Design and Implementation of Cloud Based M-Health Application for an Electronic Medical Record System

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Abstract. Around the world, health information technology has progressed and different countries have adopted various EMR (Electronic Medical Record) systems. Some of the long-time medical inefficiencies known in developing countries can be resolved by the use of (EMR) systems. This paper presents the design and implementation of a proposed electronic medical records management system that allows the medical data of a patient to be effectively managed. In this context, we propose an overall system architecture along with its functional components and we present an android-based mobile application that helps both the patient and the medical practitioners to manage the patient's medical information and details. The UML formalism is used to model our application and for its building, we used Java programming language under the Android Studio development environment and we used the cloud for medical data access, sharing and storage.

Keywords: Mobile health · Electronic medical record · Cloud computing · Mobile application

1 Introduction

In developed countries, the use of Electronic Medical Record (EMR) technology has already started and has become an important tool for the doctors, while in developing countries the rhythm is still slow and still using a paper-based system and manual processing method. In Algeria, medical centers (clinics and hospitals) still rely on paper medical records system and handwritten notes to monitor patient's state, inform and make decisions, that tends to be the standard rather than the exception and their information system (if any) is generally used for management not for care. The difficulty to deploy the technology is due to a number of limitations such as the lack of ICT infrastructure, the lower efficiency in service delivery, and the lack of technical assistance required to maintain such healthcare systems [1]. This causes on the one hand more manual work that is heavy and hard for the medical personals and on the other hand a quantity of frequent and archived information, which leads to a difficulty in the search and consultation of the medical records, and generates a remarkable loss of time especially in the event of an increase in the number of patients. This complexity frequently

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leads to mistakes, which have a significant impact on daily activities in hospitals, clinics, and other healthcare institutions. The following are some of the main reasons for moving to a "paperless" environment: (1) Enhancing the level of care by proving medical documentation, (2) raising personnel efficiency, (3) reducing record keeping space [2].

Indeed, quite often, patients are asked to describe their history each time they see a new healthcare professional, which is not evident especially in the case where the patient has several illnesses followed by different specialists. Particularly, during a consultation, the doctor's observations are not registered, and even if they are, they could not be shared. Thus limiting collaboration and coordination between patients and medical staff.

In order to provide continuity of care, patient's data must be shared between healthcare organizations, the clinicians should be able to access to the complete clinical history of the patient and retrieve relevant medical information. This is vital for decision making and delivering the appropriate treatment and desirable services.

Cloud computing introduces a new business model that provides numerous benefits to the healthcare industry as a whole [3]. Patients and healthcare organizations would gain advantages from using the cloud in medical services since it would improve patient quality of service, cooperation across healthcare institutions, and lower IT costs.

This paper is part of a global context of the healthcare sector and patients' follow-ups. In particular, aimed to enhance the patient lifecycle's efficiency and facilitate access to his medical data as well as their updates to ensure better monitoring of the patients' health state and improve the quality of the offered healthcare services. The main contribution of this work is that the proposed system can replace the present care methods in Algeria for monitoring patients and processing their medical records which are mostly manual and paper-based and do not use cloud computing technology. Furthermore, Medical centers in Algeria could benefit from the usage of a cloud-based EMR. It has the potential to provide benefits such as real-time monitoring of patient data, reduced waiting time at health care service delivery points, and improved overall quality of delivery in Algerian healthcare by reducing data retrieval delays. In addition, the proposed system architecture uses role-based access to medical records, it can connect and share health data to authorized users (healthcare experts and patients) where and when needed. The developed mobile application offers the possibility of solving the management of patient medical records and the optimization of their retrieval process, by defining a good organization of the collected data to facilitate the search for documents, setting up a complete database for medical records, medical consultations, various examinations and their results as well as ensuring better communication and consistency of information. To accomplish this, we chose the Android mobile platform since it is open-source, free, and has a big community in comparison to other platforms. We'll take the advantage of Cloud Computing to guarantee the user's health information access, share, and better storage capabilities.

The remainder of this paper is structured as follows: Sect. 2 discusses the background and technologies behind EMR system. Section 3 discusses some relevant existing works. Section 4 presents the proposed system architecture and design. Section 5 outlines the implementation of our proposed system. Finally, Sect. 6 concludes the paper.

2 Background

2.1 Electronic Medical Record (EMR)

Electronic Medical Record (EMR) is defined by the International Organization for Standardization (ISO) as the storage, secure exchange, and access to patient information in digital format by multiple authorized users. This data comprises information from the patient's past, present, and future [4]. The principal goal of EHR is to maintain an integrated, efficient, and high-quality health system. In other words, EMR refers to any information about a patient's health. Over time, this data is regularly and continuously collected and recorded in electronic format. Authorized people will have access to all or part of this information if necessary, without care for the location or time.

EMR has made a big difference in the way healthcare is delivered, decreasing mistakes and improving the effectiveness of health care. Access to all patient history information is made easier, which enhances treatment, focuses on information, and decreases medical diagnostic errors. Generally, a patient may have many health care providers; exchanging patient information among them enhances communication and improves the quality of the care services given. The use of new technologies such as cloud computing is effective in the successful implementation of EMR.

2.2 Cloud Computing

Because of the continuous need for mobility, mobile devices have become the most access channels for the users, and it's the same for mobile applications, which are available in a variety of sectors, including healthcare [5]. For patients and physicians, mobile phones with modern technologies like Cloud Computing provide a helpful application platform for data processing, transmitting, and disseminating on an "anywhere, anytime" basis [6].

Even though cloud computing is now becoming the key technology for the storage and analysis of large data sets both in academia and industry [7]. Cloud is a kind of service model that provides processing power, a large amount of storage, networks, and other computational resources which can be scaled according to users' needs. Cloud computing features and functionalities will enable developers to create safer, cheaper, and better applications. Cloud data sharing is easily available for all devices that can connect to the server from any location and in any form.

3 Related Work

Over the last decade, interest in healthcare and well-being has increased among the population. Several solutions and approaches have been proposed in order to improve the healthcare systems. EMR effectively organizes and manages patient information, reduces errors, and produces detailed reports on patient histories and services. It also allows instant communication between several actors and users [8, 9].

The study [10] presented cloud-based solutions on EHRs systems in different scenarios. The first scenario is for a bigger hospital and second is for a network of Primary Care Health centers. The purpose of this study is to analyze the best scenario for the deployment of Cloud Computing. [11] developed a cloud-based application architecture-based integrated strategy to improve the health-care system. The system is built on a three-tier cloud architecture that includes rich internet application for client, simple DB for server and a logic layer. The work also uses a data mining method to retrieve important data from the rising number of EMRs. The authors in [12] aimed to address concerns about EMR privacy in the cloud by storing and distributing personal health information effectively while also offering a system access control mechanism. [13] focused on cloud-based EMR maternal and child health outpatient care. The study in [14] created an Enterprise Electronic Cloud-Based Electronic Health Record System. Patients medical records such as digital medical imaging, pharmaceutical data, and doctor's notes were all integrated and available in real time via the proposed system, which could store, retrieve, archive, and update them.

4 Proposed System Architecture and Design

The architecture of a cloud-based Electronic-Medical Records system is presented in Fig. 1 below:

The cloud-based system presented in the architecture is an important component by which patients and health workers can access, store and retrieve electronic health data in the cloud from anywhere and at any time through the use of internet facilities. It consists of:

Authentication Server: Authentication and authorization are handled by this part of the system. It determines if a user of the system has the right to do the desired activity. The authentication server provides access to authorized users to the system's records and resources while denies unauthorized users. This is accomplished by providing username and password for users (Admin, Patient, or doctor). If the username and password match those stored locally, the system gives access to the user; otherwise, the user is denied access .

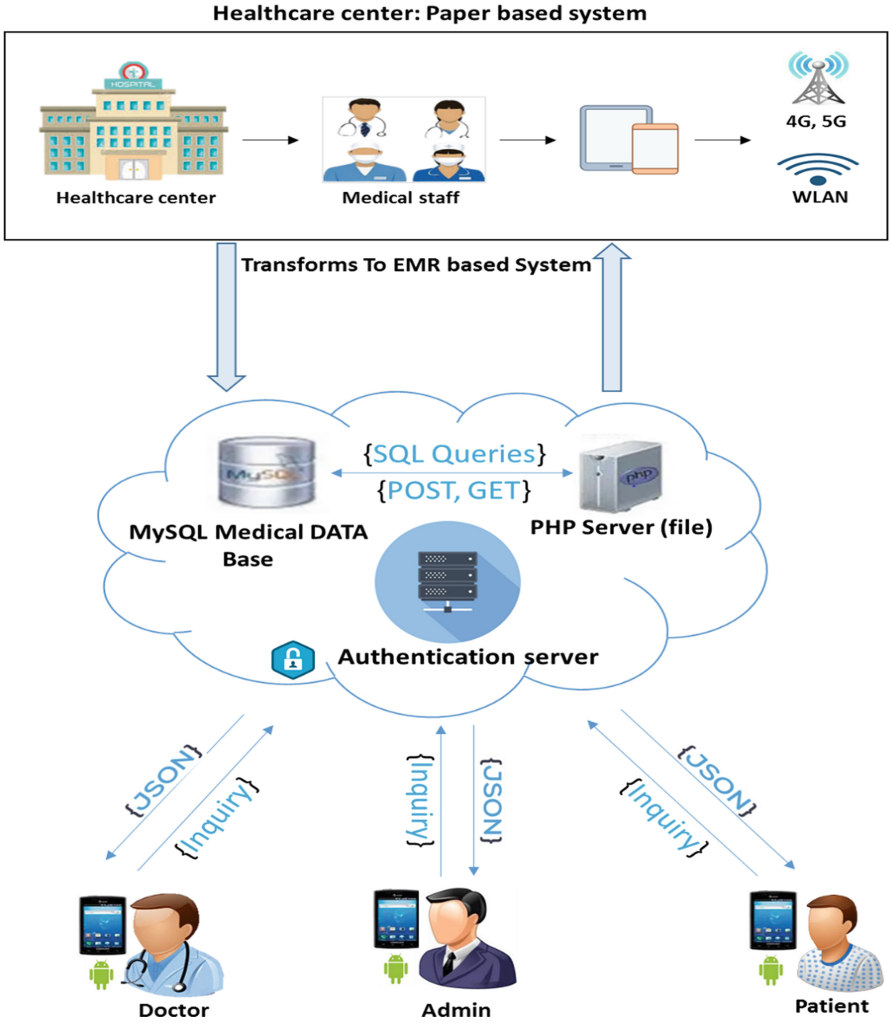


Fig. 1. Architecture of Cloud Based Electronic Medical Record System.

MySQL Medical Data Base Server: Located on the cloud and provides the ability to store electronic medical records, retrieve and update patient information. The user can access to the EMRs through the mobile application using an internet connection. The patient's medical information is stored in a unified standard format which can be retrieved via query commands.

The android mobile Application retrieves information from the server that hosts EMR database via PhP files. First, the application sends an HTTP request to the server with the address of the PhP script it needs. (2) Access to the database is via PhP files. Each PhP file contains MySQL queries for a particular task. (3) The database is responsible for inserting the data into the tables (POST methods) or returning the result of a selection (GET methods). (4) The returned result is in JavaScript Object Notation (JSON) format (a format that is readable by the android application). (5) The result is transferred to the application.

The android mobile application aims to ensure the proper management of the patient's medical file so different users (Medical staff and patient) can consult and manage patient medical data. Figure 2 illustrates the use case diagram for medical staff functions.

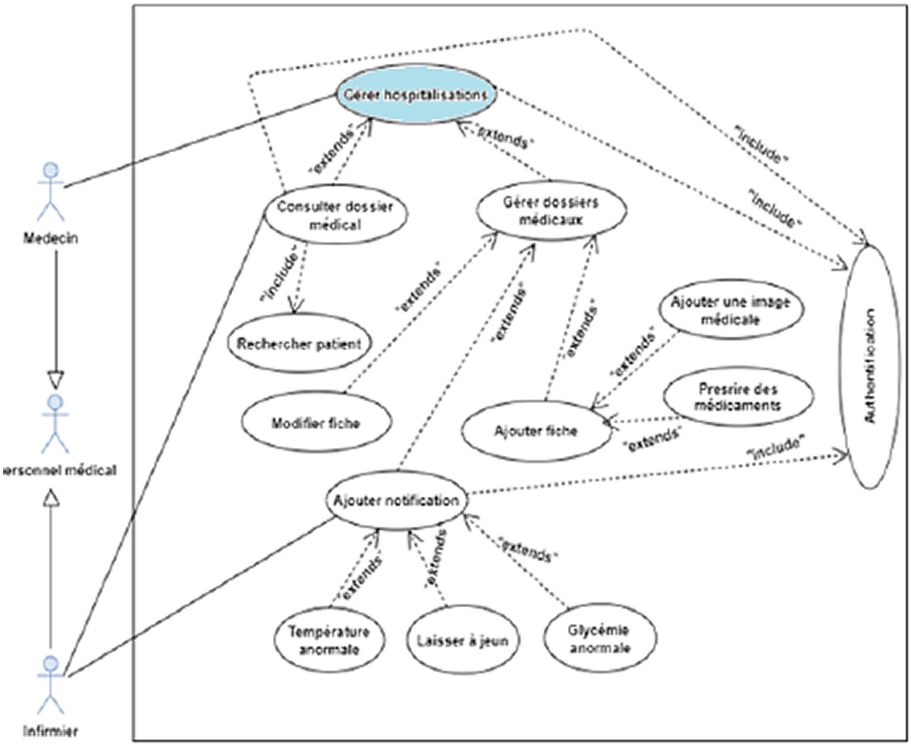


Fig. 2. Medical staff use case diagram.

The class diagram of our system is given by Fig. 3.

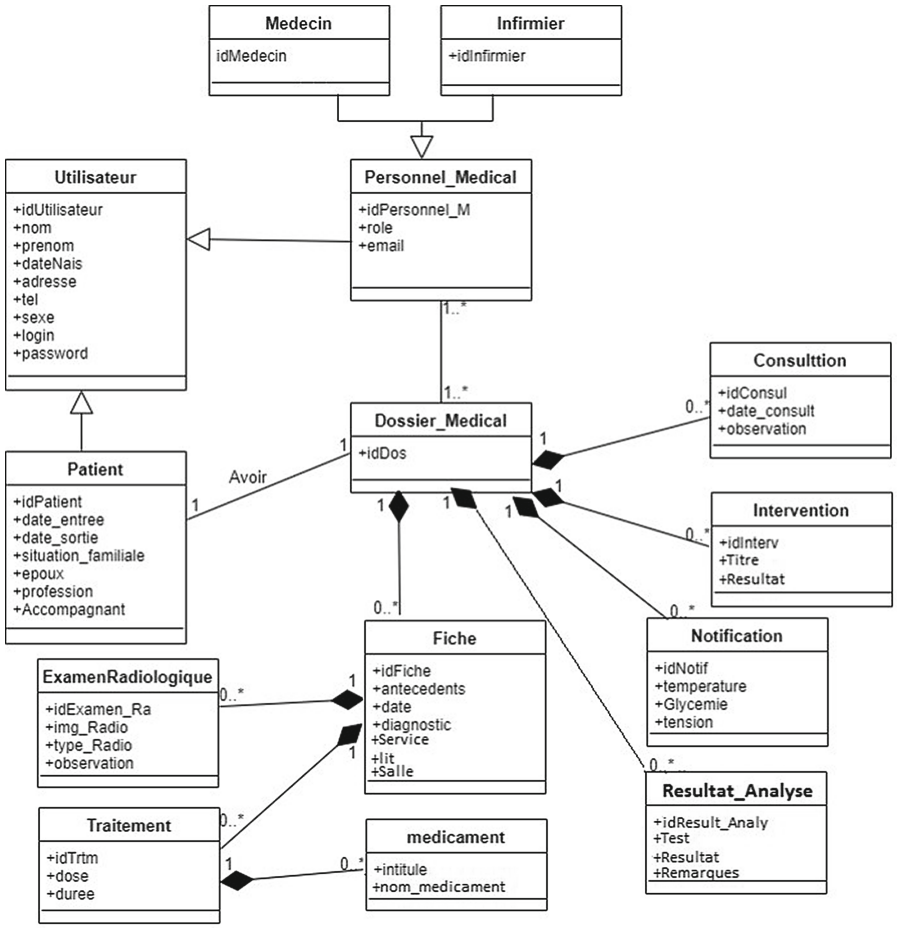
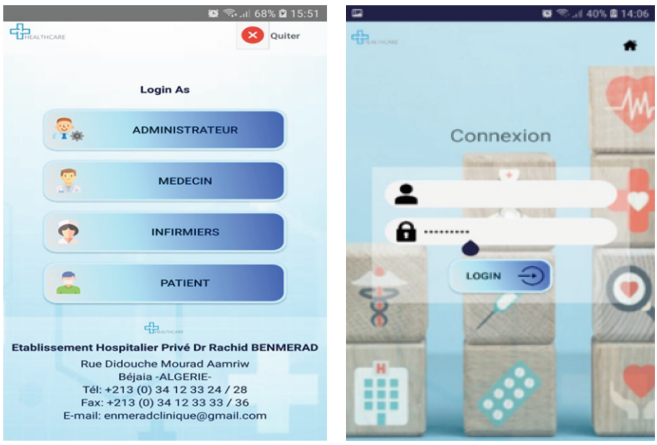


Fig. 3. Class diagram of our application.

5 Implementation of Prototype

To prove the usefulness of the proposed system, we have implemented an android-based mobile application prototype to manage patient EMR. In the following, we will present some of this application views.

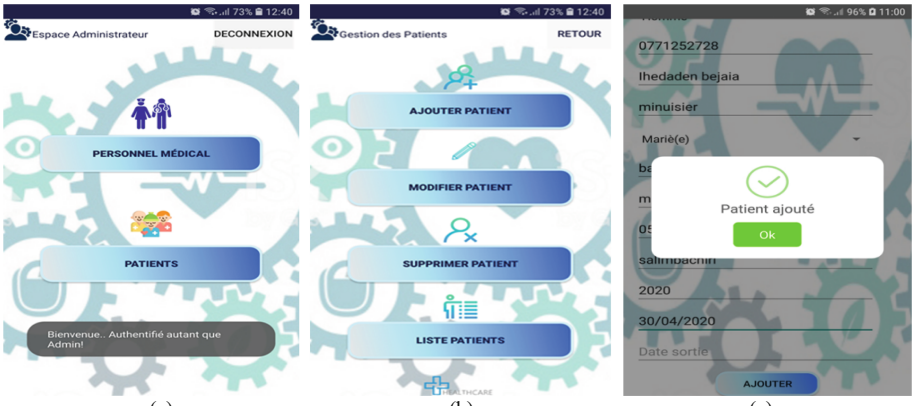
Initially, the user should login the application with their username and password. Figure 4 captures a preview on the home page and application authentication.



(a) (b)

Fig. 4. (a), (b) Users login and authentication views.

After the login page, at the administrator view, the administrator chooses patients, and the patient management page launches, he clicks on add a patient, fills out the form and validates Fig. 5.

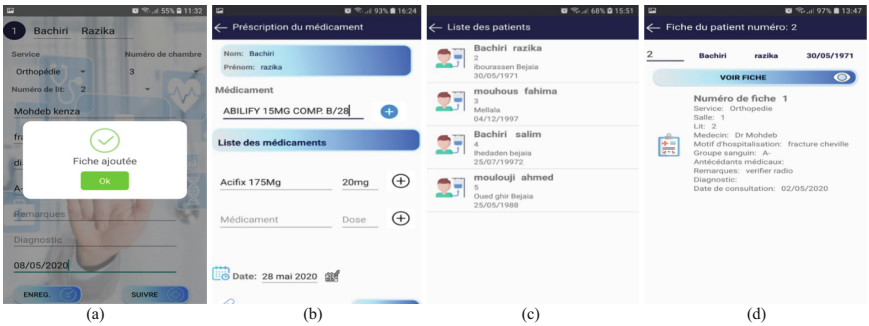


(a) (b) (c)

Fig. 5. (a), (b), (c) Administrator space.

After the login page, at the doctor view, a menu of his tasks appears. By clicking on hospitalization, another interface is displayed, and the doctor clicks on new file to create a file for the patient. Then, the doctor enters the patient's first and last name, fills out the form and saves. Once the file has been successfully added Fig. 6(a), the doctor will be redirected to the interface Fig. 6(b). The doctor clicks on *medication* if he wishes to prescribe medication, the drug prescribing interface load. The doctor can consult the medical files of the patients by clicking on *Consult file*, the list of patients is

loaded Fig. 6(c), when he clicks on a patient from the list, the file (or files) of the latter is displayed Fig. 6(d).



(a) (b) (c) (d)

Fig. 6. (a), (b), (c), (d) Doctor space.

The patient can only consult his file and access to his measurements, medications and history without having the possibility of modifying his data.

6 Conclusion

In this work, a cloud-based electronic medical record was designed and implemented. The proposed EMR system can replace existing methods to manage medical records in developing countries such as Algeria, which are mostly paper-based and do not use cloud computing technology. The adoption of a cloud-based EMR would allow the ease of access to patient's medical data, improve patient management, work productivity, and reduce wait times for health-care service delivery, which offer the possibility of truly personalized healthcare.

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