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Software Development Issues and Challenges in Digitalizing an Existing Health System for Tuberculosis Patients: A Case Study in Malaysia

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***Abstract*— Tuberculosis (TB) is second only to HIV/AIDS as the greatest killer worldwide due to a single infectious agent, and is one of the top killers among infectious diseases in Malaysia. In Malaysia, the TB incidences are increasing every year. Although the TB treatment success rate is increasing, the number is still not very promising compared to those in neighbouring countries. A study showed that patients treated without close observation by the hospital have a substantially higher risk of adverse outcome. The study also showed that a large proportion of unsuccessful treated cases could be identified and prevented at an earlier stage if the patients are closely observed by the hospital. As a result, we initiated a project called "Wellness Community: M-Health for TB patients" in an effort to enable the hospital to closely monitor and communicate with TB patients by utilizing information and communications technology. We developed a prototype of M-Health system which deploys push and pull technology to allow doctors or TB specialists push messages or medical advices to their patients using mobile devices or to pull/retrieve any messages sent by patients to the system. Doctors and specialists can also view the patients' medical records using the system. Furthermore M- Health for TB Patients can help hospital to educate their TB patients more about the disease. This paper discusses the software development issues and challenges in developing the system.**

***Keywords*—mobile technology, online messaging, tuberculosis, agile software development**

I. Introduction

Tuberculosis (TB) is a kind of lung disease caused by bacteria called Mycobacterium tuberculosis. It is an airborne-disease; it spreads from a person to another person through the air when people with active TB cough, sneeze or spit. The common symptoms of TB include generalized cough, tiredness or weakness, weight loss, fever, and night sweats [1]. If the infection in the lung worsens, then further symptoms can include chest pain, coughing with sputum (material from the lungs) and/or blood, and shortness of breath [1].

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According to the World Health Organization (WHO), about one-third of the world's population has been infected with latent TB. These people have been infected with TB bacteria but are not yet ill with disease and cannot transmit the disease [2]. People infected with TB bacteria have a lifetime risk of falling ill with TB of 10% [2]. However, people living with HIV, malnutrition or diabetes, or people who use tobacco, have a much higher risk of falling ill with TB.

A study showed that patients treated without close observation by the hospital have a substantially higher risk of adverse outcome [3]. The study also showed that a large proportion of unsuccessful treated cases could be identified and prevented at an earlier stage if the patients were closely observed by the hospital [4]. Based on an interview with Dr. Mustafa Kamal Razak, a specialist doctor in the Department of Respiratory, Hospital Sultanah Bahiyah in Kedah, Malaysia, some problems for hospital to closely observe their patients during the treatment process include:

1. Most of the patients stayed far away from the hospital (more than 30 kilometers) and thus their willingness to undergo all the treatment process were compromised by the travel cost.
2. TB patients are not well educated on the TB disease, and thus causing them to underestimate the consequences of not following the treatment process tightly.
3. Information and communication tools for the TB patients to communicate with doctors and vice versa are lacking.
4. An information system that can help them to educate the patients about the knowledge of TB disease is lacking at the hospital.

TB patients are required to go through a 6 month treatment process in order to recover from TB [4]. Consequently, the hospital is looking for a communication technology which can help them monitor the patients and motivate them to complete the whole treatment process.

As a result, we initiated a project called Wellness Community: M-Health for TB Patients to improve the management and monitoring of TB patients who are undergoing treatment and allow TB patients to communicate with doctors at anytime and anywhere. This project is a collaborative effort between the School of Computer Sciences, USM and the Hospital Sultanah Bahiyah in Alor Setar, Kedah. The aim of this project is to study on an effective way for the hospital to closely monitor and communicate with their TB patients by utilizing information and communications

technology and subsequently propose the M-Health system for TB patient.

M-Health system for TB patients is an information and communications system for the hospital to manage TB patients' treatment progress and communicate with their TB patients and vice versa. TB patients (especially those from remote areas and poor background, and who are less educated) will be able to communicate with doctors regarding their treatment and enquire for advices using SMS (Short Messaging Service). Doctors can read and reply their patients' SMS, and even send reminder messages to them. Moreover, M-Health system allows doctors and TB specialists to view and manage detailed information of the patients such as treatment progress, x-ray images and medical history online via their mobile devices. A dedicated server (M-Health server) is deployed to handle the SMS or messages sent by doctors, TB specialists and TB patients, as well as the services for managing patients' information. The system provides a fast and convenient way for doctors and TB specialists in providing better medical advices to the patients. The main objectives of this project are:

- To improve the management of TB patients' medical information and monitoring of the progress of TB treatment at the hospital.
- To improve the compliance of TB patients having to follow their treatment tightly.
- To enable any medical complications of TB patients to be identified at an early stage.
- To provide an easy and convenient access to TB patients' information and messages for doctors and medical staff in the hospital.

II. Technical Background

This section presents some studies on tuberculosis cases, mainly in Malaysia. In the effort to provide a better system design and a well-accepted system by the users, we perform some studies on existing health related systems. Thus in this section, we also explain a summary of selected existing systems based on their usability and service features.

A. *Tuberculosis*

Tuberculosis (TB) is second only to HIV/AIDS as the greatest killer worldwide due to a single infectious agent, and is one of the top killers among infectious diseases in Malaysia [2]. In 2010, 8.8 million people fell ill with TB and 1.4 million died from the disease and this is equal to more than 3,800 deaths a day in Malaysia [2]. Malaysia recorded a total of 19,337 new cases in that year [5]. TB occurs in every part of the world , and over 95% of cases and deaths are in developing countries, with 60% of new cases occurred in Asia in the same year [2]. TB remains as the top killer of people living with HIV, contributing one quarter of all deaths in HIV, and also among the top three cause of death for women aged 15 to 44, with 320,000 women died from TB in 2010 [2]. The number of people falling ill with TB has been declining slowly over the years, with the death rate dropping 40% between 1990 and 2010 [2]. However, in Malaysia, the number of incidences is increasing every year.

B. *Health-related Systems*

With tuberculosis (TB) being one of the major diseases in the world, various kinds of methods have been developed to help combat this disease. We discussed various kinds of tuberculosis-related systems from the Internet. Study on existing systems can improve our knowledge in understanding the current trends of technology, system features and applications from other developers and researchers. This knowledge will help us in designing the M-Health system and providing a suitable user interface for the doctors. Finally, it will help us to develop the M-Health system that suits the needs of the doctors from the Hospital Sultanah Bahiyah. Table 1 summarizes the nature/type and features of the existing systems.

Table 1. Summary of the Nature/Type and Features of the Existing Systems

System	Nature/Type	Features
staffTRAK-TB [6]	Information System Software	Provide TB Information and Education, Manage Patient Information
CDC WONDER OTIS [7]	Web-based Information System	Provide TB Information and Education
I-TIS [8]	Web-based Information System	Provide TB Information and Education
TBDB [9]	Web-based Information System	Provide TB Information and Education
MyTB [10]	Web-based Information System	Provide TB Information and Education, Manage Patient Information
Mocha TB Detect [11]	Mobile App	Provide TB Information and Education, Provides TB Screening
TB Mobile [12]	Mobile App	Provide TB Information and Education

C. *Messaging Technologies*

Messaging is the place where doctors can communicate with their patients using SMS [13] [14] [15] [16]. The UI (User Interface) of messaging is designed in a similar manner to the common chatting application which is available nowadays [17] [18]. Therefore, we propose a prototype of M-Health system can display all messages sent in by the patients and sent out by the doctors to a particular patient. After the doctor entered the message and clicked on the send button, the mobile application will send the message to the server, and the message will be stored in the server's database. The procedure to send out the SMS is handled by the message handling service from the server.

Message handling service is a Windows service that runs in the background of the Windows operating system. Its main function is to handle any transmission of messages between the M-Health server and the Global System for Mobile (GSM) modem – a modem that contains a Subscriber Identity Module (SIM) card, which is used to send and receive messages from and to any mobile phone numbers, in our case.

III. Design And Implementation

In this section, we will discuss about the system architecture of the system and the system module breakdown (nurse's module, doctor's module and administrator's module). We will also explain the development methodology used in this section.

A. *System Architecture*

Figure 1 shows the M-Health system architecture. The system consists of client application (web application and mobile application) that is used by the doctors. The web application will function as the main platform to be used by users such as doctors and nurses. The mobile application is an additional feature that is specially designed for the doctors and TB specialists for advising, monitoring and viewing TB patient information. The M-Health server is used to store the patients' information and medical records, as well as handle any data retrieved by doctors and also the communication between the doctors and their patients. The GSM modem is used to receive and send any SMS from and to the patients. The doctors and TB specialists can retrieve their patients' information and medical records from the server by using the client application. Doctors and TB patients can communicate with each other via M-Health platform by utilizing SMS technology. TB patients can send SMS to the system using mobile phones and doctors can view and reply their SMS from their mobile device or from the web application. Messages sent by patients with highest priority will be pushed to the web application, mobile application and also doctor's personal mobile phone. In addition, data transfer between the client side's application and the server will be secured using client/server authentication and data encryption methods, as well as require doctors and specialists to login into the system using self-created user password in order to access the patients' information.

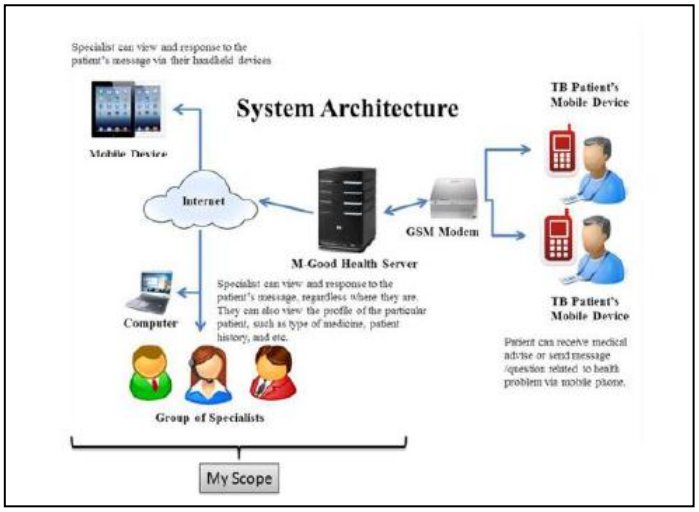

Figure 1. System Architecture Diagram of Wellness Community: M-Good Health for TB Patients

B. *System Module Breakdown*

Figure 2 shows the M-Health system components. The main system components are divided according to three types of users (doctor, nurse and admin). Therefore, three modules are introduced. The web-based application consists of all three modules whereas the mobile application consists of one module only (the doctor's module). Since only the doctors or TB specialists will be using the mobile application but not the nurses and system administrator.

Figure 2. . System Module Breakdown of Wellness Community: M-Good Health for TB Patients

1) Nurse's Module

Whenever a new patient came for new TB treatment, they will be required to fill in their personal information and medical records. This module is designed for the users to add new and manage patients' information in the system.

- *Add New Patient*: Register new patient and also fill in the required patient's information into the system database.
- *Manage Patient*: View list of registered patients, and allows editing of patients' information.
- *Assign Patient to Doctor*: Assign patients to a specific doctor or a group of doctors.

2) Doctor's Module

This is the main module of the system. This module is designed for doctors to view and manage patient information and medical records, as well as provide a communication mechanism for doctors to communicate with their patients.

- *Doctor's Workspace*: View and manage patients' information and medical records. Doctors will add new or update information about patient's treatment progress, including their medical records and recovery progress. Doctors are able to set patients' priority in this sub-module.
- *Messaging*: Allows doctors to view and reply patients' SMS, and also send scheduled message to patients as reminder message. SMS sent by patients with the highest priority will be sent not only to the system, but also to the doctor's mobile phone.

- *Add Medicine Information*: Add TB medicine information into the system database for quick references by the doctors.

C. *Development Methodology*

We develop the M-Health system using the agile development methodology. The reason for choosing the agile development is due to the needs for an adaptive method of development. During the development process of the M-Health System, we need to interact and get feedback from the hospital frequently because we want to avoid misunderstanding communication and therefore we want to fulfill the hospital requirements. Thus agile development methodology provides the flexibility in responding to change whenever user requirement changes. No long term planning is required and user requirements are updated from time to time in order to achieve satisfying results for the users. Multiple iterations of planning, designing, prototyping and user reviews might be necessary to ensure the system is stable and reliable for long term usage by the hospital. The agile development approach started off with planning including requirements specifications, and then followed up by system analysis, system design, implementation and prototyping, testing and lastly user reviews and acceptance testing. These stages might be repeated until satisfying results are achieved.

IV. Challenges

One of the key challenges faced during the development of this project is the Graphical User Interface (GUI) design for mobile devices. It took some time to design the user interface for the few sample forms provided by the doctors as there is a lot of required information in the form to be completed. The consideration of validations in the user inputs is also important to ensure no errors during data entry before committing the entered data into database. Database design is also time consuming due to the large number of fields and data required.

Besides, the mobile application development has to be compatible and closely resemble the web-based application as well. Therefore, for any update onto the web application, an update on the mobile application should be implemented at the same time. Since web application and mobile application share the same database, the editing of database fields should be taken into consideration.

Finally, the consideration of the operating system version on the mobile device is also important. In this prototype we use an Apple iPad which has backward compatibility until version 4 only while the version of iOS is version. Any versions which are lower than version 4 are not be able to run the mobile application.

V. Feedbacks and Further Recommendations

A workshop was conducted to demonstrate the M-Health system to the representative of medical team from Hospital Sultanah Bahiyah. The team includes doctors, TB specialist, nurse and admin staff. The doctors were very pleased with the developed system, and agreed that the system will be very useful in helping them to manage their TB patients and to improve the quality of TB treatment. However, the doctors also gave some constructive feedbacks for further improvement of the system. The feedbacks are as follows:

- Minimize differences between the user interface design in the system and the original design of the form.
- The system should be able to display multiple patients' medical records sorted by date, so that doctors can easily access them.
- Enable group chatting between group of patients and group of doctors.
- Add repeat function to the reminder messages.

After analyzing the feedbacks given by medical team, future work that should be done in order to improve the M-Health system are listed as follows:

- Redesign the user interface to resemble the original design of manual form.
- Create a "larger view" user interface showing patient's treatment progress and a list of patient's medical records, doctor's comment and tagged message which are sorted by date.
- Add local clinic module – To enable local clinic access certain information about the patients, such as updating the status of patients taking medicine.
- Add report module – To show summary and report of all patients and their status in an organized format.

VI. Conclusion

In conclusion, Wellness Community: M-Good Health for TB Patients has helped the hospital to improve the quality of TB treatment to TB patients not only within the state of Kedah, but throughout Malaysia. The current prototype system has already established a solid platform for many further improvements and upgrades of the system. Nevertheless, this system can help the authority in fighting against TB disease in the long run.

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