



Principles and Application of Mobile Cloud Computing in Payments and Health Care Solution

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Abstract. In an attempt to curtail and prevent the spread of Covid-19 infection, social distancing has been adopted globally as a precautionary measure. Statistics shows that 75% of appointments most especially in the health sector are being handled by telephone since the outbreak of the Covid-19 pandemic. Currently most patients access health care services in real time from any part of the World through the use of Mobile devices. With an exponential growth of mobile applications and cloud computing the concept of mobile cloud computing is becoming a future platform for different forms of services for smartphones hence the challenges of low battery life, storage space, mobility, scalability, bandwidth, protection and privacy on mobile devices has been improved by combining mobile devices and cloud computing which rely on wireless networks to create a new concept and infrastructure called Mobile Cloud Computing (MCC). The introduction of Mobile cloud computing (MCC) has been identified as a promising approach to enhance healthcare services, with the advent of cloud computing, computing as a utility has become a reality thus a patient only pays for what he uses. This paper, presents a systematic review on the concept of cloud computing in mobile Environment; Mobile Payments and Mobile Healthcare Solutions in various healthcare applications, it describes the principles, challenges and opportunity this concept proffers to the health sector to determine how it can be harnessed is also discussed.

Keywords: Cloud computing · Mobile cloud computing · Mobile Health · Mobile payment · Security and privacy

1 Introduction

The COVID-19 pandemic is spreading rapidly and widely throughout the world, and as a result of its contagious nature the demand for online services has grown tremendously. There has been an up surge in the demand for online services most especially in the health sector where medical personnel are obliged to convert their day to day activities electronically and online. Research conducted by the American Medical Association found that most physicians saw an enormous advantage in using mobile device during the pandemic period. Consequently, the introduction of mobile technology in the

health sector had improved previously slow-growing areas in the health sector such as telemedicine and Ehealth. The health sector generates significant amounts of data daily, hence democratizing and securing access to this information is important therefore MCC in the health sector offers mobile healthcare delivery access to resources such as Electronic Health Record (EHR) and others medical services that are available on demand through computing infrastructure, applications and share, transmit, and process these data efficiently to be delivered to users as a service wherever and whenever it is needed on the clouds rather than the old traditional standalone application on local servers. Mobile cloud computing (MCC) has been identified as a promising approach to enhance healthcare services, with the advent of cloud computing, computing as a utility has become a reality thus one only pays for what he uses. In mobile cloud computing the cloud performs the heavy lifting of computing-intensive tasks and stores huge amounts of data.

This implies that data storage and processing are taken to a remote cloud outside of mobile devices hence mobile cloud computing (MCC) is known as an auspicious concept that presents a platform that provides better quality and rich computational resources. Mobile cloud computing in medical application will minimize the limitations of traditional medical treatment such as medical errors, security, privacy and small physical storage. The health sector generates significant amounts of data daily, democratizing and securing access to this information is important hence MCC in the health sector offers mobile healthcare delivery access to resources such as Electronic Health Record (EHR) and others medical services that are available on demand through computing infrastructure, applications and share, transmit, and process these data efficiently to be delivered to users as a service wherever and whenever it is needed on the clouds rather than the old traditional standalone application on local servers. Other advantages include Real-time automated analytics based on artificial intelligence routines and machine learning algorithms and promoted cooperation.

Although the concept of mobile cloud computing in the health sector seems so promising there are several factors such as loss of data governance, poor safety standards, user distrust of provided security issues include data bottlenecks, resource constraints, unpredictable performance, data locks and critical bugs in large-scale distributed cloud systems that affects MCC performance and may result in a catastrophic consequences in healthcare. The rest of the paper is presented as follows. Section 2 presents mobile cloud computing and healthcare Sect. 3 highlights the principles of mobile cloud computing Sect. 4 presents mobile cloud computing Architecture Sect. 5 highlights the opportunity and challenges of mobile cloud computing. Section 6 concludes this paper.

2 Mobile Cloud Computing and Healthcare

Cloud computing enables access to information stored from any location at any time, that can be used by any individual or organizations to increase productivity performance and drastically reduce cost [5]. NIST (National Institute of Standards and Technology, USA) defined Cloud computing as “a concept that enables a convenient, ubiquitous and provides computing resources through a network and server’ [6]. Mobile Cloud Computing is the integration of cloud computing and mobile devices and harnessing the unlimited services offered by the cloud through mobile devices [7]. This implies that in

MCC capital cost and management is reduced as a result of network-connected resources shared to maximize their utilization. MCC healthcare applications can be classified into Imaging Information Applications, Biosignal and Telemonitoring Processing and Electronic Health Record.

A. ELECTRONIC HEALTH RECORD (EHR). An Electronic Health Record (EHR) is used electronically to collect and manage patient's health information by hospitals. This information includes patient's allergies, vital sign, medication and patient's medical history. [2] reported on Electronic health record and its adoption by MCC and today various applications have been designed to use e-Health data. [3] focused on the integration of MCC and e-healthcare records and how these records can be secured in the MCC environment.

[4] were concerned by the limitations of wearable devices in MCC and suggested that an offline ciphertexts be generated when accessing polices and data.

[4] raised the issue of security in the cloud most especially in a case were voluminous data are stored by the cloud and stated their fears about cloud security issues in Personal Health Record (PHR) access. [4] presented an encryption-based paring method that could improve protection and accessibility of the user. [5] studied Electronic Medical Record (EMR) and its implementation in the cloud and highlighted the need for the integration of several data into a single platform and provides a similar accessible user interface.

B. Medical Imaging Storage Technologies. Picture Archiving and Communication System (PACS) is a medical imaging technology tool used to transmit and store images and relevant clinical report digitally in a secured manner. As a result of the growth of digital medical images throughout the healthcare sector the need for data analysis of images is very important [6]. [7] designed adaptive-self approach which offers a high-resolution medical image transmitted and retrieved in a reliable way over a network.

[8] presented a mobile cloud medical image administration system, which offer patients and physicians accessibility to medical data.[9] proposed a secured MCC infrastructure for the storage and transmission of data [10] develop an MCC storage system which can effectively manage medical images and health records of patients.

C. Biosignal Processing and Telemonitoring. Bioprocessing processing and Medical telemonitoring provides a platform that enhances the growth of health care services and reduces medical costs. [11] went on to say that bioprocessing creates an enabling environment for healthcare services no matter the distance this implies that it processes, collects, analyses and uses the information collected. [16] highlighted an MCC ECG telemonitoring technique adopted for children with mental disorder. [14] designed an MCC system that enable medical personnel such as doctors, nurses and to interact effectively in healthcare service provision. [15] designed an MCC that provides emergency through local medical personnel to patients. [13] proposed MCC healthcare system to analyze and capture real time biomedical signals (such as Blood pressure and ECG) from users located in different locations. [17] opined that MCC overcomes the limitations associated with the use of mobile devices such as CPU power and memory size in performing task which involves lots of time and energy thereby enhancing the benefits

and capabilities of mobile devices. [18] highlighted another benefit of MCC by using multimedia applications as an example. Mobile cloud computing resolves the challenges of mobile devices by storing large multimedia files on the cloud that can be available to mobile users whenever a request is made hence resulting in a better performance. MCC enable patients to be monitored in real time from any part of the world and at any time.

Medical telemonitoring can be referred to the process of collecting biosignals from the human body, information gotten from this process can be used in monitoring and providing a better clinical diagnosis [22]. [19] presented an Electrocardiogram (ECG) measurement system which was created based on a mobile cloud infrastructure, to efficiently report health issues for elderly people. [20] proposed a mobile cloud vital sign detection system which stored and extracted user data, characteristics and history for each individual user under different circumstances, however when there is an emergency an alert would be reported. MCC have also been adopted and utilized for different kind of diseases and diagnosis [22]. Many researchers have said that medical telemonitoring improves healthcare efficiency and reduces medical costs [15].

3 Principles of Mobile Computing

MCC Mobile cloud computing combines mobile computing, cloud computing, and mobile Internet into one solution. It can be defined as the availability of cloud computing services in a mobile setting. It combines the benefits of all three technologies and is thus referred to as mobile cloud computing. Mobile cloud computing is a novel computing model in which data processing and storage are relocated from mobile devices to powerful and centralized cloud computing platform which can be accessible on mobile devices via wireless connections and web browsers.

This is similar to cloud computing, but the client side has been enhanced to make it mobile-friendly, but the core concept remains the same MCC can be split into cloud computing and mobile computing. Mobile user sends a request to the cloud via a web browser or desktop application, and the cloud's infrastructural managerial component allocates resources to the request and lunch a connection, while mobile cloud computing's monitoring and calculating functions are implemented to ensure QoS until the connection is established.

4 Mobile Cloud Computing Architecture

Mobile healthcare (m-healthcare) was developed to provide easy accessibility to mobile healthcare users to the resources such as (e.g. patient electronic health records) and provide a variety of distributed services. MCC is applied to healthcare to limits the errors such as small storage, medical errors and security of the traditional medical applications [23]. Mobile Cloud Computing is seen as "an infrastructure where data is been processed and stored outside of the mobile device" [24].

In [25] MCC is seen as a new model for mobile applications: "which is moved to a powerful and centralized computing platform in the cloud" (Fig. 1).

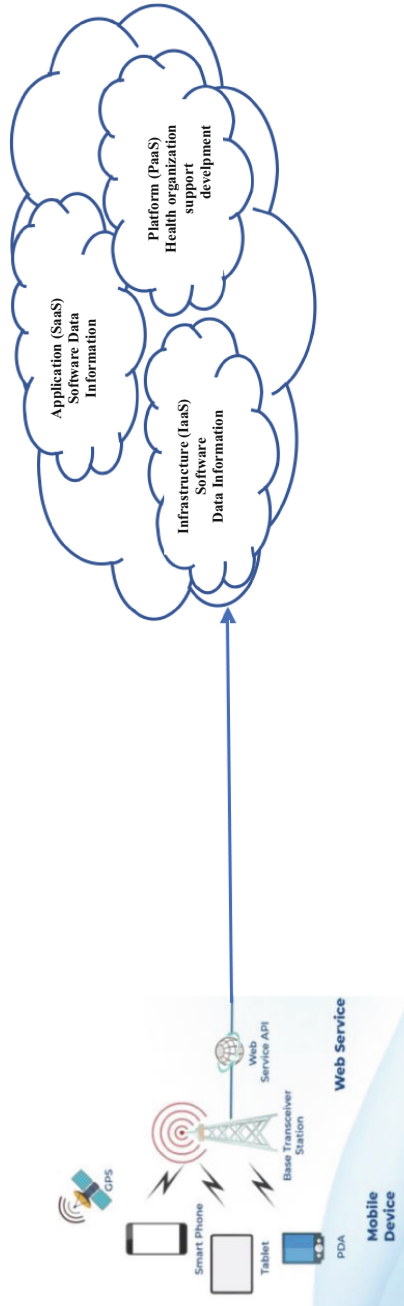


Fig. 1. Mobile cloud computing architecture

5 Opportunities and Challenges of Mobile Cloud Computing in Health Care

Mobile Cloud Computing require huge amounts of communication and computational resources which involves access to necessary health information anywhere and at any time hence the need for networked healthcare [15]. Although Mobile Cloud Computing offers great benefits, there are still some limitations such as data storage on the cloud, and protection of user's privacy from unauthorized access and from malicious attacks [27].

- Collaboration

Collaboration entails sharing of data. MCC has made data sharing much simpler and easier to achieve. MCC enable medical records to be remotely shared securely with important healthcare providers such as doctors and pharmacists from any location in the world real time. MCC also offers a platform for conferencing and updates on patient current health situations making MCC an ideal partner for healthcare personnel.

- Cost

MCC offers a platform through which services are paid for on the go. This implies that a patient only pays for the services they use.

5.1 Security Challenges of Mobile Cloud Computing in Health Care

MCC guarantees security because cloud service providers such as Azure and AWS used several protection techniques such as customer-controlled encryption, network fireball and take precautionary measures to adhere with privacy regulations such as GDPR and HIPAA []. MCC has the capacity to raise alarm when there is a malicious activity. However, Covid- 19 and social distancing has generated voluminous amount of data most especially in the health sector where most people with little or no idea about information security issues prefer making consultation or working from home rather than going to the hospital. As shown in Fig. 2, the Security challenges of MCC-based healthcare applications could be categorized into Application, Data privacy, Internet Service Provider, CCE and Personal devices.

The use of MCC for data collection during the pandemic has been very phenomenal in curbing the deadly coronavirus disease and also discovering a medication that can eradicate the disease, however, vast majority of patients would rather prefer consulting from home which has led so many into to using their personal devices to transfer and also access data from the Internet, these methods may not be secured enough because data can be copied or hacked in the process.

The demand by users on Internet service providers (ISPs) as a result of the pandemic has been huge and has turned out to be a major challenge for Internet service providers (ISPs). [31] reported that the use of the internet in some European countries was up to 50%. As traffic reached a peak of 30% most ISPs in the UK had to relax data limit on

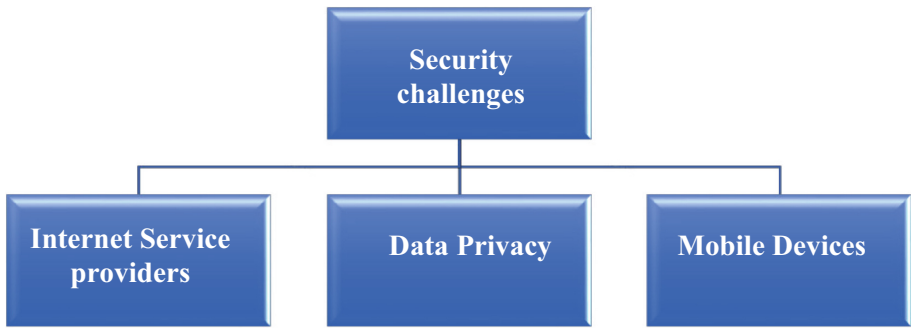


Fig. 2. Types of mobile cloud computing challenges in the health care

some of their internet platform in order to accommodate millions of Britons learning or working from home which resulted in ISPs downsizing on the quality of streaming device a typical example is the case of Netflix an online media platform famous for entertainment and streaming movies, prior to the Covid-19 era aired their videos using high definition because of the downsizing most Netflix videos were played in standard who had to air their video in standard [32].

5.2 Application Challenges

The issue of social distancing made learning or working from home inevitable however this challenge led to evolutionary social media application that enable people from various location and at any time communicate as if they were together. [31] highlighted the need for a remote collaboration tools which enable a collective group of people working together without being physically together. virtual meetings and virtual work have become the best way to work and interact from home a typical example of work apps are Zoom, Ding talk and WeChat Work [32]. As a result of the rapid growth of work application it has been a major target for hackers as most of these applications has be hacked and pirated due to the security faults in the application. In January 2020, America's Zoom jumped from No. 180 to No. 28 at the end of February 2020 in terms of installs and downloads [32].

5.3 Personal Devices

Majority of those working from home barely understand the security issues surrounding the use of personal devices. Personal devices such as laptops, tablet and personal which hasn't been in use for a while might require an antivirus or an update for the operating system before it could be used on line. Cybercriminals have malicious software that tablets unsecured mobile devices to and gain access to vital information on these devices [32].

6 Conclusion

The application of cloud computing in healthcare seems promising as it offers flexibility, scalability, cutting down medical cost as computing as a utility has become a reality

allowing a patients pay for what he uses and empowers global collaboration in the health sector which in turn can positively impact the health care in numerous way.

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