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Medical Image Data Management System in Mobile Cloud Computing Environment

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Abstract. This paper describes about the management of medical image data in a cloud computing environment with access to mobile users through a mobile application to help the patients and doctors to view patient health records and prescriptions on their handheld devices that supports Android OS. The application that has been effectively implemented allows a flexible medium for patients to access vital health records at their convenience, without a need to visit the hospital to view the same. The application is an advantage to people residing in remote areas and who cannot access hospitals in cities at tease. This paper summarizes the implementation details and the results of the application. With the feasibility of the medical data management in such an environment established, the paper describes some challenges faced and future work planned.

Keywords: Medical image processing, Mobile Communication, Mobile OS, Cloud Computing, Android OS, EyeOS

1. Introduction

Healthcare information systems are designed today for the convenience of the user who obtains its benefits efficiently. Accessibility and availability are the criteria on which an application is designed for its success in the IT market. ([1], [3]) The data has to be accessible from anywhere in the world at any time and the easy transaction of data to the mobile devices. Transparency in the data storage, transaction and maintenance can be achieved through the cloud computing concept. In the earlier days, physical storage of data and its maintenance was a major problem to build such medical applications. With the advancement of technology, cloud computing enables for the convenient storage of user data, through sharing of resources and framework. Through cloud computing, healthcare services can be provided through the cloud network and operations can be performed without any delay. Mobile devices today, are used in abundance by the common man. As these devices are equipped with robust features, it is necessary to make them a vital source for providing information. By integrating the cloud computing and a mobile device the healthcare services can be easily utilised and operated by the patient. The technology can be effectively applied for maintaining medical image data in a cloud computing environment and mobile device supporting Android OS. The paper describes implementation details of a Hospital Management System (HMS) and the results of the application. With the feasibility of the medical data management in such an environment established, the paper describes some challenges and future work planned.

2. Mobile Healthcare Systems

Healthcare systems are the need of the hour today for enabling in producing accurate results of medical information and in proper communication of the results to the patient or the doctors for further analysis [8]. This requires the patient records to be accurate and accessible. Several studies have demonstrated that the limited access to patient-related information during decision-making and the ineffective communication

among patient care team members are proximal causes of medical errors in healthcare. . Thus such healthcare systems are required to solve the problem of communication between the hospital and the patient. Mobile systems are the most efficient ones to provide such a anytime-anywhere service. Hence Mobile Healthcare Systems are designed to provide such user specific services. The goal of mobile health care system is to provide health care services to anyone at any time without any constraints of place, time and character. A Mobile Healthcare system indulges with mobile technologies to design and develop them and help people to monitor their own health care.

3. Mobile Cloud Computing

Cloud computing helps in providing resources to client on an on-demand basis through the web service interface. Mobile cloud computing is a type of cloud computing in which some of the devices that are used for providing the services, are mobiles [4]. Mobile devices have many constraints imposed upon them because of the desirability of smaller sizes, lower weights, longer battery life and other features. These constraints cause inflexibility in hardware and software development for these devices. Cloud computing can be used to allow the mobile devices to avoid these constraints by making the resource intensive tasks and complex functions to be performed on desktop systems and having the end results sent to the device. [3] This enables the Mobile Cloud Computing to be a very efficient and effective way to develop robust applications in the healthcare sector. The end user will benefit, as they can share resources and applications without high capital expenditure on hardware and software resources. The end users can easily run the applications from the mobile without any costly hardware to run applications as the operations are run within the cloud [7].Here the HMS application been developed using the Android mobile operating system. Since it is an open source operating system and very flexible for building applications, it becomes a robust platform for the healthcare applications.

4. Application Overview

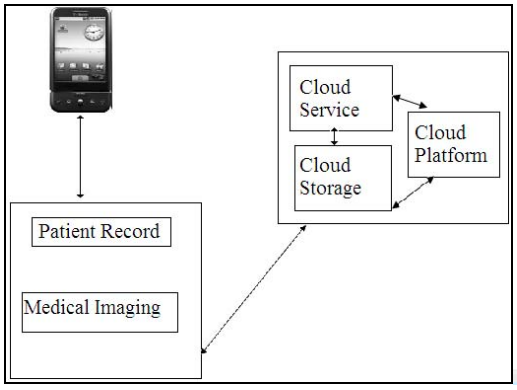

Fig. 1: System architecture of a cloud computing based Hospital Management System (HMS)

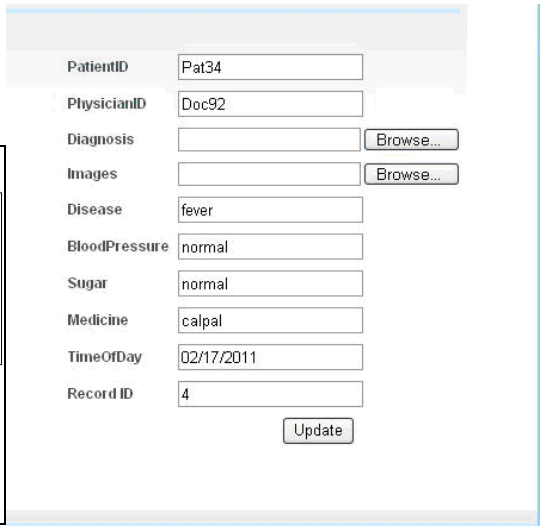

Fig 2. Patient Health Records updated by the physician

The HMS application is designed to make available the prescriptions and health records, medical image records (like scanned images etc.) of patients, on their Android powered mobile phones. The health records are stored and managed in the cloud OS. The records are transferred from the cloud to the mobile device, where it is displayed. EyeOS is the cloud platform used to build this application. This cloud OS can be easily downloaded for free. Since Android powered mobile devices are available in the market at affordable rates, they can be easily used in such healthcare applications. ([2], [6]) Several authors have already presented ideas of mobile platforms for information exchange (like text and images) over internet. The MADIP system ([3], [5]) is a distributed information platform allowing wide-area health information exchange based on

mobile agents. But most of them are based on expensive and inflexible communication methods that require the installation of software and hardware components. These issues are solved using the cloud computing concept, as there is no need for extra storage and computation medium. The information that resides in the cloud is managed by the hospital management staff and the doctors (for uploading prescriptions and medical image records). The Android OS supports the connection to the Cloud OS that allows the patient to retrieve, modify, manage and upload medical images and text data using the internet services and REST API concepts like HTTP URLs. [3] The image support is provided by DICOM protocol and the pixel data of images are compressed by the JPEG standard. [12] The progressive coding allows the user to decode large image files at different resolution levels optimizing this way network resources and allowing image acquisition even in cases network availability is limited. The code for performing wavelet decoding on mobile devices in has been modified to support the JPEG2000 standard on the Android platform. Image annotation is also supported, using the multi-touch functions of the Android OS. [9] The system architecture of the implementation is shown in Fig 1.

5. Application Implementation Details

The project is divided into two modules. The client module serves the mobile (Android OS device) end functionalities and the server module contains the Cloud OS. The client module coding is performed and tested using the Java Eclipse. Android SDK toolkit is first enabled in Java Eclipse and then coding is done for the mobile end cloud application and for the connection oriented details between the Android OS and Cloud OS. Also, the Android device screens are designed with respective elements using the IDE and coding is performed for every element's action. The cloud is accessed from the mobile through Web APIs [3] and coding is given for the same. The cloud OS used in the application is EyeOS. [11] The EyeOS has all the features that are available in a normal OS. The front end web pages are designed in XML files and the backend database support is provided by Oracle 10i Express Edition. The HMS page has authentication screens for Patient, Doctor and Administrator separately. The tables are created for Patient, Doctor and Administrator details. Patient ID and Doctor ID is generated for every patient and doctor for authentication purposes. A patient can register his/her details and can sign-up for free. Patient can then fix appointment with the doctors. Doctors also have to sign-up and register their details. All these details are stored in the database for each screen operation. Doctors can view their appointments, update the medical prescriptions (Fig 2.) and upload medical images. The administrator approves the patients' files and the doctors' files after proper authentication. The database connectivity is established in the cloud location files.

The entire process works as follows: (a) the client at the mobile end opens the cloud application as either patient or doctor and is authenticated by the cloud end. (b) The client enters his/her profile details by registering first, and then logging in. The username is the corresponding 'id' and password is the one set by him/her in the cloud server. (c) Then the Patient id is required to "search" for the records under that id. Then the particulars, diagnosis details and medical images are viewed by selecting the same via the checkbox. (d) When the user requests for an operation in the mobile end, the request is sent via REST API like HTTP URL to the cloud OS. (e) The cloud OS responds by sending the requested information by searching in the database and sending them back to client. (f) The mobile application checks whether there are any files that were received and are waiting to be downloaded, and will download them and make them viewable to the client.

There are features in Android SDK that makes the received content to be fit to the screen size. Apache Tomcat server was used to contain the XML servlets of the cloud server and XAMPP control panel was used to run the Apache Tomcat server. The results were tested through the Android SDK in the Java Eclipse IDE.

6. Evaluation Results

The HMS application was tested in both the mobile end and server end. Tests were performed on the medical images of different file sizes and also on text files. Examples of the medical images of MRI, CT, X-Ray, Ultrasound transmitted from cloud computing server and displayed in the mobile device are shown in Fig 3, 4, 5 and 6. The medical images are supported by the DICOM file format. The images are compressed using JPEG2000 compression. The compressed images are uploaded in the Cloud server by the physician

and the images are transmitted to the mobile device. EyeOS allows image file sizes up to 2MB. EyeOS has tools like EyeOS Image Viewer that can adapt to the DICOM image files, that are compressed by JPEG2000 compression (.jpeg support).

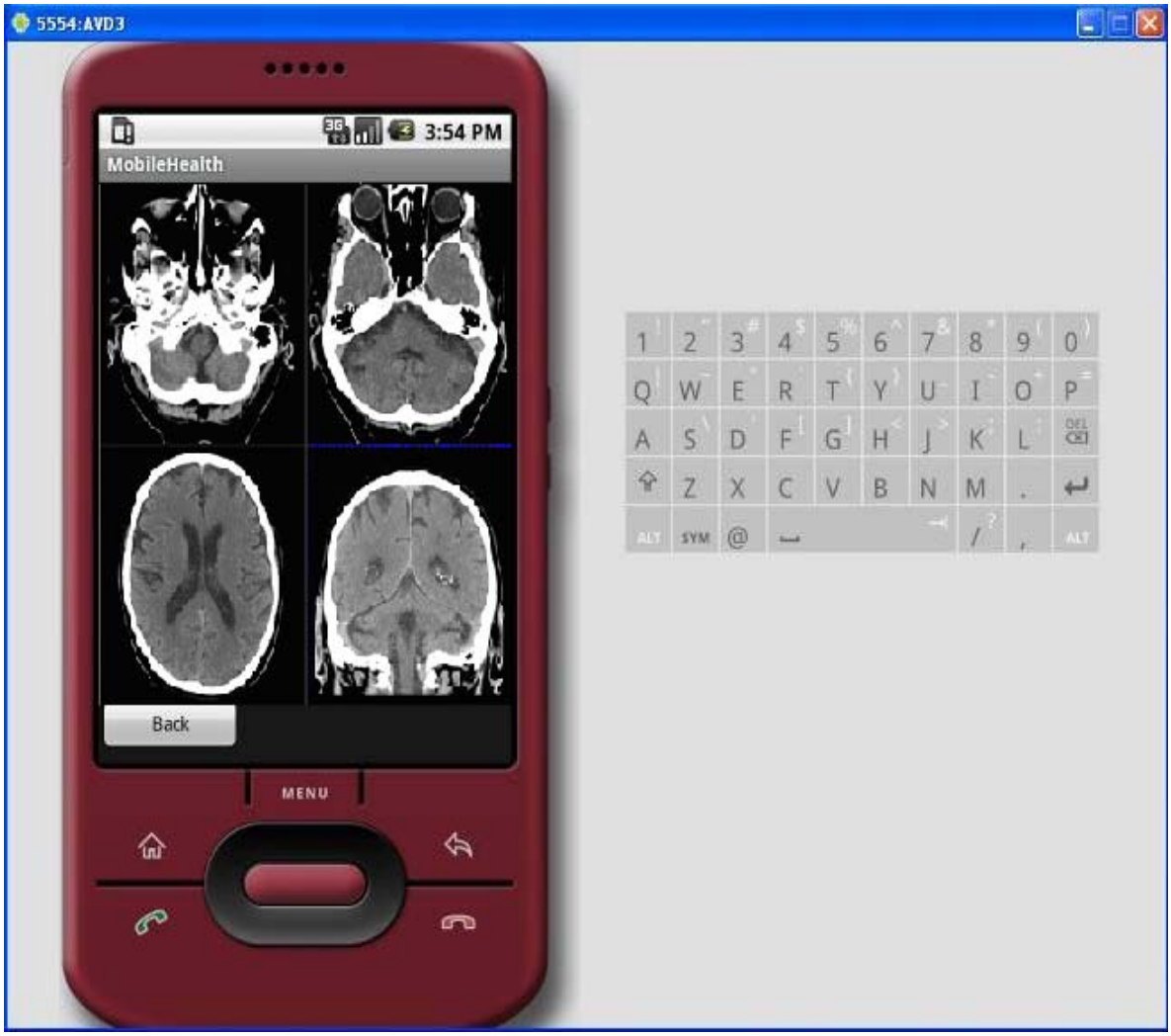

Fig. 3: CT Scan image in Mobile device

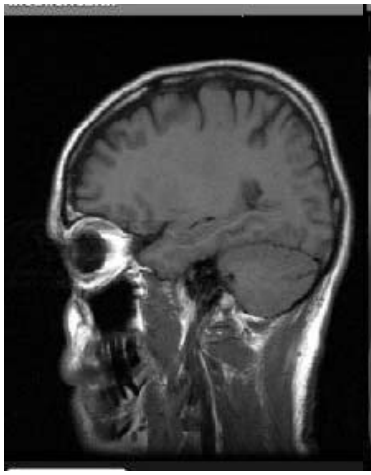

Fig. 4: MRI Scan image in Mobile Device

Fig. 5: X-Ray image in Mobile Device

Fig.6: Ultrasound image in Mobile Device

The approximate transmission time for the various medical images, using the EyeOS cloud server is shown in Table1 below:

MEDICAL IMAGE TYPE(JPEG2000 COMPRESSION)	FILE SIZE	TRANSMISSION TIME (approx.)
MRI	0.123MB	2.75 sec
X-RAY	0.125MB	1.35 sec
CT	0.278MB	1.05 sec
ULTRASOUND	0.318MB	3.75 sec

Table 1: Transmission time for compressed DICOM images using EyeOS Cloud Server

7. Conclusion and Future Work

The HMS application was built for providing vital connection between home healthcare and primary healthcare providers for making their work easier. The application is cost-effective and a boon for elderly people who find it difficult to come to the hospital and spend time for collecting the medical records or prescriptions and also for people in remote areas. It also benefits the patients to make available the medical records while consulting different physicians at any given time. [13].

The application implemented as below serves as a basic platform for further research in the areas of (a) compression of medical images for more efficient storage in the server and faster communication (download) time to mobile device, (b) security and privacy implementations of the medical data at cloud computing server side (c) implementation of healthcare standards like HL7 and HIPAA for data maintenance and communication (d) image operations at mobile interface like zoom in / zoom out at the time of viewing and analysing.

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