online file storage	The interface allows users to upload and download files. Storage space and file sizes are 200 and 2 GB, respectively.
2	Digital video software/ patient entertainment	Users can download popular movies, then view them on web-browser which helps to entertain and comfort the COVID-19 patient
3	Patient's data editing / handling	This is another online application that helps the user with word processing and editing data
4	E-commerce software (such as medical enterprises)	The e-commerce application allows business leaders to assess new chances without a significant amount of upfront investment.
5	Spreadsheets	This cloud application helps the patients share the information and the exact symptoms in order to initiate treatment
6	Online treatment facilities	This allows COVID-19 patients to have free communication with the medical personnel, which helps in better treatment.

4. CHALLENGES OF CLOUD APPLICATIONS IN HEALTHCARE DOMAIN

Despite the increase in the use of cloud applications, there is an ongoing challenge in the domains of security, and the availability of cloud computing applications, in particular for a healthcare system that archives and processes patient data [22], [23]. The healthcare providers can take an additional step for providing secure access and storage of data. They should pay more attention to backups and disaster recovery sites for preventing the loss of data [34]. Furthermore, raising the awareness of users about the threats when using unsecured devices may affect this issue [35]. There are growing opportunities for cloud computing to highlight itself role in the healthcare domains, specifically in the COVID-19 situation [36]. Future research of cloud services in the health domain should be attempted upon some vital issues including internet speed, and security facts and improve data security and increase the user's trust.

5. CONCLUSION

The dependency on cloud computing services has dramatically increased in the healthcare domain, particularly in the COVID-19 pandemic. In this pandemic, the volume of data generated from various sources is increasing which is needs novel technologies for data storage systems, and storage mechanisms. With this approach, the use of cloud-based healthcare services would become more popular to manage and analyze patient data. However, health cloud applications may have security risks, raise the awareness of users about the threats when using unsecured devices may decrease these risks. In general, there are clear advantages of health cloud applications which attracted tremendous attention in recent years.

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