Monitoring System Heartbeat Detection Based on Internet of Things (IoT) IBM Bluemix

Andry Fajar Zulkarnain*, Gunawan Rudi Cahyono, Arief Trisno Eko Suryo, and Akhmad Ghiffary Budianto

Departement Electrical Engineering Faculty of Engineering, Lambung Mangkurat University, Lampung, Indonesia
andry.zulkarnain@ulm.ac.id

Abstract. The design of this system is a real-time measurement of heart rate based on the Internet of Things (IoT) method of IBM Bluemix. Analysis of ECG (electrocardiogram) is using the help of sensors AD8232 and Arduino as useful hardware to determine the frequency of the patient's heartbeat. The results of sensor data will be sent to the IBM Bluemix cloud as a system monitoring tool. Beats per minute heartbeat (bpm) is one of the parameters to determine the frequency of the heart. In the mechanism, this system is connected to the physician, where data from the patient's heartbeat will be accessible at all times to always be aware of the patient's condition. The device also features an alert system that will send notifications if a patient's condition is considered dangerous and requires quick action to handle.

Keywords: IBM Buemix; AD8232; Arduino; Monitoring; Electrocardiogram (ECG)

1 Introduction

Health is the grace of each person where the heart is one of the vital organs that affect one's health. According to data from the American Heart Association more than 190 countries show disease illness remains the number one cause of death of the world with 17.3 million deaths at any time, where the figure is expected to increase to more than 23.6 million by 2030 [2].

To find out one example of coronary heart disease, the method used to diagnose is to use an electrocardiograph (ECG) device, the ECG will record changes that may occur in the heart [3]. Its history of ECG use began in 1903 which was pioneered by Einthoven using Galvanometer. With a galvanometer, which is a very sensitive instrument, it can be noted a small difference from the heart voltage. ECG can be used to diagnose abnormal heart rate, heart rhythm disturbances, and heart muscle damage. Therefore, this research study will discuss the monitoring of heartbeats detection system with Arduino and ECG based Internet of Things (IoT) IBM Bluemix.

Therefore, this research will discuss the monitoring of the heart rate detection system with Arduino and EGC based on IBM's Internet of Things (IoT) Bluemix. The use of ECG devices uses the AD8232 sensor configured with Arduino Uno Wi-Fi which sends

A. Putro Suryotomo and H. Cahya Rustamaji (eds.), *Proceedings of the 2023 1st International Conference on Advanced Informatics and Intelligent Information Systems (ICAI3S 2023)*,
Advances in Intelligent Systems Research 181,
https://doi.org/10.2991/978-94-6463-366-5_20

sensor data results to IBM Bluemix as Cloud Computing. Inside IBM Bluemix will display the values of ECG sensor data which will be used as monitoring of heart attack detection.

2 IBM Bluemix

IBM Bluemix is a cloud-based service that allows users to create, deploy and manage cloud-based applications quickly and securely. On Bluemix users can edit the application code and its data directly. Bluemix also facilitates users in accessing existing services to be merged into an app on Cloud Foundry.

Fig. 1. Bluemix Service

As for some features Bluemix used in this research include:

- Internet of things Platforms

Internet of things (IoT) Platforms is a service that gives users a kind of toolkit including gateway devices, device management and access of an application [6]. In this case, IoT Platforms are used as a gateway to connect an Arduino Uno Wi-Fi device combined with the AD8232 sensor to transmit sensor data to IBM Bluemix.

- Node-red

Node-red is a browser-based tool for creating an Internet of Things (IoT) application where in its visual programming environment makes it easy for users to create applications as "flow" [8]. On node-red are connected between services in Bluemix into a single unit in forming a system.

- Cloudant NoSQL DB

A database distribution service designed to store sensor data results by utilizing the existing flexible JSON scheme on the IoT Platforms service. Cloudant is ISO27001 and SOC2 Type 1 certified, to ensure data integrated Encryption and security features remain secure and protected [7].

- Freeboard

Freeboard is a third service found on IBM Bluemix that is used to display the visualization of sensor data. Freeboard configured with node-red service.

- Twilio

Twilio is a cloud-based communication platform used on IBM Bluemix to do SMS notification in real-time in the program to display the results of heart rate sensor data.

3 Hardware Design

In carrying out the system function design hardware is needed to perform the monitoring process of the heart rate detection system. AD8232 Single Lead Heart Rate Monitor module serves to measure electrical activity in the heart where electrical activity in the heart is analogous and mapped as an Electrocardiogram (ECG) [9][10].

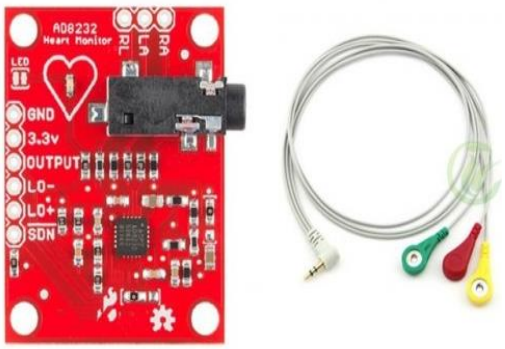

Fig. 2. AD8232 Sensor

AD8232 sensor is equipped with 3 pieces of an electrode that is attached to the patient's body to perform heart rate measurements. The standard technique of electrode mounting on the patient's body by Einthoven method is done in 3 places corner of the body those are:

- Lead I formed by making the left arm (LA – left arm) positive electrode and right arm (RA – right arm) negative electrode. Orientation angle 0^0.
- Lead II formed by making the left foot (LL – left leg) positive electrode and right arm (RA – right arm) negative electrode. The orientation angle of 60^0.
- Lead III formed by making the left foot (LL – left leg).

The positive electrode and right arm (LA – left arm) negative electrode. Orientation angle 120^0 [4].

AD8232 module has nine connection pins which in this study only used five pins consist of two digital pins Led Off Detect (+) and Led Off Detect (-), Output is analog, grounding (GND), and an operating voltage of 3.3 volts connected to the Arduino. The required pins are Digital pins (LO +) and (LO-) connected with pins 9 and 8 on Arduino. The output pin serves as the output signal to transmit the heart rate results is connected with the A0 pin on the Arduino. The grounding pin (GND) is connected with the grounding pin (GND) of the Arduino. And the operating voltage pin of 3.3 volts is connected to pin 3.3 voltage on the Arduino.

Arduino used to support the system Arduino Uno Wi-Fi. This board combines Arduino Uno and Wi-Fi chips ESP8266 as a communication protocol path between hardware with IBM Bluemix. The communication protocol path used is Message Queuing Telemetry Transport (MQTT). As for the sensor data transmitted from Arduino to IBM Bluemix JavaScript Object Notation (JSON)[1].

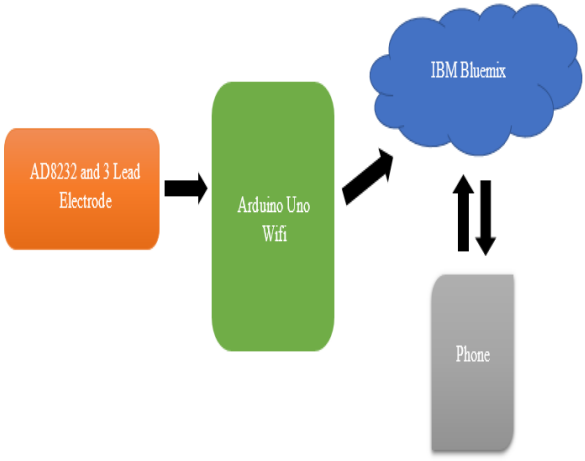

Fig. 3. Block Diagram System

The interconnection between systems is described in the following block diagram. The patient first checks the heart by using 3 lead electrodes on the AD8232 module. Arduino will process the results of sensor data which will then be sent via wireless to IBM Bluemix. On IBM Bluemix data will be displayed in the form of visualization that can also be monitored via mobile phone.

4 Software Design

The process of the software starts from the Arduino sketch to determine the parameters of the sensor data to be used in monitoring the heart rate detection system. In the sensor data section consists of analog data measuring 3 lead electrodes placed in the body of

the patient will get the parameter value from the analog output sensor AD8232. For the range of the correct AD8232 data fluctuates between 200 and 700. Cardiac pattern data is considered true if it has hills and valleys that form PQRST waves. These four waves represent of cardiac activity that are components of a single ECG wave. From these results, it can be said that the system was able to detect the patient's heart activity well [5][11]. Then for the second data that is data per beats per minute (BPM), result from measurement of heart pattern. Based on sources obtained from the American Heart Association, as for normal heart rate target based on age range as follows:

Age	Target HR Zone 50-85%	Average Maximum Heart Rate, 100%
20 years	100-170 beats per minute	200 beats per minute
30 years	95-162 beats per minute	190 beats per minute
35 years	93-157 beats per minute	185 beats per minute
40 years	90-153 beats per minute	180 beats per minute
45 years	88-149 beats per minute	175 beats per minute
50 years	85-145 beats per minute	170 beats per minute
55 years	83-140 beats per minute	165 beats per minute
60 years	80-136 beats per minute	160 beats per minute
65 years	78-132 beats per minute	155 beats per minute
70 years	75-128 beats per minute	150 beats per minute

Fig. 4. The target category of resting heart rate is average per age

Furthermore, after obtaining the results of the measurement of cardiac pattern sensor data, the sensor data will be transmitted through the MQTT protocol with the wireless network in Arduino. Previously configurations must be made by entering some parameters in the IBM Bluemix IoT Platforms service, including organization ID, device type, device ID, authentication method, an authentication token associated with Arduino for devices to connect with IBM Bluemix.

After the results of AD8232 sensor data connected to IBM Bluemix through IoT Platforms service then the next will be done processing the sensor data by utilizing the service node-red.

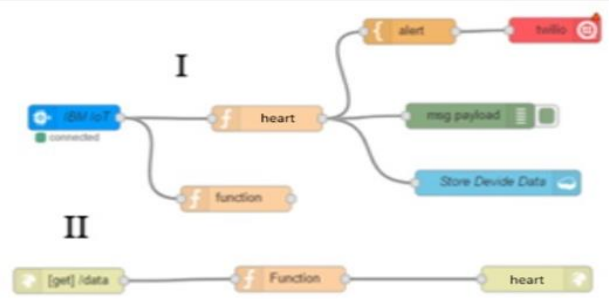

Fig. 5. Node-Red Scheme

The picture above is a scheme of the red node for monitoring the heart rate system. The flow scheme on the red-node is divided into two parts: the first part for processing and processing of sensor data and the second part for visualizing sensor data. The first flow starts from creating an IBM IoT node that is configured with IBM's IoT Platforms Bluemix service. Then create some node function to make the parameters of sensor data that will be displayed and stored in the database. The function of the node alert is that if there are values of sensor data that are considered to exceed normal limits then it will automatically send notification via short message service (SMS) by utilizing Twilio service on IBM Bluemix. As for the second flow sensor, data will be displayed by using freeboard visualization application by utilizing the node function to change the parameters of the sensor data into global so that it can be accessed more widely and followed by using HTTP get node and HTTP response to display the sensor data results through the Hypertext Transfer Protocol (HTTP) to be accessed by freeboard applications.

To display the results of heart rate sensor data as a support system monitoring process is done by utilizing the third application is freeboard configured with node-red on IBM Bluemix. There are several stages of configuration performed on freeboard applications to display in the form of visualization of sensor data from the heartbeat.

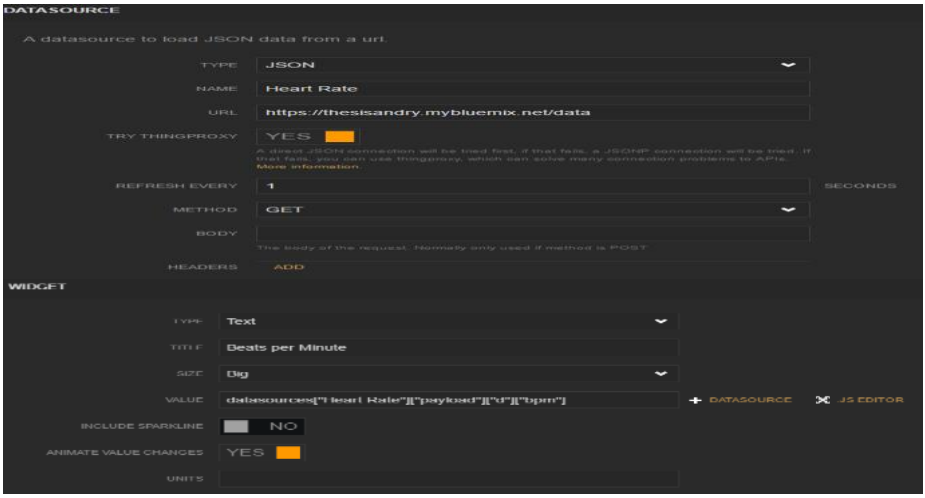

Fig. 6. Configure Freeboard

On the fretboard, there are two stages of configuration is data source and widgets. For the data source, a sensor data adjustment based on the red node of IBM Bluemix is a data type, URL address, length of a refresh of sensor data and data retrieval method. While the widget is done in the form of data tuning type widget that is displayed for sensor data and data source from heart rate sensor data.

5 Implementation And Testing

After doing the design stages in hardware and software, the next step is the implementation and testing of heart rate monitoring device. For the implementation of the system monitoring device consists of a combination of Arduino Uno Wi-Fi and AD8232 sensor as shown below:

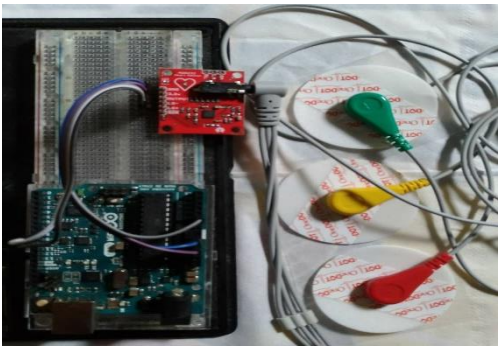

Fig. 7. Implementation Result

5.1 Data Sensor Testing

In IoT Platforms IBM Bluemix displays the results of heart rate sensor data obtained from AD8232 sensor measurements. The results of JSON-format sensor data and the interval of each sensor 10 millisecond (ms).

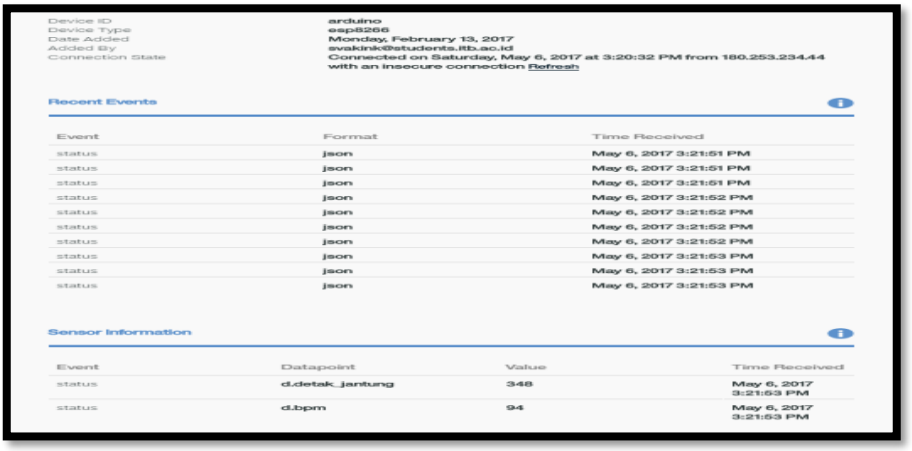

Fig. 8. Data Sensor

5.2 Node-Red Testing

In the configured flow node-red in each node, if all nodes are connected properly, it will display the sensor data results from the heart rate measurement. Then the sensor data that has been obtained is forwarded to the database to store the results of heart rate measurement data and to the application freeboard to display in real-time visualization.

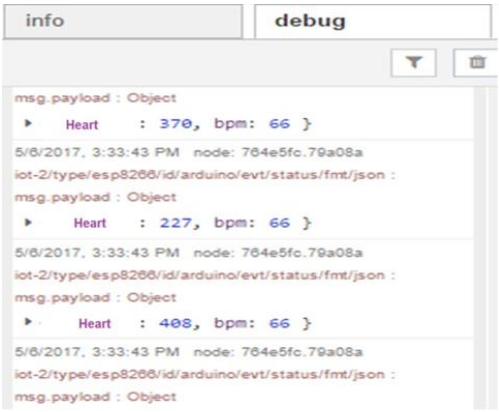

Fig. 9. Node-red Testing

5.3 Database Testing

The test database involves the value of the sensor data taken from the IBM IoT Platforms Bluemix scheme of flow between nodes on the node-red. For databases stored on the Cloudant service in JSON format.

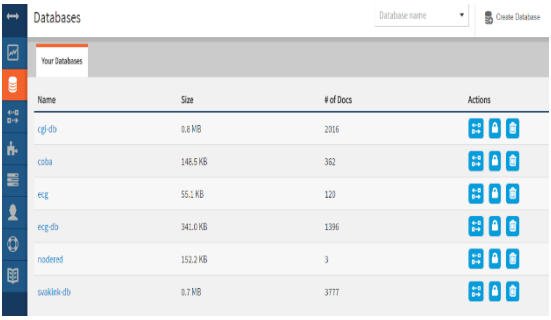

Fig. 10. Database Testing

5.4 Visualization Data Sensor

The results of visualization of sensor data for heart rate monitoring using two types of widgets that display data in the form of beats per minute (bpm) result of heart pattern

measurement and PQRST waveform graph. For the visualization of sensor data results from display data in real-time based on heart rate measurement devices.

Fig. 11. Visualization Data Sensor

6 Discussion

This research is to design an ECG device that can monitor the activity of heart rate user's movement using the AD8232 sensor with cloud-based IBM Bluemix. The required function has been fulfilled in this paper. Hopefully for the future will be more developed cloud-based devices for health and to be more practical and efficient. As well as for the further development of this research it is a necessary type of simpler lead electrode using wireless to facilitate the process of heart rate measurement.

References

1. Alkaff, M., Zulkarnain, A.F. and Rizqi, M.I., 2022. IoT Based Monitoring and Control System of Siam Banjar Orange Plants using Fuzzy Logic Control. IT Journal Research and Development, 7(1), pp.86-98..
2. http://news.heart.org/american-heart-association-statistical-report-tracks-global-figures-first-time/stat-story-12-17-03/
3. Karkra ,Shruti, and Butola, Rajat, "Arduino Based Health Reconnoitre System," International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5 Issue 6, June 2016.
4. Astuti, Aprilia Tri, Nuryani, and Lestari, Anik, "Automatic Electrocardiogram and QRS Interval Determination," Faculty of Math and Science: University Sebelas Maret.
5. Fauzi, Denta Ismail," Portable Tensimeter And Elektrocardiograf Design Based On Arduino Microcontroller," Faculty of Mathematics and Science : Sepuluh Nopember Institute of Technology.
6. https://console.ng.bluemix.net/docs/services/IoT
7. https://docs.cloudant.com
8. https://nodered.org
9. B.Patil, Harshavardhan and Umale, VM, " Arduino Based Wireless Biomedical Parameter Monitoring System Using Zigbee," International Journal of Engineering Trends and Technology (IJETT), Volume 28, Number 7 , October 2015.

10. Bhardwaj, A. and Kaliyar, R.K., 2023. Analyzing IoT Temperature Sensor Application on IBM Bluemix Cloud.
11. David, V., Ragu, H., Duraiswamy, R.K. and Sasikumar, P., 2021, January. Iot based automated indoor agriculture system using node-red and ibm bluemix. In 2021 6th International Conference on Inventive Computation Technologies (ICICT) (pp. 157-162)