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IoT blood pressure monitoring system

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ABSTRACT

The number of patients in hospital keep increasing every year and, some patients's blood pressure must be measured by medical staff regularly. This means that the medical staff need to attend to the patient routinely and several readings are required in each session to make sure the results are accurate. Therefore, there is a need to simplify the monitoring process inside hospital in Malaysia. In this work, IoT Blood Pressure Monitoring System (IBPMS) is designed to monitor patient's blood pressure remotely. This project use Raspberry Pi as a gateway to view the value of blood pressure online. Result showed that the design is capable to transfer data from blood pressure detector through the network using USB TTL serial cable which is directly attached to the Raspberry Pi. User can also view the blood pressure reading continuously from Telegram application and email service. Furthermore, the system can measure the value of blood pressure accurately when user is in sitting position.

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1. INTRODUCTION

The National Audit Department mentioned in its most recent report that emergency and trauma departments (ETD) at certain Malaysian hospitals were overcrowded, understaffed, underfunded and under equipped. The number of patients keep increasing and the Ministry of Health (MOH) must shoulder the heavy liability of providing health to the best of its capacity to all Malaysians. Thus, there is a need to simplify the monitoring process inside the hospital in Malaysia. It is easier to have online monitoring system to show every condition in engineering [1]. One method is to use Internet of Things (IoT) to monitor the patient's health. Nowadays there are a lot of applications being designed and implemented to increase the efficiency of hospital's management [2]. IoT blood pressure monitor is designed and developed to help the hospital's staffs monitoring the blood pressure reading of a patient remotely. This will reduce the dependability of the patients towards the hospital's staffs as well as enhancing how doctors make their decision based on patient condition at real time. IoT blood pressure monitor is also valuable for elderly or disability patients who might have difficulty to go to the hospital to check on their condition. The system is able to expand the medical services setting from patient's home to the doctor's facility.

Recently numerous researches had evolved the blood pressure monitoring system from many sorts including electronic sphygmomanometer, conventional sphygmomanometer and aneroid sphygmomanometer. Baharuddin in [3] mentioned two methods that can be used to measure the blood pressure, first method is using stethoscope and the second method is the automated type which is by the usage of high technology. Monitoring system based on IoT was discussed in [4, 5] using ZigBee technology. Ling in [6] proposed a blood pressure monitoring device which can connect to a computer and record the information but no IoT was implemented so far on the system. The research project proposed by Chao Li in [7] aims only at heart disease issues and not blood pressure. Numerous medical devices sensors were combined to analyse the rate of the heart disease patient. Dimitrios and Jonathan [8] suggested the design of IoT technologies have to enact universal design in order to better include elderly in managing their health and improving quality of life. Jahan in [9] used NRF module and LM358 sensor to measure systolic blood pressure and the results were compared with sphygmomanometer readings. An application system introduced by Salah in [10] measures the pulse rate and blood pressure of the swimmer and transmits the values to the rescuer mobile application. Smart healthcare monitoring system proposed by [11] used Node MCU connected to WiFi for sending patients health information and provides an alert by sending an email. Li in [12] developed a wireless blood pressure monitoring system using Zigbee and the system is observed using personal computer. Priyanka in [13] has developed health monitoring system using Arduino and Blynk Application. In this paper, ESP32 development board was used to enable the IoT function using WiFi. The proposed work in [14] developed a health monitoring system using GSM and raspberry pi module where the system able to send messages to the doctor in order to be subsequently analyzed for medical opinion. In [15], an IoT system is proposed and developed with the help of oxygen saturation (SpO2) measurement sensor, blood pressure sensor, temperature sensor, Bluetooth, Arduino. Bolivar in [16] presented the development of a wireless communication prototype, based on a physical arterial blood pressure monitor which will be able to send data to a web server due to ESP8266 Wifi interconnection module. An Arduino based health monitoring system was suggested by [17] where the data will be sent to computer for monitoring using LabView software. In [18], the Raspberry pi module was used as the microcontroller to send the health monitoring status of a patients to the server. Healthcare monitoring system was suggested by [19] where the data was sent to a webpage, which updates every two minutes.

A lot of previous works used database to monitor the developed system, where in this work the output is sent to mobile application and Gmail rather than personal computer. The suggested system in this paper has advantage in term of mobility, where the doctor or the hospital staff able to monitor the patient whenever possible. The rest of the paper is organized as follows. Part 2 explains the overview of the research method used in this paper. Results and analysis are elaborated in Part 3 and finally, the author concludes the findings of the paper in Part 4.

2. RESEARCH METHOD

This project consists of software and hardware implementation. The block diagram of the system designed is explained in Figure 1. The overall system is controlled by Raspberry Pi that able to detect data from the blood pressure device and send them over the internet for user to view it from Telegram and mail application. This application can be observed by anyone who has the authorities to access the data and information inside the server.

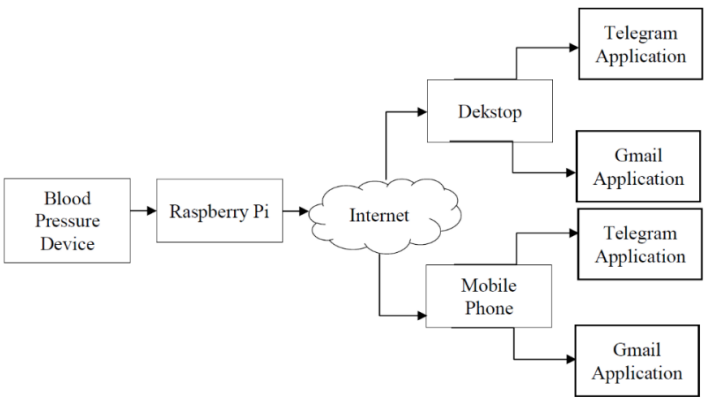

Figure 1. System block diagram

2.1. Software configuration

In order to complete the project, few softwares have been used to make sure the implementation can be done successfully. H-term is a monitoring tool used to read and view the serial data transferred from blood pressure detector to Personal Computer (PC). Figure 2 shows the display in H-term software where it able to display three types of data appears on the blood pressure detector continuously. Putty is another software tool used in this project where it was being used for network file transfer application. PuTTy is the medium software to run the program to execute on Raspberry Pi. To use PuTTy, one must make sure the IP address from Raspberry Pi has been checked and insert correctly. This is done to make sure the PuTTy can communicate with the Raspberry Pi device. Figure 3 shows that the PuTTy Software is used as a medium to run Python Programming language.

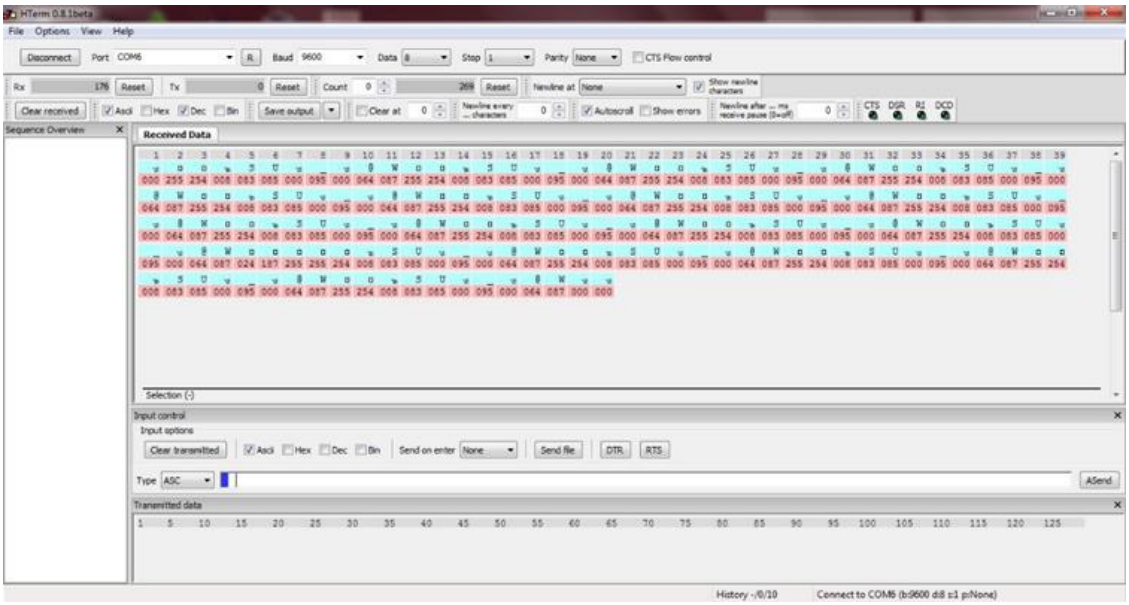

Figure 2. H-term software

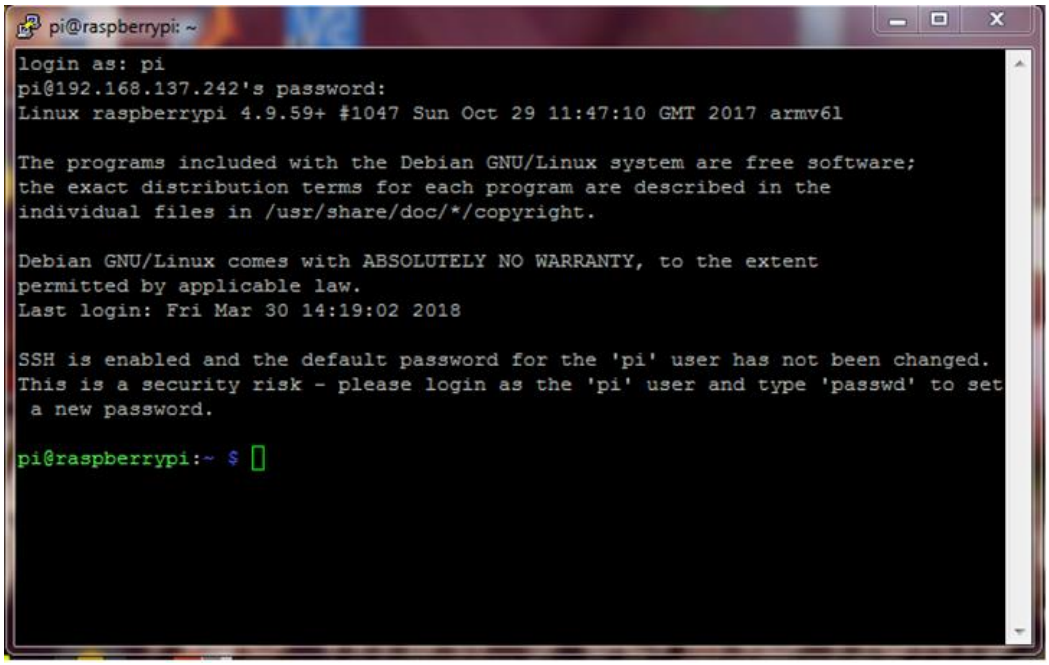

Figure 3. Putty software

The system flowchart is shown in Figure 4. The system starts when a user switch on the blood pressure device. The user then has to wait for the device to obtain the blood pressure measurement. The output will be displayed at Juice SSH Application before being transferred to email and Telegram application. JuiceSSH is a useful Android application that able to manage Linux servers easily.

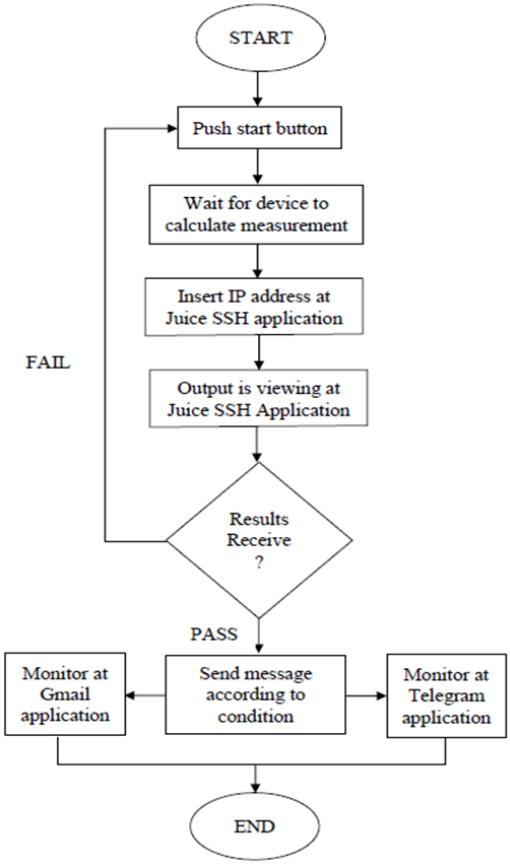

Figure 4. System flowchart

2.2. Hardware Configuration

Universal Serial Cable (USB) to TTL Serial cable is used to transfer the data obtained from the blood pressure detector to a personal computer (PC). There are two methods of internet connectivity in this project, by using Ethernet cable and wireless adapter. Raspberry Pi model B+ V1.2 is used in this project where it has 40 General-Purpose Input/Output (GPIO) pin. Raspberry Pi required 5 volts to power on the device and it can be done by connecting the USB cable to the PC. The blood pressure device used in project is a wrist type that has the model number CK101. The blood pressure data from Electrically Erasable Programmable Read-Only Memory (EEPROM) will be transferred to PC by using USB to Universal Asynchronous Receiver-Transmitter (UART) cable. Figure 5 shows the blood pressure device used in this project.

Figure 5. Blood pressure device model

3. RESULTS AND ANALYSIS

Figure 6 shows the completed designed prototype. The blood pressure detector which is a wrist type is connected to Raspberry Pi using a USB cable. Raspberry Pi is then connected to WiFi dongle for internet connection. A wireless connection is needed in order to transfer the data over the internet.

Figure 6. Product prototype

3.1. Results on Telegram and Gmail applications

The displays on Telegram application is shown in Figure 7 and the screen capture from Gmail account is depicted in Figure 8. Basically three information were displayed on both applications, the blood pressure readings; the summary of blood pressure readings; and the timestamp about when the information arrived. Based on information from American Heart Association (AHA) [20], the blood pressure is considered as normal if the systolic readings is below 120 mmHg and elevated if the systolic reading between 120 to 129. The rest is considered as stage 1, 2 and hypertensive. Based on that information, summary is made by programmer according to individual's systolic readings whether the readings are normal, low blood pressure, or high blood pressure.

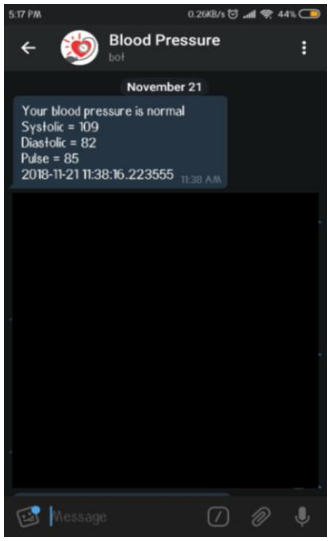

Figure 7. Telegram Application

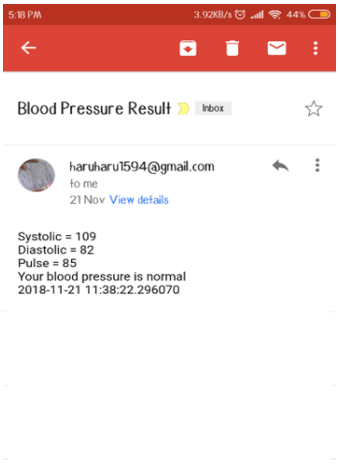

Figure 8. Gmail Application

3.2. Accuracy of blood pressure based on user's position

Figure 9 shows the data taken to observe the accuracy of readings based on the position of user. The user is having a normal blood pressure reading at the time the data was taken. Sitting position shows the blood pressure in normal condition, while in the standing position the blood pressure shows in high blood pressure level and at the lying position is at the low blood pressure. The best accuracy of the readings is obtained when the user is in sitting position with hand straight.

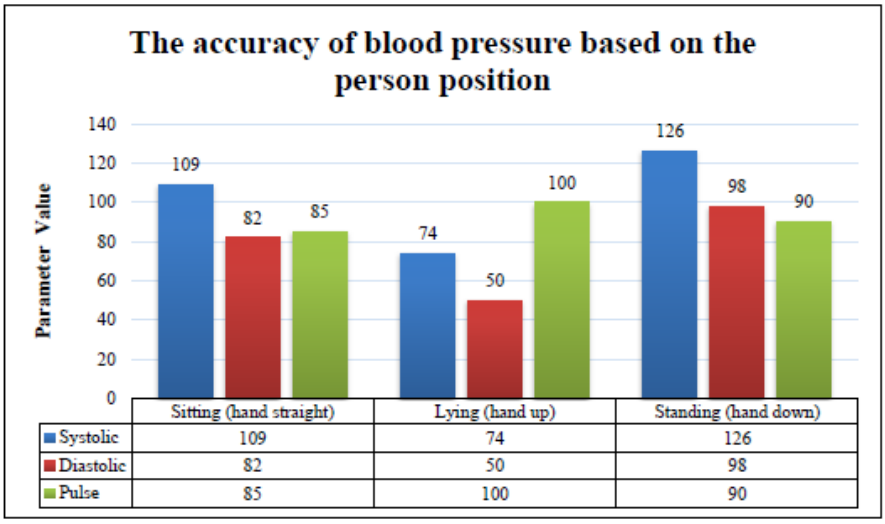

Figure 9. Comparison of received messages duration between WiFi and Ethernet Cable

4. CONCLUSION

This paper presents the design and development of IoT blood pressure monitoring system using Raspberry Pi. Results showed the system is able to read and send the data to both Telegram and Gmail application. The system has been designed and analyzed successfully. In future the connection between Raspberry Pi and blood pressure detector can be made wirelessly so that the design looks more compact. Besides, the design could be extend to read other health items such ECG. Futher more, different types of wireless technologies such as WiFi [21-23], Multi-hop Wireless Network (MWN) [24] and Device-to-Device (D2D) communications [25-27] can be incorporated into the system.

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