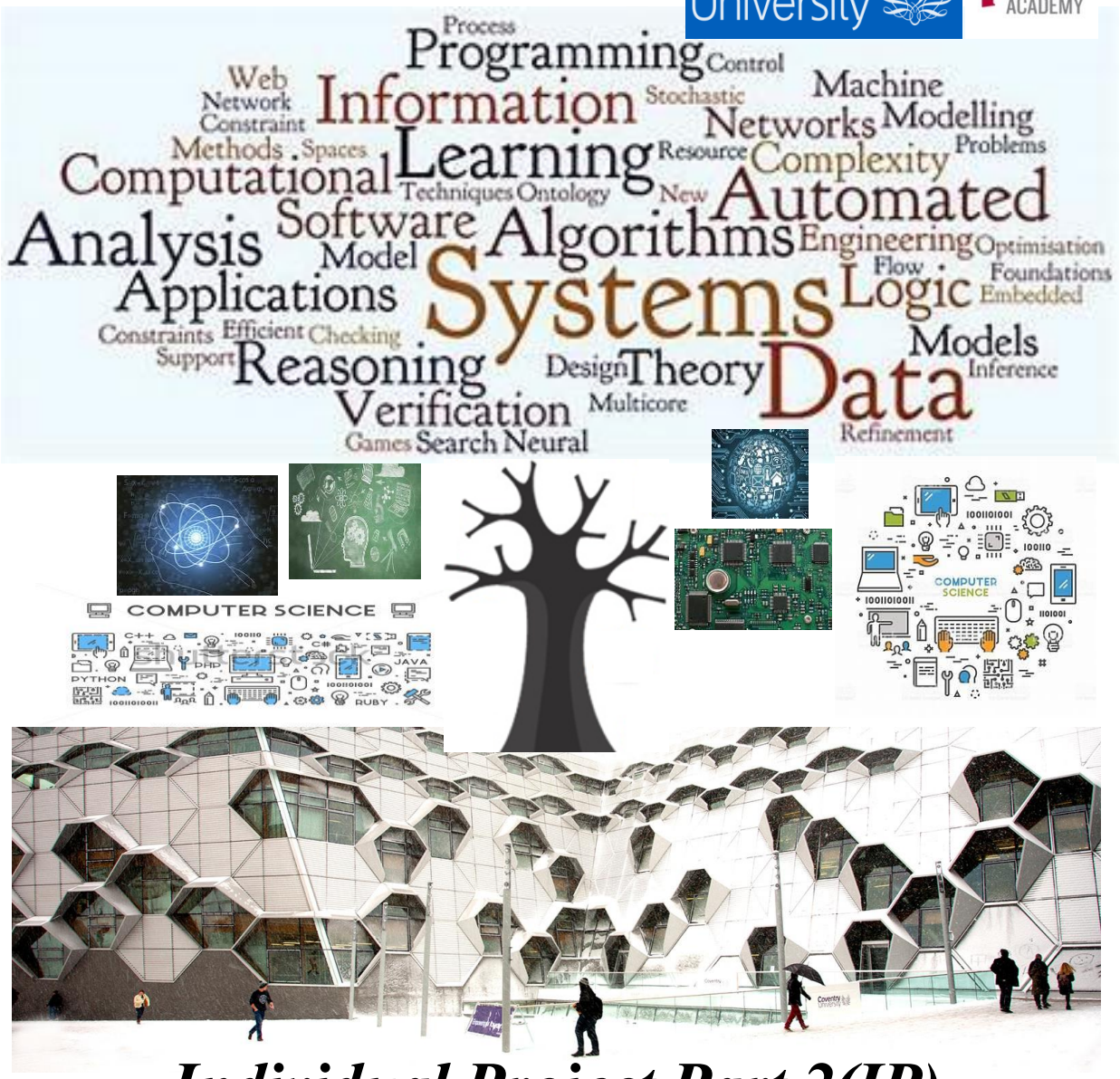

Individual Project Part 2(IP)

Project Report

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Submission Date: 06 March 2018

Project Title: Mass (Group of people) Monitoring Heart Rate System

Table of Contents

Abstract

Looking at healthcare, understanding heart rate can be a lot useful to everyone who are of concern to their health status and well being. That is because heart rate is related to many area not only illness, diseases or exercise but also normal human being. By understanding more about heart rate, it can also acts as an indicator to give out warning first hand before it is too late. Currently, many companies have come out with their own design of wearable devices and smart phone application to allow users to conveniently monitor their own heart rates. However, almost all of these smart devices are mainly only for personal usage and I find it not useful enough. There are a lot more potential in using these wearable devices. And in this project, I am hoping to come up with additional ways to further utilize the wearable device by designing a system that is able to monitor the heart rate and provide assistance when in emergency through an Android application. And then to go even further, to create a system that is able to monitor multiple users' heart rate in real time mode simultaneously. Just like shrinking the whole hospital monitoring system down to a portable version which can be easily use in the palm of a hand.

1. Introduction

As I was brain storming through for an idea for the final year project, an unfortunate incident had happened at the company that I am currently working at. A colleague of mine had just passed away and the news that we received was he passed away due heart attack while alone at home. His children had went to stay with his divorced wife for the weekend, therefore no one was with him when this had happened. His children only found his body when they came back home. This is a real thing, not a joke (as shown in the figure 1.a below).

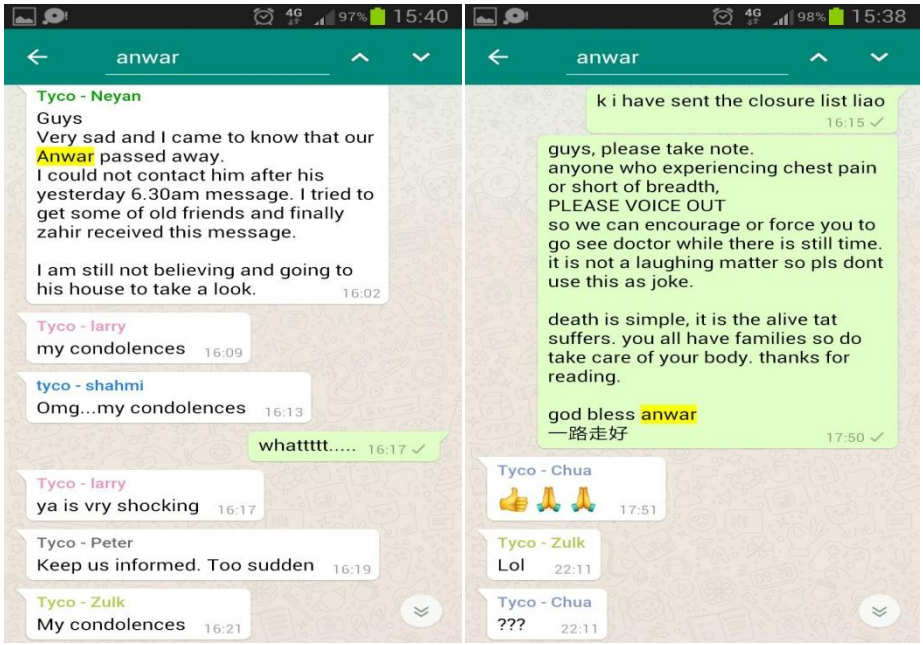


Figure 1.a Whatsapp Chat

If only there was someone at home or nearby him when this had happened and was able to call for help immediately or perform emergency Cardiopulmonary Resuscitation (CPR) on him, then he might have been saved.

1.1 Objective

The main objective of this project is to attempt to come up with a method of notifying others for immediate help when one has fallen into the danger zone e.g. sudden heart attack.

Second objective of this project is to be able to simultaneously monitor multiple users' heart rate and combining main objective function into this.

1.2 Background

This is where I started to think. Are there any ways to help prevent this kind of situation from happening? I know I am not a doctor, therefore I can't find ways to cure heart attack but at least I can try to find ways to prevent as prevention is always better than cure. So instead of finding a cure for heart attack, I should look in the direction of how to improve the survival rate during heart attack. What are the possible ways of prevention? How and what are the alternate ways of allowing other people know that they are in danger where they are unable to call for help. Currently, the available market solution are wearable devices that monitor individual health status, and there is no such thing as warning or notification. When a person is in danger, he or she had probably already reach a point where they are unable to help themselves, not to say call/shout for help (example fall into concussion, the whole body feels weak, don't even have the energy to talk, and is about to faint or already fainted). A lot people lost their lives due to the waiting time for treatment or for ambulance to arrive. I myself also having high blood pressure and often works alone, which is kind of dangerous if I were to suddenly fall into accident. So, is there such a device that is able to provide warning or request for help? I need to ask myself, Why initiate this project? What prerequisites are? What results expected on completion?

1.3 What is heart attack?

First I must have a brief understanding of what is the illness here before I can proceed in the right direction. As researches shows that there are actually few types of heart attack. When heart attack occurs, depending on the person's body, could be heart beating slower and slower or beating faster than normal.

Bradycardia is a slow, abnormal or irregular heart rate condition where the heart beats under sixty beats per minute (BPM). It can be a very serious problem when the heart isn't providing enough oxygen throughout the body thus causing the person to feel dizziness, shortness of breath, fatigue, lack of energy, sweating, weakness in body or fainting spells (Mark 2017).

Tachycardia is a type of heart rate disorder where the heart rate beats faster than normal and exceeds the normal resting rate. At the point where the heart pulsates too quickly, it pumps less proficiently and lesser blood flow to the remaining of the body causing lack of oxygen to the myocardial cells which leads to heart attack (Christian 2017).

1.4 What Is a Heart Rate Monitor?

Heart rate monitor (HRM) devices are mostly utilized to gauge the intensely of a person exercising by measuring the heart beats per minute in real time or recording for later studies. The information collected can be immensely beneficial for the person using it. Example, for cardio patients, it can help them to keep track and stay within the safe zone on a daily basis or for exercisers, they can use it to monitor their heart rate during their exercises to guide their workouts. And the most accurate heart rate monitor are those machines hooking up to patient in the hospital. Depending on the person using the heart rate monitor, each objectives may vary (Kim 2013).

1.5 Types of Heart Rate Monitors

There are few types of heart rate monitors in the market but the most common and popular types are the wireless chest strap, pulse monitor wrist watch and finger to wrist method. Basically, the heart rate monitor is split into electrical pulse, in-ear measurements, optical technology (Jill 2018).

1.5.1 Chest strap heart rate monitor (electrical pulse)

A wireless sensor is mounted onto the chest strap (require wet, moisture contact with the skin around the chest area just underneath the bosom, to get precise readings) will distinguishes the heart beat electronically by detecting the electrical activity (electrical signal emit off by the heartbeat) using the transmitter and rely the information to a receiver, which will displays current heart rate. The chest strap provides the most accurate heart beat information as compare to other types of heart rate monitors (Nederhood 2016).

Figure 1.5.1a Chest Strap

Pros: Chest strap types provide nonstop heart beat readings and allow one to move uninhibitedly, so they are useful for practically any type of exercises e.g. badminton to soccer and such. Some athletes preferred chest-strap models to the wrist-only models as they can have a records of the activities without stopping to touch the device to take a reading.

Cons: One have to wet the chest strap first to get a reading and some of the models requires to send the heart beat to a mobile phone, which can be inconvenient for individuals who might rather not carry their phone while exercising or working out. The elastic band that wraps around the body with electrode pad may feels uncomfortable to most individuals.

1.5.2 Optical heart rate monitor (optical sensing technology)

Optical heart rate monitor gather heart beats data from "photoplethysmography" (PPG) which is a process that utilizes the light shining through the skin and interacting with the flowing blood in the veins to measure the blood flow. Optical emitters from the built-in sensor in the monitor emits different wavelengths of light and interact with the blood flowing under the skin. The light refracts off the flowing blood and another sensor in the monitor captures the light scatters information. The information can then be processed with algorithms to deliver understandable heart beats readings. Optical sensing technology are currently used on wrist band, arm band, ear bud, temple, finger to wrist (Palladino 2017).

Figure 1.5.2a Smart Band

Pros: Although continuous real time heart rate information is not as accurate as compared to chest straps, users feel more comfortable when wearing on wrist or arm. There is user display showing the information at real time without needing additional items.

Cons: More expensive and less accurate as compare to chest strap using electrical pulse technology and may not get readings from tattooed or dark pigmented skins. Tougher to use and more distracting as there are many other inbuilt functions which may requires the user to touch. (Example, the wrist band that I have bought has a lot other functions. Although I can just shake to wake the band up, I still need to tap through all the other functions first before arriving to the heart rate function that I need)

1.6 Why choose this product?

I shall look into optical heart rate monitor (wrist band) as it is a popular way of measuring the heart rate of individuals. And existing market already have a lot of different brands of smart watch or wrist band that was created to help individuals take care of their health. It is comfortable and affordable by every level of people.

From existing market solution, I chooses wrist band for their small, slim and most important inexpensive as a solution to my project. But existing wrist band only collect data of heart rate for individuals. Therefore my idea is to first create a monitoring and notification system. Then next idea is to create a control centre and a way to connects these wrist band together.

1.6.1 Ways of integration of existing solution

My idea is to integrate existing market solution and come up with a product where allows one to inform others as these products are basically just for individual taking note of their health status. If there is a control centre where the centre can monitor the status of other personal, and able to get real time updates, won't that be a much better solution to reduce the chances of people dying from heart attack alone at home, at work or at any place.

Idea 01

Figure 1.6.1.a Monitoring Heart Rate Notification System

Idea 02

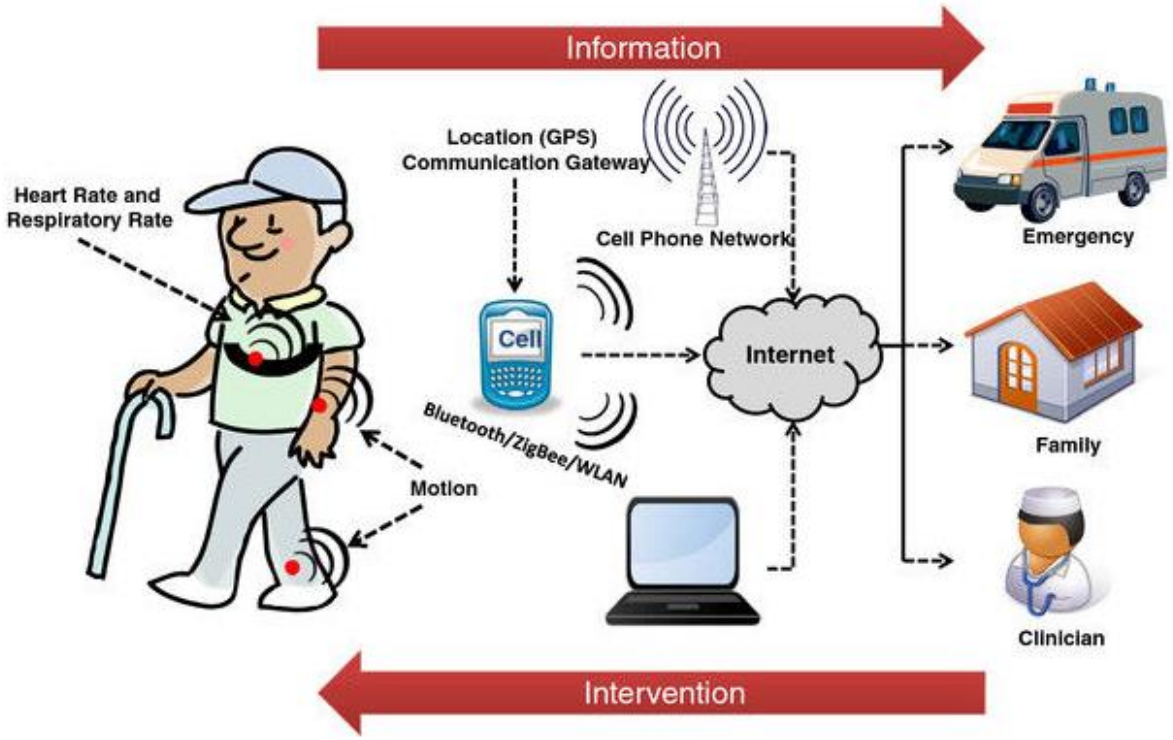


Figure 1.6.1.b Monitoring Heart Rate Control System
(https://jneuroengrehab.biomedcentral.com/articles/10.1186/1743-0003-9-21)

My idea is:

1) The individual wears the smart band on the wrist to monitor his/her heart rate at real time. The smart band will then transmit the data collection from the sensor in the smart band and pass through wireless connection to the smart phone.

2) The application in the smart phone will process the transmitted data collected by the phone and compare to the initial settings that was set in the application.

3) Once the real time heart rate exceed the danger zone settings, the application will request the smart phone to send notification to get for help.

4) Assigned help centre received the call or message and immediately proceed to the individual in distress.

Basically, this idea is split into two parts which are:

1) smart watch/band

2) application in mobile phone

1.6.2 Specification - Ideas that can also use in other situations

There are many situation where a lot of people tend to be alone, be it work or not working .

Imagine a person is having a evening run alone in the park where not many people are around and suddenly, that person have a heart attack and fall to the ground. Since he is suffering from heart attack, he has no chance of giving himself self help and would require others to provide assistance. But if there is a device that is able to detect the changes in his/her heart rate and quickly give notification to his/her dearest. His/her family member could first thing rush to his/her side and provide assistance before it is too late.

Imagine a child got lost which shopping with his/her parent. The parent was busy looking at items to purchase without realising their child has got lost. The child got panic and started to cry, his/her heart rate will also increase due to the panic and a notification was immediately sent to his/her parent. The parents will have first time notices of something went wrong with their child.

Imagine a teacher taking a class of thirty students for a physical exercise which is running around the school compound. That teacher probably won't even be running together with the whole group and would be just waiting at the ending point. Suddenly, a student have heart attack and fallen on the ground. The surrounding students near that fallen student will probably be in a shock where they just stood on the ground, unable to do anything. But if the device sent a notification to the teacher, that teacher can get first thing notices and rush to the fallen student as soon as possible and provide emergency first aid.

Imagine an elderly alone at home doing his/her daily routines which is walk around the house or watching television and suddenly have a heart attack. No one is around to even notice that he/she is in difficulties not to say call for help and that person just falls down and passed away on the cold floor until the body started to rot and pungent smell spreads to the neighbourhood before someone finally called the police to break in to the house to find the corpse on the floor.

There are many real life scenarios that had happened before and most of these cases actually can help save a person's life. With immediately CPR perform on the fallen person, there are many chances of able continuous physical pumping of the heart while waiting for the ambulance to arrive to the scene before everything is too late. Every minute counts to prevent a life being lost therefore prevention is always better than cure.

Currently, only life support machines in hospital are attached to the many patients monitoring their health status. When a patient went into shock, emergency notices are sent to the duty nurses who will immediately rush over to the patient. So basically, this idea is something similar to shrinking the whole hospital monitoring system down to a portable version.

2. Requirement Engineering

2.1 Story Board

First thing to starting off the project is to sketch, write or draw the story board to pre-visualizing the project in a form of sequence. This is to sketch out the rough idea that has form in the mind, on how the process will roughly flow and then choosing the type of software methodology that is suitable for this project and applying project management methodology.

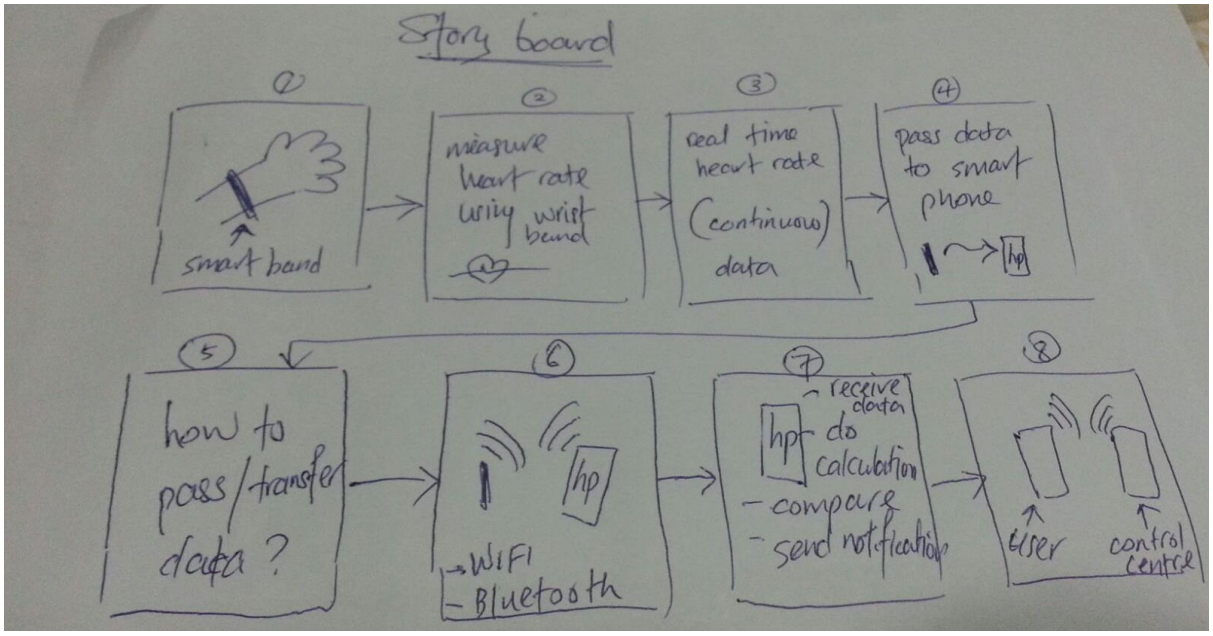


Figure 2.1.a Story Board

2.2 Software development life cycle (SDLC)

Next is to plan the process on how to go about creating the project in terms of planning the system, developing the planned system, testing the developed system and finally deploying the finished product. The planning can be split into few phases in a software development life cycle:

1) Initiation Phase - beginning of idea,

2) System Concept Development Phase - defining the scope,

3) Planning Phase- develop project management plan,

4) Requirements Analysis Phase - analysing requirements from user,

5) Design Phase - turn requirements into detail design,

6) Development - turn design into prototype,

7) Integration and Test Phase - prove that development is matched to requirements

8) Implementation Phase - also known as deployment of system

9) Operations and Maintenance Phase - operating manuals and maintaining system

10) Disposition - end of system activities

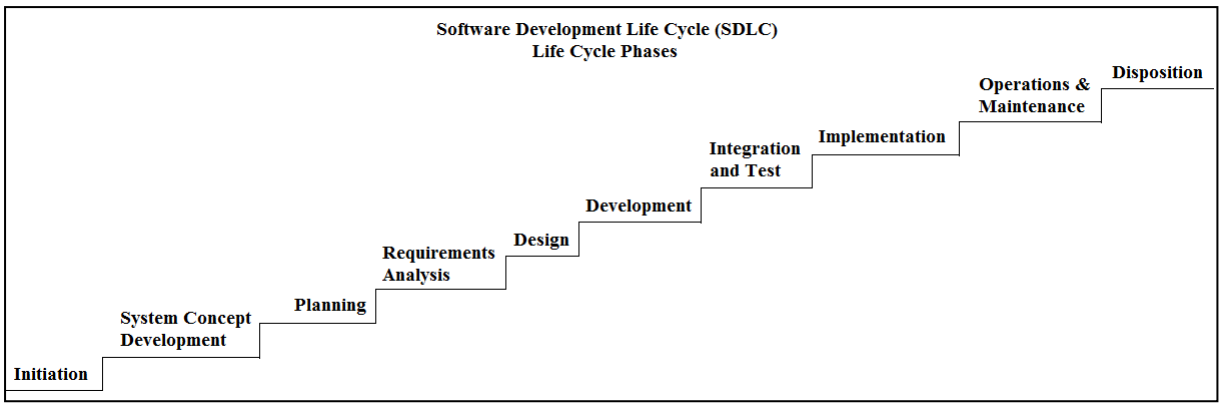


Figure 2.2.a Software Development Life Cycle

Before starting of the software developing, let's take a look into what are the types of software methodologies to choose for the software development process

2.3 Types of Software Development Life Cycle (SDLC) models

2.3.1 Waterfall model

Waterfall model is a traditional method that is straight forward which runs linearly by taking the step by step phases. Only upon one phase is done, then the next phase will kicks in (Margaret 2007a).

1) Requirements - What is my software going to do?

2) System Design - Drawing out a blueprint from the requirements,

3) Design Implementation - Begin the work,

4) Verification and Test - Testing whether it works properly

Pros: Straight forward, easy to understand and use

Cons: Not flexible and if one phase went gone, have to restart all over again

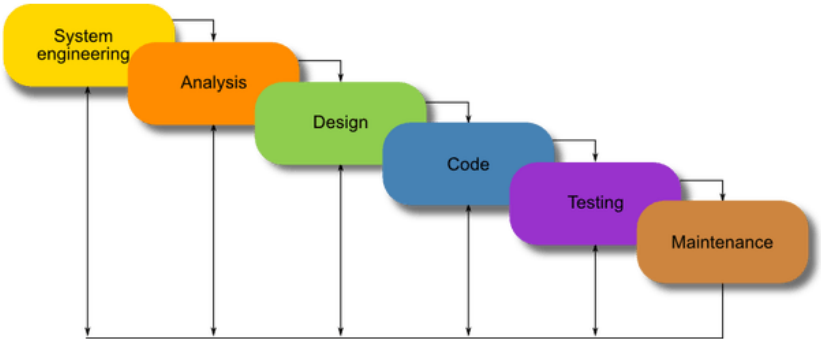


Figure 2.3.1.a Waterfall Model

2.3.2 Rapid Application Development (RAD) model

Rapid application development uses minimal planning, lesser time on planning and lesser resources to produce the product in a short period (Margaret 2016).

1) Business Modelling - designing the product

2) Data Modelling - refining the information into objects

3) Process Modelling - transforming objects into necessary function

4) Application Generation - producing the prototype

5) Testing and Turnover - testing of prototype

Pros: Produce prototype faster thus reduced development times

Cons: not suitable for high technical risk

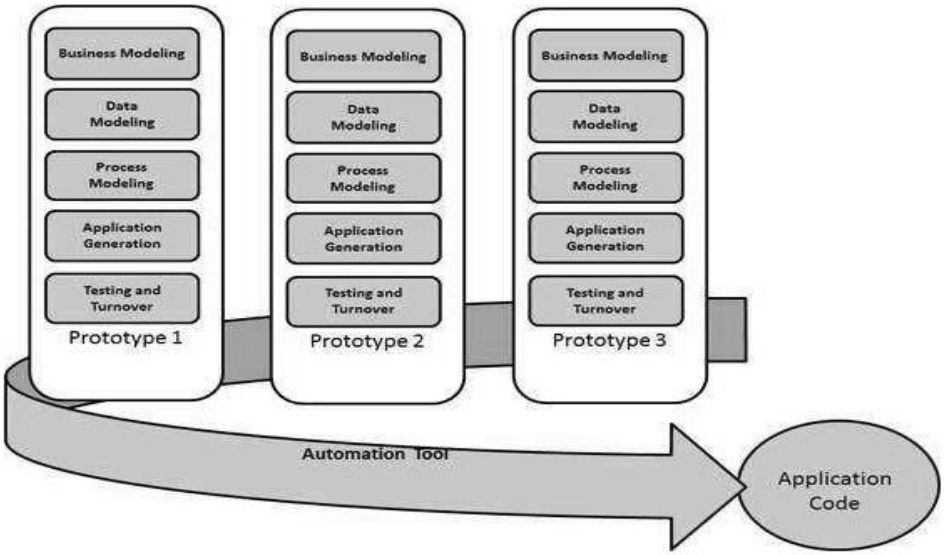


Figure 2.3.2.a Rapid Application Development Model

2.3.3 Spiral Model

Spiral model combines both prototyping model and waterfall model most suitable for huge projects that involves with continuous integration and enhancement (Margaret 2007b).

1) Planning phase - streamline requirements

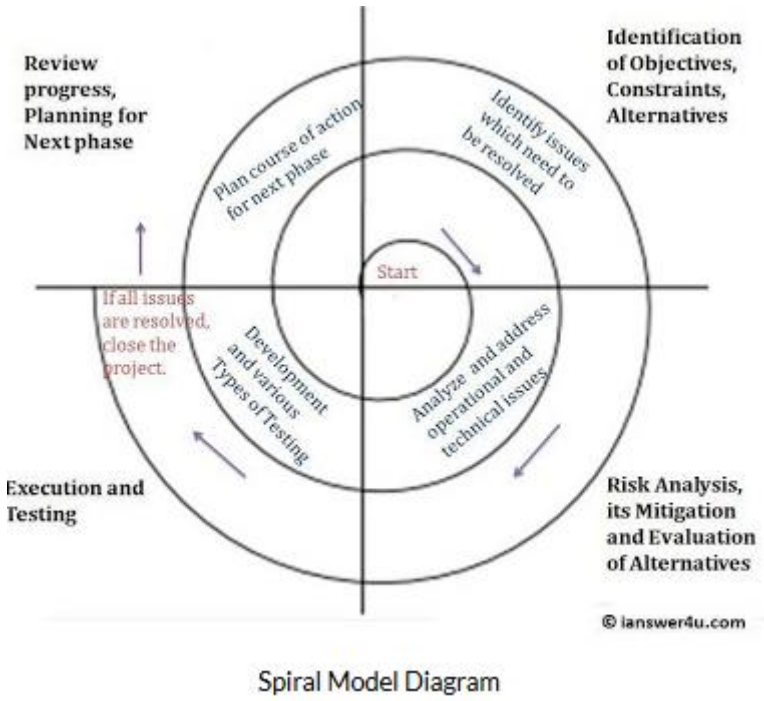
2) Risk analysis phase - identify potential risk and plan strategy

3) Engineering phase - development and test

4) Evaluation phase - feedback and approval

Pros: Most flexible

Cons: High cost and not suitable for low risk projects



Spiral Model Diagram

Figure 2.3.3.a Spiral Model

2.3.4 Prototype Model

Building a prototype first to understand the requirements (Margaret 2005)

1) Requirement gathering and analysis - identify basic requirements to begin

2) Quick design - quick designing base on basic requirements

3) Building prototype - develop initial prototype

4) Evaluation - review prototype

5) Refining prototype - revise and enhance prototype.

6) Engineer product - actual product produced

Pros: better understanding of system that is quickly developed

Cons: may increase complexity

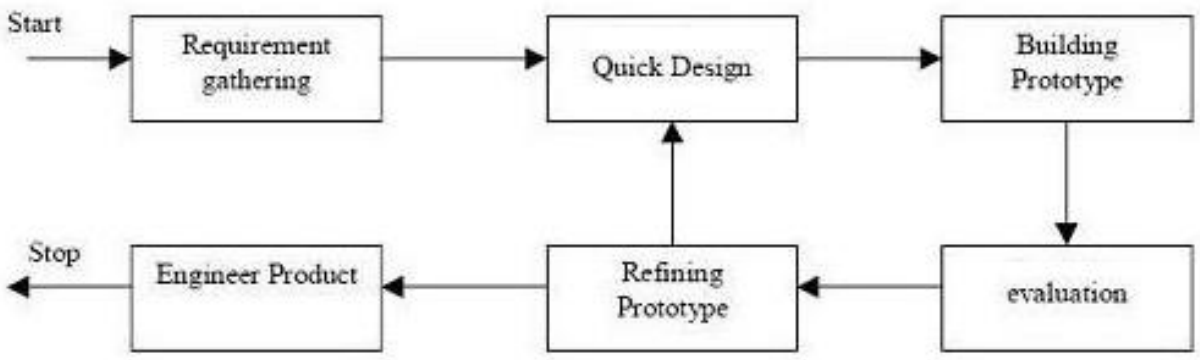


Figure 2.3.4.a Prototype Model

2.3.5 Big Bang Model

Big bang model do not require to follow any specific process and do not require much planning (Andrew 2017).

Pros: simple and flexibility, little or no planning and few resources required, easy to manage

Cons: very high risk with uncertainty and may be expensive

2.3.6 Others

There are a lot different types of high level software methodologies:

1) Behavior - Driven Development (BDD)

2) V - Model

3) Chaos Model

4) Incremental

5) Lightweight

6) Structured systems analysis and design method

7) Unified Process (UP)

8) Test Driven Development (TDD)

9) SCRUM

2.4 Choosing which software model

Waterfall model is too time consuming and high risk. If any part within the model has gone wrong, chances of redoing the whole thing will result in losing huge amount of time.

Each model has their pro and cons and the ideal way is to take the individual pro and mix together to achieve the most ideal outcome.

I choose **Big Bang model** as it is ideal for small project. And since this is an individual project which I am the only one doing everything including planning and development. Using this model will allow me to focus on possible resources with little or no planning to start off the initial phase. As the wearable devices that I am planning to use can be buy off the shelves and together with basic knowledge of Android Application Development gained from previous term and the direction of the idea that I have. It is also a good learning aid for me with not much knowledge in many areas, therefore I think that big bang model suit me the best as a starting point. But I should just rely heavily on the model, this model is to just provide me with a head start and then combine **Rapid Application Development (RAD)**.

Software configuration management

It is important to have a proper software configuration managements. The purpose is to help keep track and record down all the changes that have been made. And proper versioning control will helps to monitor and track of files that are stored and with a date and time attached to it (Stuart 2005).

2.5 Analysis Model Diagram

Identify analysis model diagram elements/objects:

User	Administrator	Measuring Hear rate
Collect Data	Comparing System	Notification System
Send Data	Calculation	Send Message

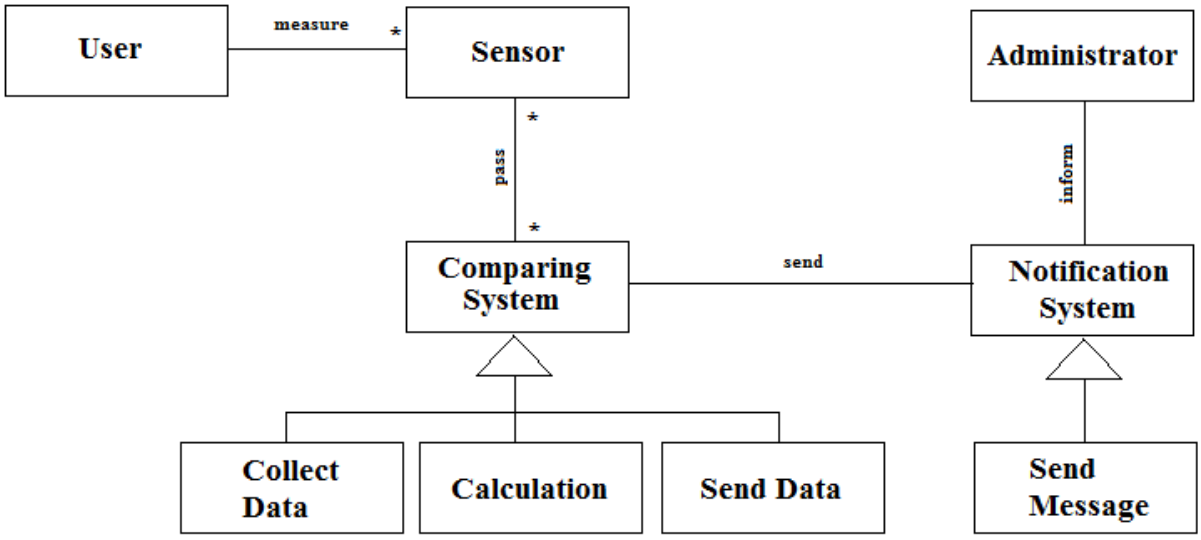


Figure 2.5.a Analysis Model Diagram

2.6 Project Management Methodology

It is important to deliver quality product and yet keeping the cost within budget constrain and still deliver as scheduled.

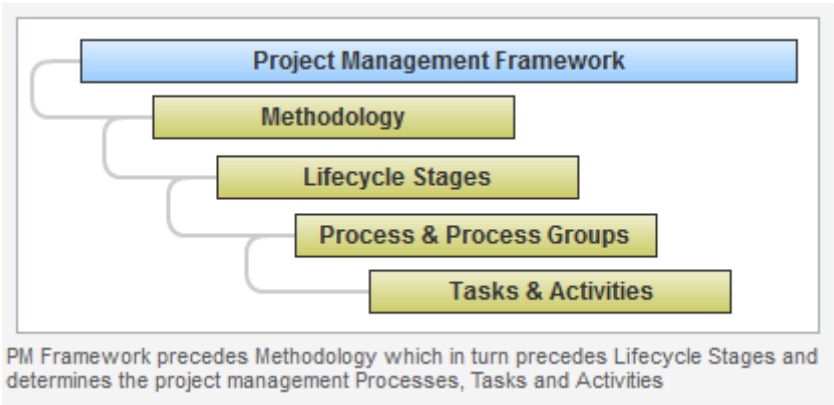


Figure 2.6.a Project Management Framework

Selecting software project management tool.

2.6.1 Kanban Online Tool

It is very important to have sufficient tools to assist in helping me utilize whatever resources is available to me to help me organise, manage and store my project more efficiently.

In this case, I am using Kanban online tools (Kanban Tool 2018) to visualize my workflow, analyze and improve the process using Kanban method of to-do-list, in progress and done.

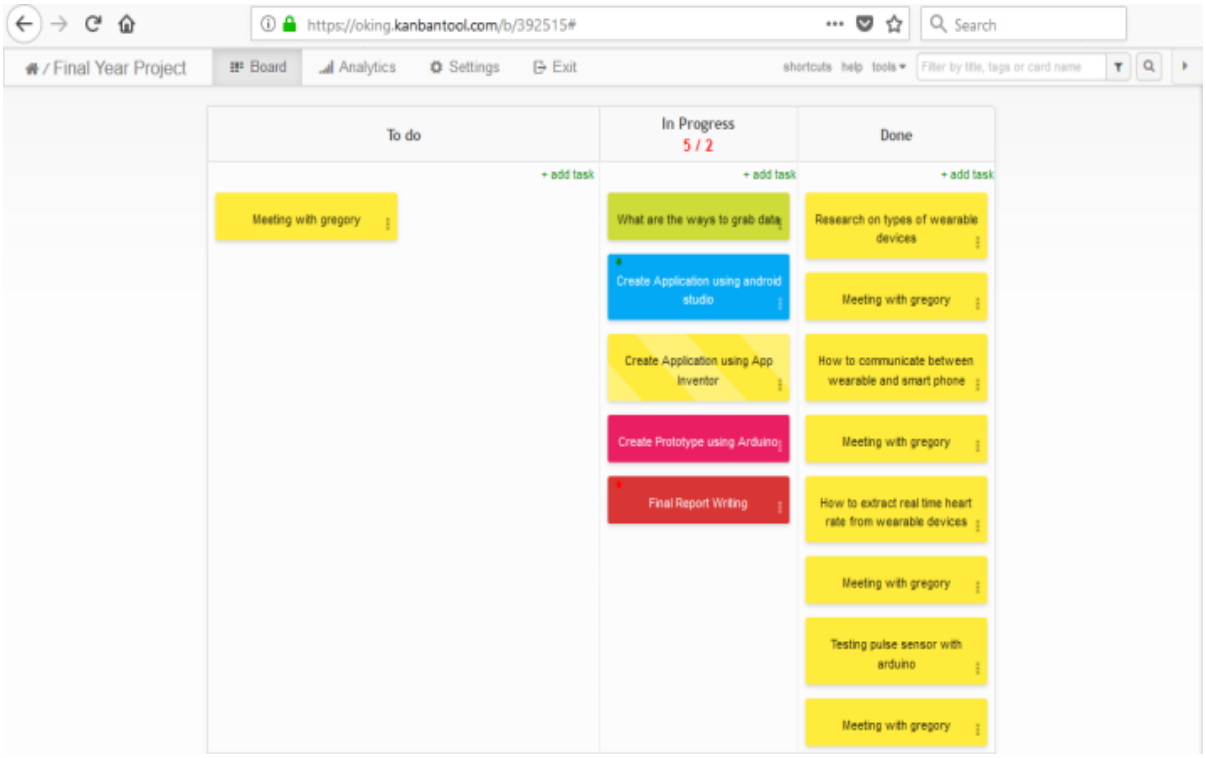


Figure 2.6.1.a Kanban Online Tool (https://kanbantool.com/)

2.6.2 Github

And I am using Github.com and desktop version (as show in figure below) to do the versioning control of my project where all the documents and codes will be stored for hosting, recording, modifying, subversion and tracking bug and issues purposes.

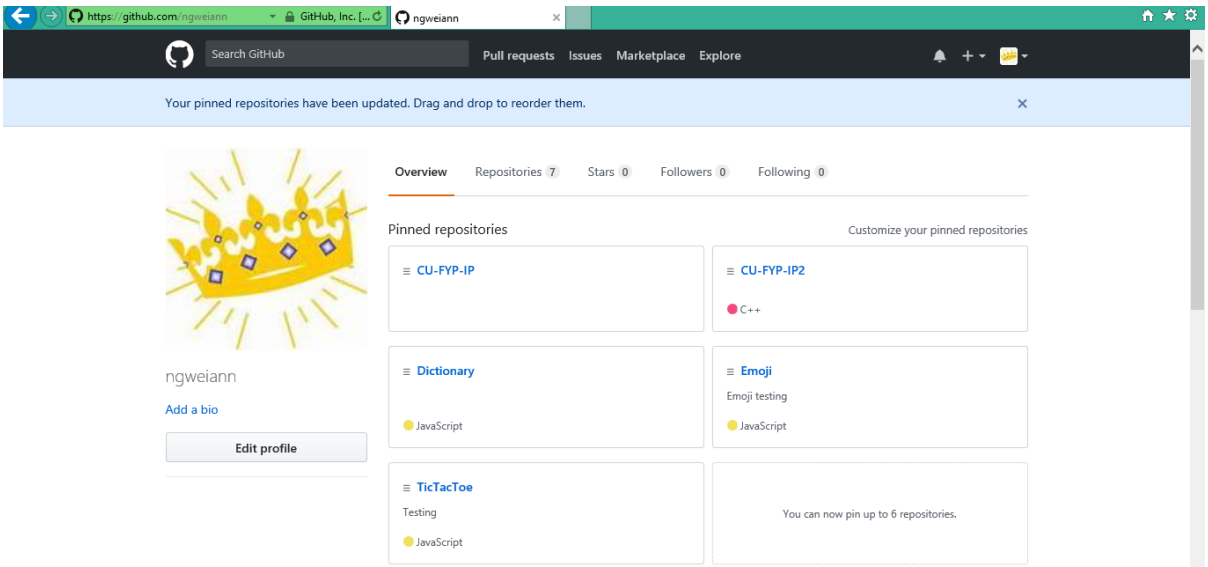


Figure 2.6.1.b Repository Hosting Service (https://Github.com/)

2.7 Initial Schedule Planning

I will have to plan an initial schedule of my work flow on how to utilize the time frame I was given to product the prototype for this project. (estimate)

Time frame given = 4 months

Initial schedule

	Year	2017						2018									
	Month	Nov	Dec					Jan				Feb				Mar	
	Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Plan	Purchase Prototype																
	Create Application																
	Researching																
	Develop Prototype																
	Testing																
	Documentation																

Figure 2.7.a Initial Schedule Plan

3. Prototyping Tools

3.1 Purchasing product to for prototyping

I proceed to purchase three different types of smart band both online and off the shelves.

3.1.1 X9 Smart Bracelet

This model of wrist band was developed and manufacture from China therefore requires some time for them to ship this product to Singapore.

Figure 3.1.1.a X9 Smart Bracelet

3.1.2 K1 Smart Bracelet

This model of wrist band was developed and manufacture from China therefore requires some time for them to ship this product to Singapore.

Figure 3.1.2.a K1 Smart Bracelet

3.1.3 Fitbit Charge 2

This model is available off the shelf in local stores.

Figure 3.1.3.a Fitbit Charge 2

3.2 Installing Android Application

3.2.1 Android Studio Integrated Development Environment (IDE)

Official recognize Integrated Development Environment (IDE) for developing android application with a huge community in the internet providing assistance to developers (Android Studio 2018).

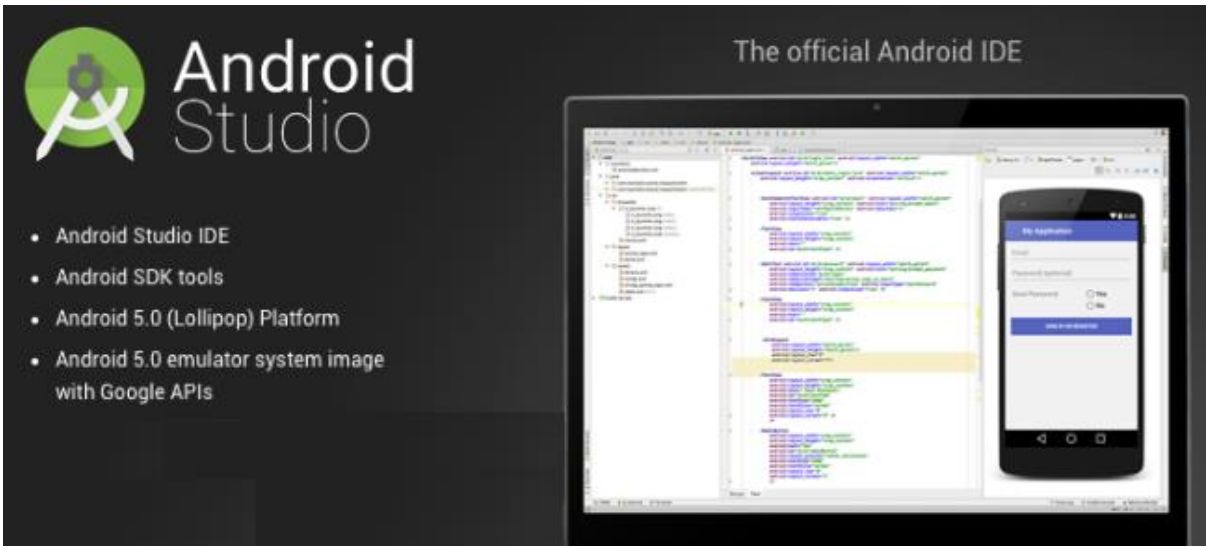


Figure 3.2.1.a Android Studio IDE

4. Beginning

To start off the project, the first thing to do is to use the smart bands that I have purchase and test out the heart rate functionality, make sure the smart band work as they are supposed to and no defective parts. The three smart bands each are able to measure real time heart rate though the accuracy are a bit off when compare the three of them together.

Next, is to create an android application (using android studio) that can capture the heart rates.

4.1 Open Source Codes

There are lots of sample coding developed by other developers who placed on the cloud for the purpose of sharing information therefore it is a good place for me to do research and self upgrade on things that I do not know. After looking through lots of tutorials and video clips samples on the internet, I am unable to find any sample that is similar to my idea (which is a good thing, meaning my idea has marketable value) but it is also a bad thing meaning I will not have references if I am to bump into obstacle.

4.2 Communication

As I have already purchase the wearable devices, and I have my own smart phone. As vendors that developed the smart band usually provide their developed application. But so far as I know, there is no way of decrypting an application back to source code. The companies do not wish to allow rival company get hold of their source codes to prevent competition and of course market share loss.

Therefore I will need to create my own application and the first thing will be the communication portal between wearable devices and smart phone. After some researches, two types of communication has been identified, which is the Wi-Fi and Bluetooth. And existing source codes for communication can be found in the sample and tutorial codes in the internet. By following closely and some modification, communication between wearable devices and smart phone application has been establish.

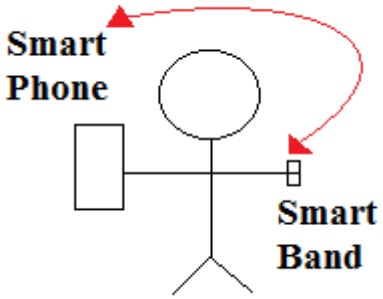


Figure 4.2.a Communication between smart phone and band

4.3 Heart rate data transfer

Next step is to grab the heart rate data from the smart band and transfer to the android application. The sensor within the smart band will sense and collect the real time heart rate information and transfer upon request by third party. In this case, the android application that I am creating will be considered as the third party. I will have to add codes into the application to request for data from the wearable devices.

4.4 Problems Encounter

And soon enough, the moment I started developing the application in android studio, I immediately bumped into obstacles almost right at the beginning. It seems that I as a third party developer do not have the access to data transmitting out from the wearable, as different vendors have their own type of syntax of coding. There is no universal standard of coding that allows me to just grab data freely. And so I started to explore into this area of domain.

4.5 Data Protection Act

Apparently, there is this Data protection Act (DPA) in placed to protect personal data from illegal or unauthorised usage. Looking further into details, Freedom of Information Act (FIA) comes into play therefore some read up is required to understand the boundary that I am stepping on.

4.6 Problem domain

There are many companies that create and produced many variety of devices and software configurations as each company treat the rest as competitors thus a lot information are kept secret in order not to lose out to each other thus resulting in fragmentation problem in the wearable and smart phone domain.

As shown in the figure below, there are many different companies under the "others" option for the wearable devices. Although the wearable devices are being developed in many ways, it is still possible to classify the group into two types of categories which are smart bands and smart watches. These companies developed their own software platforms involving multiple systems for users and third party developers usage (Example applications, Software Development Kits and RE presentational State Transfer Application Programming Interfaces)

Each company develop their own platform that empowers the accumulation of information. By utilizing the services accessible on these platforms, both the users can gain access to the gathered information and third party developers can fabricate new applications and services under certain conditions given by the company.

Figure 4.6.a Wearable devices unit market share

4.7 Data Collection

Wearable devices allows different ways of distinctive manners by which information from the sensors within the devices can be gathered by other different types of frameworks. In the figure shown beneath, demonstrates the several different types of frameworks that can be engaged in the smart watch information gathering situation, example smart phone, wearable, computers, servers and cloud services. Two types of frameworks that are widely recognized are the proprietary and third party.

4.7.1 Proprietary System

Proprietary systems provided and maintained by companies are used to collect users' information, to perform investigation and to give information and scientific outcomes to users and to approved third parties.

4.7.2 Third party System

Third party system such as services and applications for wearable devices and smart phones, and software programs for computers can be developed and maintained by external parties to provide particular functionalities. Every one of these segments is proposed to perform some particular capacities:

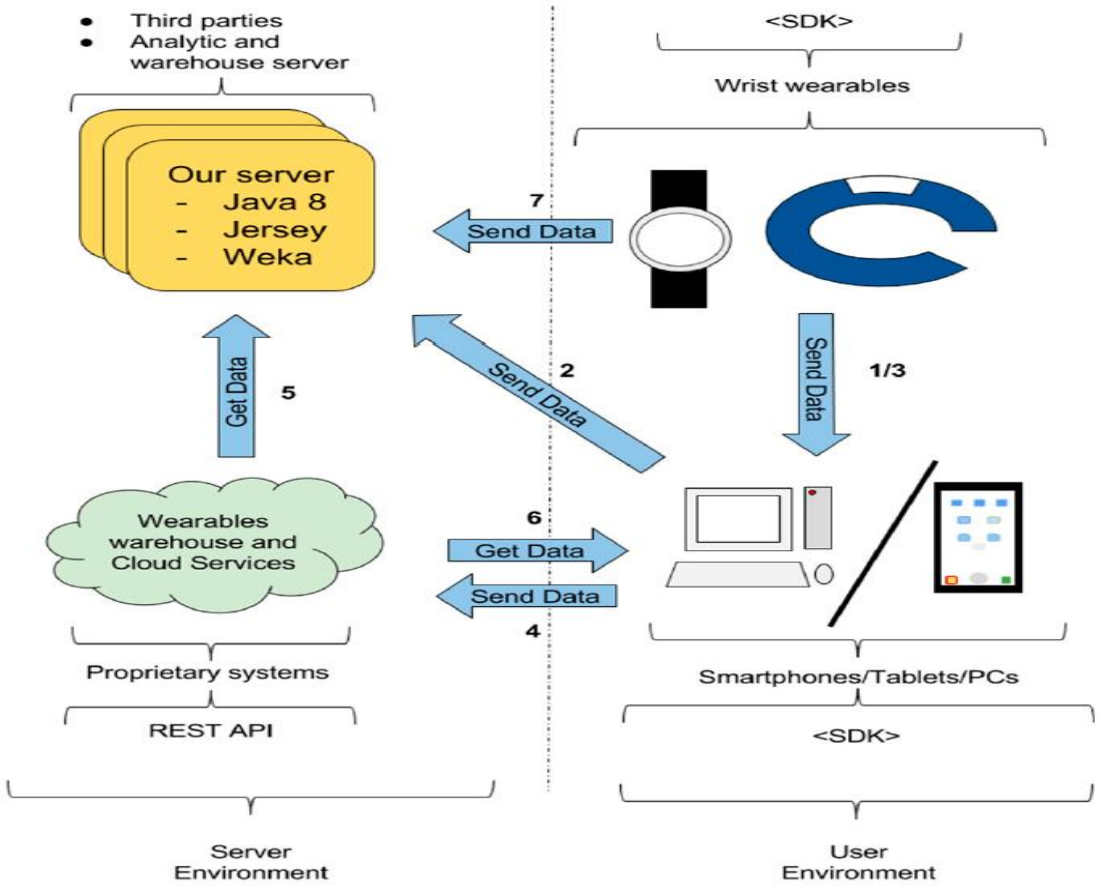


Figure 4.7.a Systems involved in the wearable devices data collection scenario

Each wearable device includes a native Software Development Kit (SDK) empowering the development of applications, however with no particular support for sensors gathered information exchange. Utilizing these native SDK is conceivable to create applications that gather information from wearable devices and then transfer it through non specific correspondence facilities (e.g. Bluetooth, Wi-Fi). These solutions involve high complexity and have many issues, such as battery drains within the devices. Therefore, I concentrate on the solutions provided by the companies to support information accumulation and transfer in an integrated way.

4.8 Data Transfer

There are two types of **transferring** data:

1) Warehouse data transfer - Taking the data from proprietary warehouses.

Warehouse data systems have to keep up to date as all the data are transferring from devices to the cloud through their services and these data are then stored into the warehouse. Inserting to and extracting from warehouse are based on scheduled data transfer (Comparatio 2008).

2) Wearable data transfer - Taking the data directly from the wearable sensors.

Comparing warehouse data transfer to wearable data transfer, warehouse data transfer has some distinct disadvantages such as collection of data in real time mode. Transferring of information from wearable devices to the proprietary warehouse could be at random, depending on the schedule timing of transferring defined by the companies developers. Sometimes, the setting of transfers timing can even be a few days to a week. As for wearable data transfers, the data transfers can be created at particular time interims. Raw data can be capture from wearable data transfer where as data has undergo some processing before transferred to proprietary warehouse.

And there are two methods of **accessing** data:

1) Direct access - the third party directly accessing the data from either the wearable or the warehouse

2) Indirect access - by creating a gateway between the data from the source

From these two transferring and accessing method, a total of four different types of configurations can be distinguished in which data can be produced.

4.8.1 Method 01 - Indirect access for Wearable data transfer

The transferring of data utilizing the smart phone application to the third party system after collecting the data from the wearable as shown in the figure below.

Interface (1) - A native application inside the smart phone act as a listener to grab the events from the wearable device though either Wi-Fi or Bluetooth.

Interface (2) - A native application inside the smart phone sends the information collected from the wearable device to the server (the smart phone application stores the information collected from the wearable devices when internet connection is not accessible).

This method will need gigantic effort in developing an application that required to run in the smart phones first and then grabs the events from the wearable device. And in addition to some wearable devices, there is also a need to develop an application for the wearable devices to keep record of the sensor data and then transfer it to the smart phone application.

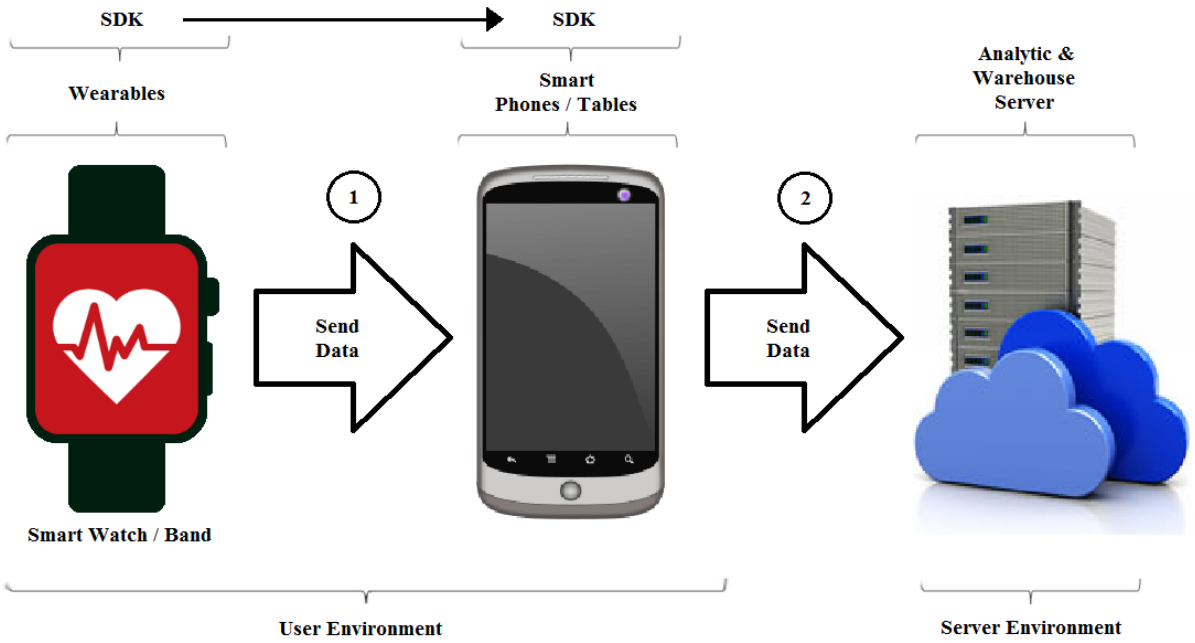


Figure 4.8.1.a Method 01 - Indirect access for Wearable data transfer

4.8.2 Method 02 - Direct access for Wearable data transfer

This method requires the wearable device to collect the information gathered from the sensor within the device and direct access to the web servers to transfer the information, provided with internet connection ability example build-in SIM card or Wi-Fi access. And in addition, the energy consumption on the wearable device is too great, therefore, this type of configuration is not a valid option.

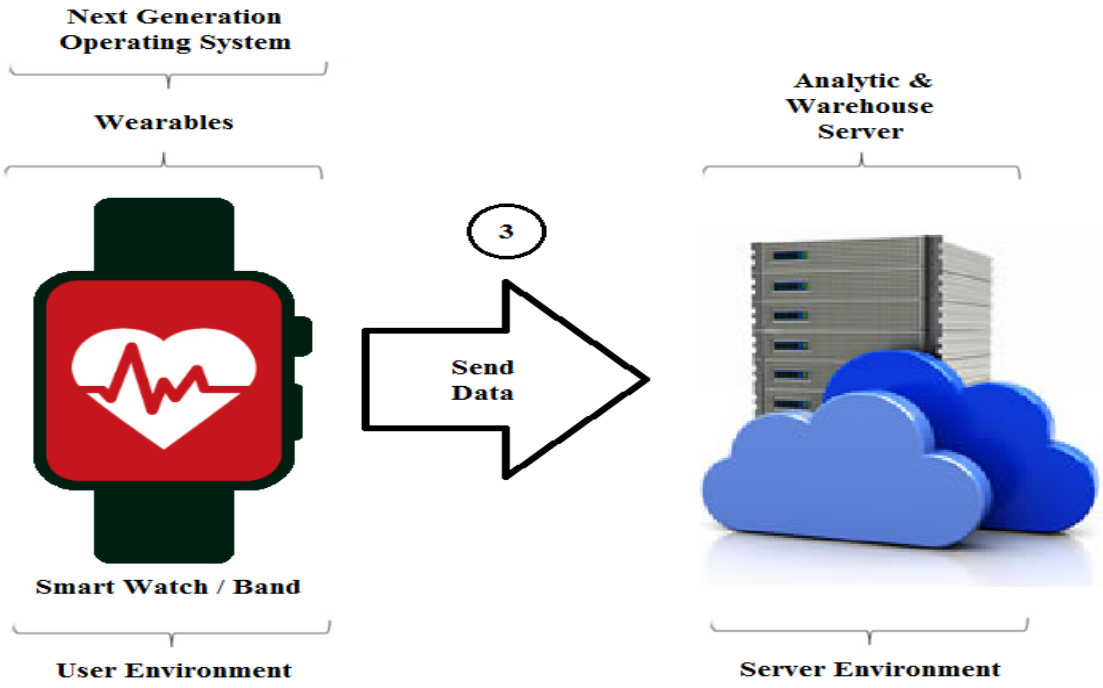


Figure 4.8.2.a Method 02 - Direct access for Wearable data transfer

4.8.3 Method 03 - Indirect access for Warehouse data transfer

This setup includes indirect access to the proprietary warehouse utilizing a smart phone. As shown in the figure below, demonstrates the way by which information can be transferred through interface 6 and 7. An application running on the smart phone/tablet gets the information from the proprietary warehouse and cloud service. Next, this application sends the information to the third-party server. This type of configuration is needed in the cases where the warehouse does not provide a REST API but it allows operation from the SDK.

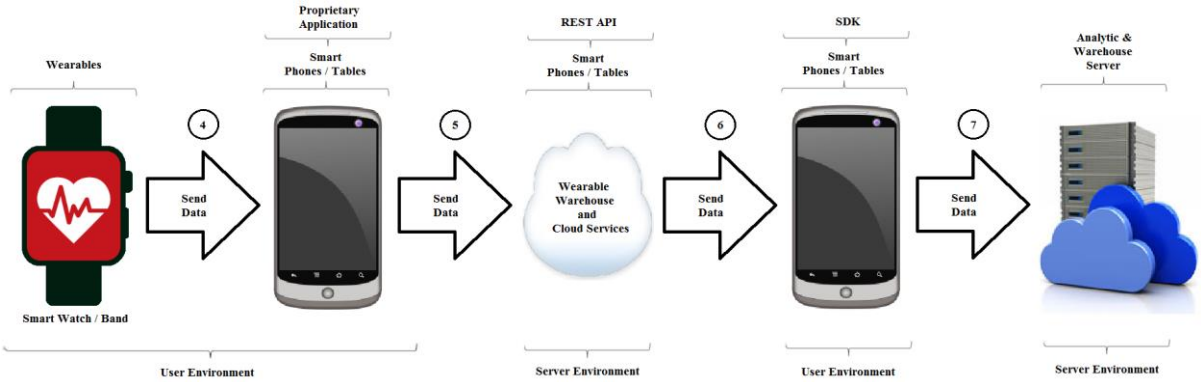


Figure 4.8.3.a Method 03 - Indirect access for Warehouse data transfer

4.8.4 Method 04 - Direct access for Warehouse data transfer

The third party server obtains the information utilizing the proprietary warehouse REST API.

Interface (8) - The wearable device sends information to its proprietary warehouse and this is performed through the proprietary transfer solution. This solution depends on an application running in an intermediate smart phone, which acts as a gateway towards the server. The wearable sends the information to the intermediate application utilising Bluetooth and this transfer is performed periodically because of the energy demands of the Bluetooth connection. If this transfer cannot be performed for a period of time, the information may be summarized or even lost.

Interface (9) -The information is transferred from the intermediate smart phone to the wearable warehouse.

Interface (10) - The wearable warehouse receives requests from third party systems through the REST API and then delivers the requested data.

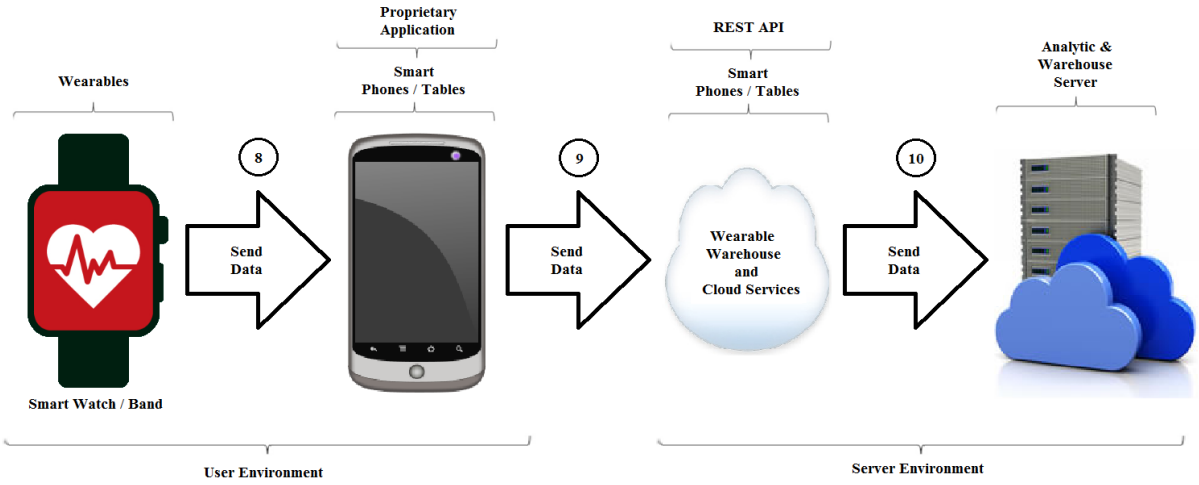


Figure 4.8.4.a Method 04 - Direct access for Warehouse data transfer

4.9 Choosing the method

My idea is to have real time heart rate information therefore any method that associate with warehouse will not work. And so I am left with direct and indirect wearable data transfer methods. The ideal way is direct wearable data transfer but current market solution produced most of the smart watches or bands are without Wi-Fi access points or SIM card option as the battery drainage is too high. Therefore, I chose to use the indirect wearable data transfer method as the rest of the methods are not feasible.

I will need to access the wearable device to get the heart rate real time data and also create an application that will run in the smart phone which act as the control centre which does the processing and notification.

I started off by creating an application in android studio with the function of activating the Bluetooth of the smart phone. Next, I will create the scanning of nearby devices using the Bluetooth. Then, I continue to the part where connects the device which in this case is the smart bands. The codes for these three parts are quite common and can be found in the internet as open sources. The next part is where the problem starts to arise. After I have connected the smart band to the application, I will need to get the real time heart rate that is within the smart band and transfer the data into the smart phone. I search the internet for a very long and apparently it cannot be done. Reason being every smart bands manufacture do not want to give something away when they can sell the APIs for more money. Google has published APIs with respect to wearable devices but the APIs created belongs to each smart watch maker, not Google.

Fitbit is using the direct access to warehouse data transfer method, which is raw heart rate data collected from the smart band is transferred to an application created by Fitbit which is installed on the smart phone and when the smart phone has internet connection, the data will be sent to the warehouse for storage. Individuals will have to access the warehouse to see the summaries. Companion APIs are accessible by applications which run within the Fitbit mobile application only.

4.9.1 More Obstacles from wearable devices manufacturers

4.9.1.1 Garmin

Garmin does allow some option in getting the heart rate data but with a high price of five thousand dollars license fee to request for their Application Programming Interface (API). Otherwise, there isn't a way to get hold of the real time data (Garmin 2018).

Figure 4.9.1.1.a Garmin Development

4.9.1.2 Apple (Watch)

Apple (watch) do not support direct access to the heart rate sensor.

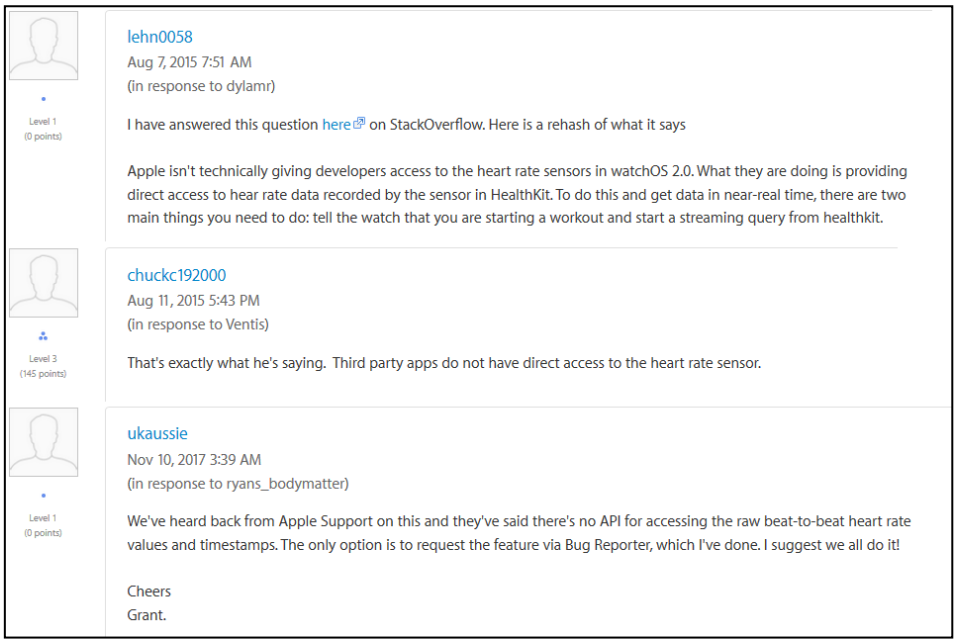


Figure 4.9.1.2.a Apple Development

4.9.1.3 Pebble (Watch)

Pebble (Watch)was a company that produce smart band and it also allows developers to access the raw sensor data from their wearable devices but was bought over by Fitbit company in year 2016.

Figure 4.9.1.3.a Pebble Development

4.9.1.4 Jawbone

Jawbone was another company that produce smart band but the company undergo liquidation in the year 2017. From their website, we can see that jawbone do not allow developers to access the raw sensor data (JAWBONE 2018).

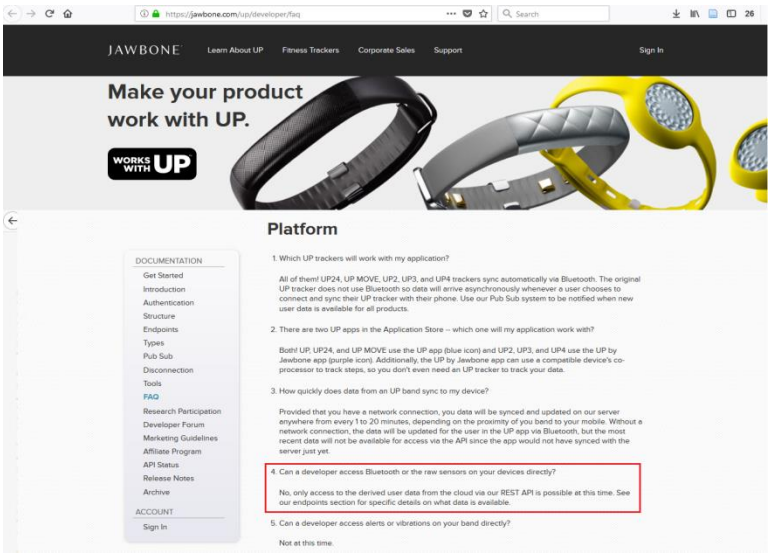


Figure 4.9.1.4.a Jawbone Development

4.9.1.5 Microsoft (Band)

Microsoft has developed Microsoft Band which is a smart band with fitness features but announced stopped development and sales for the line of devices in the year 2016. It was a popular model where developers were able to access the APIs and grab the real time data (Microsoft 2018).

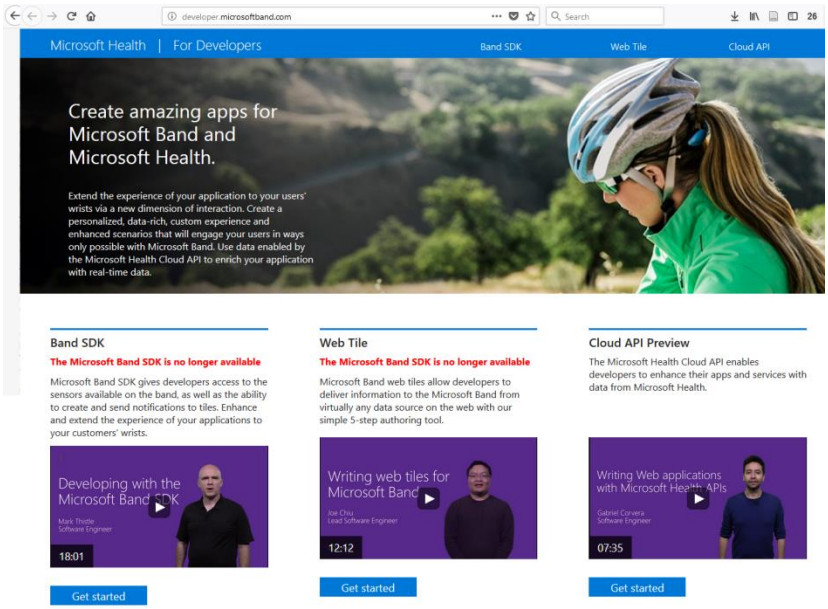


Figure 4.9.1.5.a Microsoft Development

4.10 Seek Advices from experts

From all these research, I have came to a conclusion that companies that developed smart watches/band and allows developers to gain access to the API were bought over while companies that do not allow access to the API are still growing strong. Without the access to the data layer of the wearable device, grabbing the raw data is almost impossible without any direction.

As I have spent too much time searching for ways to overcome all these obstacles, the time ticks without stopping and remaining time before due date is getting lesser and lesser. Therefore I decided to seek for advices from developers who are working in these field.

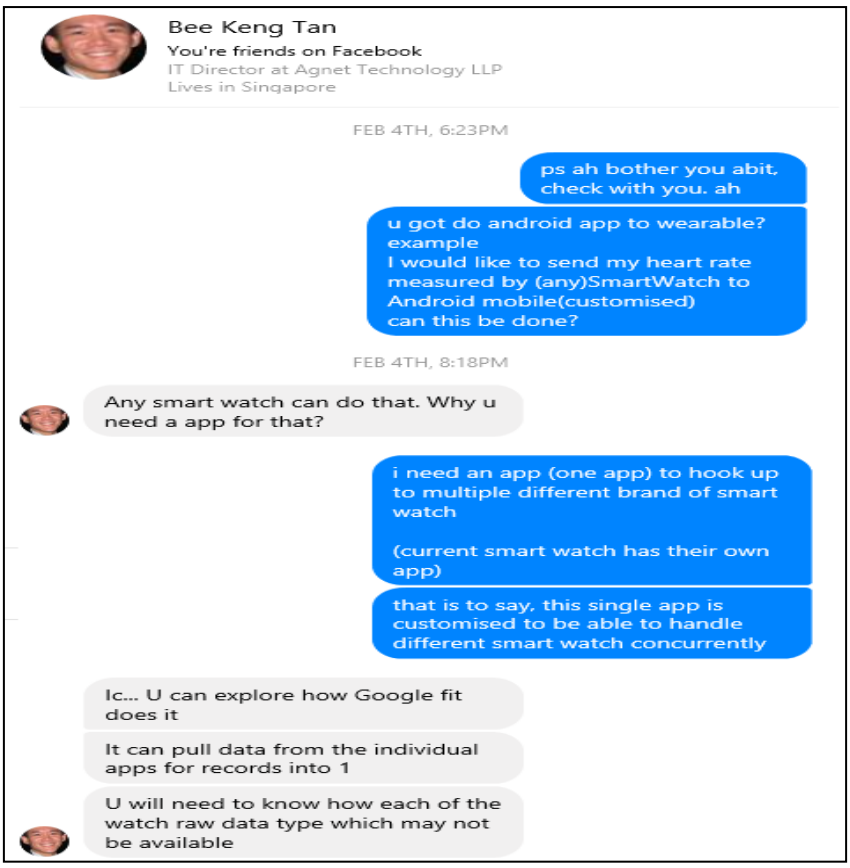


Figure 4.10.a Mobile Application Developer Friend

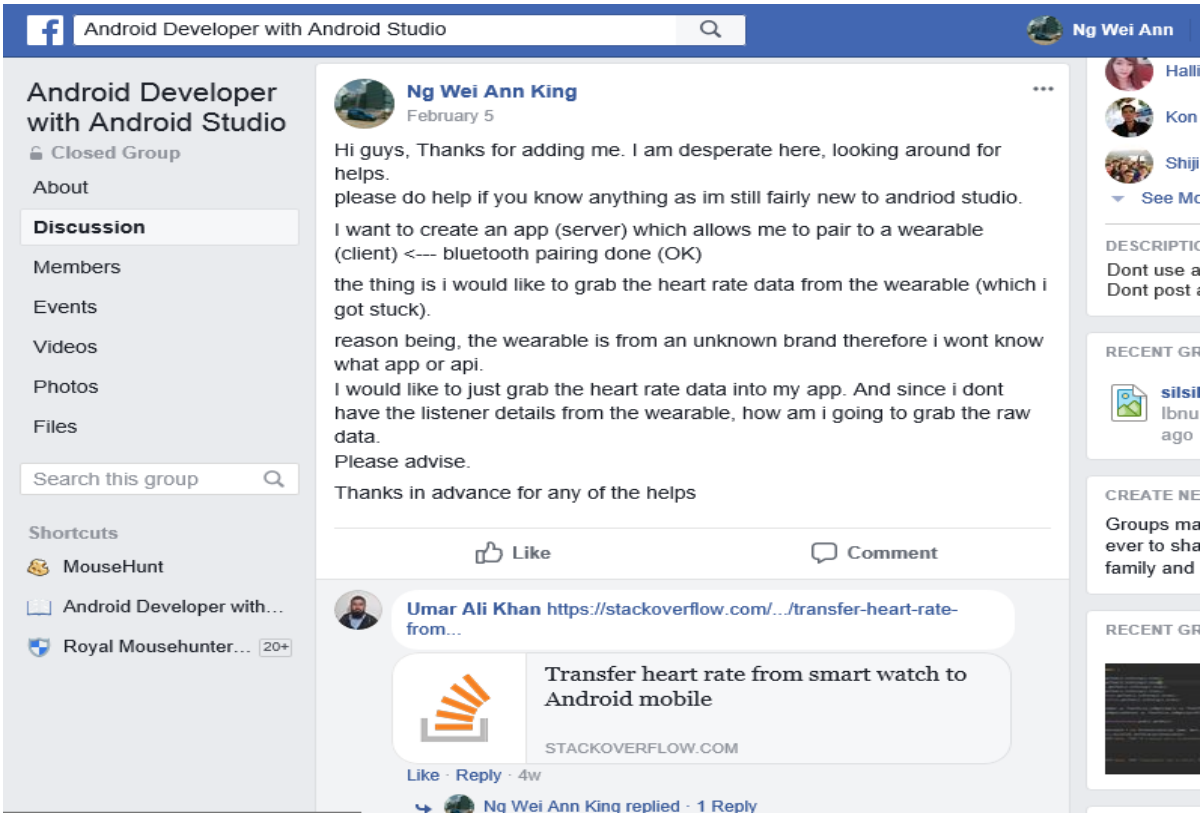


Figure 4.10.b Online Android Application Community

4.11 Abandon Plan

After searching around looking and unable to find an answer to the problem I am facing, I decided to abandon this plan as time is running out for me. I decided to approach another direction where I can do some modification and may still produce the prototype.

Just like Product Owner in SCRUM, if the product owner deem the process not suitable to go on, he/she has the authority to announce interrupt or even abort.

Therefore looking at current time line and do some estimation calculation, I deem myself as I will not be able to find a proper solution with the remaining time.

There are times when saying "NO" doesn't mean escaping, and forcing oneself might not lead to a way out. But instead of being a pig-head, it might be good to step out of the box and look at other alternatives.

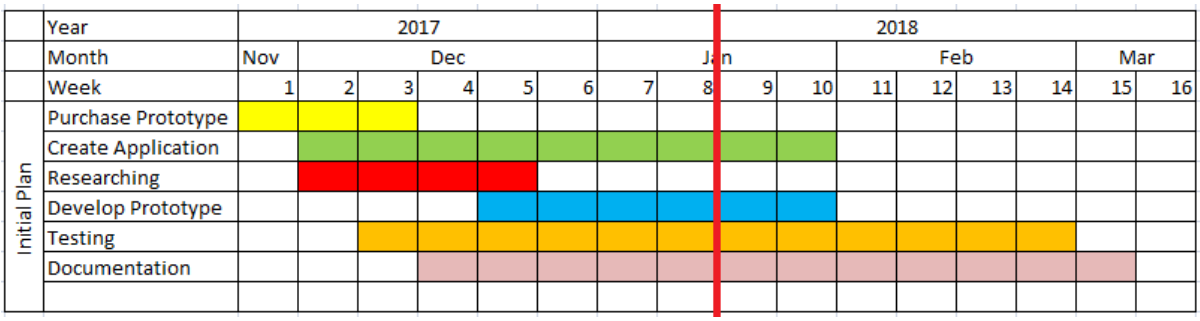


Figure 4.11.a Current timeline status

5. New Direction

Previously, the problem I encountered was unable to get real time heart rate information from smart watch/band. Therefore I should look into how am I able to get real time heart rate. The first thing that came into my mine is the sensor which is required to sense the heart rate. I did some research on what types of sensors available in the market and I came across pulse sensor.

5.1 Pulse Sensor

Pulse sensor is an open source optical heart rate sensor that was designed for plug and play onto Arduino board to incorporate reliable real time heart beat which is accessible to anyone (Yury 2011).

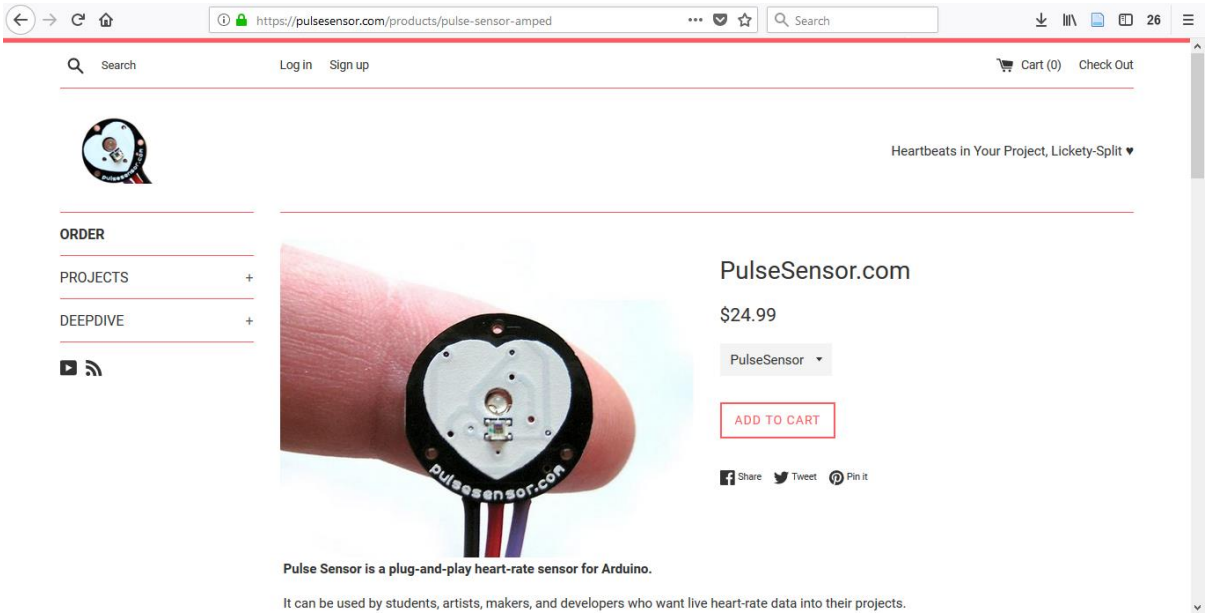


Figure 5.1.a Pulse sensor

From the same website, I noticed that this pulse sensor is able to sensor and transmit real time heart beat to a device called Arduino. Therefore I started looking into what is Arduino and see how to integrate the both of them together.

5.2 Arduino Board

Arduino is an open source hardware and software company that design and build microcontrollers board for electronics projects with the mindset of easy to use and capable of controlling hardware using the Arduino board (Garrison 2011).

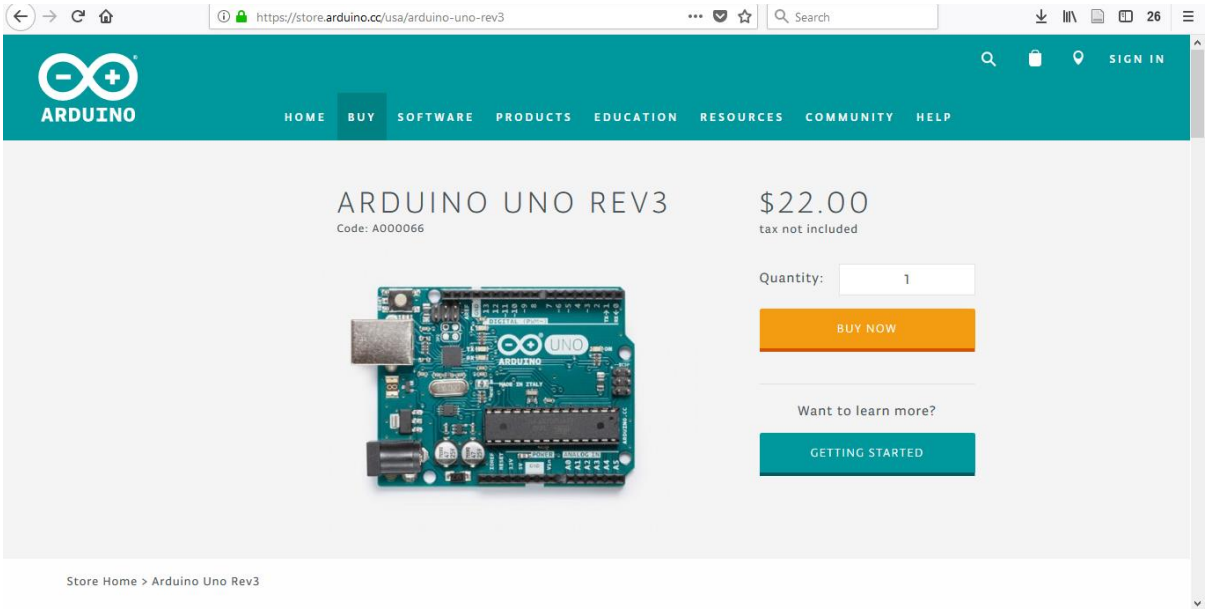


Figure 5.2.a Arduino Board

Next, I need to think of how to create the communication between the Arduino board and the smart phone.

5.3 Bluetooth Module

HC-05 module is a Bluetooth module that can operate in either a master device or as a slave device which is easy to use the Bluetooth Serial Port Protocol that is designed for wireless communication (sayem2603 2014: 05).

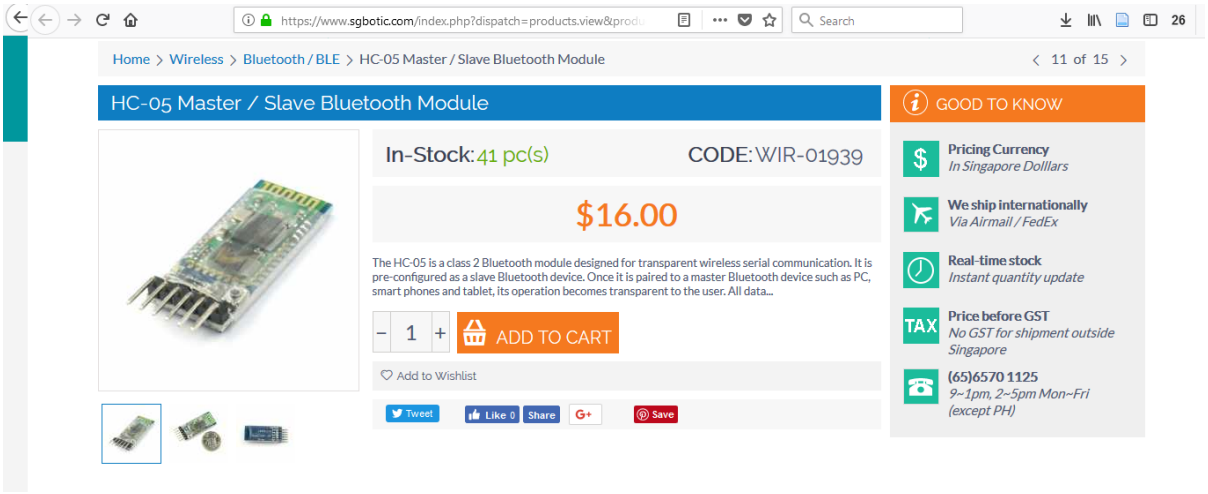


Figure 5.3.a HC-05 Bluetooth Module

After researching and linking all the possible ideas together, it seems that with the above three parts combine together, it can give me real time heart beat with easier communication.

5.4 Modifying Previous Idea

Using all the information gathered, modifying and building prototype base on new idea by purchasing required parts that are available.

Figure 5.4.a Modified Monitoring Heart Rate Notification System

5.5 Installing Arduino Integrated Development Environment (IDE)

Arduino Software (IDE) is a text editor program for writing, editing and debugging of codes in high level language and uploading the written codes onto the Arduino board (Akshay 2016)

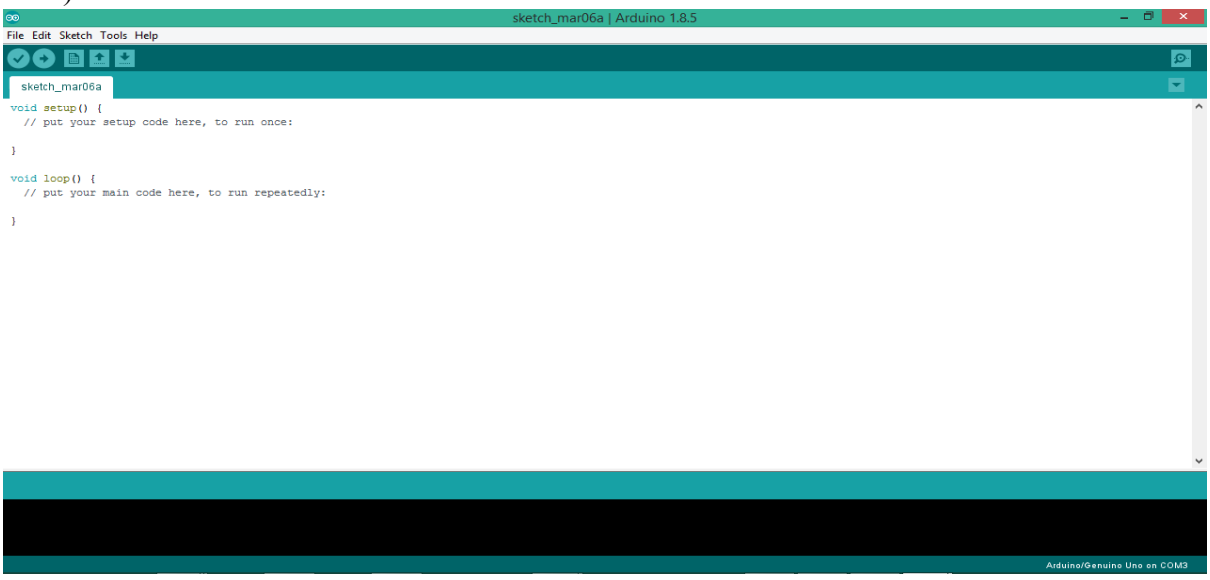


Figure 5.5.a Arduino Integrated Development Environment (IDE)

5.6 Building prototype

5.6.1 Arduino board and pulse sensor

After purchasing required parts, it is time to start building the prototype. First by connecting the pulse sensor to Arduino board and do testing to confirm both parts are working.

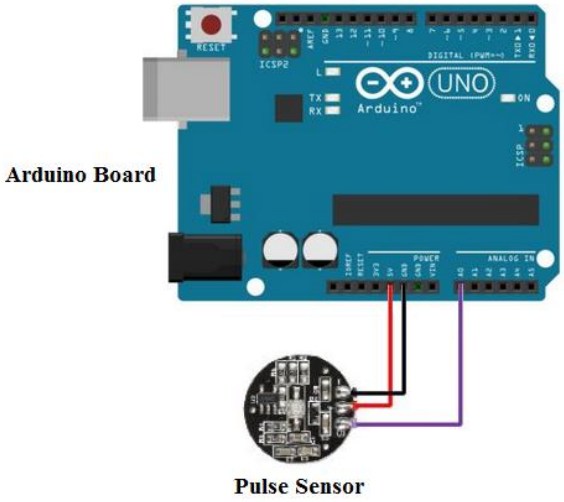


Figure 5.6.1.a Sketch of Arduino board and pulse sensor

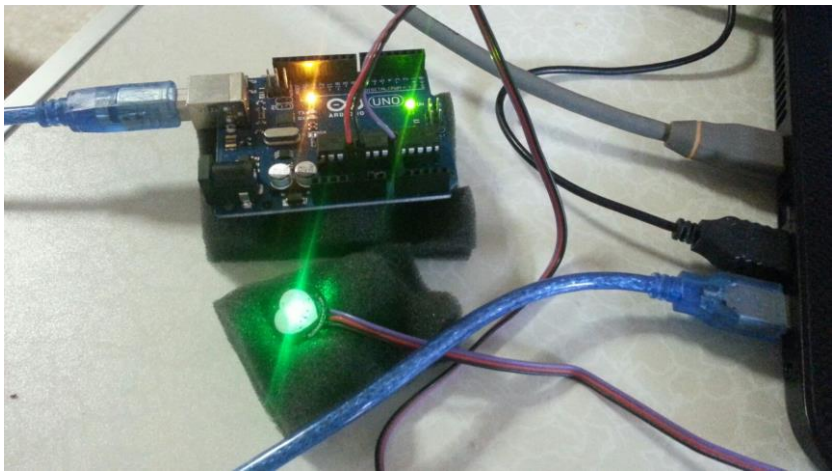


Figure 5.6.1.b Actual Arduino board and pulse sensor

5.6.2 Arduino board and HC-05 Bluetooth module

Next, connecting HC-05 Bluetooth module to the Arduino board and perform testing.

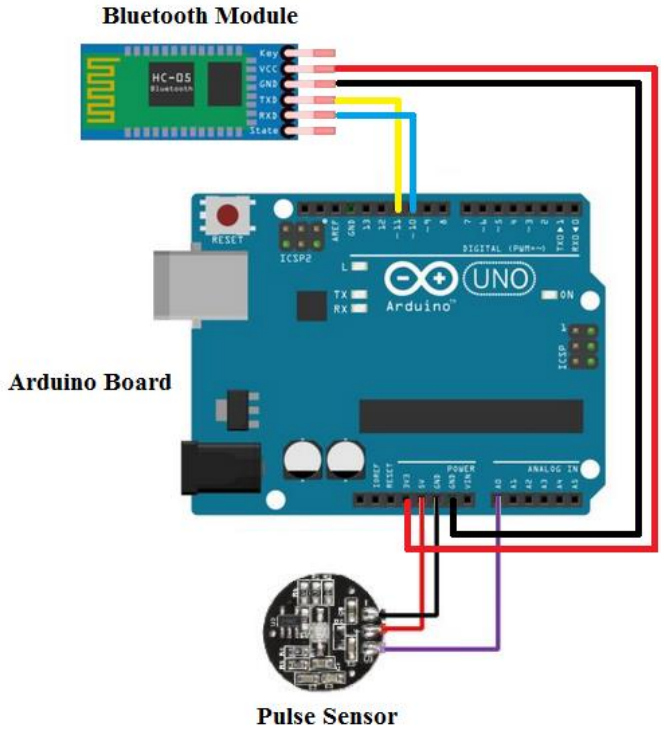


Figure 5.6.2.a Sketch of Arduino board and HC-05 Bluetooth module

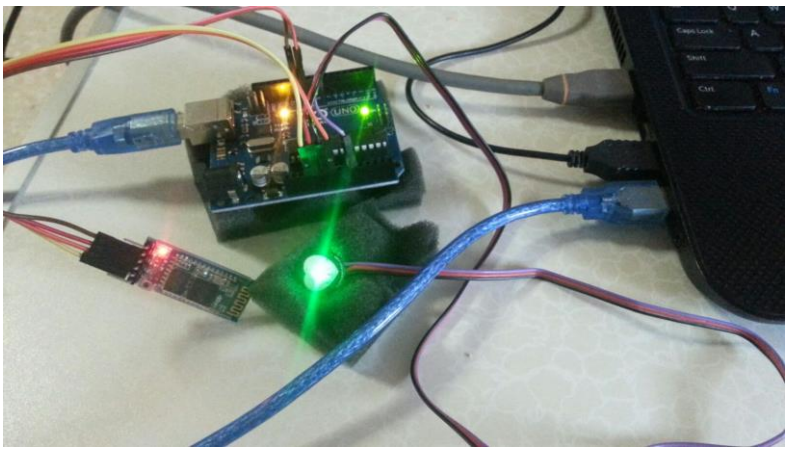


Figure 5.6.2.b Actual Arduino board and HC-05 Bluetooth module

5.6.3 App inventor

App Inventor is an open-source web based system created by Google using graphic interface that allows developers to create android applications in an easier way by using connecting blocks system instead of coding, Current, app inventor is maintained by the Massachusetts Institute of Technology (MIT) (wolber 2013).

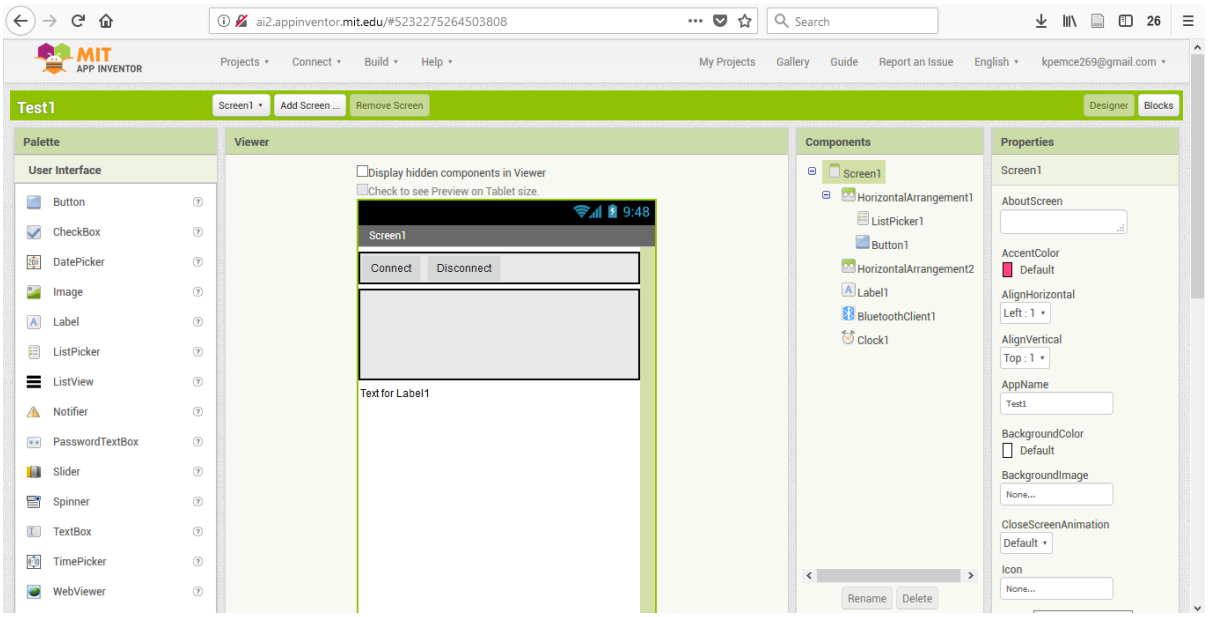


Figure 5.6.3.a App Inventor Designer page

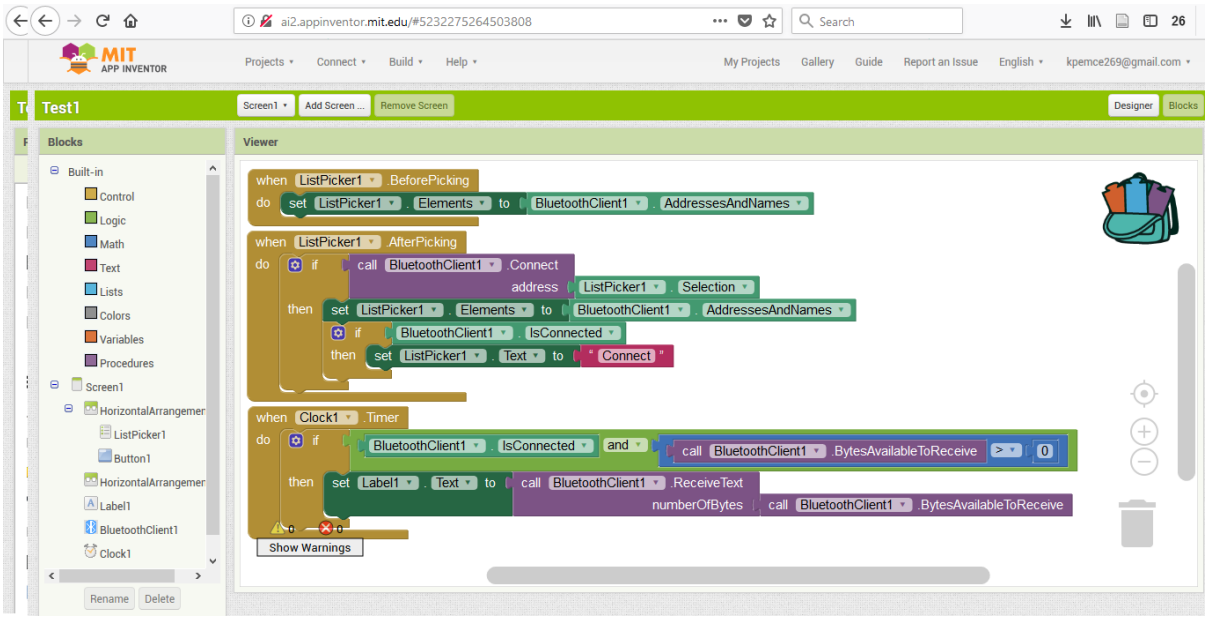


Figure 5.6.3.b App Inventor Block page

6. Software Testing

It is important to have testing as testing will helps to explore, locate and discover all the possible errors that might be hiding within the project which no one exploit it until it is too late. It is also important to know that testing occurs in every stage of the project, that is to prevent or reduce serious damage that may affect the overall workflow.

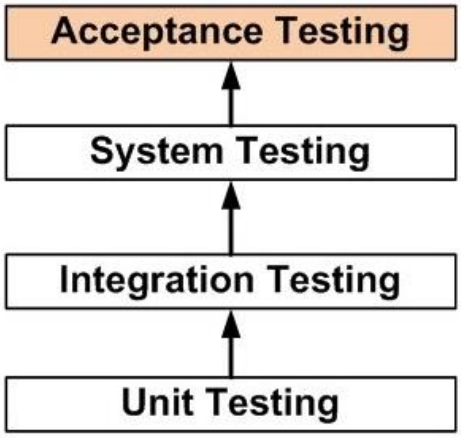


Figure 6.a Software Testing

6.1 Unit Testing

It is a practice of testing to verify the codes in the functions are working as expected and help identify errors that may have occurred in the logic or algorithms to prevent from breaking functionality (Tom 2012).

Example:

- Testing of individual unit of codes that are written in the Arduino IDE.

- Is the Arduino board able to receive and store the data that pulse sensor has collected?

- How to verify the data is correct?

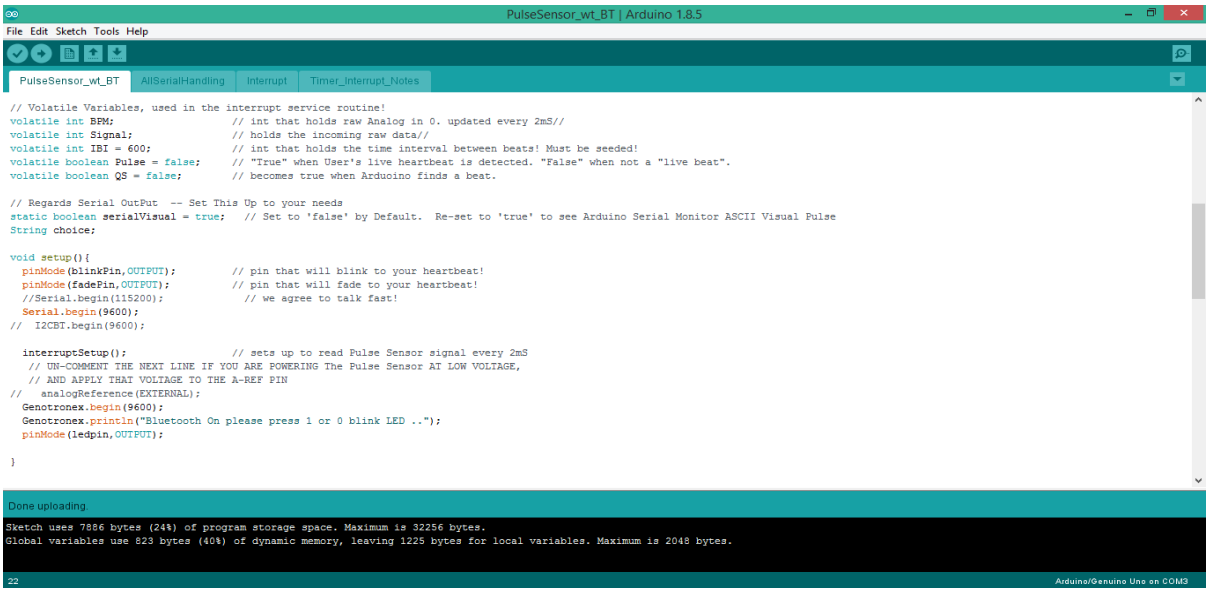


Figure 6.1.a Unit Test Sample

6.2 Integration Testing

Integration testing focus on the interfacing of individual units of software to check whether each unit are still working correctly when they are connected to each other (Martin 2018).

Example:

- Testing of Arduino board and pulse senor in unit testing has passed.

- Testing of Arduino board and Bluetooth module in unit testing has passed.

Performing integration testing to check whether the Bluetooth module is able to transmit data collected from pulse sensor to listener in android application.

6.3 System Testing (Verification and Validation Testing)

Testing is used to evaluate and determine whether the software development process satisfies and fulfil users' requirements and functionality .

Example:

- The idea is to get real time heart rate raw data from user. Has the data successfully collected using the above method?

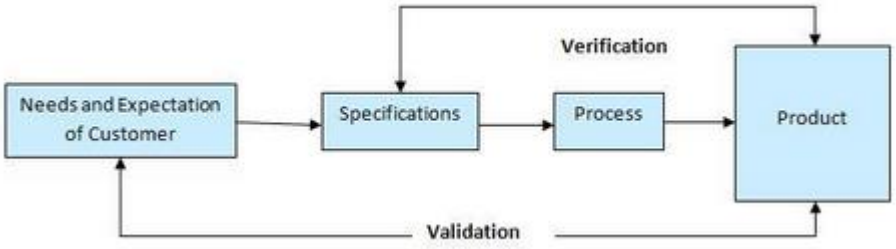


Figure 6.3.a System Testing

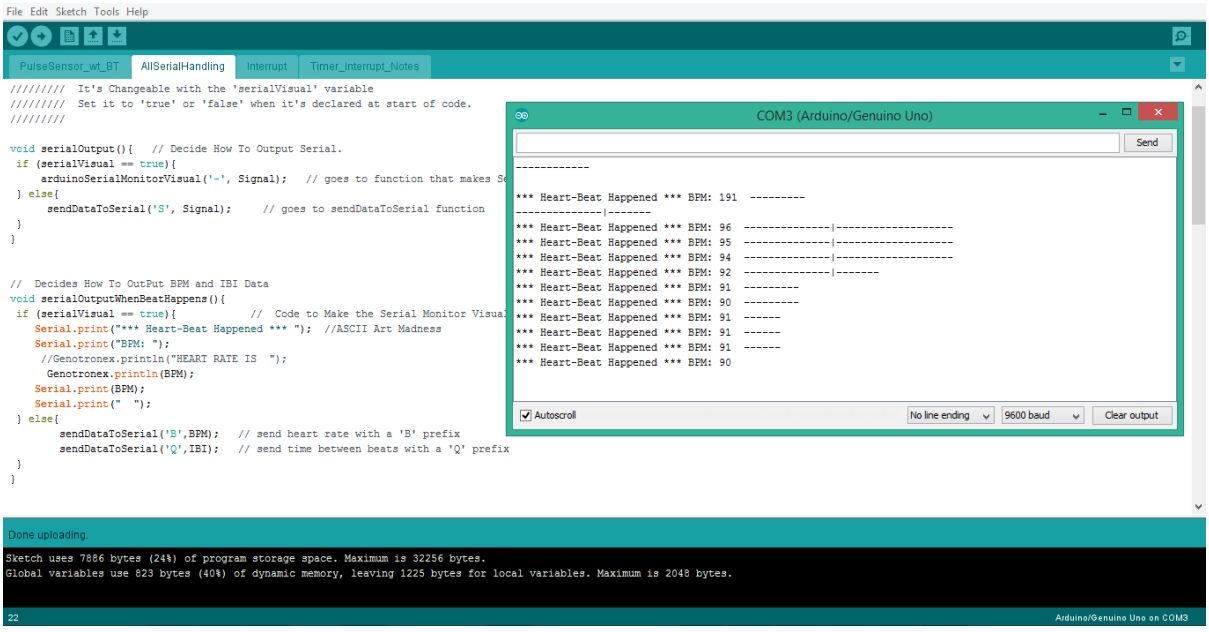


Figure 6.3.b System Testing on Arduino IDE

6.4 Acceptance Testing

Using black box testing method to test the system and check whether the system satisfies the acceptance criteria and by the user or customers whether to accept the system or not (Scott 2007).

Example:

- Producing the prototype and getting person to do black box testing on the prototype

6.5 Product Prototype

Testing of android application to receive real time heart rate and sending of notification upon entering warning zone.

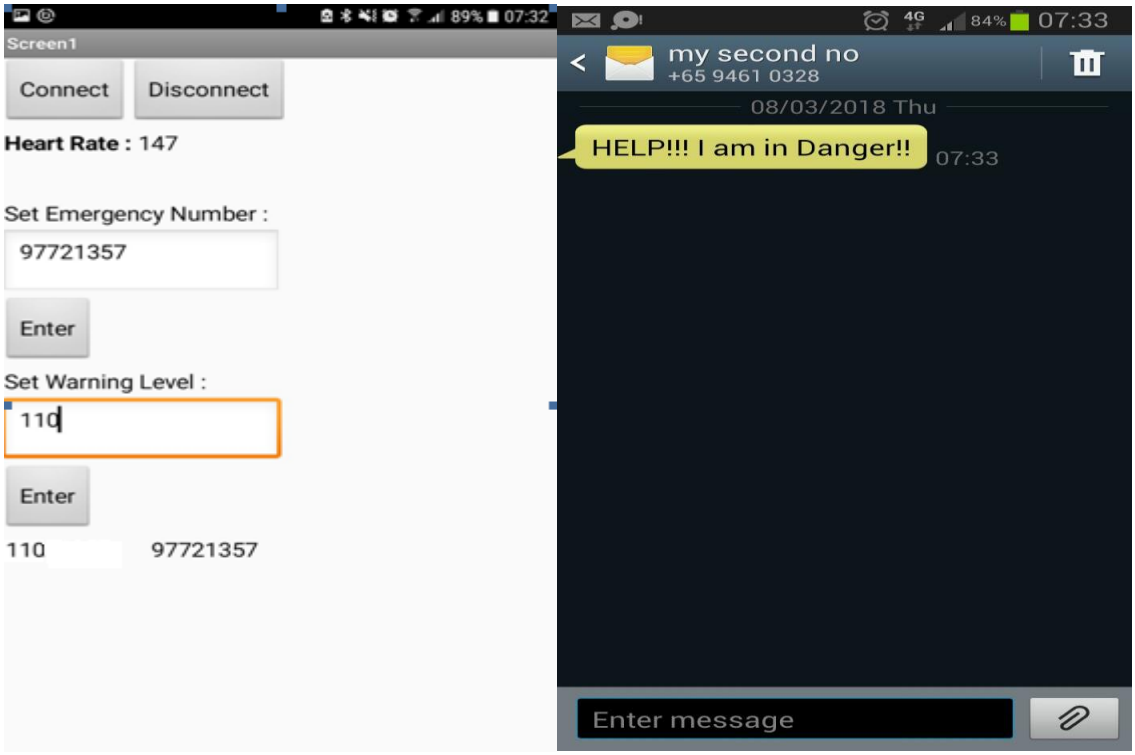


Figure 6.5.a Product prototype

6.6 New plan timeline spent

With the remaining amount of time, squeezing every available time slots to push maximum usage of time proved that it can still be done (but super tiring).

	Year	2017						2018									
	Month	Nov	Dec					Jan				Feb				Mar	
	Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
New Plan	Purchase Prototype																
	Create Application																
	Researching																
	Develop Prototype																
	Testing																
	Documentation																

Figure 6.6.a Timeline Schedule

7. Future Recommendation

From the user point of view, this idea that I have thought up is consider valuable as the focus is on the well being of individuals and there are more ways of further improving. The most important part of this project is the raw data information which can be used in other directions.

The ultimate idea is almost similar to shrinking down a total hospital facility into a smaller, portable solution. Just imagine, the ability to have all functionality of hospital in the palm of your hand, won't that be super amazing.

Further improvement to this project are:

1) By implementing GPS location function into the application. When the application sense the user is in danger and send notification to the control centre, the GPS location information is also sent along together will further reduce the time for the control centre to find and locate the user in distress. Emergency rescuers can pin point the location immediately without wasting addition time and arrive promptly without any further delay.

2) With the algorithm of the radius of signal transmitting and receiving, calculation and showing the direction (north south east or west) on the display of the smart phone can be useful for those who are senseless in direction. Image your child is lost in a huge crowd in a shopping district and your child is in distress. Searching for a small child could place a problem and GPS doesn't function properly when there are huge clouds covering the sky blocking the satellites or high rise buildings in the surrounding or satellites are not in place.

3) Activating text to speech function on the smart phone will enable the smart phone to read a distress message loudly and keep on repeating from the phone to alert the any nearby personal e.g. "Help, Somebody, Help". As it is human nature for people to tend to listen and look out for distress call, this method is also additional function to alert others for immediate assistance.

8. Reflection Report (Lesson Learned)

The reason why I choose this project in the first place was, previous there are few companies that still allows developers to access raw data and there are more and more new brands of wearable devices entering the market which leads me to believe and assume that the data could be easily acquired, but who knows a company can simply just decide to pull the product off the shelves that easily. Therefore, it is best to say that don't assume things will always go your way but also don't give up that easily.

Proper project management will helps to reduce risks that may occur during developing software and allows me to focus the work and allocation of resources on the right place to effectively capture any potential issues that may arise.

Choosing the right software methodology helps to set me on a right direction and improve the developing of the software, instead of blindly trying bits and pieces, here and there.

In this case, I have chose Big Bang Model and got caught in the error where I am unable to continue the initial idea which also means that the three wearable devices I have bought became useless (loss of money) and I have to purchase additional parts to continue the project.

Online cloud services and collaboration tools are very useful for saving spaces and acquiring information with ease. I have bumped into a part where the project report I was writing did not save into the computer and causes me to panic as the whole file just disappeared. I have no ways of retrieving the document at all but because I have push the document into the cloud services, I was able to at least get back the last piece of information that I have written without total lost. Therefore it is very important to have version control system for me to be able to store, retrieve or even rollbacks the programs, scripts, documents, program codes or test suites when critical errors was discovered through the whole project process and I am unable to figure what could have gone wrong or lost of files.

Constant testing of the project is very critical at every stages of development. It is from the multiple tries and testing that I found out I am unable to proceed further in the mid stage where integration test between the wearable devices and smart phone had failed. And I choose to abort the initial idea to prevent further damages which in this case the damage is unable to produce a single working prototype for the final demonstration.

It is very important to know what direction I am going and not get lost along the way. But when lost, doesn't mean should keep on walking in circles. Surely, there must be a way out as "Nothing is impossible in this world, just whether do you have the capability or knowledge to do it". I can't do it, doesn't mean other people also cannot.

9. Conclusion

A lot of times were spent on trying to find ways to extract the heart beat data from different wearable devices but it prove to be futile as majority of the companies developed the wearable devices for the purpose of selling to earn money. Due to this kind of action, other developers are unable to further improve on the quality of the devices which may enable individuals to enhance and live a better life. Companies are making use of whatever chances they can get to earn before the product obsolete. Though some claim to release their codes as open source but certain things are still kept hidden with a price tag attached to it. One of the reason most companies feared is that other competitors might extract their information and develop an almost identical replicate but at a lower price, which leads to them protecting those important information. As each developer of the company have their own syntax of coding, it is not easy to decode the programs, not to say steal from them.

And there are other factors that also need to take into consideration and battery's life span is one of them. Almost all the companies that developed wearable device emphasis on the life span of the battery, which is to last as long as possible. That is also the reason why developers are not willing to store real time data due to the high battery drain. But nowadays, every smart phone users are heavily utilizing their phones to a point that they have to charge once to twice per day. Therefore, for wearable devices, battery's long lifespan seems to be of less important and should at least last for one whole day on full usage before charging will be good enough.

The storage space in the wearable devices is also another area of concern which is also why developers are not willing to store real time data but instead to transfer data to the cloud servers for storage. But technology is improving and the size of storage space is constantly reducing. Currently, there are already one terabytes micro security disk (SD) card. Constantly reading and writing on the micro SD card which may spoilt the card faster is another area of concerns but companies are developing high endurance, high temperature resistance micro SD cards, therefore this area of concern should be a lot lower.

The overall weight and the comfort of the wearable device will be of another concern where users do not wish to carry a heavy object on their body.

Maybe in the future when other developers are able to shrink the size of Arduino board down to the size of a smart watch or to a portable size, that could be the day where a lot things that wasn't possible previously, will now be possible to develop. Probably some companies are willing to invest on researching better technologies to further improve the current methods, e.g. double sided printed circuit board (PCB) with onboard operating system together with built-in Bluetooth module and using smaller battery and micro SD card as storage space. We will just have to wait for that day to come.

10. Parts Purchased for this project

	Item Purchase	Price	Purchase from Company
01	Fitbit Charge 2	$248.00	Challenger
02	K1 smart bracelet	$24.00	Lazada.sg
03	X9 smart bracelet	$19.90	Qoo10.sg
04	Arduino Uno Board (original)	$35.70	Sgbotic
05	Arduino Uno Board (clone)	$21.00	TRobotics
06	Pulse Sensor (original)	$39.50	Sgbotic
07	Pulse Sensor (x2) (clone)	$18.00 (x2)	TRobotics
08	HC-05 Bluetooth module	$16.00	Sgbotic
09	Bread Board	$4.50	Sim Lim Tower
10	Jumper Wire (x2)	$4 (x2)	Sim Lim Tower
	Total spent	$452.60	

11. Link

Source code saved in github

https://github.com/ngweiann/CU-FYP-IP2

12. Reference

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Note to self

It is good to attempt challenges but it is also a risk that challenge may fail. But without failure, there won't be improvement and things will remain as though nothing has happened. So, **don't give up**. At least you live your life to the fullest instead of just following other people's footstep, living a dull life.