CSIS0801 Final Year Project 2013-2014 Interim Report

Biometric Information with Smartphone

Health-ie

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1. Introduction

Our everyday lives are increasingly influenced by information technology. The emergence of smart phone and wireless devices has reshaped our lifestyle and allowed innovations in different aspects of our lives. The incorporation of wireless technologies into our everyday lives not only creates new means of communication, but also provides solutions to simplify the daily tasks and improve the quality of life.

Medical technology, in particular, have benefitted from the introduction of wireless technologies like Bluetooth, resulting in the invention of portable medical devices that measure various biometric information and provide real-time results. Through connection with other wireless devices like smart phones, the biometric information can be analyzed for more detailed monitoring of health conditions and stored for long term monitoring and future use and analysis. Also, the information can be easily shared to other smart phone users for regular updates of health conditions.

The incorporation of wireless technologies into medical services is bringing a revolution to the existing medical system. In the past, medical consultation and monitoring has been limited to face-to-face consultation with the presence of doctors and nurses. Long period monitoring is thus time-consuming for the doctors and resource-consuming for the patients. Now, with the introduction of wireless consultation and monitoring, real-time consultation and long-period monitoring can be achieved with little cost. This also allows certain conditions and diseases that are often passive and recessive to be diagnosed and monitored. As a result, the overall quality of medical services received by a patient can be improved.

In this project, latest wireless technologies (Bluetooth 4.0) and mobile devices (Android 4.3) are used to provide new means of monitoring health conditions
through the checking of biometric information, in particular the heart rate information of the user. An Android 4.3 application is written to handle the readings from a Bluetooth 4.0 Low Energy heart rate belt. Based on the heart rate values, the application provides functionalities to the heart disease patients to monitor their health conditions. It adopts the name “Health-ie”, a portmanteau of “health” and “selfie”, meaning that the application allows users to monitor their health actively by themselves, just like taking selfies (self-portrait photos).

2. Project Aim and Outcome

The aim of this project is to make use of the latest Bluetooth 4.0 Low Energy medical devices and Android 4.3 devices to help heart disease patients monitor their health conditions. An Android 4.3 will be written which works with the provided Bluetooth 4.0 Low Energy heart rate belt, Wahoo Blue HR Heart Rate Strap. The resultant Android application will provide the following functionalities:

i. Instant heart rate monitoring

ii. Notifications and reports based on specific heart disease

iii. Portable medical profile

A detailed description of the functionalities and their implementation will be discussed in the “Core Features” section.
3. **Background Information**

The project employs the latest wireless technologies, including Bluetooth 4.0 and Android 4.3, to build the application for heart disease (cardiac dysrhythmia) patients. Below are some of the new features of these technologies and a brief description of how they are incorporated into the project:

**i. Bluetooth 4.0 Low Energy (BLE)**

Bluetooth 4.0 was released in July 2010 and is currently the version adopted by most Bluetooth device and mobile device manufacturers. Its low energy mode (BLE), also known as Bluetooth Smart, includes the latest batch of innovations and several advantages over the previous Bluetooth standard mode:

- **Low energy consumption**

  BLE has a much lower energy consumption rate than standard mode. A BLE device can run for months simply on a button cell. This ensures the medical devices built using BLE can run continuously to monitor the health conditions of users for a long period of time without the tedious and troublesome process of changing battery.

- **Low latency**

  BLE devices communicate using short pieces of data known as attributes. Less energy and time is required to send these attributes, and thus BLE devices enjoy low latency of as short as 3 ms for communication. This ensures real-time update of health conditions and immediate detection of any abnormal condition.
- Long range

BLE devices can maintain connection within a range of up to 50 m. This eliminates the need for regular reconnection in everyday use due to some trivial reasons such as going to the toilet or handing the mobile phone to another person.

BLE employs the central-versus-peripheral model of connection, which simplifies the connection and reception of data from Bluetooth medical devices. Also, BLE has provided some predefined profiles for different health devices based on the Generic Attribute Profile (GATT), including the Heart Rate Profile and Glucose Profile, which includes some data fields (characteristics) commonly used by the devices, such as battery level and heart rate level. This simplifies and standardizes development of applications and devices based BLE.

In this project, the BLE medical device employed is Wahoo Blue HR Heart Rate Strap, which is a chest belt that provides continuous detection of heart rate. Being water-proof, it supports various usages such as everyday monitoring or fitness tracking, and also functions in different conditions. The application will be built using the heart rate data from the belt and develop functionalities for the user to view, store and analyze the data.

ii. Android 4.3

Android 4.3 was released in July 2013 and is the first version of Android to provide built-in support for BLE, including a new connection mechanism for pairing with BLE devices. Thus, Android 4.3 is the lowest version of Android system supported in this project.
iii. **Personal Health Systems (PHS)**

All the various devices and applications used for monitoring health and wellness can be incorporated into a personal health system (PHS) which provides all-in-one healthcare services. Through the adaptation of PHS, healthcare can be conducted in an active manner: the user can monitor his health conditions directly by himself without always consulting the doctor. Also, through telecommunication, doctors can receive real-time notifications and updates of the users’ conditions and provide over-the-air advices. In this way, hospital admission rate can be reduced. Medical service providers can be notified immediately when emergency situations occur. Thus, the survival rate of acute sickness patients can be increased.

This project is an adaptation of PHS into Android smart phones, thus allowing heart disease patients to actively monitor their conditions in everyday lives and also on-the-go. The users can also keep a record of their personal medical profile through the application.

4. **Research Outcome**

In order to develop an application that can make good of the user’s heart rate data and cater to the needs of heart disease patients, research has been done for a better understanding of heart diseases and the existing health mobile applications.

i. **Heart Diseases**

Also known as cardiovascular diseases, heart diseases represent a large class of diseases that involve both the heart and blood vessels, in addition to heart attacks. Common heart diseases also include coronary heart disease, high
blood pressure, heart failure and cardiac dysrhythmia. There can be various causes for heart diseases, and patients are not limited to a specific age range. For this project, cardiac dysrhythmia is the target type of heart disease that the application provides service.

*Cardiac Dysrhythmia*

Cardiac Dysrhythmia, also known as arrhythmia, represents the conditions of having erratic heart beats: the heart beats may be irregular, too fast or too slow. There are many different causes for the disease, including problems with atria (upper chambers of heart), ventricles (lower chambers of heart) and blockages in heart. Symptoms include palpitations (abnormal awareness of the beating of heart). Though cardiac dysrhythmia is often not harmful, it can sometimes be fatal. In fact, it is one of the most common causes of death while travelling to hospital, as it can cause Sudden Cardiac Death (SCD). The three main types of cardiac dysrhythmia are:

**A. Atrial Fibrillation (AF)**

AF is the most common type of cardiac dysrhythmia. It is the rapid and irregular beating of the heart due to the fibrillation (uncoordinated twitching of individual muscle fibres) of atria, and is caused by the malfunctioning of the pacemaker. Symptoms include palpitation, fainting, fatigue, shortness of breath, chest pain and congestive heart failure. These are also accompanied by a risk of stroke five times higher than normal.

According to the persistence of its occurrence, AF can be classified into four types:
- First detected: one-off diagnosis
- Paroxysmal: occurrence stops within one week
- Persistent: occurrence continues for more than a week
- Permanent: occurrence continues for a much longer period

B. Tachycardia

Tachycardia is the condition of having much higher heart rate than normal. Usually, it means heart rate above 100 bpm (beat per minute). Tachycardia may arise from different parts of the heart, with AF being one of the causes. Symptoms of tachycardia include chest pain and low blood pressure. Prolonged occurrence of tachycardia may lead to ischemia, the reduced efficiency of the heart.

C. Bradycardia

Bradycardia is the condition of having much lower heart rate than normal. Usually, it means heart rate below 60 bpm, those this level is relative to the medical conditions of a person. For well-trained athletes, their heart rates may be much lower even when they are in good health conditions. Symptoms of bradycardia include fatigue, weakness and dizziness.

Heart Rate

As mentioned above, heart rate is an important indicator of the conditions of cardiac dysrhythmia patients. Thus, it is used as a tool of monitoring cardiac dysrhythmia in the application. The three main usages of heart rate are:
A. Resting heart rate (RHR)

Resting heart rate is the heart rate of a person when the body is at rest. It is usually around 60 – 100 bpm, though it varies with age, gender and health conditions.

For tachycardia and bradycardia patients, continuous monitoring of RHR together with statistical reports allows them to monitor the situations and progress of treatments. For those who are in suspect of having tachycardia or bradycardia, monitoring RHR can also provide a more accurate detection of presence of the diseases.

B. Heart rate variability (HRV)

HRV is the variation in the time interval between heart beats (R-R intervals). Continuous monitoring of HRV together with statistical reports allows AF patients to monitor their conditions. It can also assist the detection of the disease.

There are currently various statistical methods of calculating HRV using R-R interval values. One of the commonly used methods is pNN50. pNN50 is the proportion of successive R-R intervals (known as N-N intervals here) differing by more than 50 ms in the sample period. It can be used to indicate the variation of R-R intervals over a certain period of time.

C. Maximum heart rate ($HR_{max}$)

Maximum heart rate is the upper limit of heart rate without negative impacts on the body. It is used to measure exercise intensity and plan for the appropriate heart rate zones for training. The $HR_{max}$ level varies with age and gender. Estimation of the $HR_{max}$ of a person can be done using the
following formulae:

Male: \((220 - \text{age}) \text{ bpm}\)

Female: \((216 - 1.09 \times \text{age}) \text{ bpm}\)

It is an important indicator for cardiac dysrhythmia patients to pay notice to, as their heart rate may easily exceed the \(HR_{\text{max}}\) level and put them in fatal conditions.

**Conclusion**

As discussed above, heart rate monitors such as heart rate belts can be used to monitor the conditions of cardiac dysrhythmia patients and also detect possible occurrences. With careful design of application, the heart rate data can be analyzed to provide the users with useful reports and feedbacks and thus assist them with their treatments.

**ii. Existing Mobile Apps**

There are quite a number of medical mobile apps measuring heart rates in Apple App Store and Google Play Store.

For the mobile apps in Google Play Store, most of the heart-rate-related apps have the following characteristics:

1. Measuring heart rates for a short period of time
2. Integrated in sports applications
3. Showing simple statistics of heart rates for users to view.
4. Rarely using Bluetooth 4.0 devices
For the mobile apps in Apple App Store, most of the heart-rate-related apps have the similar characteristics as those in Google Play Store except Bluetooth 4.0 devices are more widely adopted for measuring heart rate since Bluetooth 4.0 have been supported much earlier by IOS then Android.

To conclude, for heart disease users, the existing mobile apps could not provide measurement of heart rate for a long period of time and could not show a detailed medical report for doctors.

5. **Project Scope**

   **i. Core Features**

   In pursuit of the functionalities specified in the project aim, the following features have been designed:

   **A. Portable and Personal Medical Profile**

   The application allows the user to enter his personal information and medical history and thus stores a medical profile of the user. Personal information such as sex, age, weight and blood type provides important parameters for the analysis of health conditions. The user will be requested to set up the medical profile by filling in this information during the first time of use. Later, he may add other medical information, such as allergies, diseases and current prescriptions, to expand and complete the profile. All the information will be stored locally in a SQLite database.

   The application thus provides an all-in-one medical profile of the user for medical usages that can be viewed when needed. This helps the user to store and remember detailed medical information that is often hard for normal
B. Real-time Heart Rate Analysis

The application provides one-click pairing with the heart rate belt and instant monitoring of the heart rate based on the data received from the belt. With the easy-to-use interface, the user can easily pair with the heart rate belt and check his heart rate whenever and wherever he wants. Both text and graphical representation of the heart rate data are provided to the user, together with the provision of other useful data such as the battery level of the belt and the altitude of the user. Also, the application is designed to run in the background of the Android system, which eliminates the redundant process of reconnection and pairing every time the user wants to use the application and allows him to obtain real-time measurements and updated statistics at will. A home screen widget will be provided for the user to check his heart rate directly without always needing to enter the application.

Based on the heart rate data, various analyses may be provided to the user. For example, charts can be generated to show the daily, weekly and monthly changes of heart rate values for comparison. Also, the R-R interval and heart rate variability estimations will also be provided to Atrial Fibrillation patients. As the heart rate belt in use only provides heart rate measurements but not exact intervals between each heart beat cycle, R-R interval and HRV can only be estimated based on the heart rate values. The estimation methods used are:

- R-R interval:

  $60 \div (\text{heart rate value}) \text{ ms}$
HRV:

pNN50 method (the time period of 1 minute will be used for estimation.)

C. Notifications and Emergency Alerts

Running in the background of the system, the application monitors the heart rate of the user, and automatically issues notifications when the heart rate is not within the normal range and alerts when the heart rate has exceeded maximum heart rate level. The normal range and maximum heart rate are calculated based on the personal information of the user and the specific heart disease he is suffering from. For example, the maximum heart rate of female is lower than that of male, while a younger person has higher maximum heart rate than an older person.

Notifications and alerts will be provided in several options, including both the notification through the smart phone and notification to other people, such as the user’s relatives and doctors. For notifications in the phone, the user may choose from the following:

- Notifications in the notification bar
- Vibration
- LED light notification
- Peeping

For notification to other smart phone users, SMS and email may be chosen. The user can also configure the receivers of the notification. When triggered, the message will be sent automatically to the receivers by the predefined handlers in the application. This allows the relatives and doctors of the user to be notified
even when the user is in urgent conditions and unable to send the message himself.

D. Exportation of Medical Reports

Once a heart rate belt is paired, all the heart rate measurements received will be stored locally in the SQLite database of the application. Also stored are the HRV values and accompanying metadata. Thus, long term monitoring and analysis of the heart rate data may be conducted. The stored heart rate values and medical profile information may be outputted for further usage. The stored data can be converted into .csv spreadsheets for usage in other applications.

Also, the medical profile together with the heart rate values can be exported into reader-friendly medical report, with heart rate and heart rate variability data in graphical representation, in .pdf format. This can serve as a detailed report and record of the health conditions of the user over a long period of time, and can ease the diagnosis and consultation process of doctors. The user may choose their desired output method, and they can generate the output file with data from a selected time period.

ii. Expected Usage

It is expected that users use the application to measure their heart rate for a very long period of time, for example, more than 10 hours, so as to collect enough data of their heart rates and generate useful statistics to the users and doctors.
6. **User Interface Design**

   i. **Design Principle**

   There are five design principles:

   - Focusing on the users
     
     The design of the application focuses on different type of task-driven users.

   - Displaying appropriate objects
     
     The design displays only the right object to the users.

   - Proper, real time feedback
     
     The design provides immediate feedback so that the users know the applications reacts properly.

   - Predictability
     
     It is designed in a way that user could predict which buttons can be clicked and where to find the functions they want.

   - Fault-tolerance
     
     The application provide fault-tolerance user interface so that the applications can give proper feedback and direction to users even when they operates the applications in a wrong way.
ii. **Considerations**

There are three main considerations of our design

- **Age, skill levels and disabilities of users**

  The application mainly focuses on middle aged people to old people and heart disease users, with some basic knowledge on operating smart phone.

- **Different task-driven users**

  The application is designed for different task-driven users, mainly includes:

  1. Checking the heartbeat instantly
  2. Generating medical report for doctors
  3. Switching different mode of measuring heart rate
  4. Checking the connection between their mobile and the Bluetooth device
  5. Switching on and off the notification function

- **How users operate the application**

  It is expected that users would keep track on their heart rate for the whole day even when they are sleeping or doing exercise.
iii. Design

A. Starting Page

The starting page will be displayed for around 1 second.

B. Home Page
The home page consists of two parts. The first part is the menu buttons below, which provide users quick access to different pages. The second part is the main screen with four big buttons on it. The four big buttons are designed for four different types of task-driven users.

The first big button is designed for users who would like to check their heart rate instantly.

Heart rate and the corresponding heart rate level would be shown when the heart rate measuring device is connected. If no device is connected, the button will be dimmed and “N/A” would be shown and replaced the readings.

The second big button is designed for users who want to turn on or turn off the notifications.
When the notification is turned off, the icon will be dimmed and the word “OFF” is shown.

The third big button is designed for users who want to check if the bluetooth device is connected or not.

![Device Connected](image1)

The name and battery level of the Bluetooth device are shown on the button. When no device is connected, the button will be dimmed and the words “None” and “N/A” will be shown.

The forth big button is designed for users who want to change the mode of the application.

![Exercise Mode](image2)

The exercise can be turned on, off or changed to auto.
C. Medical Report

There are four main screens to display personal information and different types of medical report. Users can swipe to explore different pages in medical report.

The first page is about personal information

Different types of personal information are listed, including name, date of birth, age, blood group, height, weight, special medical condition and allergies. The edit button can be clicked to edit the personal information.
The second page is about daily report.

Different statistics are shown on this page, including daily average heart rate, maximum heart rate, minimum heart rate and average R-R. It also includes a button for generating detailed report.

Users can choose the date to generate the report and whether to include their personal information or not.
The third page is about weekly report.

Different statistics are shown on this page, including weekly average heart rate, maximum heart rate, minimum heart rate and average RtoR. It also includes a button for generating detailed report.

Users can choose the starting date to generate the report and whether to include their personal information or not.
The forth page is about monthly report.

Different statistics are shown on this page, including monthly average heart rate, maximum heart rate, minimum heart rate and average RtoR. It also includes a button for generating detailed report.

Users can choose which month to generate the report and whether to include their personal information and the weekly statistics or not.
The report mainly includes personal information, numerical and graphical statistics.

### Medical Report

**Personal Information**

<table>
<thead>
<tr>
<th>Name</th>
<th>Chan Tai Man</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date of Birth</td>
<td>09/04/1970</td>
</tr>
<tr>
<td>Age</td>
<td>43</td>
</tr>
<tr>
<td>Blood Group</td>
<td>A</td>
</tr>
<tr>
<td>Height</td>
<td>170 cm</td>
</tr>
<tr>
<td>Weight</td>
<td>60 kg</td>
</tr>
<tr>
<td>Special Medical Condition</td>
<td>None</td>
</tr>
<tr>
<td>Allergies</td>
<td>None</td>
</tr>
</tbody>
</table>

**Monthly Statistics of heart rate**

1\textsuperscript{st} week
- Maximum: 140 bpm
- Minimum: 60 bpm
- Average: 100 bpm
- Average RtoR: 1 ms

2\textsuperscript{nd} week
- Maximum: 140 bpm
- Minimum: 60 bpm
- Average: 100 bpm
- Average RtoR: 1 ms

3\textsuperscript{rd} week
- Maximum: 140 bpm
- Minimum: 60 bpm
- Average: 100 bpm
- Average RtoR: 1 ms
D. Monitor

The monitor consists of two parts. The first part is the numerical live view of the heart rate and pNN50. The second part is the graphical live view of the heart rate. Different colored areas represent different safety level of the heart rates of the users. Green is the optimum and red is the maximum or minimum.
E. Device connection

The device connection page shows the device name, signal strength and battery level to the users when a heart rate measuring Bluetooth device is connected. If no device is connected, the Bluetooth icon will be dimmed. The icon can be pressed to search for a Bluetooth device to connect.
F. Notification Settings

The Notification settings page includes different settings concerning notification. Users can customize their settings here. They could turn on or off the all the notification, customize email, SMS and WeChat notification and turn on or off the notification sound.

G. Settings

The final main page is the Settings page. Some general settings, for example, font size, feedback, help and whether to start when mobile is turned on, are included in this stage. However, the items in settings have not been finalized yet. As a result, the setting page has not yet been designed.
7. Database Schema

SQLite database is used to store the medical profile of the user and the heart rate data obtained from the heart rate belt and the accompanying metadata such as time and the estimated R-R interval value. Also, the estimated heart rate variability values and corresponding altitude values are stored. For the convenience of generating reports, average heart rate will be calculated regularly and stored in the database. Storing using database allows a large amount of data to be stored and retrieved easily and in an organized manner, thus supports continuous storing of heart rate readings and metadata. The database schema is as follows:
### medical_profile

The table containing the personal information of the user

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Attribute</th>
<th>Size</th>
<th>Not Null</th>
</tr>
</thead>
<tbody>
<tr>
<td>_id</td>
<td>Primary key</td>
<td>INT</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>first_name</td>
<td>First name</td>
<td>VARCHAR</td>
<td>20</td>
<td>Y</td>
</tr>
<tr>
<td>last_name</td>
<td>Last name</td>
<td>VARCHAR</td>
<td>40</td>
<td>Y</td>
</tr>
<tr>
<td>nickname</td>
<td>Nickname</td>
<td>VARCHAR</td>
<td>20</td>
<td>N</td>
</tr>
<tr>
<td>birth_date</td>
<td>Date of birth</td>
<td>DATETIME</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>blood_type</td>
<td>Blood type</td>
<td>CHAR</td>
<td>3</td>
<td>Y</td>
</tr>
<tr>
<td>height</td>
<td>Height (cm)</td>
<td>INT</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>weight</td>
<td>Weight (kg)</td>
<td>FLOAT</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>sex</td>
<td>Sex</td>
<td>CHAR</td>
<td>1</td>
<td>Y</td>
</tr>
</tbody>
</table>
ii.  

*heart_rate*

The table containing the heart rate readings

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Attribute</th>
<th>Size</th>
<th>Not Null</th>
</tr>
</thead>
<tbody>
<tr>
<td>_id</td>
<td>Primary key</td>
<td>INT</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>date_time</td>
<td>Exact time of reading</td>
<td>DATETIME</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>value</td>
<td>Heart rate value</td>
<td>INT</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>rr_interval</td>
<td>R-to-R interval</td>
<td>FLOAT</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>type</td>
<td>Sports / Monitor type</td>
<td>INT</td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

iii.  

*heart_rate_variability*

The table containing the heart rate variability values derived from heart rate readings

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Attribute</th>
<th>Size</th>
<th>Not Null</th>
</tr>
</thead>
<tbody>
<tr>
<td>_id</td>
<td>Primary key</td>
<td>INT</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>date_time</td>
<td>Exact time of reading</td>
<td>DATETIME</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>value</td>
<td>Heart rate variability value</td>
<td>FLOAT</td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>
iv.  *average_heart_rate*

The table containing the average heart rate in specific time periods

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Attribute</th>
<th>Size</th>
<th>Not Null</th>
</tr>
</thead>
<tbody>
<tr>
<td>_id</td>
<td>Primary key</td>
<td>INT</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>date_time</td>
<td>Beginning of period</td>
<td>DATETIME</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>value</td>
<td>Average heart rate</td>
<td>INT</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>type</td>
<td>Length of period (min)</td>
<td>INT</td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

v.  *altitude*

The table containing the altitude corresponding to the heart rate readings

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Attribute</th>
<th>Size</th>
<th>Not Null</th>
</tr>
</thead>
<tbody>
<tr>
<td>_id</td>
<td>Primary key</td>
<td>INT</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>date_time</td>
<td>Beginning of period</td>
<td>DATETIME</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>value</td>
<td>Altitude value</td>
<td>FLOAT</td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>
vi. **allergies**

The table containing the allergy information of the user

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Attribute</th>
<th>Size</th>
<th>Not Null</th>
</tr>
</thead>
<tbody>
<tr>
<td>_id</td>
<td>Primary key</td>
<td>INT</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>name</td>
<td>Name of allergy</td>
<td>VARCHAR</td>
<td>20</td>
<td>Y</td>
</tr>
<tr>
<td>description</td>
<td>Description of the allergy</td>
<td>VARCHAR</td>
<td>255</td>
<td>Y</td>
</tr>
</tbody>
</table>

vii. **android_metadata**

The table containing the metadata required by Android system

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Attribute</th>
<th>Size</th>
<th>Not Null</th>
</tr>
</thead>
<tbody>
<tr>
<td>locale</td>
<td>Locale of database</td>
<td>TEXT</td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

8. **Connection with BLE Health Device**

In the application, connection with BLE health devices is done using the new connection mechanism provided by Android 4.3, which is created especially for BLE devices. It makes use of the two newly added classes, BluetoothAdapter.LeScanCallback and BluetoothGattCallback, to handle device scanning, device connection, service discovery, service connection and data receiving actions.

The resultant Android class, BluetoothService, handles pairing with the heart rate belt, receiving of the data and the storing and analyzing of the data. The user only
needs to start the service and it will automatically handle all the work. Heart rate data, together with the current time, is stored into the database whenever a new value is received from the belt, and is sent together with battery level and RSSI level (signal strength) to the other components of the application for display and graphical representation. The screenshot below shows the outputs of BluetoothService:

![Screenshot of BluetoothService](image)

Written as an Android service, BluetoothService can continue to run in the background while the user is not using the application. Heart rate data can thus be continuously and undisturbedly received from the belt for long-period logging. This
also allows different components of the application to receive real-time updates of heart rate data, making functions like home screen widget possible.

Notification will be shown on the notification bar once pairing with the belt has completed, allowing the user to enter the application simply by touching it. On connection lost, the user will be notified immediately and they can choose to reconnect by starting the service again. Other functionalities like emergency alert is also handled by BluetoothService, thus allowing users to be notified and alerted even if they are not using the phone.

### 9. Revised Schedule

<table>
<thead>
<tr>
<th>Month</th>
<th>Ho Kam Lung</th>
<th>Lau Ka Hing</th>
</tr>
</thead>
</table>
| Jan   | • First Presentation  
       | • Setup of the database | • First Presentation  
       |                           | • Implementation of the functionalities based on the medical profile |
| Feb   | • Widget  
       | • Data exportation | • Implementation of the UI and functionalities |
| Mar   | • Real-user testing  
       | • Fine tuning of the functionalities | • Testing  
       |                           | • Fine tuning of the UI |
| Apr   | • Real-user testing  
       | • Final report and presentation | • Finalizing the implementation  
       |                           | • Final report and presentation |
i. **Testing**

After implementing the designed features, testing and debugging of the application will be performed by the project members, followed by the fine tuning of the application. Also, in order to test for the effects of the functionalities in helping cardiac dysrhythmia patients, around five to six patients will be invited to use the application for real-user testing. Due to the limit in project span, each user will only be asked to use the application together with the belt for one day, during which each of them will be required to perform everyday activities with heart rate data collected by the belt and stored by the application. Afterwards, they will be asked to provide feedback on the functionalities of the application for fine-tuning and evaluation of the effectiveness of the application. After real-user testing is conducted, the application will be finalized.

10. **References**

Android 4.3 - http://www.android.com/about/jelly-bean/

Android Bluetooth Low Energy -


Android Services -

http://developer.android.com/guide/components/services.html


Bluetooth Smart - http://www.bluetooth.com/Pages/Bluetooth-Smart.aspx

Bradycardia -

https://www.heart.org/HEARTORG/Conditions/Arrhythmia/AboutArrhythmia/Bradycardia-Slow-Heart-Rate_UCM_302016_Article.jsp
Cardiac Dysrhythmia -
http://www.medicinenet.com/arrhythmia_irregular_heartbeat/article.htm

Heart Diseases -
http://www.webmd.com/heart-disease/default.htm?names-dropdown=KY

Heart Rate Monitors - http://www.brianmac.co.uk/hrm.htm

Heart Rate Monitors For Heart Health -

Heart Rate Training Zones - http://www.brianmac.co.uk/hrm1.htm

Heart Rate Variability - http://circ.ahajournals.org/content/93/5/1043.long

Maximum Heart Rate - http://www.brianmac.co.uk/maxhr.htm

Personal Health Systems -

Resting Heart Rate - http://www.netfit.co.uk/fitness/test/resting-heart-rate.htm

SQLite Documentation - http://www.sqlite.org/docs.html

Tachycardia -
https://www.heart.org/HEARTORG/Conditions/Arrhythmia/AboutArrhythmia/Tachycardia_UCM_302018_Article.jsp