Framework for a Cloud Based Health Monitoring System

A. B. Adeyemo
Computer Science Department
University of Ibadan, Nigeria
sesanadeyemo@gmail.com

W. O. Adesanya
Gneneral Studies Department
Federal College of Agriculture Akure
Nigeria

O. Ariyo
Computer Science Department
University of Ibadan
Nigeria

ABSTRACT
Cloud computing is a new paradigm that has gained much ground in the software industry and it provides applications, platforms and infrastructure over the internet. It has been widely recognized as the next generation's computing infrastructure and it offers several advantages to its users. Electronic Health Record systems (EHR) are increasingly being deployed within healthcare institutions to reduce the problems and limitations of the paper-based approach but its deployment has been slow due to high investment and maintenance cost. This study presents a framework for a Cloud Based Health Monitoring System. The Cloud database acts as the central data bank to which user's medical data can be uploaded from both mobile device applications and web browser devices and then downloaded for analysis by the medical practitioner for user's (patient) monitoring and guidance. Prototype applications were developed and the implications of the unconstrained adoption of eHealth application usage were examined.

CCS Concepts
• Applied computing → Life and medical sciences → Health care information systems • Software and its engineering → Distributed systems organizing principles → Cloud computing

Keywords
eHealth; cloud computing; mobile computing.

1. INTRODUCTION
The term eHealth has been describe by various authours and international organizations such as the British Columbia eHealth Steering Committee [1] and World Health Organization [7] as the application of Information and Communication Technology (ICT) for the efficient storage and management of health information for effective provision of health services. The term eHealth or (e-Health) was said to have carried over to the health sector by marketers and practitioners in the industry rather than academics who saw it as a means of introducing the e-buzzword (such as e-business and e-commerce) to health related issues [3]. The broad goals of eHealth are summarized in the resolutions of the 58th World Health Assembly and these include [7]: The drawing up a long-term strategic plan for the various areas of the health sector to help improve the development and implementation of health administration, provision of appropriate legal framework and infrastructure, and encouragement of public/private partnership; The development of ICT infrastructure; building closer relationships with private/non-profit ICT organizations; Reaching out to communities and vulnerable groups and providing them with appropriate eHealth services; Mobilization of multi-sectoral collaboration for the determination of evidence-based eHealth standards in order to share knowledge of cost-effective models, thereby ensuring quality, safety and ethical standards, respect for the principles of confidentiality of information, privacy, equity and equality; Establishment of national centers and networks of excellence for best practice, policy coordination, technical support, service improvement, information to citizens, capacity building and surveillance for health-care delivery; The establishment and implementation of national electronic public-health information systems; Improvement of the capacity for surveillance of and immediate response to disease outbreaks and public-health emergencies.

The implementation of eHealth systems promises to provide benefits to the patients, members of the public at large, care providers and the health system [1] by: provision of improved health care outcomes for all concerned; Provision of support for improved public health protection through easy and readily available self-care, access to patient information wherever the patient may be, which ensures reduced risk of duplicated laboratory test and medical conflicts. Other benefits include easier access to clinical information, ease of sharing of information which provides improved care coordination across care provides which results in a better cost effective and sustainable health care system.

Cloud computing is an Internet-based computing model that provides shared computer processing resources and data to computers and other devices on demand. It is a framework for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources such as computer networks, servers, storage, applications and services which can be rapidly provisioned and released with minimal management effort or service provider interaction [5]. Cloud computing and cloud storage solutions provide users and business enterprises with various capabilities to store and process their data in third-party data centers which could be located far from the user.

CoRI'16, Sept 7–9, 2016, Ibadan, Nigeria.

The Cloud computing architecture consists of front-end platforms called clients which could be servers, (fat, thick, thin, or zero) clients, tablets and mobile devices. The client platform interacts with the cloud data store through an application middleware, web browser, or virtual session. The three main categories of cloud computing are: private clouds, public clouds and hybrid clouds. Private clouds are used exclusively by a single organization comprising multiple consumers. Public clouds are open access clouds that the general public can access. Hybrid clouds are infrastructures that combine two or more cloud deployment models (e.g. private and public). Some studies that have addressed the problems and implementation techniques for cloud based systems include: Rolim et al [8] and Saif et al [9].

According to the mobile cloud computing forum, mobile cloud computing can be described as an infrastructure where both the data storage and data processing happen outside of the mobile device [2]. That is a combination of mobile web and Cloud computing. Mobile devices have nowadays become one of the most common means by which users can access applications and services on the Internet. With mobile cloud computing users with mobile devices do not need a powerful configuration in terms of CPU speed and memory capacity because all the complicated computing modules can be processed in the cloud. Advantages of mobile cloud computing for the mobile device user includes: Extending battery lifetime, provision of access to processing capabilities beyond what obtains with a mobile device, improving data storage capacity, reduction in the cost of computing computer intensive applications, improvement in reliability etc. Mobile cloud computing when applied to mobile healthcare systems helps overcome the limitations of traditional medical services. It provides users with convenient means to access resources like patient health records and a variety of on-demand services in the cloud rather than having standalone applications on local servers. Some of the services mobile cloud computing can offer in mobile healthcare systems include: Comprehensive health monitoring services, intelligent emergency management systems, health-aware mobile devices which can detect pulse rate, blood pressure etc, access to healthcare information etc [2].

In this study a framework for a cloud based eHealth software application that can be used by users at home to upload medical test data obtained from medical test equipment's to a cloud storage infrastructure that can be accessed anywhere by medical doctors and other authorized health practitioners for effective monitoring of users health status is proposed.

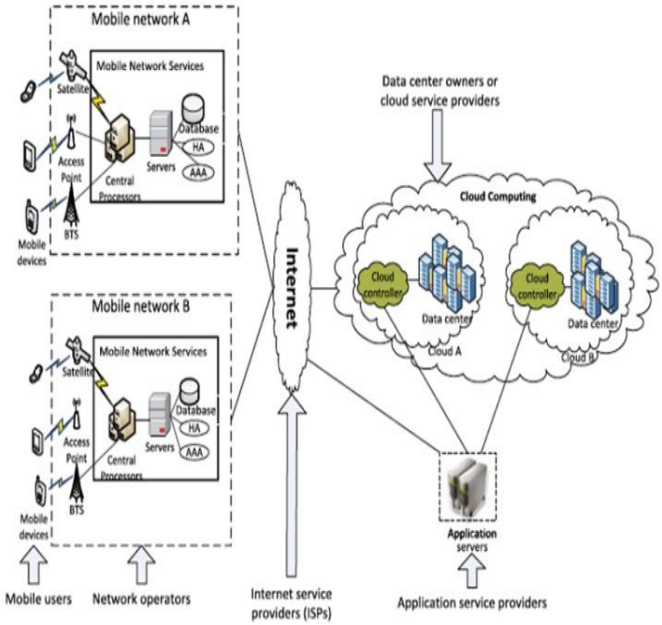

Figure 1: Mobile cloud computing architecture [2]

2. MATERIALS AND METHODS

The proposed system architecture presents a conceptual scenario where a user can upload health information at home to a cloud based storage facility which can be accessed remotely by doctors or medical practitioners for the purpose of monitoring and giving of timely medical advice which might be needed by the user. Information that the cloud based health monitoring system should be able to collect includes data for medical conditions such as diabetes, hypertension, cardiovascular problems and even common ailments such as feverish conditions for which there are household medical test equipment's that can be used to carry out these tests. In addition to these data on exercise and dietary programs can also be collected at home and uploaded to the cloud based storage facility. Processing of the data will be carried out using cloud based software applications and results which can also be downloaded in real time can be used for monitoring the health status of the patient or even automatically give warnings when an anomaly occurs.

The components of the framework are:

Mobile or web based users (patients) who can carry out basic health test such as urine analysis, blood pressure test, diabetes test, calories tracking etc. at home and enter the data into a mobile application running on an android operating system or a web based software application (web site) hosted on a cloud platform.

Alternatively the data can be collected at patient's bedside in a health facility by anyone authorized to do it (such as health practitioner, system administrator etc) and uploaded into the cloud based database through either a mobile or web based interface.

The medical doctor (or medical practitioner) who can access the uploaded data, analyze it and generate reports that can be used for monitoring the health status of the user.

Figure 2 presents the USE CASE diagram of the Cloud Based Health Monitoring System. The backend database application will be hosted on a cloud platform e.g. Windows Azure Cloud, Amazon Web Services or Google cloud. Some of the relations in the database include:

1. Administrator ID: unique identifier for system administrator(s).
2. Administrator username: contains information about administrator username.
3. Administrator password: contains information about administrator password.
4. Doctor ID: unique identifier for all doctors.
5. Doctor username: contains information about doctor username.
6. Doctor password: contains information about doctor password.
7. Doctor report: contains information on current report on user by the Doctor.
8. User ID: unique identifier for all users registered in the database.
9. User name: contains information about user name, first name and last name.
10. User gender: contains information about user gender i.e whether male or female.
11. User age: contains information about user date of birth
12. User photo: contains the users photograph.
13. User address: contains information about the users contact address
14. User phone numbers: contain information about users phone numbers
15. User primary health facility: contains information about users hospital or medical facility where user normally uses.
16. Consultation date: contains information about date data is being uploaded**.**

The application will also include relational database tables for medical test results such as: urine test data, diabetes test data, blood pressure test data, body temperature, heartbeat rate etc. The application will use security as a service on the cloud to protect mobile applications. The users will not have to worry about security issue because it is ensured by the security vendor.

3. IMPLEMENTATION TECHNIQUES

Prototype front end applications for the system were implemented for either android or Windows based device which would be hosted on a cloud platform. Figure 3 presents the screenshot of the mobile application version being used by a doctor displaying user data that can be accessed by the doctor monitoring them in real time, while figure 4 shows the web browser based version. A home user will record his test records and input the data to the cloud database using either a mobile device app or desktop computing device. When the doctor wants to get the access to the health record, he has to be authenticated that he has the right to access the records. The doctor downloads the health record, analyses it and can send back a medical advice to the user in real time. Based on this, the system can be used to formulate a health management scheme according to the user's health status including daily/weekly/monthly meal and exercise plans.

4. IMPLICATIONS OF THE UNCONSTRAINED ADOPTION OF eHEALTH APPLICATIONS

The use of ICT in healthcare raises a number of challenges related to unconstrained adoption of eHealth applications. Some of these have been categorized as being legal, ethical or governance issues. Legal issues include the need for the provision for adequate legislative framework which provides legal clarity in terms of products and services that relate to eHealth in Nigeria. Those things to be addressed include: understanding the privacy and protection of personal health data such as electronic health records, telemedicine, pharmaceutical sales over the Internet, and the liability of health professionals [10]. Ethical issues should address the fact that members of the public are increasingly using the Internet for information on health issues, and sharing information through the social network facilities offered by the web [10]. This has raised information integrity and authority of information issues. eHealth governance issues such as the alignment between business and IT governance and how these can be harmonized to to achieve a positive effect on healthcare performance also have to be addressed [10]. In order to address these issues there is therefore the need for Nigeria to have an effective eHealth strategy in place. According to Naphtal [6] "Nigeria's slumber in embracing eHealth to address the challenges in its healthcare system has cost the country more than N81 billion annually to medical tourism, the gainers being India, South Africa, Dubai and some European countries where highly developed healthcare system integrated with ICT has helped to provide succor for many". Nigeria obviously stands to gain from the adoption of eHealth practices considering the statistics attributed to medical practitioners in the country which shows that the Nigerian public is grossly underserved health-wise. It is worthy of note that among the developing countries Philippines [7] and South Africa [4] have been able to develop eHealth strategies/policies alongside many notable developed countries, while Nigeria is still lagging behind. Evidently

Nigeria stands to gain a lot from adopting eHealth practices. However without the necessary regulatory structures being put in place the whole process is subject to abuse.

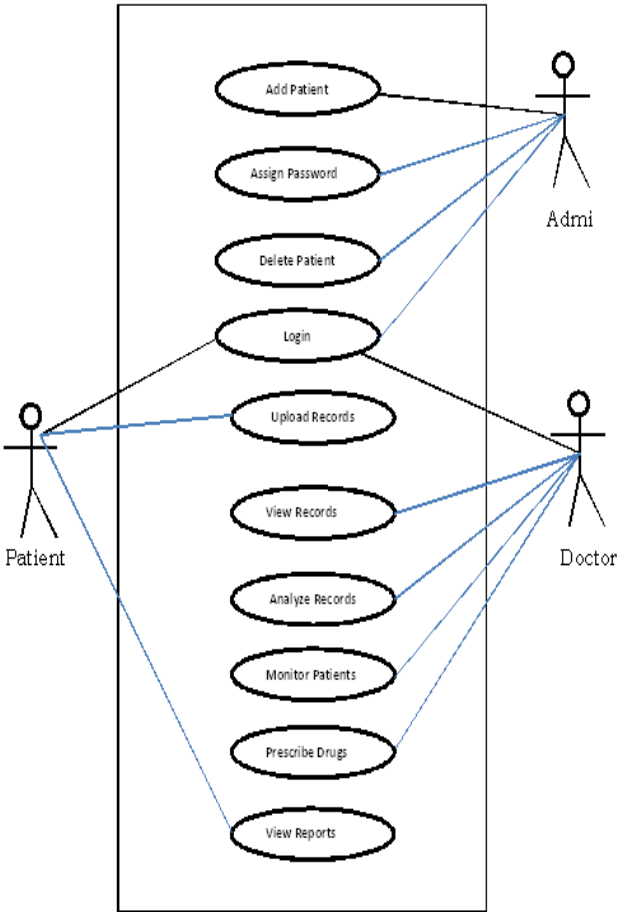

Figure 2: USE CASE diagram of the Cloud Based Health Monitoring System

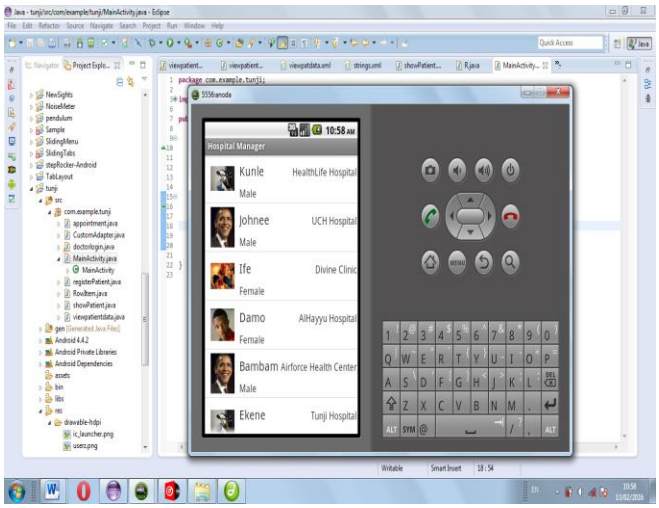

Figure 3: Screenshot showing user data that can be accessed by doctor monitoring them in real time using mobile device app.

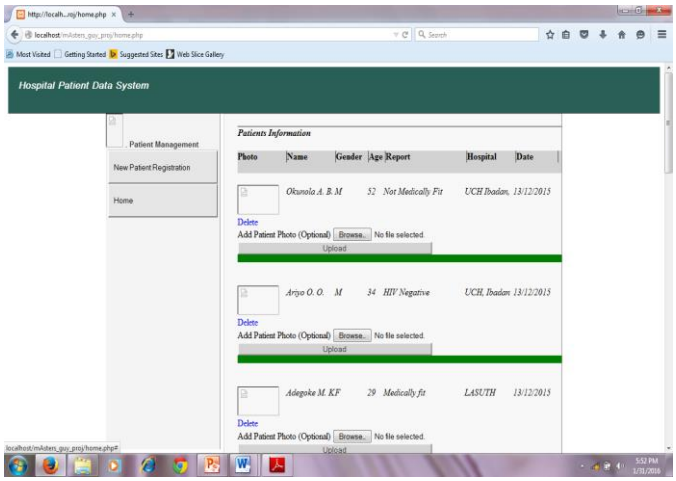

Figure 4: Screenshot showing user data that can be accessed by doctor monitoring them in real time using web application hosted on cloud platform

With the advent of the Internet cross boarder or Inter-country consultations for health problems, diagnosis and drug administration are taking place and cannot be controlled. Furthermore when eHealth applications are developed and used without the necessary regulatory structures in place, who bears responsibility for any adverse issues arising from drug maladministration or uploading of wrong content in these applications or web sites? All these underscore the urgent need for the Nigerian government to join hands with the stakeholders and ensure that Nigeria has a viable eHealth strategy/policy in place.

5. CONCLUSION

In this study, a framework for a cloud-based health monitoring system has been proposed. This framework provides a method for monitoring user's health status in real time by medical practitioner's irrespective of the location of both the user and the doctor. The medical practitioner who is authorized to view patient data can have access to the data at any time it's required. Users can also upload results of tests carried out in-house without having to make frequent visits to the health institution for analyses and diagnosis.

6. REFERENCES

[1]. British Columbia eHealth Steering Committee, (2005), eHealth Strategic Framework for British Columbia, November 2005, ISBN 0-7726-5437-9

[2]. Dinh, H. T., Lee, C., Niyato, D. and Wang, P. (2013), A survey of mobile cloud computing: architecture, applications, and approaches. Wirel. Commun. Mob. Comput., 13: 1587–1611. doi: 10.1002/wcm.1

[3]. Eysenbach G., 2001, What is eHealth?, JMIR Publications, Journal of Medical Internet Research, Vol 3, No 2

[4]. Foster R., The development of the South African eHealth Strategy assessed against the recommendations of the WHO/ITU eHealth Strategy Toolkit (undated)

[5]. Hassan Q., 2011, Demystifying Cloud Computing, The Journal of Defense Software Engineering. CrossTalk.2011 (Jan/Feb): pp 16–21.

[6]. Naphtal A, (2014), Nigeria Must Use ICT to Drive National eHealth Policy Strategy, Retrieved from: http://mobileworldmag.com/nigeria-must-use-ict-to-drive-national-eHealth-policy-strategy/ (13 April 2015)

[7]. Philippines eHealth Strategic Framework and Plan 2013-2017, 2013, Department of Health, Department of Science and Technology, Philippines, September 11, 2013.

[8]. Rolim, C.O, Koch, F.L., Westphall, C.B., Werner, J., Fracalossi, A., Salvador G.S, 2010, "A Cloud Computing Solution for Patient's Data Collection in Health Care Institutions", Second International Conference on eHealth, Telemedicine, and Social Medicine, pp. 95 – 99.

[9]. Saif, S., Wani, S., Khan, S., 2010, "A Network Engineering Solution for Data Sharing Across Healthcare Providers and Protecting Patients Health Data Privacy Using EHR System" Journal of Global Research in Computer Science, Vol 2, No 8.

[10]. Whitehouse D., George C., Duquenoy P., 2011, eHealth: Legal, Ethical, and Governance Challenges: An Overview, In: Med-e-Tel 2011, 6 - 8 April, Luxembourg, Available from Middlesex University's Research at http://eprints.mdx.ac.uk/7728/