Mobile Personal Profile Tracker Using Tagging Technology

By

Than Sook Wei

A PROPOSAL

SUBMITTED TO

Universiti Tunku Abdul Rahman

in partial fulfillment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (HONS)

Faculty of Information and Communication Technology

(Perak Campus)

JANUARY 2015

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Signature : _____

Name : THAN SOOK WEI

Date : _____

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ABSTRACT

In this project, the author developed a system that is primarily for the usage in the healthcare field. The primary aim of the project is to ensure the availability of important medical information and also to make increase the speed of accessibility to relevant medical information. The system shall be for assisting healthcare personnel to automate some of the work that are tedious and prone to the human errors. The system will be able to manage patient's information by using a mobile application that support NFC feature to read the wristband of patient that embedded with NFC tag. Besides, the system will allow medical personal to check the vital signs of patients and decide whether there is a need to notify the respective doctor about the patient condition.

The system only requires that the patient's information needs to be entered into the wristband that embedded with NFC tag when they admit to the hospital at the beginning. Once that is done, the patient should be advice to wear the wristband all the time. Any hospital staff with a mobile that integrate with NFC feature and this system will be able to read the wristband to identify each patient. By uniquely identifying the patient, more data can be retrieved from backend database to support further decision making process.

The final deliverable will enable the system to successfully help in automating some of the workflow in the hospital and allow more efficiency management in the hospital.

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CHAPTER 1: INTRODUCTION

1.1. Problem Statement

Technology plays an important role in the human daily life. In recent years, technology is improving in a fast pace. The technology improved either in aspect of memory storage, processing power, mobility or etc. Nowadays, it is not uncommon to see many companies and organizations emerging the use of technology to their business. There is an increasing concern on how to utilize the technology to help medical personnel better in their daily job tasks and hospital management.

Healthcare is the world's largest industry (Janz, Pitts, & Otondo, 2005) and its market size is continuously growing. Recent decades, most countries in the world assign large financial resources to the healthcare sector. To overcome this increment, the current healthcare industry has decided to transform the current base system to information technology (IT) base. Achieving a high operational effectiveness in the healthcare sector is an important objective for organization performance evaluation. Efficiency used to be considered as the primary indicator of hospital performance. Traditionally, some of the tasks in healthcare industry is done manually on papers or manually input to system. The manual power has its limitation which may delay the process of medication and management. Therefore, healthcare industry has been working hard to find solutions to utilize the current IT technology in order to deliver a more efficient and reliable system for the purpose of improving the quality of care.

Since healthcare industry is a growing industry, it faces many challenges of providing safe and quality of healthcare services (Ngai, Poon, Suk, & Ng, 2009). Besides, healthcare industry also intent to reduce the operation costs which mainly caused by the human and systematic errors or current system. Normally, medical personnel like doctors, nurses, surgeons, or etc. have forced to take full responsible for those errors that may cause high risk to the patients. The following will be some significant challenges faced in most hospitals in the management of patients and equipments:

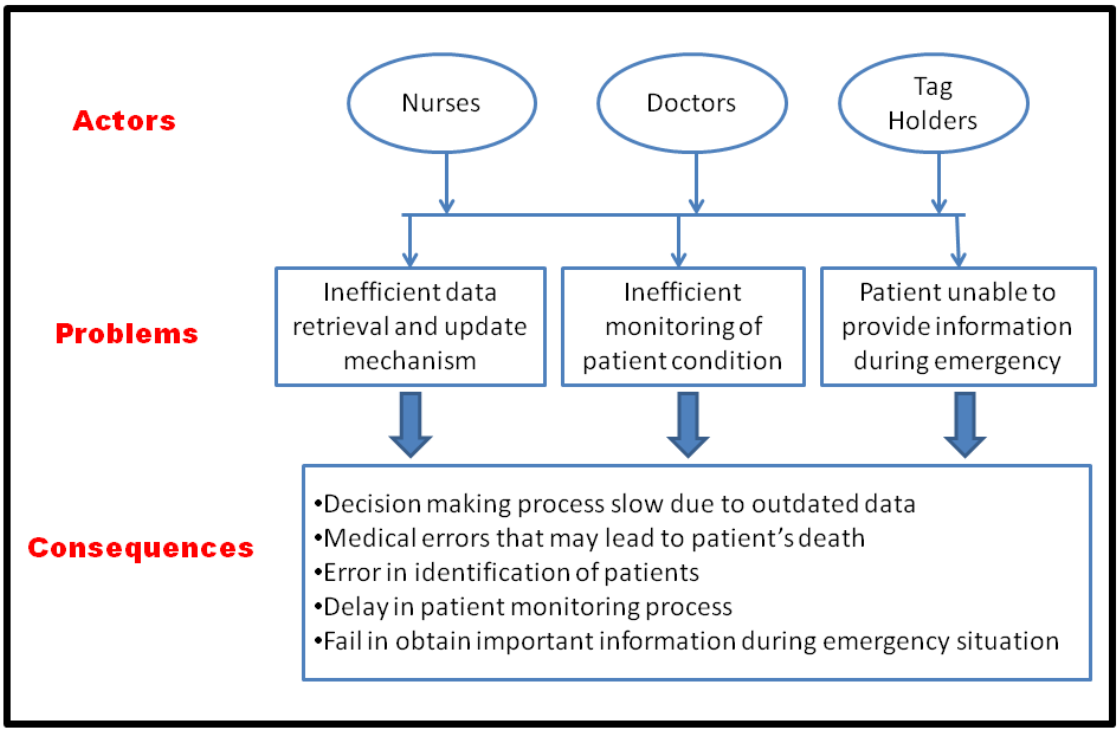


Figure 1: Summary of current challenges faced by hospital

1. Inefficient work flow

Inefficient workflow exists in hospital because of inefficient way of handling patients' profile. For example, doctors or nurses wasted time looking for medical history of patient. The situation goes worse when the patient is in emergency. At the same time, nurses find it tedious to input and update patients' record all the time and mistakes often occur after a hectic day of working. Most medical records of patients are still record by hand nowadays and nurses found it difficult to find different departments with the aim of complete the record. At the same time, most hospital encountered problem such as mistakenly identify newborn baby. This may caused a severe problem in a hospital. In order to solve the difficulty and decrease the mistake that might be occur in this process, a system is needed to automate most of the part of work.

2. Inefficient monitoring of patient condition

Medical personnel often involved in emergency situation which any delay of rescues process may be fatal. Some patients required frequent monitoring of their heart rate reading, blood pressure reading and etc. Beside of monitoring, nurses need to compare the vital signs with the

thresholds set by doctor and have to decide whether there is a need to inform respective doctor-in-charge about the current vital signs and condition of patient. If there is a need of informing doctor, nurses need to search for the contact number of doctor and make call to him or her. It may be a time consumed process as nurses need to search for the contact number of the doctor before they are able to make that call successfully. Besides, informing doctor about the vital signs through phone call may be unclear and confusing.

3. Delay in medication process when unable to determine information of patient

In an emergency patient may not be able to speak and give vital information to alert others about your special health needs. Medical providers must sometimes treat emergency patients without having basic medical information about the individual or any way to contact someone who could provide vital information. Therefore there is a need for a solution that is able to obtain important medical information (blood type, types of medication that he/she is taking, insurance policies. etc.) in a quick and seamless manner. Hospital may face situation like running out of blood supply of certain blood type. The problem may bring serious consequences especially during emergency situation when patient need large supply of blood. Contacting other hospitals to request for blood supply one by one is time consuming and not efficient at all.

Three of the challenges mentioned above such as inefficient workflow of hospital, inefficient monitoring of patient condition and delay in medication process when unable to determine information of patient bring significant effect on the operational effectiveness of the hospital management. In order to deal with all challenges mentioned above for the sake of medical personnel, a more effective yet systematic system for hospital management is needed.

1.2. Background and Motivation

Near Field Communication (NFC) is one of the latest wireless connectivity technologies that enable convenient short-range communication between electronic devices. One of those electronic communicating devices such as NFC tag may be passive, meaning that it has no energy source (no batteries, no solar cell). Based on the Radio Frequency Identification (RFID), it uses magnetic field induction to enable communication between electric devices. Nowadays, NFC offers the ultimate in convenience for connecting all types of consumer devices and enables rapid and easy communications. Hence, there is a growing in number of NFC feature applications available for public uses.

Figure 2: Overview of NFC energy and data transfer

NFC technology normally involved more than two electronic devices which is either active or passive device. The active device is called as a reader and has built-in power supply which enables them to propagate electric signal. On the other hand, the passive device is known as a tag or sometimes a card. Both reader and tag have coils but not antennas. When the reader coil is energized, it generates a magnetic field. When reader and tag get very close, the coils form a transformer and tag is now able to draw energy from the reader (epxx.co, 2013).

Emerging of NFC technology has brought many impacts to various aspects regardless in a small vision or bigger industry. For example, in San Francisco, mobile payments for parking are handled by PayByPhone which is an application that integrated with feature of NFC (Agrawal, 2012). Besides, Japan Airline (JAL) has launched the first commercial service that enables passengers to use their NFC phones as boarding passes for its Japan Airlines (Lambert, 2012). Another new concept developed by Hyundai is actually inventing in new feature which allow users to access their car and interact with it using NFC-enabled smartphones (Kim, 2012).

Generally, the implementation of NFC technology in our daily life can categorize into few categories summarized as figure below.

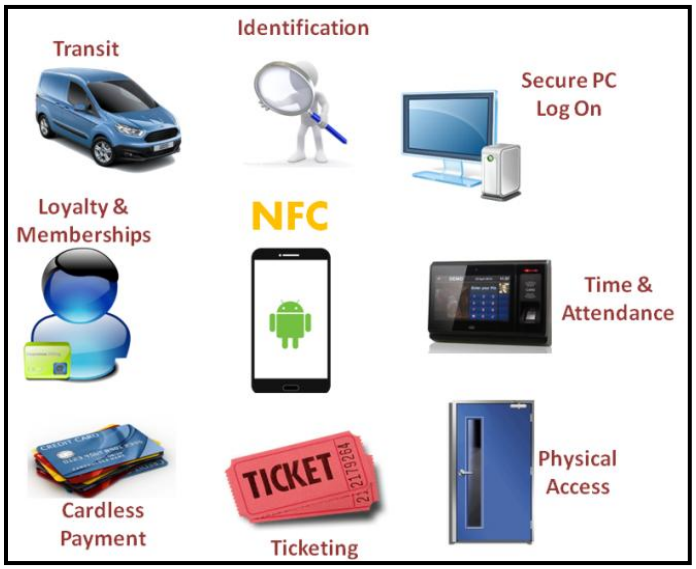
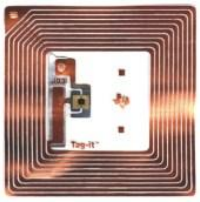


Figure 3: Example of functions of NFC Technology

There are some reasons of choosing NFC technology out of the tagging technology having now in the market. The comparison of three of the tagging technology is summarized in the following table.

Differences between RFID, Barcode and NFC

Parameters	RFID	Barcode	NFC
		 1D Barcode  2D Barcode	
Line of sight	No line of sight required	Line of sight required	No line of sight required
Reading range	**Passive UHF RFID:** - Up to 12m (fixed	From several inches up to several feet	Up to 10cm

	readers) - Up to 6m (handheld readers) **Active RFID:** - Up to 30m or more		
ID capabilities	Uniquely identifies items	Identifies only item category	Uniquely identifies items
Simultaneous identification	Read multiples tags at a time	Read only single item at a time	Read only single item at a time
Visibility of tag	Not important, still can scan tag inside boxes or bags	Important, can only scan visible barcode	Not important, still can scan tag inside boxes or bags within range
Security, counterfeiting	High security, hard/almost impossible to clone	Easy for copying/counterfeiting	Easy for copying/counterfeiting
Privacy	If not destroyed or deactivated, tag may be read remotely	No private data available for remote reading	Secure, as only short range reading is available
Rewrite, reusability	Support read and write capability	No write capability, static information	Support read and write capability
Tag lifetime	More than 10 years as can be reuse and rewrite	Depends on carrier material as no reuse is allowed	More than 10 years as can be reuse and rewrite
Harsh environment resistance	Can be used in harsher environment	Weak, difficult to read in dark and dirty environment	Can be read in dark, dirty and busy environment
Functionality if damaged	Impossible	Possible	Impossible
Interference with magnetic fields	Functionality is affected by magnetic fields	Not affected	Functionality is affected by magnetic fields
Data Storage	More data storage capacity (128 Kilobytes for active tags)	Limited data storage capacity (7 Kilobytes of numeric data for QR code)	Limited data storage capacity (maximum storage capacity up to 8 Kilobytes)
Size	Medium, small ($25mm^2$), tiny ($2mm^2$)	Medium, small	Medium, small
Attachment	Currently requires two steps: tag creation and tag attachment	Single step: can be easily printed on boxes during manufacturing	Currently requires two steps: tag creation and tag attachment
Communication	Single way	Single way	Two way (e.g.: Android 'beam')

Table 1: Difference between RFID, Barcode and NFC

For the barcode technology, the most significant limitations for it to be apply in the management of the current healthcare environment is the very limited of data storage and also because barcode technology required line of sight for data reading. For this project, barcode technology is less suitable for us to use as healthcare management need sufficient data storage to store basic patient data for fast retrieving. Besides, barcode technology allows identifying item category only which may make works complicated when hospital require to identify each patient and tool uniquely. At the same time, barcode technology has no rewrite capability. Each barcode need to be printed externally before dispense to patient and this cause an extra work. Each barcode printed need to be throws when it is no longer useful. This will cause additional cost to the operation cost.

On the other hand, the strength of RFID technology is the large data storage and longer reading range which make location tracking possible. At the same time, due to the long reading range, information stored in RFID tag may be easily access or modified remotely and also other hacking mechanism such as eavesdropping is possible to be done. The cost of RFID tag and reader is relatively high compared to barcode technology and NFC technology as RFID tag which is not disposable is not encouraged to be reused. Although with no doubt that with the equipments nowadays, the tags can be clean and disinfect appropriately and the chance of patient being infected by the reused tag is rather small. There are still some parties worry about the litigation issue and would not put the patient even in any small risks that will cause any uncertainty.

Lastly, NFC is a take as a subset of RFID. Both RFID and NFC are very similar in some ways except for few differences between them. Both technologies do not required line of sight and tag can be read even it is not visible as long as it is within the reading range. The biggest difference between the two technologies is the reading range. NFC has very limited reading range that needs the reader to read the tag by placing it closely to the tag. Although this may cause inconvenience to the patient if the patient is currently sleeping while the nurse or doctor need to read their tags, but in contrast privacy of patient can be more secure as only short range of reading range is available. This means that remote reading and eavesdropping of patient information is difficult. Besides, the limited data storage is also one of the weaknesses of the NFC technology compared to RFID. Basically, NFC tag or card is only able to store some

sufficient basic patient data for fast retrieving during emergency situation. However, this weakness able to overcome but integrating the application with a backend database through network connectivity to store and retrieve more information needed.

In short, NFC technology is moderately sufficient to be used in healthcare management. Since NFC technology based system is relatively easier to be developed and implement compared to RFID technology. Besides, the reasonable operational cost of NFC based healthcare management system will be more acceptable for the healthcare management personnel. Since NFC tag can also be reused, it fulfill the green environment concept and able to reduce the operation cost of the management. Hence, this technology not just improves the workflow of the healthcare environment but also reduce the expenses of the operation cost. Since NFC technology offer only limited reading range, the biggest challenges of implementing this technology is only short distance of tag read write can be done. Another issue is the limited data storage of NFC tag which cause medical personnel to do further retrieving of information from database which needed to store more data.

The motivation of this project is to develop a real-time automate patient management and notification system that can reduce the workload of hospital management. There is a need in doing this project because healthcare is certainly one of the most important industries in every country. Hence, there is a responsibility for us to explore the technologies to create a better future for the healthcare industry.

1.3. Project Scope

In this project, a Mobile Personal Profile Tracker Using Tagging Technology is designed to improve the current system of hospital in aspect of patients' location tracking, automation of patient medical profile retrieving and updating and medical equipments control. The project scope of this project is to start the establishment of a Smart Hospital. Therefore NFC based healthcare management system is proposed. Since the implementation is in healthcare industry, extra care need to be take and the system should have better failure handling. Besides, the technology should be harmless to ensure patients and medical personnel healthy and safety.

In order to achieve the goals of patient identification, the system should be able to write patient information into the NFC tag and the information should also be able to be read by a reader. An update of the information is a need for is process so that the patient information is always up to date. By enabling the read write process of the NFC tag, the patient identification process can be easily carried out.

Besides, the notification module is to enable the system to notify doctor when the patient's vital signs are going beyond the limit set by doctor. At first, checking of patient's condition will be carry out then followed by the decision making process of medical staff whether there is a needs to notify the doctor.

During emergency case, NFC holder who the system program and has been send to the hospital will be able to handle in a more efficient way as their vital information can be identified and medication can be provide as soon as information is obtained. Nevertheless, in order to reduce time delay during emergency case, the system provide new platform for holder of tags or volunteer to join and form a network of blood donor. Therefore, when hospital is running out of certain type of blood supply, request of blood can be make in a faster manner.

In the final delivery system, the system brings improvement to the hospital management workflow yet provides faster and safer medical process. At the same time, it reduces some burdens of medical personnel as part of the job task is automated. This will directly ensure the human caused medical errors can be minimized and more accurate decision making of medical personnel which then lead to patient safety and healthy.

1.4. Project Objectives

The system from this resulting project is to enable medical personnel to use NFC-enable mobile as a reader to read and write patient information on NFC tag, allow checking of patient vital signs and notify doctor if needed, allow medical staff to be able to easily access to the medical information of patient in an emergency and provide a platform for holder of the tags and also volunteers to form a network (via social network or membership) of blood donors. The objectives of implementation of NFC based healthcare management system are the following.

1. To automate patient medical record retrieving and inserting

Traditional way of patient medical record recording and retrieving is mainly human based and most work done on paper and will be keep in file for referring. This process should be improved to allow more efficient workflow and reduce human errors. By emerging NFC technology, medical personnel only need to read the tag on the wristband of patient to identify the patients and update the medical record of patients. This may minimize human writing or typing errors. In addition, it will increase the speed of workflow as record retrieving only need to read the tag without busy looking for file and papers. It can also directly avoid the inconveniences that may caused when patients are sleeping while nurse need to get information from them.

2. To allow checking of patient vital signs and notify doctor if needed

In general, medical staff checks patient's reading by monitoring machines and compare the vital signs with the values provided by doctor that may be written down on paper. Medical staff has to decide whether there is a need to inform the doctor-in-charge about the condition of patient. This process can be automated when medical staff only needs to input the vital signs to the application and checking and notification will be done automatically. Medical staff needs to provide the name of doctor that the notification should send to be. This might lighten up the burden of staff that needs to do the checking and notifying doctor manually. It can also help to avoid the time consuming process of searching for doctor's contact number.

3. To allow medical staff to be able to easily access to the medical information of patient in an emergency

During the emergency situation, medical staff should be able to access to the basic medical information of patient before any medication is given. This is to avoid patient from drug allergic and provide only suitable way of medication. Besides, medical staff often found difficulties that contacting patient's family or friends when patient unable to speak and give information to them. Therefore, public who are willing to join the program will carry a NFC tag that contains their basic information with them. In case of any emergency situation happened, NFC tag can help them to "speak".

4. Provide a platform for holder of the tags and also volunteers to form a network (via social network or membership) of blood donors

There is some situation where hospital is running out of specific type of blood supply. This situation goes worse when in a surgery or emergency rescue of patient. Normally medical staff would contact other nearby hospital for supply of blood, but contacting hospital one by one will be time consumed. Hence, this system will provide an interface then allow medical staff to broadcast the blood supply request to those people who joining the program as a blood donor or volunteer. Broadcasting request takes lesser time and able to send the request to more people or even to other hospital that joining in the program too.

1.5. Proposed Approach/Study

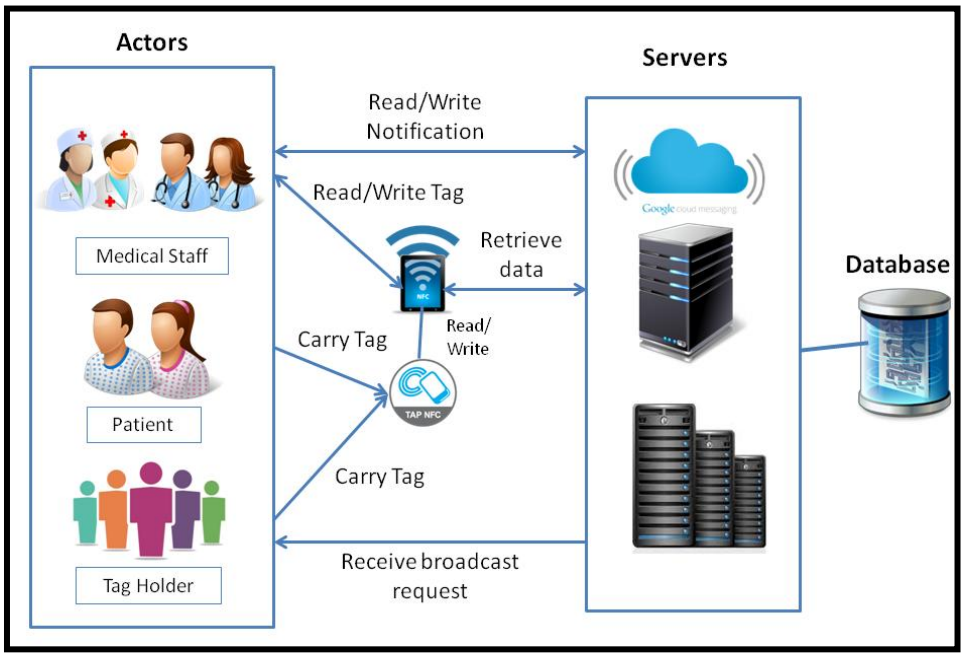


Figure 4: Block Diagram of NFC based Hospital System

The proposed approach to overcome the inefficient workflow in the healthcare management is using the NFC technology. At first, each patient is dispensed with a NFC tag which patient's information is stored into the database and some important information such as unique key patient id is stored into the tag. The purpose of storing the unique patient id into the tag is to enable medical staff to retrieve more information that belongs to that patient from database. The read/write process of patient's information into the tag and database can be done by using a NFC-enable mobile device.

By retrieving information of individual patient, checking and monitoring of patient's vital signs can be done. Staff needs only to read the NFC tag to identify patient then retrieve a set of threshold vital signs that specifically belongs to the patient. After that, comparing of vital signs will be done in background and staff can make a choice whether he or she should notify the doctor about the condition of patient. The proposed method to implement the notification module of system is to integrate with the Google Cloud Messaging (GCM) service API. Besides, multicast of blood supply request can also be done by using the same API. Multicast of request is simply broadcast the notification to everyone that in the register list.

1.6. Impact, Significance, and Contribution

Information of patients is always very vital especially when there is an emergency. There is always a need by the healthcare sector that accurate and fast information on patient be available at shortest time frame. In addition, there is always a need of proper automation of the admission procedure, hospital operation procedures and treatment information recording. The automation enables a speedier coordination of processes. Every minute in an emergency is always an important count.

With the final deliverables of this project, the system will be able to assists medical staff in the hospital to identify patients by using a mobile device that support NFC feature as a reader to read the information in the NFC tag embedded in the wristband of patients. In any healthcare field, errors should be minimized. Any delay in an immediate rescue of patient is not allowed as it may cause the patient's life in danger or even cause the patient to death. The traditional way by file searching or input manually by human delays the critical medical process while this problem can be solved by using the NFC based system.

Besides that, for the sake of reducing the number of time delaying during emergency situation, staff is now able to use the system to send notification to the doctor and informing doctor about the current vital sign of patient. Hospital can also broadcast blood supply request to the volunteer blood donors who are register to the program.

1.7. Report Organization

This paper is categorized into 7 sections.

The first section is the introduction which includes the problem statements, background of project, project scope, project objectives, proposed approach/study, and achievements that have been achieved, and impart, significance and contribution of this project.

The second section is the literature review about the technology and services that are being used in the project. The third section provides an overall of the system design and the hardware or software specification of the project.

The forth section of this paper will describe the patient identification module with NFC technology and provide the implementation of NFC technology in mobile devices. The fifth section explains the implementation of Google Cloud Messaging (GCM) service in mobile devices.

The sixth section is the implementation and testing of the application. The last section is the conclusion of the overall paper with novelties and contributions and also future work.

CHAPTER 2: LITERATURE REVIEW

2.1. Supporting Clinical Information Management by NFC Technology

The authors of this article are J. Bravo, Gasero, M. Vergara, C.Fuentus, R.Peña, R. Hervás amd V. Villarreal from Castilla-La Mancha University, Spain (Bravo, 2009). The article briefly introducing NFC technology and proposed the NFC technology based solutions to deal with three situations that aging people may face in their daily life. The proposed solution will work with mobile devices.

In this article, authors mentioned that application that utilized technology able to increase the quality of service but at the same time, there is complain from the older staff members about the using of computer in their daily activities. The authors focusing on the Radiofrequency Identification (RFID) technology but they changed the natural interaction of the technology by emphasized on the concept of obtaining services only by wearing tags. Near Field Communication (NFC) is adapted as it is comparatively lower cost than RFID. NFC technology also available in cell phone with have the radiofrequency identification reader integrated.

Due to the proposed solution is target for the aging people, authors emphasized the concept of simple interaction of the system. By this, the solution and application provided should be as easy as possible. Besides, physicians who will also interact with the system, need the system as convenience as possible so that more time can be use to focus on their work. Therefore, in order to create an application which able to maintain daily operation in an assisted environment, a Bluetooth enable NFC mobile devices will be used.

NFC technology consists of two elements, Initiator and Target which commonly known as reader and tag respectively. Besides, there are two modes of operations that are active and passive. For active mode, both devices will produce their own field of radiofrequency to send data while in another hand passive mode means that only one device will produce radiofrequency field and the other device will be used only for data loading. There are three types of NFC devices which are mobile phone, tag and reader. In addition, four modes of operation are available.

Figure 5: NFC devices and operation modes

The authors propose NFC technology based solution to be applied in three situations which commonly faced by aging people. First and foremost, the NFC house monitoring is proposed. Nowadays, monitoring of vital signs can be done by some Bluetooth enabled devices which is then can integrate with NFC mobile device to provide monitoring task. The primary interaction is actually just putting the mobile near to the monitoring device and waits for device to send data over. After the measure is sent to mobile, checking will be carried out. The NFC enable mobile will then carry out different response according to the result of checking. If there is a need, the mobile will use voice message to give advice to the user. If the measures are risky, mobile can send a message together with a unique identifier to notify the family doctor for further decision making process.

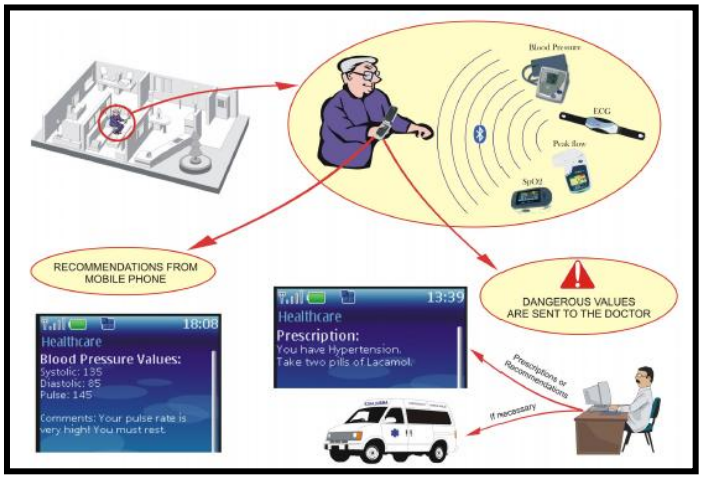


Figure 6: Patient Monitoring Process

Furthermore, NFC technology working with mobile can be implemented to be used as a mobile prescription application where public does not need to go to the hospital to refill their medicines. Finally, NFC technology can be used to share patient's medical records or history with different hospital departments or even different physicians. After the first physician's consultation, patient will receive some relevant documents after touching the correspondent NFC device which will then allows their own mobile to start appropriate application. With a Bluetooth address found in the tag, the application can send a document to another physician's computer through a Bluetooth connection. Therefore, patient could send the relevant document after touching a NFC reader or tag to begin new consultation.

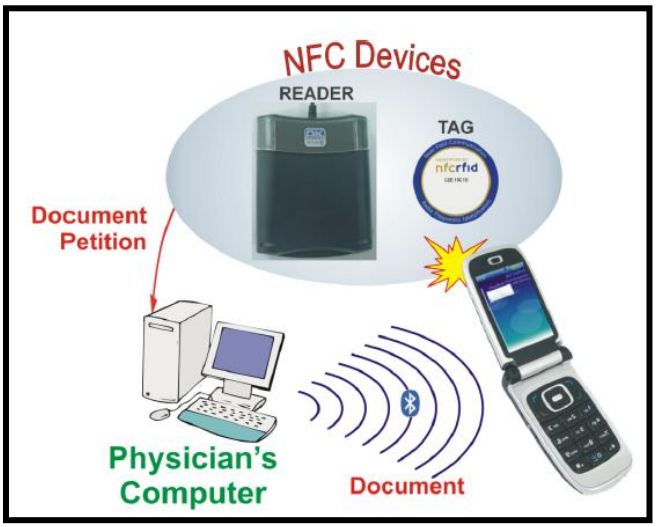


Figure 7: NFC patient record system concept overview

All three solutions proposed are using the same NFC technology and with simple interaction only. The three solutions bring negative impact too as using mobile prescription may caused inaccurate prescription have been given since the physician does not examine the patient again before deliver the prescription. At the same time, the privacy issue has to be taken care as storing important information such as medical record or links of medical record may cause lead of privacy information.

2.2. An NFC Approach for Nursing Care Training

The article's title is An NFC Approach for Nursing Care Training by Jesús Fontecha, Ramón Hervás, José Bravo from University of Castilla-La Mancha, Spain (Fontecha, 2011). The article proposed an application for nursing care to help nursing student to do their patient care tasks. This paper is arranged in five sections. Section 2 is the analysis of technology integration in healthcare environment, section 3 depicting the proposed application, section 4 discussing the details of application module while section 5 explaining the evaluation of the modules by carrying out some research followed by the last section that includes the conclusion and contribution of this paper.

This paper proposes an approach which integrates NFC-enable mobile devices and touching display. Authors believe that the advantages of applying this available NFC based technology to users will help in the aspect of reducing time and the volumes of paperwork and minimizing human error. The objective of developing this system is to assists in the training of nurses. Besides, with the help of NFC technology, problems of enter information can be reduced and the limitations of data presentation combining the mobile device with dedicated displays able to be solved.

Nurses will be able to do different daily tasks associated to patient care through simple interaction with the NFC-enable mobile devices. For instance, nurse can read a medicine tag by using NFC mobile device when he or she has to dispense medicine to patient. Besides, the intend of this proposed system is to lessen the needs to manage information and therefore will nurses can spare more time taken care of their patients. Due to the intention, nurses will be assigned with a NFC phone so that they can use to read the tag during their working time.

In this paper, NFC tag detected will launch different services which divide into touch-based service approach and specific NFC-based service approach. Firstly, the touch-based service approach is mainly used to serve the services that used to update the patient medical history or record. Information inside the tag will be read and interpreted by the NFC mobile device application before redirecting to respective service. The tag is basically used for services categorization purpose or for objects in the environment. Tag used in services categorization will then further divide into different services according its purpose. For example, tag on a patient

may able nurse to decide whether want to update the patient information, taking vital signs, dispense medication or etc. On the other hand, NFC services may be called by tagging object which can be stick to the equipments or tools in the hospital.

Type	Service	Description	Interaction	Involved Elements
Identification	Nurse Identification	The nurse is identified when she/he interacts with her/his tag. NFC mobile device is associated to nurse.	NFC	Nurse NFC phone and nurse identification tag
	Patient Identification	The patient information is showed when the nurse interacts with a patient tag.	NFC	Nurse NFC phone and patient identification tag (or bracelet)
	Object Identification	The object information is showed when the nurse interacts with an object tag.	NFC	Nurse NFC phone and object identification tag
Access & Management	Touch Display Access	The nurse is identified in the touch display system.	NFC & Touch	Nurse NFC phone, touch display and NFC reader
	Clinical History Navigation	The nurse can review patients' clinical history and pending tasks.	Touch	Touch display
	Nursing Shift Change	The nurse takes a shift change to another nurse interacting with the identification tag, NFC reader and the touch display.	NFC & Touch	Nurse NFC phone, nurse identification tag, NFC reader and touch display
Synchronization	Upload of Clinical History	The nurse updates the record of the treated patients when she/he touches the NFC reader with her/his NFC phone.	NFC & Touch	Nurse NFC phone, NFC reader and touch display
	Download of Clinical History	The nurse interacts with the NFC reader for downloading the clinical histories of their patients.	NFC & Touch	
Control & Monitoring	Medication Administration	The nurse interacts with the medication panel tags (or medicament tag) and the patient bracelet to control his/her administration.	NFC	Nurse NFC phone, object identification tag (or tag panel), patient identification tag (or bracelet)
	Clinical Tests and Samples	The nurse interacts with the tags of a tests panel and the patient bracelet to control his/her completion.	NFC	
	Vital Signs	The nurse interacts with the tags of vital sign panel and the patient bracelet to store the measured values.	NFC	

Table 2: Table of services description

For a specific NFC service like medication administration, the service will be call when a nurse needs to distribute medicine to respective patient. The overall process is start when nurse read the patient tag to get information and pending tasks of this patient. Then, nurse will have to read the associated medicine tag before it dispense to patient. Nurse may need to confirm his or he action before doing medication dispersion. Then the record of medical dispersion will be updated as well as the patient history.

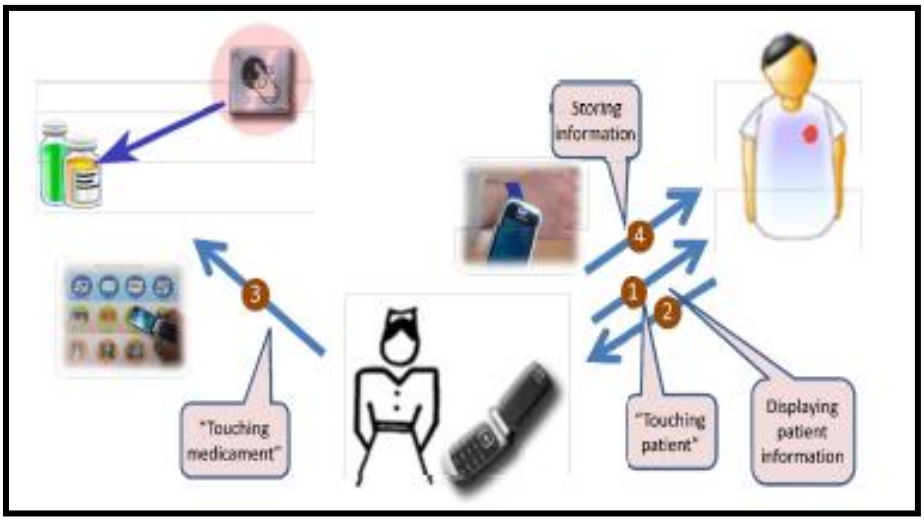


Figure 8: Medication Administration Service

The proposed system including NFC technology in the healthcare environment has contributed to improve current health care process. With integration of NFC technology and touch based mechanism, most of the nursing tasks will be automated and at the same time nurse can get a service in a usual way. However, integration of this technology and computing system is not simple as there are a lot of challenges to overcome as human nature of fear to change need time to accept and trust the new technology.

2.3. NFC Based Hospital Real-time Patient Management System

The title of article I reviewed on is NFC-based Hospital Real-time Patient Management System by Atluri Venkata Gopi Krishna and Cheerla Sreevardhan from KLUniversity, Andhra Pradesh and also S.Karun and S.Pranava Kumar from B.E, Mechatronics, MIT, Manipal (Krishna, 2013). All of them are from India.

The article proposed an architecture design for NFC-based Real-time Hospital Patient Management System (HPMS). Basically the idea is the emerging of NFC technology into current patient management system to automate and provide an accurate tracking of patient identification. Each NFC technology consists mainly of a low power smart tag and a reader. The reader transmits radio wave that is received by the antenna in the smart tag which allows the reader to read the information by converting the radio waves to readable information. Besides, more information able to be retrieved by using the output of NFC tag as an input for data retrieval from database through the internet. The NFC tag is embedded in a wristband and gives to patient during the period of their hospitalization to store patient's data.

In another hand, the article suggests six layer architecture for the NFC based hospital management system. The layers are physical layer, middleware layer, process layer, data access later, application later and user interface layer respectively. The physical layer consists of the hardware of the system. The middleware layer is an important layer that contains the interface between the smart tags and readers and also the communication between the software of NFC system to the hospital database system. After that, the process layer and data access layer are both layers related to the database system of the hospital and the application used for the creation of the events. Both layers used large volume of NFC data through SQL. After that, is followed by the application layer and user interface layer. The application layer is nothing much but the interface that allow multiple users and the user interface layer provide an user friendly and uniform environment that allow the application to be used in any OS environment easily.

Besides, this article also outlines few advantages of using the NFC based system in healthcare. The first advantage mentioned is the improvement of the patient's identification by eliminating the paper based documentation work. Most of the identification tasks able to be automate by using the NFC technology. This will increase the efficiency and reduce the manual

power directly. Besides, the second advantage is to reduce the workload and burden or medical personnel. Nurses or doctors will need not to bring heavy files around but only a smart tag reader when doing a checkup for their patients. Data retrieving and updating can be done by using the NFC technology instead of writing it down in a paper and file it manually. Another advantage is the NFC standards cover the data exchange formats and as well as the communication protocols, and are based on the existing Radio Frequency Identification (RFID).

After reviewed the article, NFC based patient management system has few advantages but nevertheless also bring few limitations. Due to the short reading range of NFC technology, the reader can only read the tag within certain short range. It will cause some inconveniences when the medical personnel want to read the tag of patient especially during the rest time of them. Besides, in order to do patients or tools tracking, NFC technology is not possible because of it short reading range. Therefore, NFC based hospital management system is not suitable for a hospital to do real-time patients or tools monitoring.

2.4. Personal Schedule Distribution Using Google Cloud Messaging

The title of article that had been reviewed is Personal Schedule Distribution Using Google Cloud Messaging by author named Victor Utomo (Utomo, 2014). The article purposed a method of distributing the scheduling of personnel in an organization which is using Google Cloud Messaging (GCM). The conventional method of distributing scheduling by bulletin board, memo or directly inform the personnel is inadequate especially where the schedule is very unstable such as frequent changes of customers' appointments. As the use of mobile devices is increase in popularity, the author proposes to a personnel scheduler application which has the capability to receive the schedule notification push by the organization. The article is basically consists of the overall system concept, the introduction and lifecycle of GCM, the purposed system design, discussion and the conclusion.

GCM is a service provided by Google that will manage all aspect of queuing of notification and delivery of notification to respective application running on Android devices. GCM components include mobile devices, application server (third party server) and Google Cloud Service Server. Besides, the article list down five primary characteristic of GCM service:

1. GCM allow third party application server to send message to Android Application.
2. Android application does not need to be running to receive notification as system that had been set up properly will wake up the application when notification arrives.
3. GCM just passing raw data message and Android application has full control of how to manage the notification.
4. Only Android 2.2 or higher that installed Google Play Store able to use GCM service.
5. GCM uses an existing connection for Google services.

Figure 9: Components of GCM

Google has a set of standard keys at different stages of GCM includes Sender ID, Application ID, Registration ID, Google User Account and Sender Auth Token. Each of the keys has different usage to ensure that all parties can be authenticated. The GCM lifecycle is a process where three primary processes involved. The three processes are enabling GCM, sending message and message receiving. Prior to these processes, the standards keys must not be null.

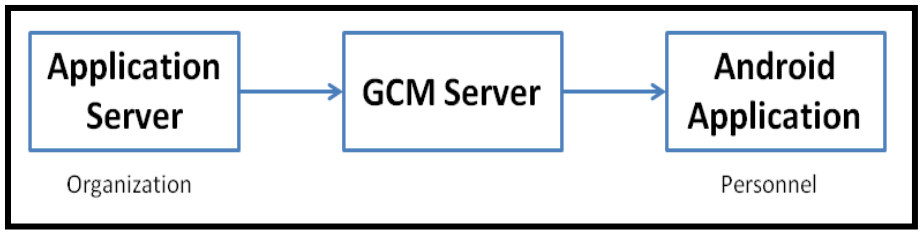


Figure 10: Block diagram of Personnel Schedule Distribution

The system architecture proposed is the same as the fundamental GCM components. As GCM is handled by Google, no extra function can be added. For android application, it acts as a user interface to receive notification push from the GCM server. The application server can be any other server that is needed to do data processing before push notification.

The article further discuss about the server-side database design of the proposed system. Database used to store extra data that need to be processed before the GCM message being push to devices. Application server acts as a sender in this system must have a sender ID and sender auth token in order to make request to GCM service. As GCM server is providing service, application server can send data or make request to GCM service through HTTP command. For the client-side functionality, Android application needs to register itself to both GCM and application server. Registration to GCM server by requesting a register ID that enable GCM

server to uniquely identify the device and know which device the notification should be send. Android application also needs to handle the message push by the GCM server by calling the onMessage event.

After reviewing this article, GCM push notification service brings advantages such as time and cost saving of organization management and reduce needs of paper work of personnel At the same time, it brings limitation too which is the system proposed allow only one way communication which are from server to client device. Problem arises when personnel need to rearrange the schedule as there is no way for an opposite way of communication.

CHAPTER 3: SYSTEM DESIGN

3.1. System Design Specification

Figure 11: System Design Specification

3.1.1. Hardware Tools

Toshiba L745 Satellite

Processor	Windows 7 Home Premium
RAM	4.00GB
Operating System	Intel® Core™ i5-2410M CPU @ 2.30GHz
Graphic card	NVIDIA GeForce GT 525M
Display	14.0 inch 1366 x 786 pixels (Max)
USB port	Yes

Samsung Note III

Operating System	Android OS, v4.3 (Jelly Bean), upgradable to v4.4.2 (KitKat)
CPU	Quad-core 2.3 GHz Krait 400 (N9005, N9002)
Chipset	Qualcomm Snapdragon 800 (N9005, N9002)
Display	Super AMOLED capacitive touchscreen, 16M colors, 1080 x 1920 pixels, 5.7 inches
Support	GPRS, EDGE, WLAN, Bluetooth, NFC, Infrared port

Mifare Ultralight NFC Tag

3.1.2. Software Tools

The system built is running at android mobile operating system and designed by using Eclipse with Android Java programming language. It is an integrated development environment (IDE) that contains a base workspace and an extensible plug-in system for customizing the environment. Written mostly in Java, Eclipse can be used to develop applications.

Android software development kit (SDK) is used to create new application for Android operating system that includes a comprehensive set of development tools. These include a debugger, libraries, a handset emulator based on QEMU, documentation, sample code, and tutorials. The officially supported IDE is Eclipse using the Android Development Tools (ADT)

Plug-in, though IntelliJ IDEA IDE (all editions) fully supports Android development out of the box. The proposed Android application client-side functionality will be developed in Eclipse integrated with Android SDK.

The NetBeans IDE is written in Java and runs everywhere where a JVM is installed, including Windows, Mac OS, Linux, and Solaris. A JDK is necessary for Java development functionality, but is not required for development in other programming languages. The application server-side functionality will be built by in NetBeans IDE environment.

Database system used in this project is MYSQL. MySQL is a database system used on the web and runs on a server. It is a fast, easy-to-use RDBMS being used for many small and big businesses. This database system able to work on many operating systems and work with many languages including PHP, PERL, C, C++, JAVA, etc. MySQL uses a standard form of the well-known SQL data language to that helps users store, organize, and retrieve data.

3.2. System Architecture

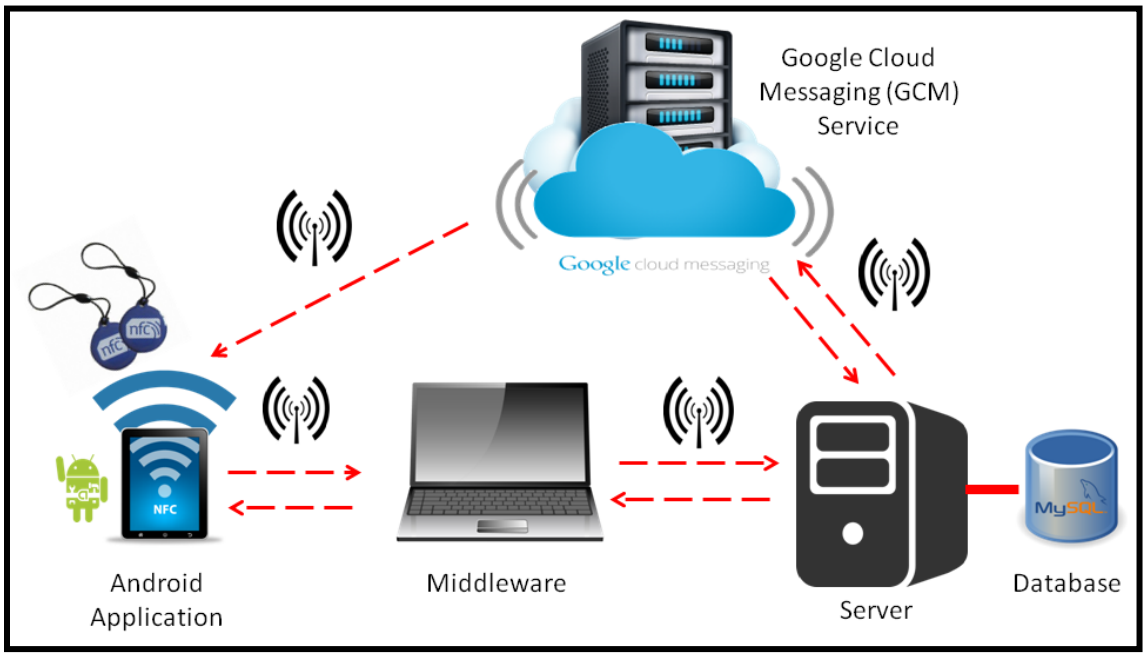


Figure 12: System Architecture

The proposed system will be build based on three their architecture. The mobile application will be at the presentation layer which acts as user interface that user to input data. Medical staff can key in patient information to store to database or check patient' vital signs before comparing to the values retrieved from database.

Then, data entered by patient will be processed before it further sends to server or database to retrieve more information. Middleware is used to allow communication between the application and the database. For example, patient id from the NFC tag will be send to server and uniquely identify the patient and retrieve all relevant information. The result of retrieving will be send back to the presentation layer after processed to a user understandable format.

When notification sending is needed, the application will received message needed to be send from user, then passed the message to the server. The user need to specify who they want to send the message and passed it to server Server will then make a service request from Google Cloud Messaging (GCM) Service. GCM will send the notification with the message to the destination device.

3.3. System Overview

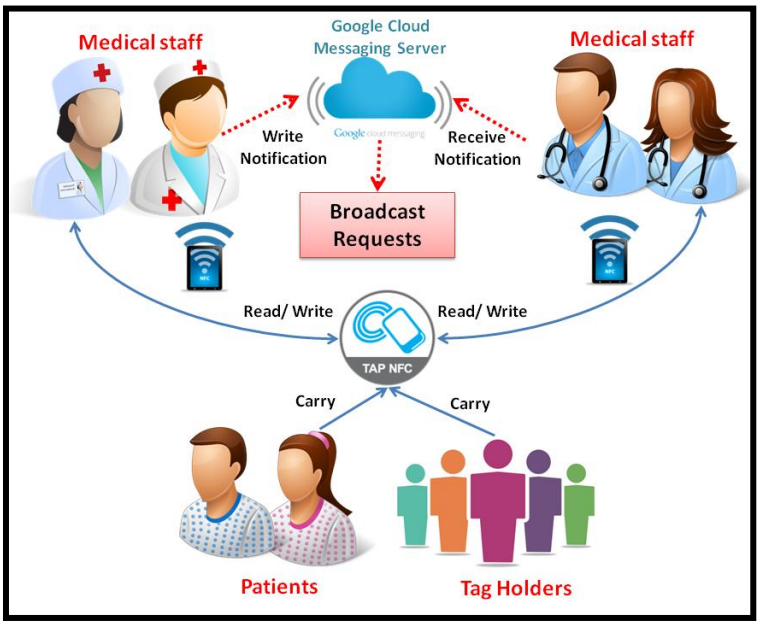


Figure 13: System Overview

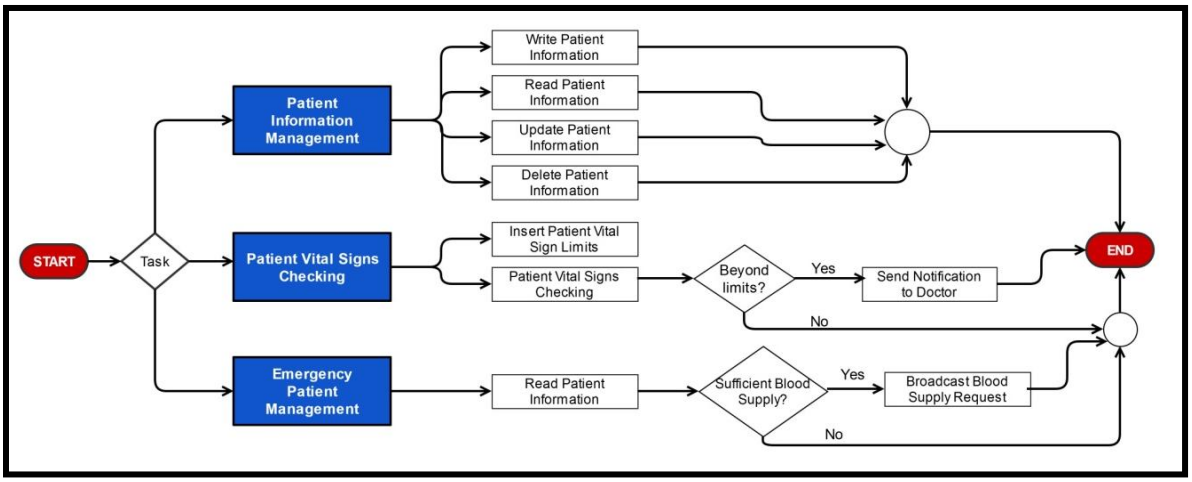


Figure 14: System Flow Chart

The proposed system is an Android application that works on a NFC enable mobile device. The system divided into three modules which is the patient information management module, patient vital signs checking module and emergency patient management module.

For the patient information management module, the application will allow medical staff to do read and write of patient information, store to the backend database and store some basic

information into the NFC tag. Whenever medical staff wants to read patient information, the staff needs to launch the application and attach the mobile device to patient tag. Patient tag will store some basic information with a unique patient identification number. By using the identification number, staff can retrieve more information from the backend database.

Secondly, nurse can check patient vital signs by comparing with the values from database. After checking, if the input vital signs are beyond the value set by the doctor, nurses will be prompt and ask whether there is a need to send notification to notify the doctor about the situation. If yes, then nurse will send the readings of vital signs to the respectively doctor as a notification alert.

Lastly, public who register their information with hospital will be given a NFC tag that contains their information. The information can be easily retrieved in case any emergency situation happened to ease the process of rescuing the patient or contacting the patient's family. Nevertheless, the emergency patient management module will allow medical staff to broadcast blood supply request to whoever that register with the hospital as a volunteer blood donors. Medical staff only needs to specify which type of blood they need and click to broadcast the request. Tag holder that successfully registers as a volunteer blood donor will then receive the notification sent by hospital side.

CHAPTER 4: Patient Identification Module

4.1. Mobile NFC Read/Write Technology

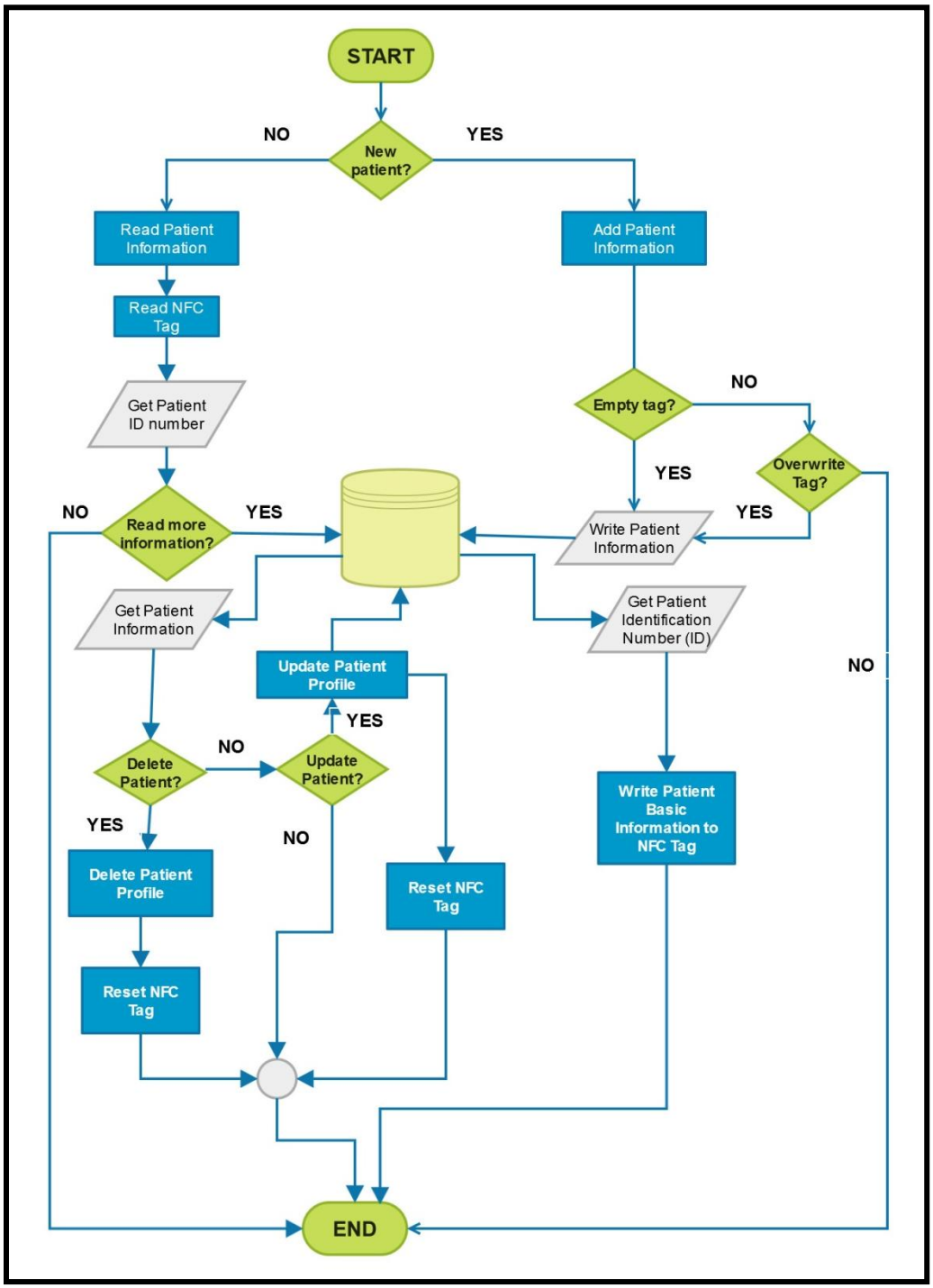


Figure 15: Flow Chart of Patient Identification

This module is mainly for patient identification which allows staff to identify the patient and read patient's basic information by reading the tag. Staff can retrieve more data by connecting to the hospital database through internet connection. Then, staff can decide whether want to delete or update the patient profile. After that, if the patient is new admitted, staff may write the patient information into the database through this application and get the generated ID from the database, then write to NFC tag that to be dispense to patient.

In this module, NFC technology is used to work with a NFC-enable mobile device to do the read/write function of the NFC tag. Nowadays, NFC technology enables the sending of messages (NDEF) between mobile to tag or even mobile to mobile. First and foremost, to ensure the system working well, mobile that is used must have the feature to support NFC. At the same time, user of the system must ensure the NFC has been enabled before using the system. Besides, in order to able to retrieve more data from the database, internet connection must be available to connect the android application to the database server.

```
// Check for NFC feature in phone
mNfcAdapter = NfcAdapter.getDefaultAdapter(this);
if (mNfcAdapter == null) {
       // Do something when the NFC is NOT SUPPORTED
}

// Check whether NFC feature is enable or disable
if (!mNfcAdapter.isEnabled()) {
       // Do something when the NFC is DISABLED
}

// Check whether Internet Connectivity is enable or disable
ConnectivityManager cm =
(ConnectivityManager) getSystemService(Context.CONNECTIVITY_SERVICE);

if ((cm.getActiveNetworkInfo()!= null &&
 cm.getActiveNetworkInfo().isConnectedOrConnecting())) {
// Do something when the internet is CONNECTED
}
```

In order to have the permission to access the NFC hardware and Internet connection, permission must be set in the AndroidManifest.xml in the application. Permission of the feature is important to ensure proper handle of NFC triggered intents.

```
<uses-permission android:name="android.permission.NFC" />

<uses-permission android:name="android.permission.INTERNET " />
```

Generally, Android uses its Intent system to deliver tags to the apps. Therefore, if several applications can handle the Intent, the activity chooser will be displayed and the user can choose any application to be opened. There are three different filters to handle tags which are ACTION_NDEF_DISCOVERED, ACTION_TECH_DISCOVERED, and ACTION_TAG_DISCOVERED.

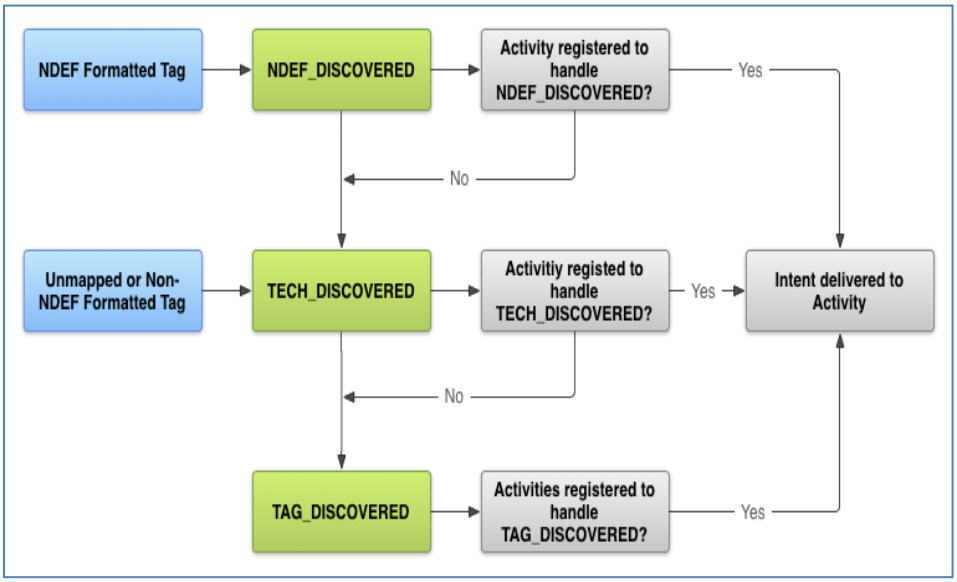


Figure 16: Process when NFC tag detected (Wondratschek, 2013)

When the NFC tag is discovered, the tag object will be pass in Intent as EXTRA_TAG. As shown in the above diagram, if a tag with NFC Date Exchange Format (NDEF) support is detected, if there is activity that registered for ACTION_NDEF_DISCOVERED with matching URI and MIME type, the intent will be passed to the activity. If a tag without NDEF support or no activity from any application is registered for the ACTION_NDEF_DISCOVERED Intent, ACTION_TECH_DISCOVERED intent will be triggered and the intent will be pass to the activity that register for ACTION_TECH_DISCOVERED. Else, the activity that registers as ACTION_TAG_DISCOVERED will be started if no activity is handling the ACTION_NDEF_DISCOVERED and ACTION_TECH_DISCOVERED intents.

For the write function to work in this module user has to enter the information to write to tag and a tag must be attached. The data that need to be written into the tag is converted into NDEFMessage. NDEF (NFC Data Exchange Format) is a light-weight binary format, used to encapsulate typed data which is specified by the NFC Forum, for transmission and storage with NFC. (Android). NDEFMessage contain an array of NDEFRecord objects. NDEFRecord object always contains a 3-bit TNF (Type Name Field). The bits of TNF contain information regarding how to interpret the information inside the NDEF message as language, coding and etc.

```
// Encapsulate message into NDEF format
NdefRecord[] records = { createRecord(text) }; //Convert text to a NDEF record
NdefMessage message = new NdefMessage(records);

// Create record type
NdefRecord recordNFC = new NdefRecord(NdefRecord.TNF_WELL_KNOWN,
                           NdefRecord.RTD_TEXT, new byte[0], payload);
```

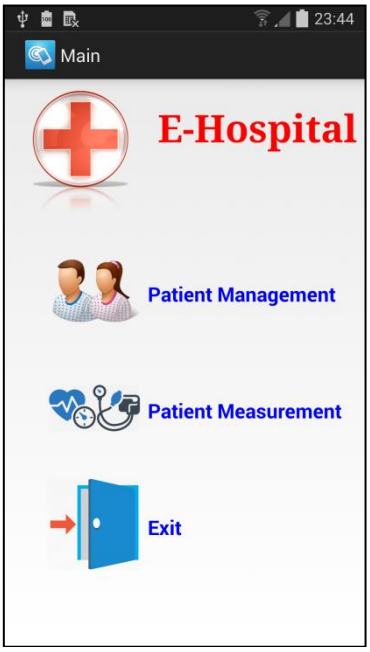
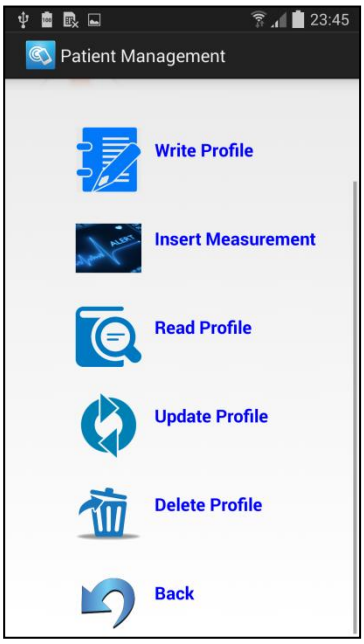
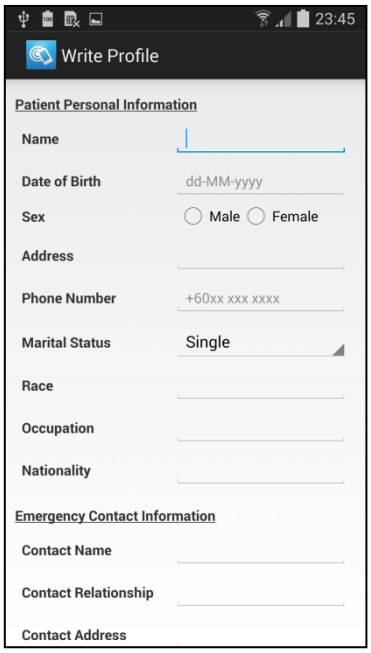
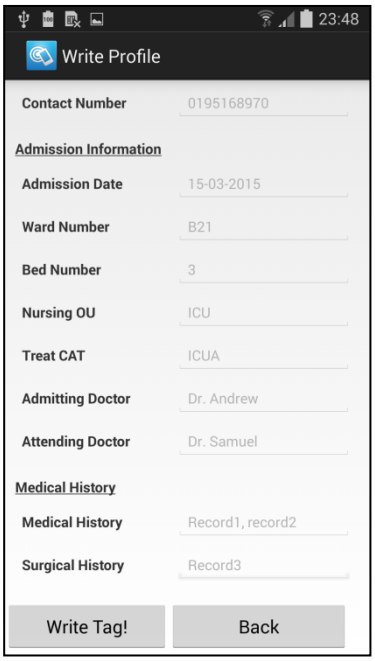
For the read function, firstly the data of NDEF message received are wrapped in an array of Parcelable objects. The entire NDEF message is parse through and the NDEFRecord is extract from the NDEFMessage but only the text type message is store to a String to be display. The bit of record in the NFC tag is check to get only text type data.

```
// Parcelable object to get NDEF message
Parcelable[] data =
intent.getParcelableArrayExtra(NfcAdapter.EXTRA_NDEF_MESSAGES);

// After get NDEF message, extract NDER records, convert it to String
for (int i = 0; i < data.length; i++) {
       NdefRecord [] recs = ((NdefMessage)data[i]).getRecords();
          for (int j = 0; j < recs.length; j++){
              if (recs[j].getTnf() == NdefRecord.TNF_WELL_KNOWN &&
                     Arrays.equals(recs[j].getType(), NdefRecord.RTD_TEXT)) {
                        byte[] payload = recs[j].getPayload();
                        String textEncoding = ((payload[0] & 0200) == 0) ? "UTF-
                                                    8" : "UTF-16";
                        int langCodeLen = payload[0] & 0077;
                        s += new String(payload, langCodeLen + 1, payload.length
                              - langCodeLen - 1, textEncoding);
              }
          }
}
```

Lastly, when the application is already opened and the tag is attach again, the application is opened a second time instead of delivering the tag directly. This is not an intended behavior but it can bypass the problem by enabling or disabling the Foreground Dispatch. Enable foreground dispatch give priority to the foreground activity when dispatching a discovered tag to an application. After the enable foreground dispatch is called, an activity must call disable foreground dispatch before its onPause() callback completes.

```
public void onResume() {
	super.onResume();
	if (mNfcAdapter != null)
		mNfcAdapter.enableForegroundDispatch(this,
	mPendingIntent, mIntentFilters, mNFCTechLists);
}

public void onPause() {
	super.onPause();
	if (mNfcAdapter != null)
	mNfcAdapter.disableForegroundDispatch(this);
}
```

4.2. Screenshots of Module

<table>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Main Menu of Application</td><td>Sub Menu of Patient Management</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Fields of patient information to store in database</td><td>Get Patient ID after storing to database. Ready to write to NFC tag.</td></tr>
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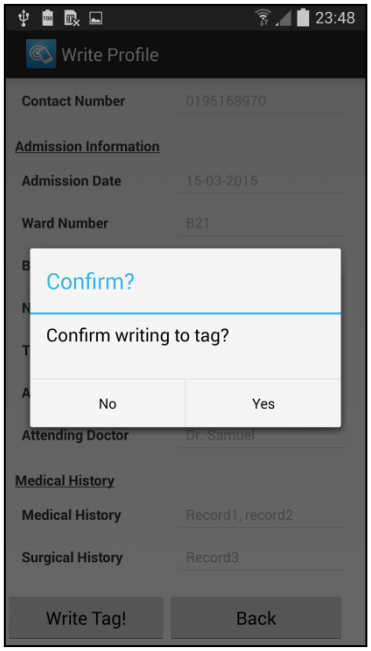
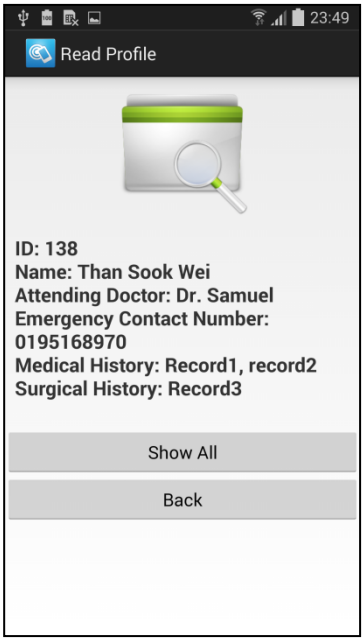
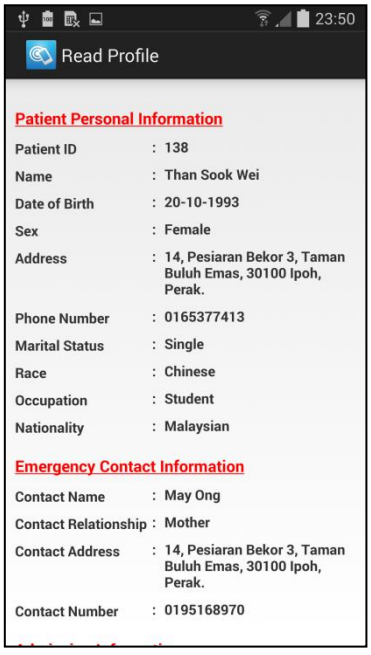


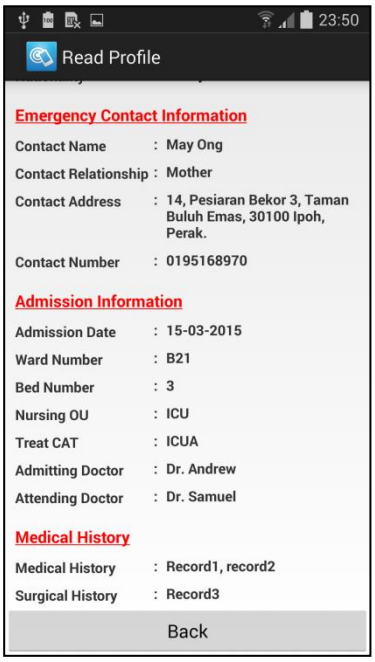
Confirmation to write to NFC Tag



Read NFC tag Information



Read full information of patient - 1



Read full information of patient - 2

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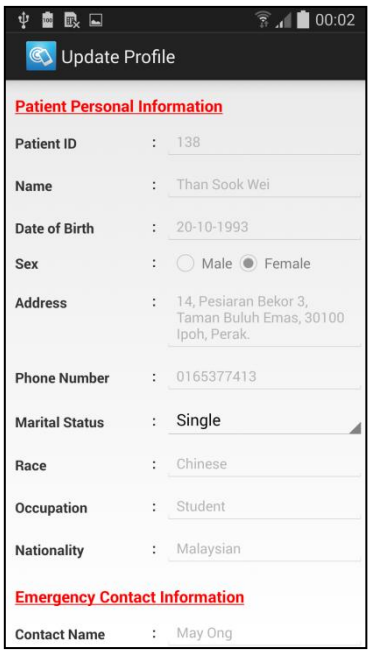
<td> 
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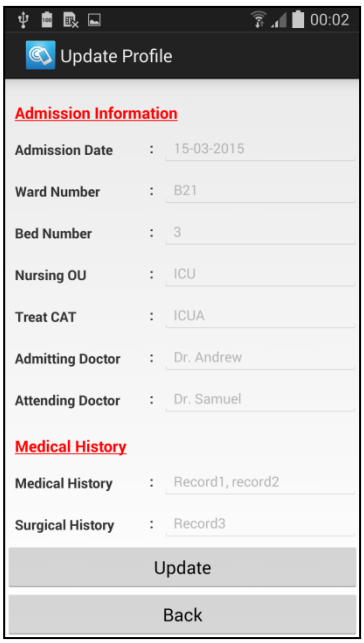
<td> 
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</tr>
<tr>
<td>View information of patient before update</td>
<td>Update button to enable updating of information</td>
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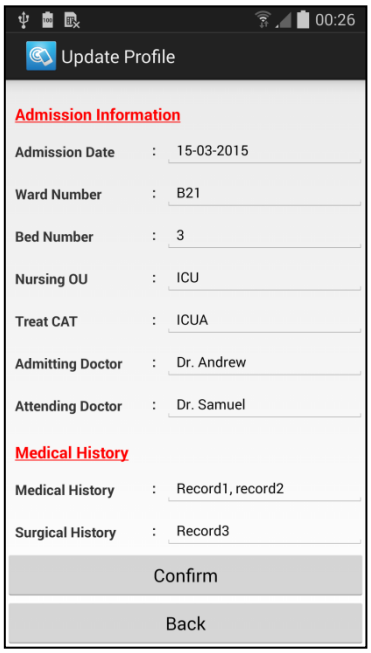
<td> 
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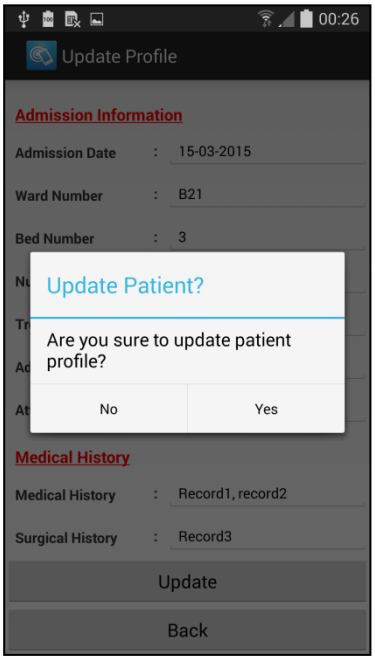
<td> 
</td>
</tr>
<tr>
<td>Confirm button to submit update of information</td>
<td>Confirmation to update patient information</td>
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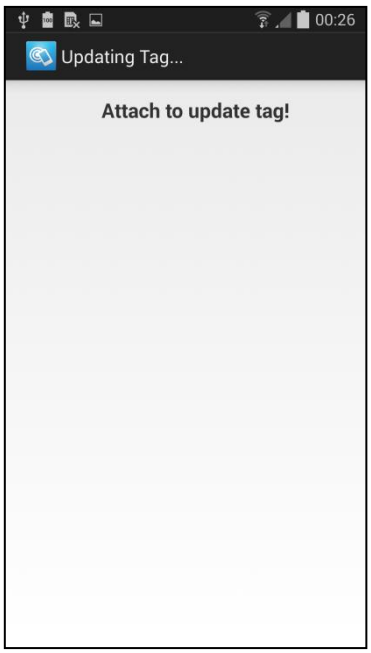
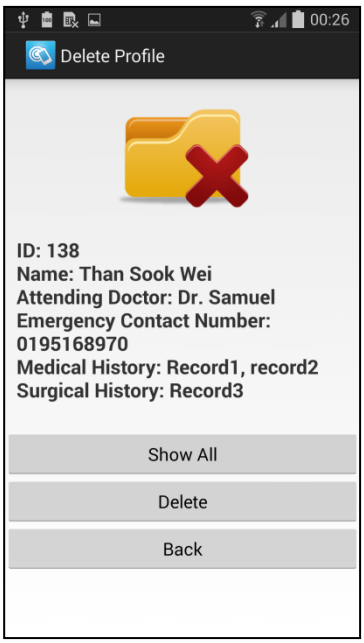
<tr><td> 
</td><td> 
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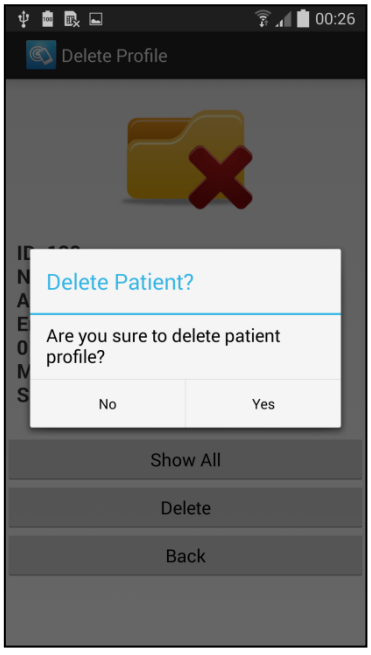
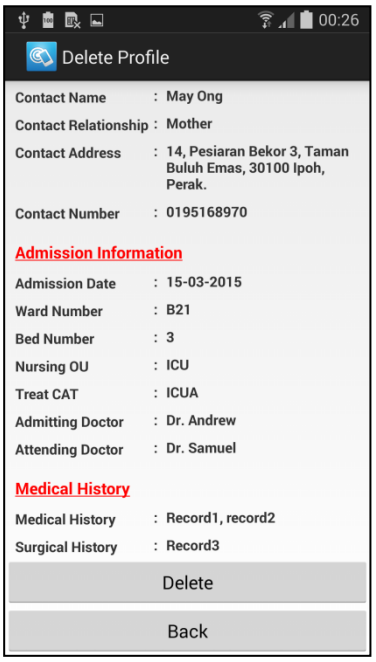
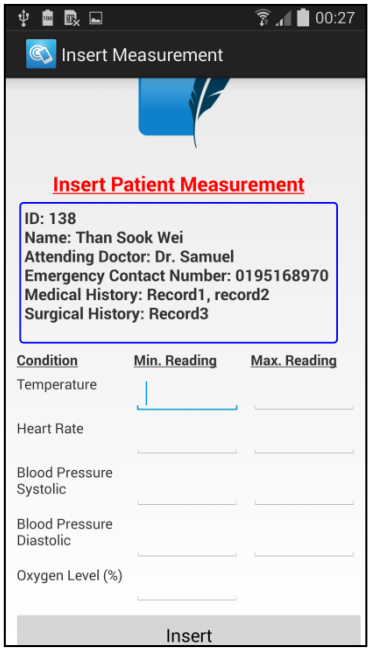
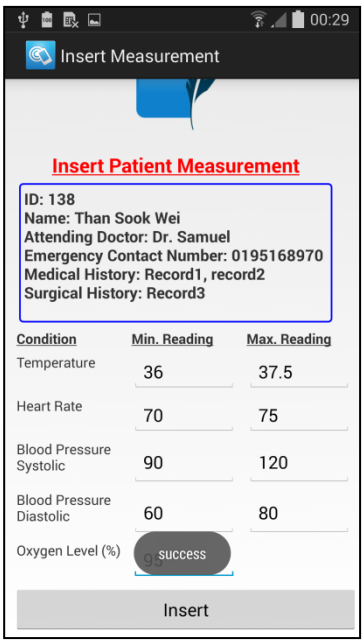
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Confirm delete patient profile</td><td>Read all information before confirm deletion of profile</td></tr>
</table>

	
Fill in patient's vital sign boundaries	Store boundaries values into the database for later usage

CHAPTER 5: NOTIFICATION MODULE

5.1. Google Cloud Messaging (GCM) Service (Google Cloud Messaging for Android)

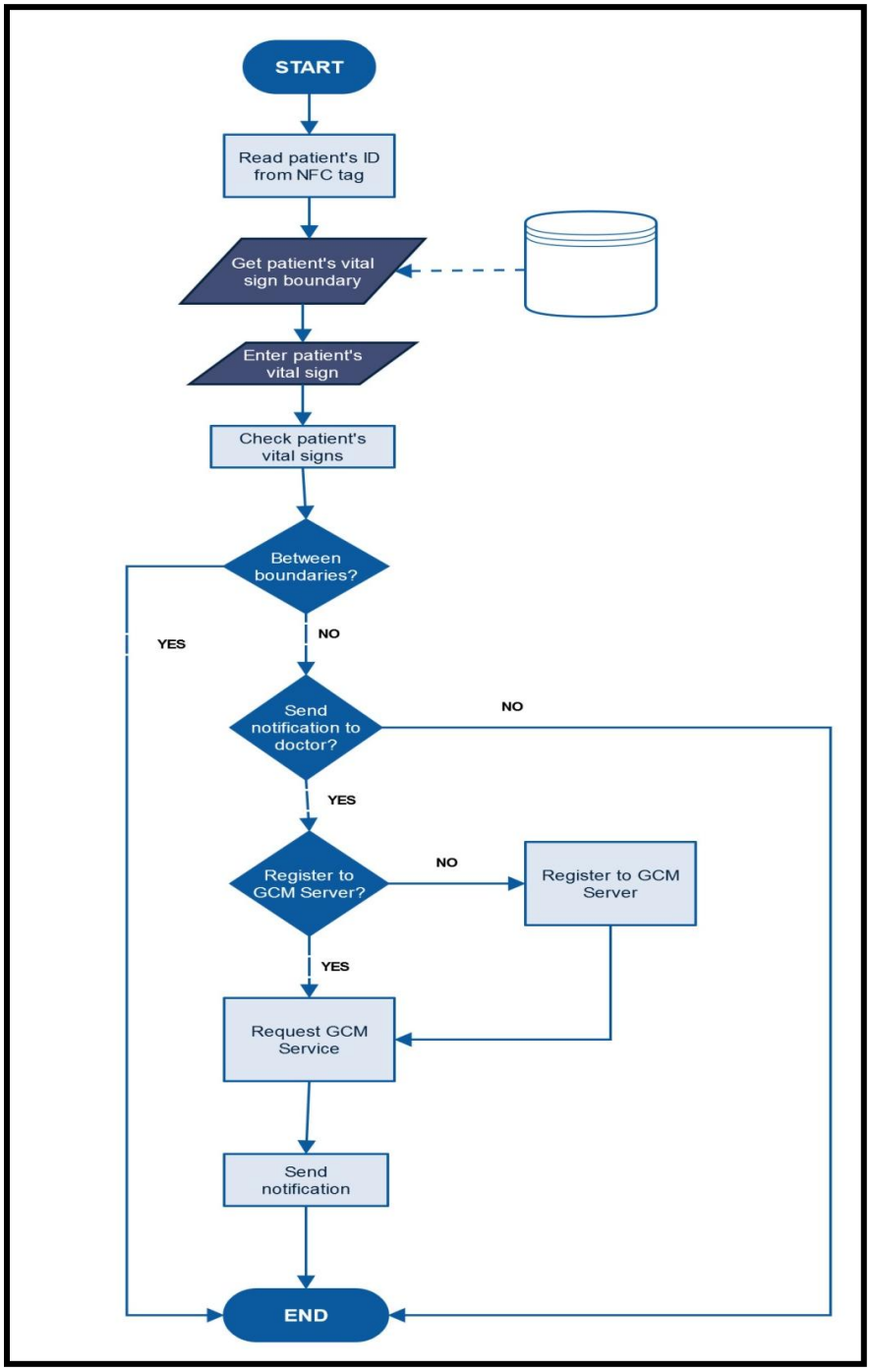


Figure 17: Flow Chart of Patient Checking

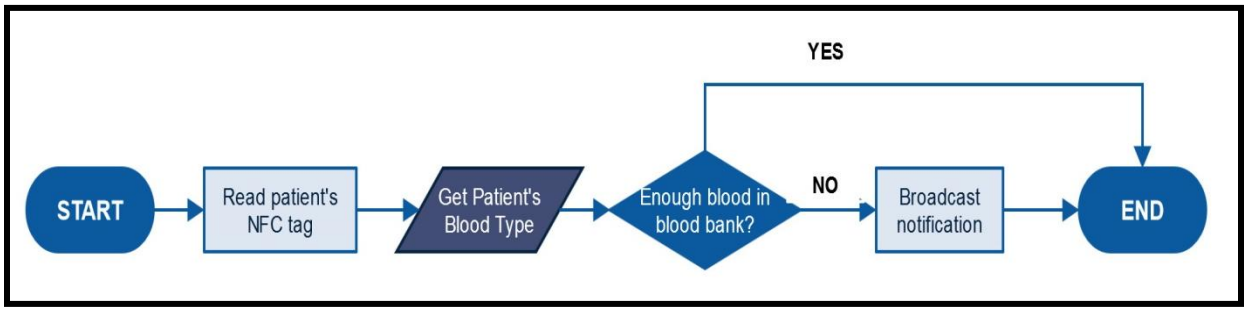


Figure 18: Flow Chart of Blood Supply Request Module

Both diagrams above are the flow chart of patient checking module and blood supply request module that both will integrate to use Google Cloud Messaging (GCM) service to work. Firstly, the patient checking module mainly use for staff to enter patient's readings of vital signs and compare with the values retrieve from database. The values from database are the boundaries of the vital signs set by doctor. If the current value is exceed the boundaries, staff will be prompt to ask whether need to notify the doctor. If there is a need, a notification will be send to the doctor-in-charge. On the other hand, some patient sent to hospital for emergency rescue may need blood transfusion. Blood in the blood bank may not sufficient and staff can broadcast request to everyone who join the program as a volunteer blood donor. Broadcast of notification is using Google Cloud Messaging (GCM) service.

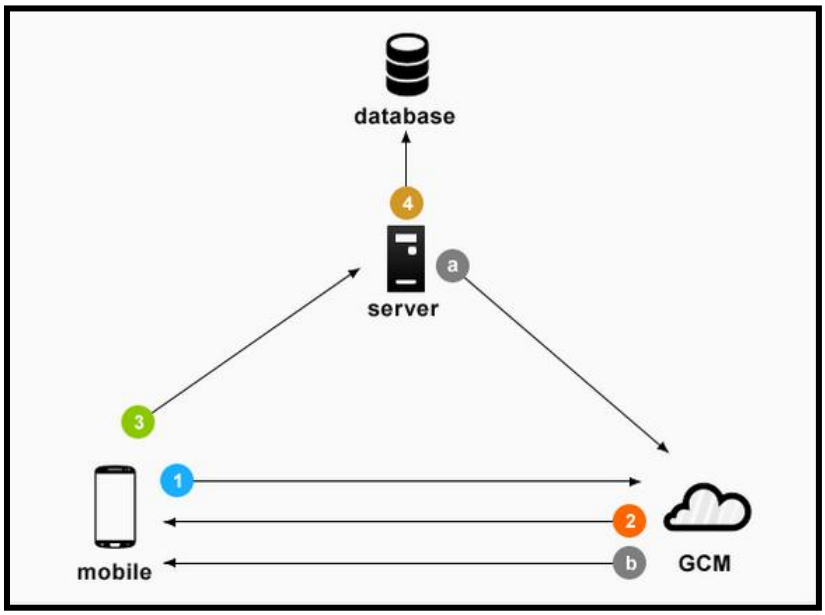


Figure 19: Overview of GCM Service (Tamada, 2015)

Google Cloud Messaging (GCM) is a service that provided by Google which allow developers to send upstream messages (from client apps to servers) and downstream messages (from server to client app). The message sent or received can containing up to 4kb of payload data. The GCM service will be responsible of handling all aspects of messages queuing, delivery of message to target device. The client apps must be GCM-enable which is registered for GCM service. There are few keys needed before client apps register for GCM service.

i. Sender ID: Project number is a number which able to acquire from the API console. It is used to identify a 3rd-party app server that is authorized to send message to the client app.
ii. Application ID: It is used to identify client app that is registered to receive message. This is to ensure that the messages are targeted to the correct application.
iii. Registration ID: An ID issued to the client app by GCM server. Uniquely identify the device that registers for GCM service. The GCM server will send message based on the registration ID.

To register the client apps for GCM service, the Android device must sends sender id and application id to GCM server for registration. After that, GCM server will issue a registration id to the Android device to be able to identify the device. When the device receives the registration id, device needs to send the id to the 3rd party server. Then the server will need to store the registration id in the database for later usage. (Step 1 to Step 4 in Figure 20) After done the registration, the application now is ready to send and receive message. Therefore, when staff needs to notify the doctor, message will be send to server along with device registration id. The registration id is already stored in the database. Then, the message will be deliver to respected mobile device by GCM server according to the registration id.

A client implementation and server implementation needed to complete the implementation of Google Cloud Messaging (GCM) service. In this project, the client implementation will be done in Eclipse Kepler with Android SDK while the server implementation will be developer using Java in JSP.

To enable an Android client able to run GCM service, a few permissions needed to add in the application's manifest. Permissions are required to make the android application support GCM service and allowing sending and receiving notification to and from the GCM server.

```
//To allow the application to use Internet connection
<uses-permission android:name="android.permission.INTERNET" />

//To able to access network state and use to detect internet status
<uses-permission android:name="android.permission.ACCESS_NETWORK_STATE" />

//To allow application to access Google account as GCM need Google account
<uses-permission android:name="android.permission.GET_ACCOUNTS" />

//To keep the device from sleeping when notification receive
<uses-permission android:name="android.permission.WAKE_LOCK" />

//To prevent other applications from registering and receiving the
application's messages.
<uses-permission android:name="com.example.gcmc.permission.C2D_MESSAGE" />

//This app has permission to register and receive data message
<uses-permission android:name="com.google.android.c2dm.permission.RECEIVE" />
```

After for the first time user of GCM server, the Android application has to register with GCM servers before it can receive it first message. The application will get a registration id after registration and it will be store so that it can be use when sending or receiving the notification. Firstly, the application should check whether the current application is already registered with GCM service and the server. Before that, the application version needs to be up to date in order to ensure that the registration id able to function well.

```
//Check for Registration ID, RETURN the ID if exists in shared preferences;
//else, check the app version to see whether it is app to date
//if so, it must clear the registration ID, since the existing registration ID
is not guaranteed to work with the new app version.

private String getRegistrationId(Context context) {
	final SharedPreferences prefs = getSharedPreferences(
		RegisterActivity.class.getSimpleName(), Context.MODE_PRIVATE);
	String registrationId = prefs.getString(REG_ID, "");
	if (registrationId.isEmpty()) {
		Log.i(TAG, "Registration not found.");
		return "";
	}
	int registeredVersion = prefs.getInt(APP_VERSION, Integer.MIN_VALUE);
	int currentVersion = getAppVersion(context);
	if (registeredVersion != currentVersion) {
		Log.i(TAG, "App version changed.");
		return "";
	}
	return registrationId;
}
```

```
//Check for the version of current application
private static int getAppVersion(Context context) {
	try {
		PackageInfo packageInfo = context.getPackageManager()
				.getPackageInfo(context.getPackageName(), 0);
		return packageInfo.versionCode;
	} catch (NameNotFoundException e) {
		Log.d("RegisterActivity",
			"I never expected this! Going down, going down!" + e);
		throw new RuntimeException(e);
	}
}
```

If the application has already registered with GCM service, application is ready to send and receive notification. Else, application has to register to GCM service first. At first, get an instance of GCM first and then call the register function of GCM and passing the Google Project ID as parameter. The method will then return the Registration ID which uniquely identifies client application. The ID will then be stored in the shared preferences of device so that the device does not need to register again.

```
if (gcm == null) {
	gcm = GoogleCloudMessaging.getInstance(context);
}

//Register for GCM, return Registration ID
regId = gcm.register(Config.GOOGLE_PROJECT_ID);

storeRegistrationId(context, regId);

//Store to shared preferences
private void storeRegistrationId(Context context, String regId) {
	final SharedPreferences prefs = getSharedPreferences(
		RegisterActivity.class.getSimpleName(), Context.MODE_PRIVATE);
	int appVersion = getAppVersion(context);

	SharedPreferences.Editor editor = prefs.edit();
	editor.putString(REG_ID, regId);
	editor.putInt(APP_VERSION, appVersion);
	editor.commit();
}
```

After registration, the device needs to share its Registration ID and username to the 3rd party server for future use such as sending the information of sender to GCM server to know which device is the notification or message sent from. In this project, the 3rd party server

(localhost server) will store the registration ID of devices in file based. The username register for each Registration ID must be unique too so that retrieving of ID by username is possible.

After that, the send or receiving of notification message is ready. The sending message has to be send to the 3rd party server through the HTTP Connection. Besides, parameters such as the username of sender, the username of receiver and the message to be sent will pass to server. The server will request GCM server by using these parameter. For multicast of notification, client does not need to specify receiver as the server will pass every username in the registration file to request for GCM service and GCM server will send notification to every registered device.

For the receiving of notification, firstly the client application needs to set up a class to receive the message send from the GCM server.

```
public class GcmBroadcastReceiver extends WakefulBroadcastReceiver {

	@Override
	public void onReceive(Context context, Intent intent) {
		ComponentName comp = new ComponentName(context.getPackageName(),
				GCMNotificationIntentService.class.getName());
		startWakefulService(context, (intent.setComponent(comp)));
		setResultCode(Activity.RESULT_OK);
	}
}
```

A WakefulBroadcastReceiver is a special type of broadcast receiver that handles the creating and managing a partial wake lock for the app. The partial wake up lock ensures that the processor of device is running, but the screen and keyboard backlight will be allowed to go off. It passes off the work of processing the GCM message to a service (typically an IntentService), while ensuring that the device does not go back to sleep in the transition.

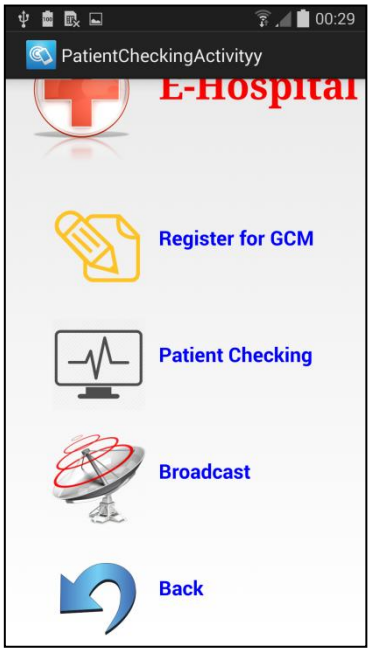
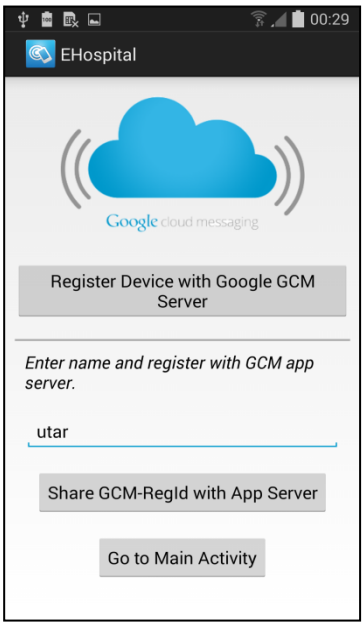
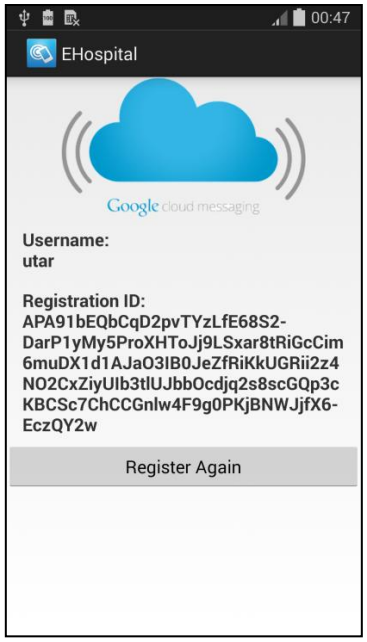
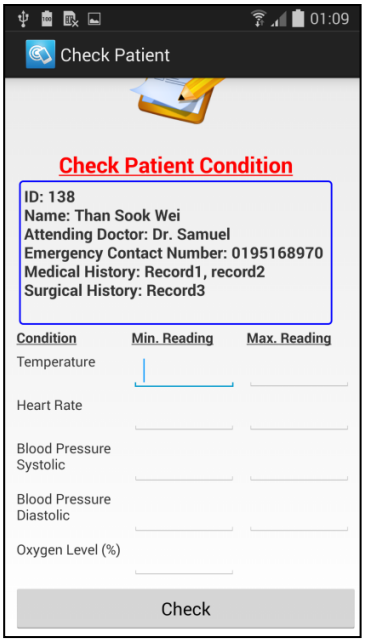
In short the client application will be able to receive the notification in background and push the notification in the status bar even user do not start the application. At the same time, the message received from GCM server will be convert into a notification message by using the NotificationCompat class. This class will take care of the creation of notification and issue the notification. In order to define the notification action, setContentIntent() method can be call to define the action when user click on the notification shown in the notification bar.

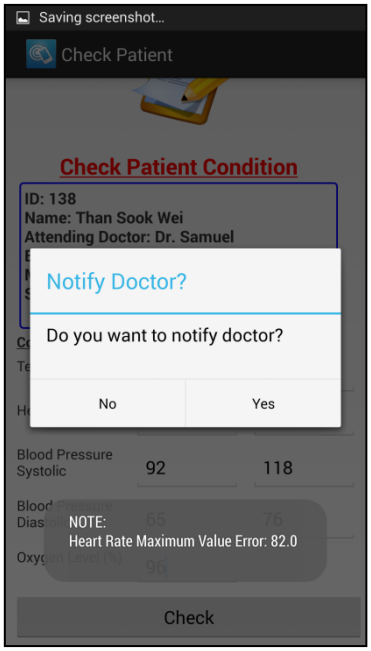
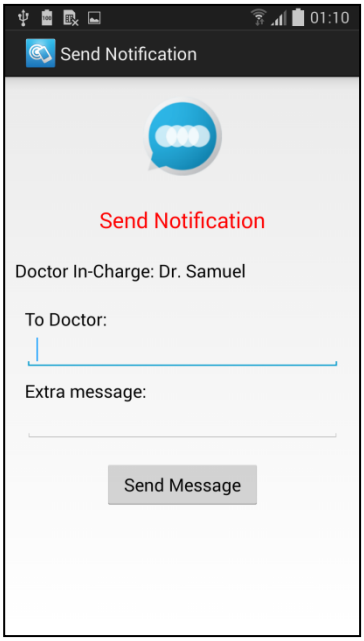
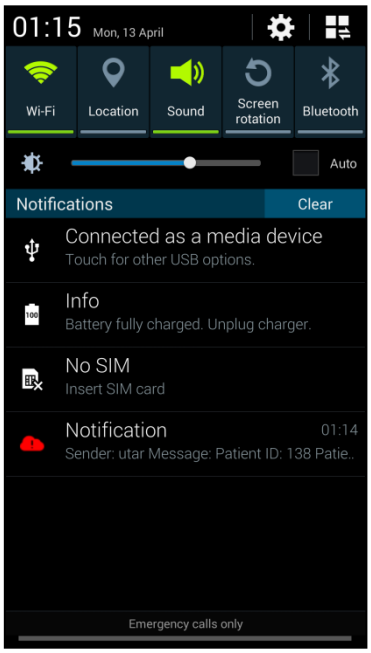
```
NotificationCompat.Builder mBuilder = new NotificationCompat.Builder(this)
       .setSmallIcon(R.drawable.gcm_cloud)
       .setContentTitle("Notification")
       .setStyle(new NotificationCompat.BigTextStyle().bigText(msg))
       .setContentText(msg)
       .setVibrate(new long[] { 1000, 1000 })
       .setSound(RingtoneManager.getDefaultUri(RingtoneManager.TYPE_NOTIFICATION));
```

In the server part GCM implementation, the server needs to get the message from client application, the username of sender and receiver. The Sender class is a helper class to send messages to the GCM service using an API Key as parameter while Message class used to create GCM message. Then the receiver destination id will be retrieve from the location where the registration is stored when device share their registration id. In this project, the registration id will be read from file. The difference between device-to-device notification and multicast notification is the amount of registration id sent to GCM server. If there is only one receiver, the id can be read from the file by using the unique username, else, if is multicast service, all registration from the file will be sent to GCM server. After that, Sender type object will send the message and registration id to the GCM server.

```
Sender sender = new Sender(GOOGLE_SERVER_KEY);
Message message = new Message.Builder().timeToLive(30)
                        .delayWhileIdle(true).addData(MESSAGE_KEY, userMessage)
                        .addData(REGISTER_NAME, fromName).build();

//SINGLE receiver → Get destination registration id from file
Map<String, String> regIdMap = readFromFile();
String regId = regIdMap.get(toName);

//Broadcast → Get destination registration id from file
List<String> regIdList = new ArrayList<String>();
for (Entry<String, String> entry : regIdMap.entrySet()) {
        egIdList.add(entry.getValue());
}

//Send message to GCM server
Result result = sender.send(message, regId, 1);
```

5.2. Screenshots of Module

<table>
<tr>
<td> 
</td>
<td> 
</td>
</tr>
<tr>
<td>Sub Menu of Patient Measurement</td>
<td>Register for Google Cloud Messaging (GCM) service</td>
</tr>
<tr>
<td> 
</td>
<td> 
</td>
</tr>
<tr>
<td>Store Registration ID and name to shared preferences</td>
<td>Enter patient’s vital sign reading to check</td>
</tr>
</table>

<table>
<tr>
<td> 
</td>
<td> 
</td>
</tr>
<tr>
<td>If value exceed boundaries values, prompt for confirmation to notify doctor</td>
<td>Send notification to doctor by specifying doctor’s name</td>
</tr>
<tr>
<td> 
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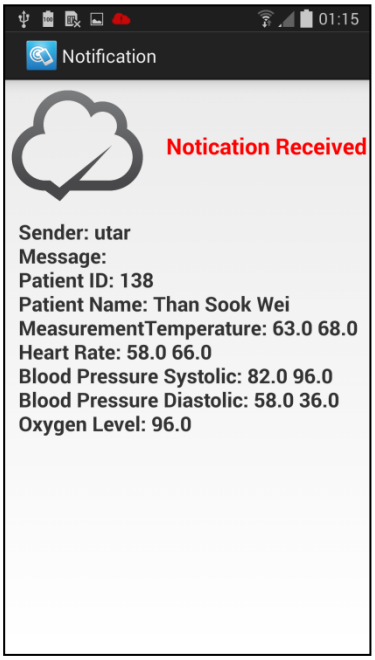
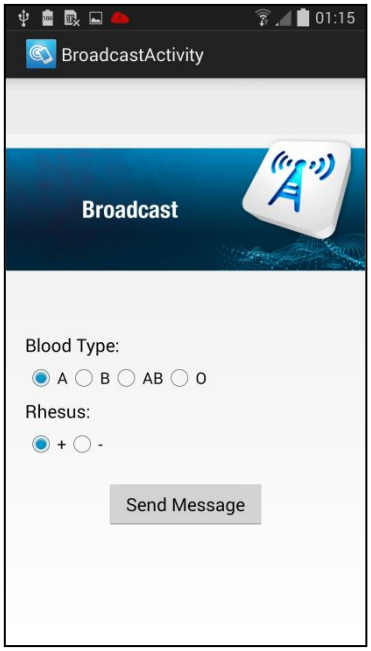
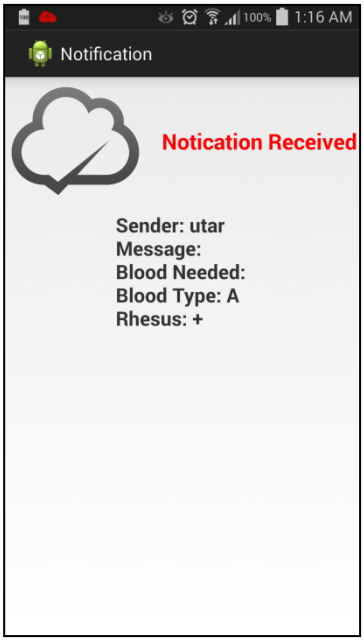
<td> 
</td>
</tr>
<tr>
<td>Notification received will shown in status bar</td>
<td>Click on notification to view details of notification</td>
</tr>
</table>

	
Specify which type of blood type before broadcasting requests	Broadcast notification in details

CHAPTER 6: IMPLEMENTATION AND TESTING

The Android application has be test to ensure that the objectives have been achieved. The application requirement validation test has been done by black box testing. Black box testing, also known as the functional testing and behavioral testing is mainly focus on determining whether software fulfills its functional requirements. Black box testing will be carry out by tester to provide input to the system and monitor for the output without taking care of the internal code structure.

Test Traceability Matrix

Function ID	Function	Function Description	Module
F001	Write Patient Information	Writing patient information to database and NFC tag	Patient Identification Module
F002	Read Patient Information	Read patient ID from NFC tag then retrieve data from database	Patient Identification Module
F003	Update Patient Information	Read patient ID from NFC tag then retrieve data from database, update information in database and NFC tag	Patient Identification Module
F004	Delete Patient Information	Delete patient profile from database and reset NFC tag	Patient Identification Module
F005	Insert Measurement	Insert patient's vital sign boundaries values	Notification Module
F006	Register GCM	Register device to GCM server	Notification Module
F007	Check Patient Condition	Key in patient's vital sign reading and compare with values from database, notify doctor if needed	Notification Module
F008	Broadcast Blood Supply Request	Broadcast requests to everyone in the file list	Notification Module

Table 3: Features to be tested

Function 1:

F001 Write Patient Information

Feature	Input	Output	Expected Output	Anomaly? (Yes or No)	Traceability
Enter patient information	Complete all fields	Information stored to database	Information stored to database	No	
Enter patient information	All empty field	Toast display empty field need to fill in	Toast display empty field need to fill in	No	
Enter patient information	Some empty field	Toast display empty field need to fill in	Toast display empty field need to fill in	No	
Write basic information to NFC tag	Data from database (Patient ID, name, contact, etc.)	All information from database stored to NFC tag	All information from database stored to NFC tag	No	
Write basic information to NFC tag	Large amount of data from database	Some information missing	All information from database stored to NFC tag	Yes	F001

Table 4: Testing Table of Function F001

Function 2:

F002 Read Patient Information

Feature	Input	Output	Expected Output	Anomaly? (Yes or No)	Traceability
Read NFC tag	Attach tag to mobile device	Show information stored in NFC tag	Show information stored in NFC tag	No	
Show All button	Click on the show all button	Show all information retrieve from database	Show all information retrieve from database	No	

Table 5: Testing Table of Function F002

Function 3:

F003 Update Patient Information

Feature	Input	Output	Expected Output	Anomaly? (Yes or No)	Traceability
Read NFC tag	Attach tag to mobile device	Show information stored in NFC tag	Show information stored in NFC tag	No	
Show All button	Click on the show all button	Show all information retrieve from database, editing is unable	Show all information retrieve from database, editing is unable	No	
Update button	Click on the update button	Input field able to be edit	Input field able to be edit	No	
Update information	Key in updated field, no empty	Information in database update	Information in database update	No	
Update information	Key in updated field, empty fields	Toast display empty field need to fill in	Toast display empty field need to fill in	No	
Update information	Key in updated field, all empty fields	Toast display empty field need to fill in	Toast display empty field need to fill in	No	
Update NFC tag	Attach NFC tag to update	Information in NFC tag updated	Information in NFC tag updated	No	

Table 6: Testing Table of Function F003

Function 4:

F004 Delete Patient Information

Feature	Input	Output	Expected Output	Anomaly? (Yes or No)	Traceability
Read NFC tag	Attach tag to mobile device	Show information stored in NFC tag	Show information stored in NFC tag	No	
Show All button	Click on the show all button	Show all information retrieve from database	Show all information retrieve from database	No	
Delete button	Click on the delete button	Patient's profile in database is deleted	Patient's profile in database is deleted	No	

Table 7: Testing Table of Function F004

Function 5:

F005 Insert Measurement

Feature	Input	Output	Expected Output	Anomaly? (Yes or No)	Traceability
Read NFC tag	Attach tag to mobile device	Show information stored in NFC tag	Show information stored in NFC tag	No	
Enter measurement values (new patient)	Only integer or float is allowed (Input type is set)	New measurement stored into database	New measurement stored into database	No	
Enter measurement values (exists patient)	Only integer or float is allowed (Input type is set)	New measurement stored into database, old measurement is deleted	New measurement stored into database, old measurement is deleted	No	

Table 8: Testing Table of Function F005

Function 6:

F006 Register GCM

Feature	Input	Output	Expected Output	Anomaly? (Yes or No)	Traceability
Enter name for registration	Input value : Utar (Not exists in registration file)	Toast display successful of registration	Toast display successful of registration	No	
Enter name for registration	Input value : Utar (exists in registration file)	Toast display repeat of register name	Toast display repeat of register name	No	
Enter name for registration	Input value : Utar (register again using own same name)	Toast display repeat of register name	Toast display successful of registration	Yes	F006

Table 9: Testing Table of Function F006

Function 7:

F007 Check Patient Condition

Feature	Input	Output	Expected Output	Anomaly? (Yes or No)	Traceability
Enter patient's vital sign reading	Only integer or float is allowed (Input type is set) – Values in bound	Nothing	Nothing	No	
Enter patient's vital sign reading	Only integer or float is allowed (Input type is set) – Values out of bound	Show alert dialog box to confirm notifying doctor	Show alert dialog box to confirm notifying doctor	No	
Enter patient's vital sign reading	Empty	Toast display to ask user fill in the fields	Toast display to ask user fill in the fields	No	

Table 10: Testing Table of Function F007

Function 8:

F008 Broadcast Blood Supply Request

Feature	Input	Output	Expected Output	Anomaly? (Yes or No)	Traceability
Enter type of blood supply needed	Choose blood type needed among radio button	Broadcast notification to everyone in the registration file list	Broadcast notification to everyone in the registration file list	No	

Table 11: Testing Table of Function F008

CHAPTER 7: CONCLUSION

7.1. Project Review, Discussion, Conclusion

This paper has given a number of reasons on improvising the current workflow system in the healthcare management system. The application developed in this project is used to improve the process of patient identification and sending notification to doctor or broadcasting blood supply request in a faster manner. Therefore, the application will be able to reduce human error when identifying patient and increase staff efficiency especially when handling emergency situation.

In order to achieve the objectives of this project, an Android application integrated with NFC technology and Google Cloud Messaging (GCM) service is developed. NFC technology is used to do patient identification by read and write the NFC tag and retrieving patient information from database to mobile devices. Besides, GCM service is used so that sending or broadcasting of notification from device to device is possible. The integration of the two technology provide a faster patient's vital sign checking and notifying doctor process can be done together.

The strength of the developed system is the application able to automate part of the patient information management. It is able to read and write patient information to the database in a faster manner. Besides, staff can easier notify doctor once the patient's vital sign is out of bound. Blood supply request can also be done by broadcasting notification which is faster in manner. At the same time, the system has few limitations too as if there is poor Internet Connection in the environment, sending of notification may be slow or even fails. Information of patient might be unable to retrieve from database due to the same problem. Therefore, Internet Connectivity is the bottleneck of the performance.

In the final delivery system, the application brings enhancement to the hospital management workflow yet provides faster and safer medical process. At the same time, it reduces some burdens of medical staff as part of the job task is automated. This will directly ensure the human caused medical errors can be minimized and more accurate decision making of medical staff which then lead to patient safety and healthy.

7.2. Novelties and Contributions

The proposed system can add more functionality to fully use NFC technology. Functionalities such as NFC based medical administration can be implemented to ease the process of medicine dispersion. All medicine check out from store should be track down by scanning NFC tag of staff. Then, staff need read patient information to know what medication the patient should take before dispersion. Doctor can update the prescription of patient just by updating the database.

Besides, patient tracking can also be done by putting mobile reading at several points in the hospital. Patient need to scan their NFC tag before in and out of some locations and the records read by reader should be save to database for tracking. If a patient did not check out a location after certain period, database may send a alert message to hospital security department so that further action can be taken. Besides tracking of patient, equipments and tools in the hospital can also be track by using the same manner.

The final deliverable system should be able to lower the burden of medical staff by automate some of their job tasks, reduce volume of paper works they need to do and save hospital operation cost. The system will save time of medical staff that usually busy on their work and allow to them to spare more time to take care of patient. Patient should be the main concern of medical staff and therefore concentration of staff should be stay on patient instead of their paper works and work beyond their work scope such as searching contact number of a doctor.

7.3. Future Work

This project can be further improved to achieve higher security and functionality. As the security of the application can be very complex tasks, this project apply only simple log in mechanism. Roles of user that claimed to be can be identified and defining the task of each role able to carry out. More research needs to be carried out to focus on the security of healthcare management and roles of each user need to be specified.

Patient's information in the NFC tag can be encrypted to avoid other people who have NFC reader to read without permission. The encrypted and decrypted function should remain only medical staff in the hospital. This means that only user of this Android application can decrypt the encrypted patient information in NFC tag. Therefore, the privacy of the patient can be ensure.

Besides, in order to have a clearer and more details version of medical history, research or interview need to be done to have a more accurate format of medical history or surgical history of patient. Hence, the application can handle the displaying of those histories in a clearer manner. Medical staff can click to view medical records in details with provided date, time and explanation which no longer only a short description.

Functionalities of Android such as achartengine can be implement to show the vital sign readings of patient by using charts so that doctor able to monitor patient's condition in an more efficient way. Therefore, by monitoring the pattern of charts, doctor or medical staff can have a more accurate decision making process.

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