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Healthcare information management utilizing cloud computing and Android OS

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Abstract— Cloud computing supports a variety of platforms, systems, and applications and offers functionality for distributed, ubiquitous, and pervasive information data management. In this work, a mobile system that uses cloud computing to store, update, and retrieve electronic health data is implemented. The mobile application, which supports JPEG2000 coding and the DICOM format, manages patient health records and medical images and was created with Google's Android operating system. Amazon's S3 cloud service has been used to assess the developed system. This article provides an overview of the implementation process and shows the system's first operational outcomes

Keywords: ***Cloud Computing, Mobile System, JPEG2000 coding, DICOM format.***

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I. INTRODUCTION

Mobile healthcare systems prioritize accomplishing two distinct objectives: making e-health apps and medical data accessible at all times and locations, as well as making computing invisible. Both patients and medical professionals can benefit greatly from a variety of applications and services supported by mobile pervasive healthcare technologies, such as mobile telemedicine, patient monitoring, location-based medical services, emergency response and management, personalized monitoring, and ubiquitous access to healthcare data.[12]

However, the implementation of mobile devices for health information management brings with it a number of difficulties, including data management and storage (physical storage problems, availability, and maintenance), heterogeneous resource interoperability and availability, security and privacy (permission control, data anonymity, etc.), and unified and ubiquitous access. The introduction of the cloud computing concept into electronic healthcare systems is one possible way to address all of the aforementioned problems.[15]

Through the provision of services on demand via the network to carry out operations that satisfy evolving needs in electronic healthcare applications, cloud computing offers the ability to access shared infrastructure and resources in a widespread and pervasive way. @HealthCloud, a ubiquitous healthcare information management system for mobile devices that makes use of cloud computing and the Android operating system (OS), was created in this context. [1]

II. MOBILE HEALTHCARE SYSTEMS AND CLOUD COMPUTING

Numerous studies have indicated that the primary causes of medical errors in healthcare are insufficient communication among members of the patient care team and restricted access to patient-related information during decision-making.[5] A shared collection of reconfigurable computing resources (such as networks, servers, storage, apps, and services) can be accessed conveniently and whenever needed through the use of cloud computing be quickly provisioned and released with little management effort or service provider interaction. [7]

As a result, it is thought that having widespread and ubiquitous access to healthcare data is crucial for the correct diagnosis and treatment procedure. Five key features, three service models, and four components make up this cloud model, which encourages availability. models for deployment. [8]The following is a summary of the main features of cloud computing.

(A) On-demand self-service:

Without requiring direct communication with each service provider, a customer can unilaterally acquire access to computing capabilities, such as server computing time and/or network storage, as needed automatically;[2]

(B) Broad network access:

Resources are accessible via the network and accessed through standard mechanisms that encourage use by heterogeneous thin or thick client platforms (e.g., smartphones); [6]

(C) Resource pooling:

Using a multi-tenant model, the provider's computing resources are combined to serve numerous customers, with various virtual and physical resources being dynamically allocated and reassigned in response to customer demand. Storage, processing, memory, network bandwidth, and virtual machines are a few examples of resources; [13]

(D) Rapid elasticity:

Resources can be rapidly and elastically provisioned, in some cases automatically, to quickly scale out and rapidly released to quickly scale. One of the main advantages of cloud computing is its flexibility in terms of the services that can be created, which allows users to quickly and affordably re-provision technological infrastructure resources. Device and location independence allows users to access systems using a web browser regardless of where they are or what device they are using (e.g., mobile phones). [21]

Centralizing infrastructure in areas with lower prices is made possible by multi-tenancy, which permits sharing of resources and expenses among a sizable user base. Using several redundant sites increases reliability, which makes cloud computing appropriate for disaster recovery and business continuity. Data centralization and more resources devoted to security usually result in improved security. Sustainability is achieved by more effective processes and better use of resources[23]

Many cloud computing services, both free (like iCloud and DropBox) and paid (like Go Grid and Amazon AWS), are already available for widespread user data management. However, with the exception of Amazon AWS, most of them do not give developers the option to design their own apps and include Cloud Computing features. Section V offers more details on the latter matter, and the section that follows explores related research in relation to mobile pervasive healthcare. [3]

III. RELATED WORKS

There is already recognition and solid evidence of the widespread use of mobile devices for healthcare information management. The advantages of employing virtual health records for senior citizen mobility care are discussed by the authors[6]. The major objective of the work is to create seamless and consistent communication flow between home health care and primary care doctors using devices like PDAs and Tablet PCs.[5]

Electronic patient records have been stored via web interfaces and smart cards. Based on mobile agents, the MADIP system is a distributed information platform that enables extensive health information interchange. The authors offer a mobile platform that uses cutting-edge compression techniques to exchange patient records and medical images over wireless networks. Most of the above listed works necessitate the deployment of certain software components and are built on proprietary architectures and communication techniques. Additionally, the works mostly concentrate on providing data to healthcare applications, ignoring data management and interoperability problems brought about by the diverse data resources present in contemporary healthcare systems. [12]

As noted in earlier sections, using cloud computing offers data management and access capabilities that address the aforementioned problems. Although it is a relatively new idea, using cloud computing for healthcare information management is thought to have a lot of potential. As far as we are aware, no other research has been done in the literature that uses cloud computing to offer ubiquitous healthcare information management services on mobile devices. [17]

IV. APPLICATION OVERVIEW

The @HealthCloud application's primary features are covered in this section, along with implementation specifics. The application's primary function is to give patients and medical professionals a mobile user interface for handling medical records. The latter translates into the storage, retrieval, and querying of patient health information, medical pictures, and patient-related data (such as bio signals). Medical staff may have originally uploaded or saved the data using a Hospital Information System (HIS) at a distributed cloud storage facility. Non-proprietary, open, and interoperable communication protocols must be used for data sharing and communication in order to be compatible with a range of Cloud Computing infrastructures. [22]

@HealthCloud provides the following features with Web Services connection and Android OS: Smooth connectivity to cloud computing storage: Web Services and the REST API are used by the primary application to enable users to retrieve, edit, and upload medical content, including patient health data, bio signals, and medical photographs Although the user has access to the resources since they are locally accessible on the device, the material is located remotely in the distributed storage elements . Patient Health Record Management: The application's interface allows for the presentation and management of data about a patient's condition, associated bio signals, and image content. Support for viewing images: While the JPEG2000 standard has been adopted to provide lossy and lossless compression, progressive coding, and Region of Interest (ROI) coding, the DICOM [18] medical image protocol is supported. [22]

By optimizing network resources, progressive coding enables the user to decode huge image files at various resolution levels, enabling image acquisition even in situations where network availability is constrained (see examples in Figure 1c and Figure 1d). To support the JPEG2000 standard on the Android platform, the code used in [10] for wavelet decoding on mobile devices has been updated. Additionally, image annotation is supported through the use of multi-touch features of the Android OS.

V. PROPOSED SYSTEM ARCHITECTURE AND MPLEMENTATION DETAILS

Shows the suggested system architecture for creating and implementing cloud-based mobile healthcare applications. The platform front-end interface, which facilitates direct user communication and storage content management, is typically one of the primary elements of a cloud computing service. The user interface may be a stand-alone application or a web client. The Cloud Storage Facilities are in charge of carrying out maintenance tasks (such as data backups) and overseeing the physical infrastructure (such as storage components).

The Cloud Service module, which manages and queues user requests, is likewise linked to the Cloud Platform interface. Lastly, the Cloud Infrastructure module handles pricing, accessibility, and user account management. Authors have previously shown how mobile devices can be used to wirelessly retrieve medical picture data from distant repositories by employing appropriate content coding (i.e., wavelet compression with region of interest support). This work has now been expanded to include communication via Web Services and incorporate the ability to communicate with cloud computing systems. In this regard, @HealthCloud was created utilizing the proper software development kit (sdk) and is based on Google's Android mobile operating system (OS).

The Linux kernel powers the Android mobile operating system. Numerous manufacturers of mobile devices already support it. The platform supports many communication protocols (CDMA, EV-DO, UMTS, Bluetooth, and Wi-Fi) and may be adjusted to larger and more conventional smart phone layouts. It is appropriate for showing medical content because it supports a wide range of audio, video, and still picture formats. Lastly, it has native multi-touch functionality, which improves the application's usability overall and enables greater editing of medical images. There are multiple modules that make up the Android OS Cloud Service client. Cloud-stored patient records are retrieved and shown by the Patient Health Record application.

The device's ability to display medical images is controlled by the Medical Imaging module. It displays both picture and audio data after decoding images in DICOM format. The image is decoded by the relevant sub-module when JEPG2000 compression is applied. An implementation of the Web Services REST API, which Android natively supports, is used to communicate with the cloud. Any application can use Web services to communicate with any other application due to the inherent interoperability that comes with using vendor, platform, and language-independent XML technology and the widely used HTTP as a transport.

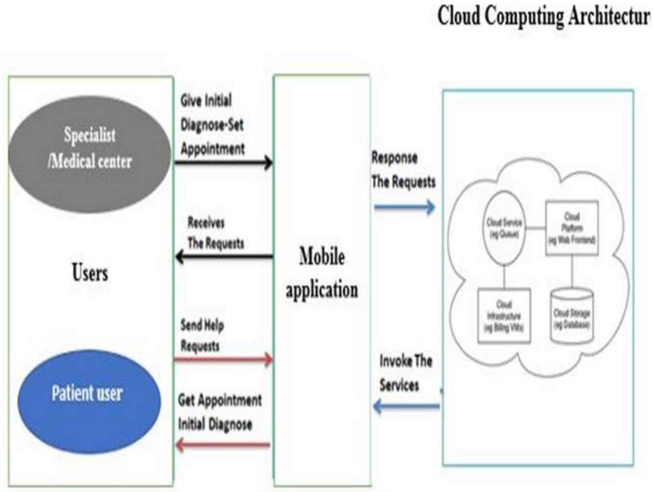

Figure 1: Cloud Computing Architecture

Data in Cloud are seamlessly stored and presented to the user as if they reside locally. This means that the Cloud repository is presented as a virtual folder and does not provide the features of a database scheme. In order to provide the user with data querying functionality, medical records and related data (images and bio signals) are stored into a SQLite file. SQLite is the database platform supported by Android. The file resides into a specific location at the Cloud and is retrieved on the device every time user needs to query data. The query is performed locally and the actual location of the data in the cloud is revealed to the applications. The database file is updated and uploaded into the Cloud every time user modifies data, respectively.

1. UTILIZING AMAZON S3 CLOUD SERVICE

Amazon Simple Storage Service has been used to make the mobile healthcare information management system a reality. The primary justification for choosing the particular cloud computing platform is that it is a well-known, commercial service with numerous successful applications. It is appropriate for handling healthcare information and offers developers the option to build their own apps for accessing the latter (PaaS model) in addition to offering consumers a variety of interoperable online interfaces for managing data (SaaS model).

2. INITIAL EVALUATION FROM THE SYSTEM IN PRACTICE

Some preliminary tests assessing the system's functionality have been carried out to demonstrate its usability. The time required to send data to the Amazon S3 Cloud storage service is the subject of experiments. The results given concern the transmission of medical images because textual data, such as a patient's medical record or a bio signal sequence, do not require high bandwidth and do not consist of massive data files. An HTC G1 smartphone running Android OS version 1.6 has been used to execute the @HealthCloud application, as described in the preceding sections. Numerous medical images with varying file sizes and modalities (MR, CT, PET, OT, and ultrasound) have been used. In Table I, the transmission times are shown. As previously mentioned, two distinct forms of wireless network infrastructure—a commercial 3G network and a WLAN—have been used.

Graphical style (encoding)	File size	Network 3G	Network 4G	Network WLAN
CT (uncompressed)	0.530 MB	1.57	1.22	1.2
X-ray	0.333 MB	1.11	0.45	0.37
MR	0.733 MB	2.40	1.50	1.22
CT (JPEG 2000)	0.110 MB	22.0	0.018	0.11
PET	0.043 MB	0.09	0.5	0.3
Mammogram	0.533 MB	1.56	1.33	1.2
Ultrasound	0.498 MB	1.47	1.33	0.50

Table 1: File Size and Network

Due to the use of commercial networks in both scenarios, traffic and other network conditions can readily skew the performance of both WLAN and 3G networks. Additionally, the overall transmission time may be significantly impacted by the Amazon S3 Cloud service's response time. Nonetheless, as the trials replicate a real-world situation in which medical data is transmitted via commercial wireless networks and the particular service, the obtained results might be regarded as suggestive. Furthermore, the amount of time required to decode and display the particular pictures utilized in the experiments have been measured. Regarding the HTC G1 smartphone phone utilized, the amount of time required for @HealthCloud to show uncompressed CT scans with 512x512 pixel resolution was 0.52 seconds, using JPEG2000 to compress CT images. Coding took 4.53 seconds at 512x512 pixel resolution. The duration required to decode OT images that have been compressed with JPEG2000 took 21 seconds and 7.5 seconds at a resolution of 3072x2048. seconds for a series of ten 600x430 ultrasound pictures pixels.

VI. CONCLUSION

The effective implementation of pervasive or mobile healthcare systems depends in large part on the sharing of medical information resources, such as electronic health data and related processing tools. Researchers, developers, and business partners in the biomedical informatics sector will be interested in the idea of cloud computing and applications like the one described in this article. The prototype implementation of a mobile healthcare information management system based on cloud computing and Android OS, called @HealthCloud, was presented in this study. The system makes use of Amazon's S3 Cloud Storage Service and permits the management of patient health records and medical photographs (supporting DICOM format and JPEG2000 coding).

Future research could involve enhancing security by integrating cutting-edge user authentication methods on the mobile device (such as speech recognition) and putting the platform in a genuine healthcare setting to assess the system's effectiveness and user acceptability.

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