

## Cloud based Heartbeat Rate Monitoring System with Location Tracking

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### Abstract

Heartbeat rate reflects an individual's physical health and the status of a person cardiovascular health. A person with poor cardiovascular health is subjected to various heart diseases including heart attack. Heart attack is one of the deadliest diseases worldwide and the number one cause of death annually. People with poor cardiovascular health are required to be monitored in order to prevent a life-threatening situation. To help on this issue, we proposed a monitoring system through cloud servers to monitor people with poor cardiovascular health constantly. This system is developed using a lightweight Bluetooth ECG sensor, Android Technology, Web application as well as cloud services provided by Firebase. This system is portable, allowing patient to carry it on a travel. The heartbeat rate monitoring system with enhanced feature of alerting and notifying user through cloud servers. The firebase realtime database allow data to be transferred in realtime and user can send an alert through a push button. The proposed system allows patient to be monitored and alert users in case of any emergencies. A location tracking is also included as an added value feature. This may help in life threatening situations that will endanger patient's life. In addition, cloud database is able to store and monitor data constantly to review patient's heart condition.

### Keywords

Heartbeat Rate Monitoring, Android technology, Web application

### Introduction

Cardiovascular diseases have been responsible for an estimated of 17 million deaths and 31% of deaths globally in 2017 (Who.int, 2017). Malaysia leading cause of death stemmed from heart diseases, or more specifically, Ischaemic Heart diseases. In 2019, 15.6% of Malaysians died due to heart diseases related to this category. It is the major factor of death for individuals for in the age group of 41 and above (Department of Statistics Malaysia, 2019). Heart failure, stroke or heart attack are generally related to the cause of death to individuals with cardiovascular diseases. Individuals with a history of heart related diseases or at risk of it may requires continuous monitoring to prevent undesirable situations or complications. The heart rate of patients or specifically the heartbeat rate variability (HRV) of the individual may need

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to be monitored to ensure their safety. HRV is measured through ECG sensors which are large machines that is expensive and generally used in hospitals to conduct tests for accurate results (Benjamin Wedro,2019). There are ECG sensors that are suitable for home use but unable to support mobility.

The proposed system aims to use lightweight ECG sensors to measure the heartbeat rate of the patient. The ECG sensor uses Bluetooth to connect with the device to transmit patient heartbeat rate data. The proposed system also support mobility while displaying their location for movement tracking. It can help locate a patient in case of emergency. The ECG sensor uses HeartyPatch sensor that is open source. It allows modifications on the code for implementation of the system. The sensor is small in size and light weight as well. The figure below shows the Hearty Patch Sensor.



Figure 1: HeartyPatch Sensor.

Cloud services usually provided three major services for users, Software-as-a-Service (SaaS), Platform as a Service (PaaS) and Infrastructure-as-a-Service (IaaS). SaaS is usually offered through web browser to customers instead of end user's devices. This means no installation is necessary for end users to use the provided service (Fu, 2017). PaaS is a service that provides users with the environment that developers can manage, develop and deliver applications. Users are able to utilize computing resources as well as prebuilt tools to customize, develop and test their own applications. IaaS is a comprehensive service that a vendor provides users networking servers and storages. Organizations utilizes their own applications and platforms within the provided infrastructure services. User does not purchase hardware and IaaS is paid by users when they needed it. The infrastructure for IaaS is scalable depending on an organization or users' storage and processing requirements (IaaS PaaS SaaS Cloud Service Models, n.d.). The figure below illustrates the cloud service model.

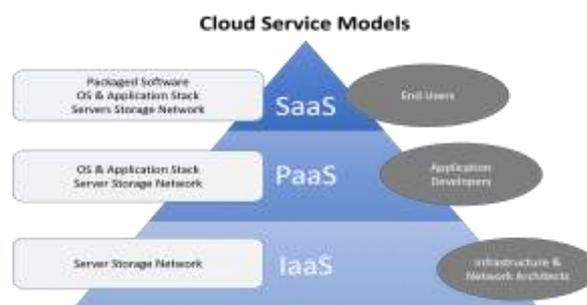


Figure 2: Cloud Service Models

In this project, we utilizes cloud services provided by Firebase. Firebase is a cloud service developed by Firebase Inc., a subsidiary of Google LLC that provided Backend-as-a-

Service (BaaS) platform that we used for the development of the system. BaaS differs from the PaaS as BaaS includes pre-built server-side application logic. The application logic includes user authentication and push notifications (Backend-as-a-Service, n.d.). We uses Firebase to authenticate users and to store user's information in the database. Firebase realtime databases stores and transmits data in realtime to mobile and web application. Any changes can be seen instantly in the mobile and web application. We chooses Firebase due to the availability and easy to access nature of Firebase, and due to widely accessible support for the service. The next figure shows backend-as-a-service. The adoption of cloud for the proposed solution allows for accessibility and constant records for the authorized users compare to storing data locally on a device. The proposed solution also allowed medical professionals to remotely access patient data when necessary and able to monitor patient's data over the span of a time period to diagnose and monitor patient 's condition.



Figure 3: Backend-as-a-Service

## Methodology

The proposed project uses prototype model as the research methodology. The methodology is a form of Software Development model where a prototype is built, test and reworked until the prototype is deemed acceptable. It creates a foundation to work into a working final prototype (Prototyping Model in Software Engineering: Methodology, Process, Approach, n.d.). This research methodology is used as it provides the advantage of detecting errors early in the stages of developing the system, as well as identifying any missing features in the system. The methodology also allow user to be involved with the development, providing feedback and pointing out flaws that usually gone unnoticed during development. The flexibility of this research methodology allows for changes to be made in the process of the development and for a better functional and complete system. The prototyping model have six phases. Phase 1 includes gathering information and analysis, where the requirements of the system are defined as detailed as possible. We conducted interviews and distribute questionnaires to gather a more complete picture of the requirements for the proposed system. Next, phase 2 involved quick design where a simple design that contains important detail of the system. This preliminary design gives a general idea of the system and helps in the process of developing the prototype. In the phase 3, a prototype was build based on the phase 2's preliminary design and data were collected. Phase 4 involves initial user evaluation on the current working prototype where the pros and cons are identified for improvement of the system. The Phase 5 involved refining the prototype. The initial prototype was modified based on the feedback from the user and a second prototype was developed. The phase repeats until the final prototype meets all the requirements. Phase 6 implement the final product for testing and evaluation and then deployed. Routine maintenance was performed periodically to prevent failures and minimizing downtimes. The overall architecture of the proposed system is depicted in figure 4 below.



Figure 4. Architecture of Cloud based Heartbeat Monitoring System with Location Tracking

## Results and Discussion

The system begins with login and registration. It is necessary for users to register an account in order to use the system. Firebase registers and authenticate users. The system encompasses of mobile application and a web application. Once the user has logged in the mobile application, it will be redirected to a page where user can either choose to connect with the Bluetooth ECG sensor or remotely monitor patient through the app. Figure 5 shows the login and registration page of the proposed system.



Figure 5: Login and Registration

The pairing feature of the mobile app connects with the HeartyPatch ECG sensor, and pairs the mobile device with the sensor through BLE (Bluetooth Low Energy) at 2.4 GHz. The device automatically transmits the data online to the Firebase realtime server. This feature requires Bluetooth functionality and location data to be switched on for the data collection. The alert button will send a notification to other users through Firebase realtime server and it will be shown in either the app or the web application. It will alert the other user about the patient at risk scenario. Next, figure 6 shows Bluetooth Pairing and Heartbeat Measuring.

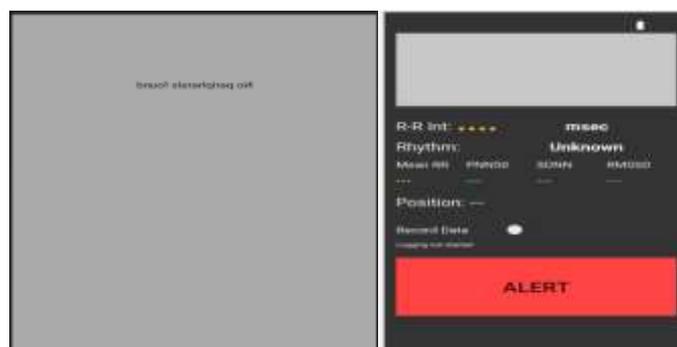


Figure 6: Bluetooth Pairing and Heartbeat Measuring

The remote patient monitoring allows the user to remotely monitor a person's heartbeat besides knowing the heartbeat last update. It shows the location of the patient and a graph that displays the heartrate. Figure 7 shows Mobile Application Remote Monitoring.



Figure 7: Mobile Application Remote Monitoring

On the other side, a web application also requires user login. User allowed to share one account with the patient and able to monitor the patient heartbeat and location in the web application. The user can observe the location, generate a graph of heartbeat and alert if the patient require help. Figure 8, 9, 10,11 and 12 reflects the information about the web applications in the proposed system.

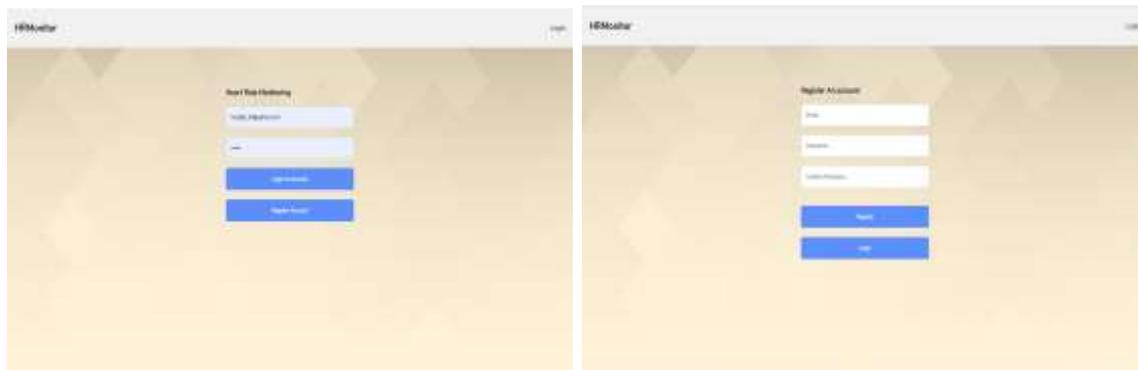


Figure 8 & 9: Web Application Login and Web Application Registration

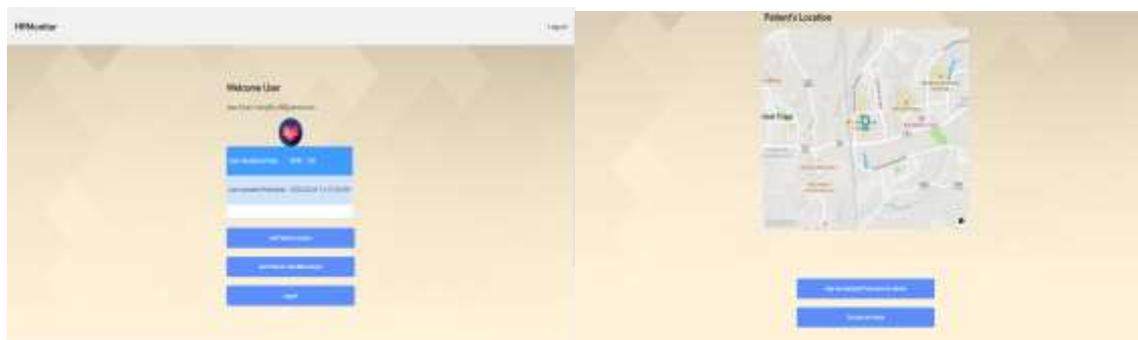


Figure 10 &11: Web Application Patient Heartbeat and Web Application Patient Location



Figure 12: Web Application Graph Measuring

Figure 13 shows data stored in the database. The changes are made in realtime and also reflected in realtime to devices connected. It allows seamless access and changes to be updated to devices connected to the cloud database. The database is stored in JSON format.



Figure 13: Firebase Realtime Database

Finally, feedback from the users are analysed. Based on the questionnaire, users agreed the approachability of the design. However, there are no negative feedback about the system. The evaluation was measured and majority of the users gave feedback that the system is helpful in monitoring patient heartbeat remotely. The bar chart in figure 14 shows overall functionality of the system. About 90% rated the overall functionality as above average.

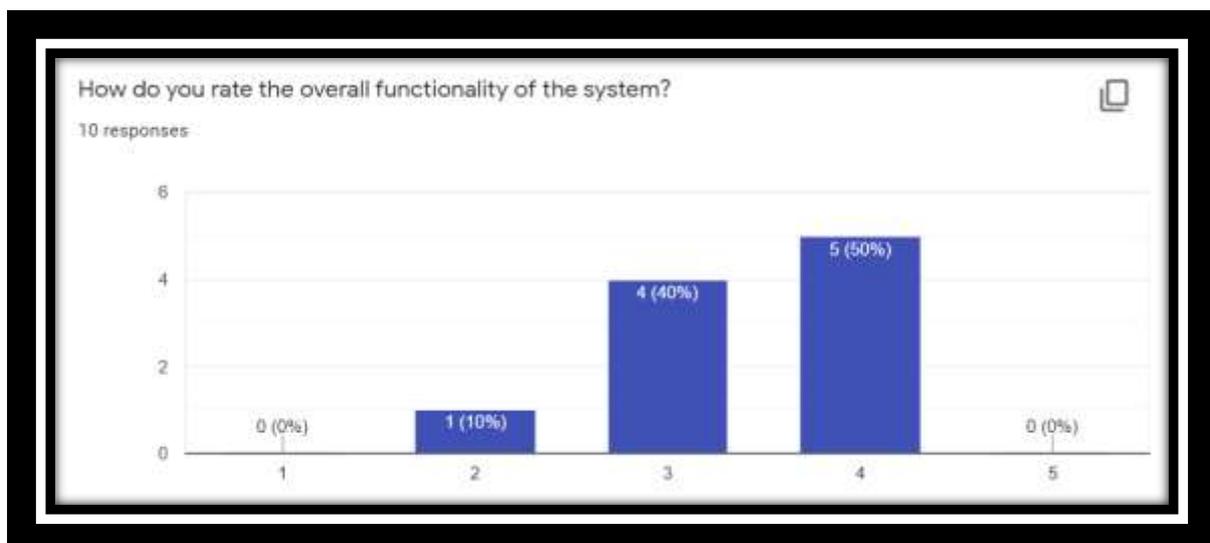


Figure 14: Bar Chart to evaluate the overall Functionality of the System

## Conclusions

The proposed system designed and tested to achieve the objectives and improve the usability of heart rate monitoring system. The proposed system designed for inexperienced user and enhance with cloud functionality and location tracking. The system consists lightweight Bluetooth ECG sensor that is flexible and convenient. This system is portable, allowing patient to carry it on a travel. The heartbeat rate monitoring system with enhanced feature of alerting and notifying user through cloud servers. The firebase realtime database allow data to be transferred in realtime and user can send an alert through a push button. The proposed system allows patient to be monitored and alert users in case of any emergencies. This may help in life threatening situations that will endanger patient's life.

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