Mobile Application of Electronic Medical Record (EMR) Systems using Near Field Communication (NFC) Technology

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***Abstract*— Medical records are preventive actions that are recorded into files stored by the health service providers. Medical records are needed by the doctor to find out the patient's historical data so that they can be served further. A medical history reporting error can result in a patient's medical care failure. To reduce administrative errors, loss of data, and the effectiveness of medical services requires tools that can provide solutions. Near Field Communication, called NFC, was the development of Bluetooth and RFID. NFC allows cell phones to store necessary data safely and be sent to other phones equipped with NFC or read by an NFC reader. Also, this NFC allows cell phones to be developed of payment (e-money) or electronic medical record (EMR). On this study has developed an Electronic Medical Record system based on Near Field Communication and EMR with NFC is expected to the replaced conventional medical record. The advantage of NFC-based EMR is the need for a short time in use, not depending on Internet access and ease in the transmission of EMR to those in need. Patient data processing is faster, accurate, and integrated with cost management to medical services providers.**

***Keywords*—electronic medical record, Near Field Communication, electronic hospital record**

I. INTRODUCTION

Hospital services generally begin by reading patients' medical records aimed at identifying patients, disease history, medication, and action[1]. The line of patients at the hospital for preventive action by a doctor selected to be late due to the process of looking medical records that takes too much time. The doctor's checks and actions recorded on the medical record file were filled in the file had a drawback in the form of malfunction or disappearance. Damage to medical records would hinder provide and customer service. Threats of service tardiness, file damaged, and loss is insurmountable by creating electronic medical records. Privacy or confidentiality, integrity, authentication, access control, non-repudiation, and availability can make using electronic medical records. Medical records that the administration has included in the EMR are accessible at any time as patients enter different hospital buildings as needed.

The availability requirements can be met if there are an Internet connection and the availability of service servers where EMR is stored. Needs technology capable of retrieval and processing data off the line and allowing data to be stored on mobile devices to be sent on servers for the medical interest is Near Field Communication (NFC) tag reader and raspberry pi. Through NFC reader data can be taken and processed off-line, but at times that allow it to be sent to servers for wilder interest. Also, NFC-based medical records allow medical records to be used by health services everywhere without depending on where the medical records were first made. The ease in accessing patient information, which ultimately helps in clinical decision-making[2] such as establishing a diagnosis, administering therapy, avoiding allergic reactions, and duplicating drugs[3]. Some electronic medical records study is done by [3], [4], [5]. In [3] the benefits of EMR, which facilitated administrative power in retrieval patient information, whereas in [4] and [5] it states that EMR is beneficial for the patient by increasing the level of health care in the health-care process. Medical records development based on NFC were developed by [6], [7], and [8]. All three studies used RFID cards to store medical records.

Many types of research have been conducted on Electronic Medical Records and other related researches. In an effort to overcome the problems surrounding EMR, a literature review is needed as one of the methods of research that will be carried out. Among them are shown in

II. THEORY THING AND PREVIOUS RESEARCH

Medical records are a history of illness suffered by patients. Identity, anamnesis, diagnose disease through the lab, and corrective actions on and off the record are kept on file both electronic or non-electronic. If the data storage is done electronically, it will require a computer using database management. Thus, the definition of medical records is seen as a system of administration of health arrangement ranging from recording, service, and corrective actions that patients receive. Medical records will be stored until they are retrieved when needed for further health care. According to the Medical Practice Act, article 46 paragraph (1) medical records are files containing records and documents on the patient's identity, examination, treatment, actions, and other services that have been given to the patient. Medical records data can be either structured or narrative, digital images, heartbeat sounds, videos, or biosignals such as ECG recordings. There are two important things related to medical records; patient record and management. Patient records are patient information recorded in written or

electronic form about the condition of health and illness. Patient records are generally individuals. The second part is management related. Management is a data processing process or compilation of health and disease conditions in order to become useful information for management, both financial and developmental conditions of the patient.

Meanwhile, smartphones technology continue to thrive with the addition of features which make the device multifunctional. Near Field Communication (NFC) tags are one of the features currently being pinned on smartphones. NFC reader enables smartphones to communicate with other mobile devices without using the cellular network at a distance of about 4 cm. Furthermore, NFC smartphones can read the data stored in smart cards (NFC tags). By 2015 for about 247 million smartphones had been equipped with NFC [14]. Near Field Communication (NFC) is a new wireless connectivity technology with a short-range radius, which evolved from the combination processes of interconnections technology and existing non-contact identifications. Products supported by NFC can simplify the interface because the NFC provides an excellent fast connection both in data transfer and information exchange also secured transaction. Communication between two NFC supported devices occurred when they were between 0 to 10 cm [16]. With a proximity device to initiate NFC connections. Another advantage of NFC is compatible with Bluetooth or wi-fi technology. NFC and Bluetooth are communications technologies with short communication range that have been integrated by mobile phones. NFC has a communication set-up time faster than Bluetooth. The Bluetooth device will need to run a manual process to identify the Bluetooth devices that will connect, the connection between 2 NFC devices can be done instantly (<0.1 seconds) [16]. Maximum data transfer of NFC is 424 Kbps, lower than Bluetooth, which is 721 Kbps. NFC has a closer communication radius than Bluetooth, less than 10 cm. NFC provides a better level of security and makes NFC perfectly suited to crowded areas and compatible with the existing RFID technology. NFC has a superior element over RFID, which can be used for two way communication and installed on smartphones [17] and equipped with devices capable of governing secure elements. This advantage makes NFC perfect for an application that requires safe storage and exchange of data on their secure smartphones such as e-payment application [18,29,30] & e-wallet [20], medical records [6], and health services [21] & [22].

NFC is a subset of Radio Frequency Identification (RFID) technology, and NFC is a short-range wireless communication technology, where the NFC mobile phone tap within a few centimeters to NFC chip. NFC uses a high frequency of 13.56 MHz and running in various data transmission rates such as 106 kbps, 212 kbps, and 424 kbps. NFC chip or NFC tag is created in a sticker which formed from antenna and IC, where the antenna will read the external sign from NFC mobile phone and activate the IC. There are two types of NFC, such as passive NFC and active NFC:

1) NFC chip is passive and works by using power supplied by the NFC mobile phone tapping it. Passive NFC chip can send information to other NFC chip without power resources, cannot process any information sent from other NFC chip and cannot connect other passive NFC chip.
2) Meanwhile, an active NFC chip can send and receive data and can communicate among active and passive NFC chips and recognized as NFC mobile phones.

There are four types of NFC chips, such as :

1) NFC CIRCUSTM ON-METAL equipped with NXP NTAG213 Integrated Circuit (IC) which work on metal surfaces that need to be identified using NFC technology.
2) NFC CIRCUSTM is designed to suit for small size application and equipped with IC such as NXP NTAG210 Micro, NXP NTAG213 and NXP NTAG216 chips, comes with UID mirror, password protection, and a fast read command.
3) NFC CIRCUSTM TAMPER LOOP is designed for tamper detection and authentication, equipped with NXP NTAG213 TT IC, where loop enables advanced digital seal functional for smart packaging and brand protection.
4) NFC Temperature Logger is a battery-powered label system, equipped with AMS AS39513 IC for accuracy logging or reading data temperature during transportation in supply chain applications for shipment quality, inventory, and logistic.

NFC technology has been deployed on a mobile phone since 2012, and NFC mobile phone has been applied in many mobile phone manufacture such as Samsung, Huawei, Xiaomi, OnePlus, Motorola, LG, Nokia, Sony and HTC and for example Samsung brand like Samsung Galaxy S4,S5,S6, S6Edge, S6Edge+, S7, S7Edge, S8,S8+,S9, S9+, Huawei brand like P10Lite, P10, P10Plus, P20Lite, P20, P20Pro, Xiaomi brand like Mi Max, Mi Max2, Mi Max Prime, Mi Mix, Mi Mix2, Mi Mix 2S, Mi4i, Mi4c, Mi4s, Mi5, Mi5s, Mi5Plus, Mi8SE, Mi5, Mi5c, Mi8, Mi8 SE, Mi6X, Mi6,Mi5, Mi5c. Using NFC in the mobile phone will help us when there is no internet access connection. Using a mobile phone which attached with NFC chip technology which can upload and download with your phone, do peer to peer communication and the most credit card has been equipped with NFC technology. The NFC mobile phone has three modes of operation, such as:

1) Card emulation where NFC mobile phone act as a credit card for payment.
2) The second is NFC read and write functionality is one-way data transmission where enable to interact with non-powered NFC enabled objects (passive NFC chip).
3) Peer to peer NFC, which allows for file sharing between two powered NFC devices, where the same like Bluetooth technology where both devices switch between active and passive when sending and receiving data respectively. Different with Bluetooth technology, NFC does not need a pairing process in communication.

By tagging NFC mobile phone to passive NFC chip, we can do some choices activities such as make a voice call by presenting the appointed phone number or get some text

message running into NFC mobile phone. Moreover, it can showing link video which can be put in youtube, or giving website link and open it with mobile phone browser, or running application which connects to play store and needs to be downloaded and installed in NFC mobile phones. Using NFC in the mobile phone can be used in many fields such as public transportation where the people depart with public transportation they can check the transportation schedule, the seat availability, time the transportation will come and including pay public transportation's fares. In this situation, mobile phone manufacture, network communication operator, and bank or fintech (Financial Technology) should have a mutual agreement. For example, for public access information, the NFC services can be applied where a mobile phone with NFC technology can be easy to access and read any information from NFC services without internet access connection.

III. PROPOSED IDEA

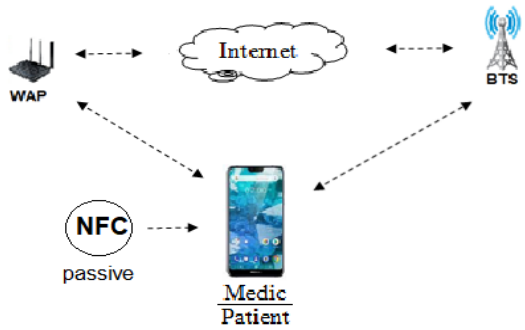

Fig. 1. System Architecture of EMR

The architectural design presents the basic framework of software systems that are built. Information system development architecture of Electronic Medical Record based on web and android-based Near Field Communication (NFC) which is shown on the following figure 1. The system will be developed in any clinics or hospitals who are interested in sharing their patients' data such as prescription, medical records, last medical visiting, symptoms, medicine allergy, and so on. The passive NFC will be attached in any place in clinics or hospital, which can be easy to access by the patient or medical staff. The active NFC or NFC mobile phone will tag the passive NFC and will give the link which can be used by patient or medical staff in order to get any information as they wish. The NFC mobile phone can connect to the system using Wireless Access Point (WAP) for connecting to the systems or using mobile data which connect to Base Transmission Systems (BTS) when their out of WAP's range connection.

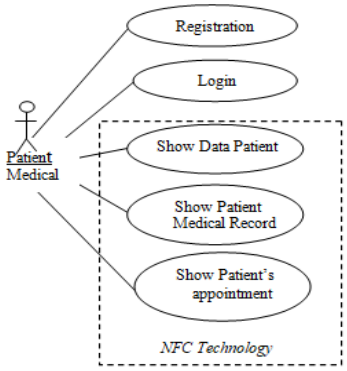

Fig. 2. Use Case of EMR systems

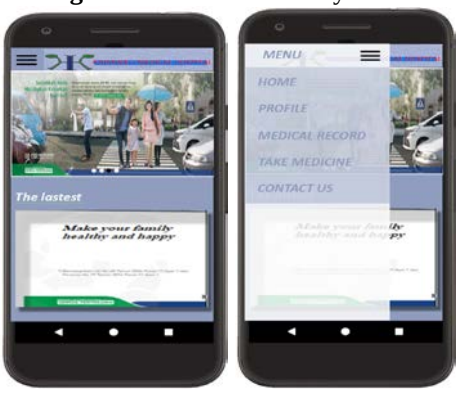

Fig. 3. Main Menu User Interface

However, in order to access the system then each NFC mobile phone should download this mobile application in Play Store and installed in your NFC mobile phone and soon do the registration, input their identification including their patient number. In the future NIK (Nomor Induk Kependudukan) as citizen ID number in Indonesia can be used and will be connected to health BPJS (Badan Penyelenggara Jaminan Sosial) or as Indonesia's health insurance scheme. For example, the patient can see their appointment, their prescription, their medicines list, their treatment, their last record appointment, their health problems, their health's expenses, and so on. Meanwhile, for medical staff, they also need to install this mobile application in their NFC mobile phone, do the registration and they can get any information regarding with their patients' information such as last doctor visiting, medical record, kind of medicine, last prescription, medicine allergy and so on.

Figure 2 shows the use case activities from EMR systems where the use case activities inside the dash box are running based on NFC technology connection. However, these use case activities can be accessed online as well as without NFC technology. Figure 3 shows the main menu of the mobile application. As mention before, both patient and medical staff they need to download this EMR mobile application and install it in their NFC mobile application and do the registration by inputting their data such as date of birth, address, occupation, contact number and so on in order to create patient or medical staff number and password. Figure 4 shows the User Interface (UI) for doing the new patient registration. After the registration, they can do login to the system by input their email as medical staff or patient ID number, including the password, where the UI

can be seen in figure 5(a). Figure 5(b) shows the UI patient medical reports.

Fig. 4. New Patient registration

a) **b)**

Fig. 5. a) Doctor and Patient's Login b) Patient Report

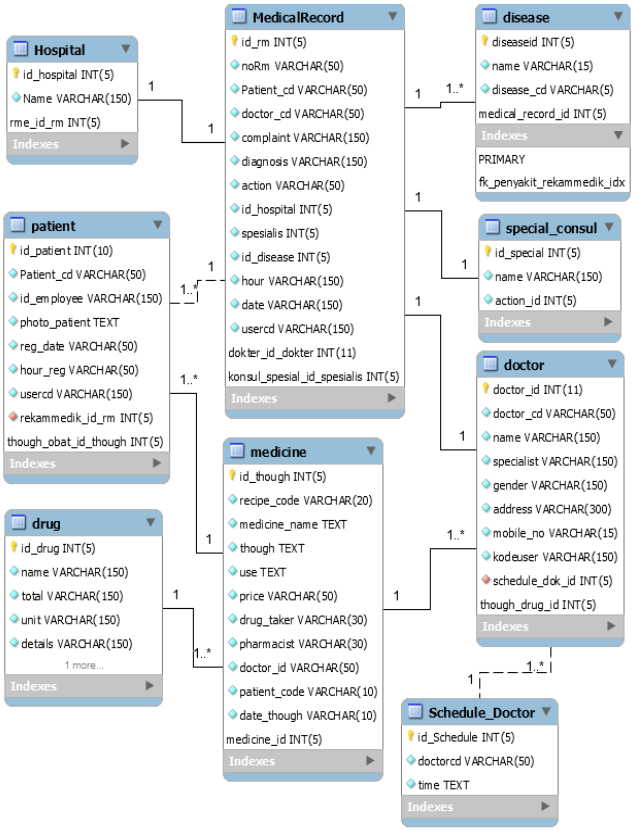

Fig. 6. Class Diagram of EMR database model design

Figure 6 shows the EMR database model design for implementation this application where there is nine tables database such as hospital, patient, drug, medical record, medicine, disease, special consul, doctor, and schedule_doctor. The table hospital contents four attributes which connect to medicalrecord table and table patient has ten attributes which connect to tables medicalrecord and medicine. Meanwhile, table drugs have five attributes and connect to table medicine, and table medicalrecord has 15 attributes and connect to tables such as hospital, patient, disease, special-consul, and doctor. Moreover, table medicine contents 13 attributes and connect to 3 tables such as drug, patient, and doctor, and table disease has six attributes and connect only to medicalrecord table. Furthermore, table special-consul has three attributes and connect to the medicalrecord table, table doctor has ten attributes and connects to tables medicalrcord and medicine, and lastly, table schedule-doctor has three attributes and connect only to table doctor.

IV. CONCLUSION

The implementation of a mobile application for EMR will help both patient and medical staff, where the patient can get the real and acceptable health information and make them comfortable and enjoy regarding with their health information and condition. Meanwhile, the medical staff can easily to access the patient's health information and straight away can help the patient with the right handling based on saving health data information. Using this mobile EMR application can avoid malpractice, where the patient can having safety health treatment, and medical staff can securely treat their patients based on previous health's information. Moreover, using NFC technology will give smooth and speed to access whenever the NFC mobile phone as active NFC can tag to appointed passive NFC.

Using this mobile EMR application will help our health treatment condition, where health BPJS as recognition as Indonesia's health insurance scheme will easily to maintain and secure health treatment in Indonesia. Moreover, sharing data patient information will reduce the malpractice and casualty in emergency treatment. The patient can quickly move from one clinic to other clinics or hospital without worry with similar questions such as last health condition, medicine allergy, and it always repeating nightmare questioning when see the new medical practice.

In the future, this mobile EMR application with using NFC technology will be extended to other activities such as health monitoring and education, where the patient can have education regarding with their health condition using forum and videos which will be saved in Youtube.

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