International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-4, April 2019

Real-Time Health Monitoring System using IoT and Mobile Applications

S. Aarthi, R. Gayathri

Abstract*: *Recent improvements in technology has made it possible for us to monitor our health status using a range of devices. It is now possible to monitor blood sugar, heart rate, temperature etc. without the need for a doctor to carry out such tasks. With these advancements in technology, it is now possible to develop a simple user-friendly health monitoring system and make it available to the community. The goal of this paper is to develop a real-time smart health monitoring system using Internet of Things (IoT), that is customized to the patient's need. The proposal includes the design of an app that would be compatible with smartphones and tablets alike. The application is used to store the user's medical information, and additionally allows people to be added as caretakers who can monitor the user's health through the app. The system would mirror functionalities available in equipment found in hospitals, with the added advantage of providing complex medical information in simpler terms, which is otherwise only understood by the medical staff. The proposed system uses Arduino microcontroller and sensors to monitor various health parameters.

Index Terms*: *Internet of Things, Patient Monitoring, Health Monitoring System, Mobile Applications

I. INTRODUCTION

In this day and age, it is now difficult for one to be conscious about their health. As healthcare goes unnoticed and untreated, people become more susceptible to health issues. Healthcare is the maintenance and monitoring of health through prevention, diagnosis and treatment. This is delivered by health and medical professionals such as doctors and nurses. However, in many sectors of the world, such healthcare is still unavailable despite improvement in both technology and healthcare. The other problem is the added expenditure of post-operative and post-hospitalization care. After the patient is discharged, follow-up at home is equally important and necessary to ensure the well-being of the patient. At home, continuous monitoring of health conditions provides caretakers visibility into the patients' path to recovery. Therefore, careful consideration must be taken for complete recovery. The process of noting down the health conditions at regular intervals is prone to user error. For example, it is possible that one forgets to take the reading at the required time, or it is also possible that a wrong entry is made. It is also important to administer medicine to the patient at the scheduled time. However, the possibility of providing the wrong pill or forgetting to administer medicine is high. These tasks can be simplified by developing a system that notifies them regarding their medication. Adoption of Internet of Things (IoT) in healthcare can significantly improve patient-care and reduce user errors. IoT is a system of interconnected devices and sensors that is capable of exchanging data. This allows them to make smart decisions. With the growth and advancements made in the area of Internet of Things, better and improved healthcare is now possible and easily accessible. The integration of IoT in healthcare can drastically reduce fatalities, and ensure a focused attention towards patients. With the integration of IoT in healthcare, it is possible to make quicker and accurate diagnosis regarding diseases and finding the best cure for it.

The idea of the proposed work is to construct a real-time health monitoring system using Internet of Things (IoT) along with an iOS app. The system consists of sensors that monitors different health factors such as blood pressure, electrocardiogram (ECG), pulse rate and oxygen saturation (SpO_2). The app is designed to record the medical information of the user such as the medicine to be taken, dosage, frequency etc. It has the added functionality of notifying the contacts (the patient's caretakers) regarding the same. The application also presents the information from the sensors at regular intervals in a simplified manner that is understandable by all. The paper is presented as follows: Section 2 states the relevant works on health monitoring systems based on Internet of Things. Section 3 elucidates the proposed system architecture, its features, advantages and implementation. Section 4 states the result analysis. Section 5 states the precis of the paper with closing remarks and the future work of the research.

II. LITERATURE SURVEY

Internet of Things (IoT) in healthcare has a multitude of benefits such as better patient-care, reduced user errors and smart decision making. A study [1] proposed the development of a healthcare system that allows guardians and doctors to oversee the health conditions of patients remotely through Internet. The system was developed using the E-Health Sensor Shield Kit, Phidgets Interface Kit and Arduino. The system also included a web interface using JavaScript, HTML5 and PHP. Study [3] suggested the development of system that monitors temperature and heartbeat using Arduino.

Manuscript published on 30 April 2019.
* Correspondence Author (s)
S. Aarthi*, Department of Computer Science Engineering, SRM Institute of Science and Technology, Chennai, India.
R. Gayathri, Department of Computer Science Engineering, SRM Institute of Science and Technology, Chennai, India.

Another study [5] focused on adopting Arduino into a smart healthcare architecture constructed on GSM/GPS technologies. The system checks the patient's blood pressure and body temperature, and notifies the doctor through SMS in the event of an emergency. A remote patient monitoring system [8] which monitors the oxygen saturation of the patient was developed. In case of the value of oxygen saturation level being lower than the specified 95% level, the system initiates the GSM shield and sends an SMS message to the doctor. Similarly, another study [9] developed a system that monitors blood pressure levels and sends the information to the doctor through SMS. Integration of mobile applications such as Android, iOS with IoT allows us to develop a user-friendly interface and make it available to everyone. A smart healthcare monitoring framework was proposed [4] to monitor health parameters such as Electrocardiograph (ECG), body temperature, blood pressure, heart rate, glucose level detector, galvanic skin response (GSR) using sensors. This framework was connected with an Android application that would display the required details and also send notifications to the doctor's phone when the threshold value is exceeded. The system is built on Arduino with various sensors such as temperature, heartbeat, glucose level detector and galvanic skin response. The importance of post-hospitalization care is stressed in a study [10] that proposed a system that repeatedly monitors the health of the patient using IoT and sensor devices, combined with an Android application. Health information is sent from the sensors to the cloud and application, which would be useful for required medical follow-up. IoT networks require a secure, wireless communication for smooth transmission of data between various devices. For this purpose, ZigBee is adopted as the global standard for wireless communications. The ease of integration of ZigBee into IoT systems and its secure nature makes it a reliable protocol. The benefits of ZigBee and mesh networking is the basis of a study [6] that aims at developing a system for pulse oximeter monitoring. Pulse oximeter are commonly used one patient at a time. Therefore, mesh monitoring is used to allow doctors and nurses to oversee various patients concurrently and remotely. The data obtained from different pulse oximeters is processed through Arduino - Nano, and finally displayed in the centralized unit. Similarly, study [7] developed a wireless sensor network that provides real-time health monitoring of patient's heart rate and oxygen saturation, using ZigBee topology. Commercial wearable healthcare systems and devices are now used by the community to monitor the number of steps taken, calories burnt, distance walked etc. Research has been conducted to develop wearable healthcare systems that monitor different health parameters. The benefits of wearable healthcare systems are multi-fold as they are cost-efficient, small, scalable and easy-to-use. A study [2] proposed a wearable real-time electrocardiograph (ECG) monitoring system integrated on a T-shirt. The ECG data is transmitted via Bluetooth (BLE) to end devices in the healthcare centres.

III. PROPOSED SYSTEM

The objective of this system is to record the various sensor information and display it to the users in a simple user-friendly manner. The recorded information which can be accessed through the app will indicate whether the reading is within the normal limits. It will also notify the user and the contacts regarding the medication requirements such as dosage, intake time etc. In this section, the components in the architecture will be elaborated.

A. System Architecture

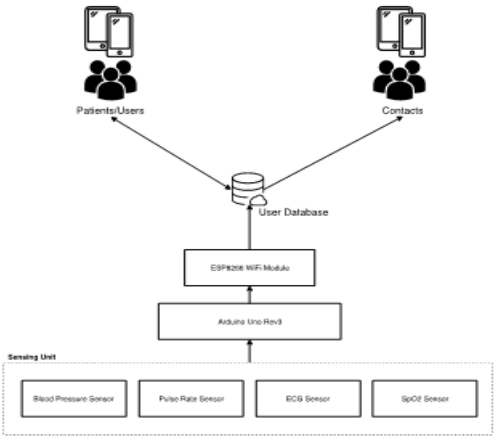

Fig. 1. Proposed System Architecture

1) Sensing Unit: This unit comprises of sensors that monitor different health parameters, namely pulse rate, blood pressure, electrocardiogram (ECG) and oxygen saturation (SpO_2). The components used are described as below.

a) Blood Pressure Sensor: BPS-BTA is a non-invasive sensor developed to measure human blood pressure. It is capable of measuring systolic, diastolic and mean arterial pressure using the oscillometric technique. Monitoring blood pressure is important because as it goes higher, there is more strain on the arteries thereby making it weaker. Due to these reasons, the chances of a stroke, heart attack, dementia is possible.

b) Pulse Rate Sensor: Pulse Sensor Amped is used in this design. Pulse rate is the measure of palpable blood pressure increase throughout the body that occurs with each heartbeat. Pulse rate can help to find cause for symptoms such as irregular or rapid heartbeat. In case of emergency, it can be used to verify whether the heart is pumping enough blood. The pulse rate can be weak, slow or fast, each of which has different causes and effects. For these reasons, measuring pulse rate is crucial.

c) ECG Sensor: AD8232 ECG is adopted to measure the heart's electrical activity at rest. ECG (Electrocardiogram) provides information such as the heart rate and rhythm. It can also provide information regarding the enlargement of the heart due to high blood pressure (hypertension), signs of decreased oxygen delivery to the heart, increased thickness of heart muscle and also reveal indications of a previous heart attack

d) (myocardial infarction). ECG is an important initial evaluation for patients suspected to have a heart-related issue. This component can be used if needed, depending upon the medical condition of the patient.

e) SpO_2 Sensor: MAX30102 Pulse Oximeter is used in the proposed design. Pulse oximeter is a non-invasive test which employs a probe that can be secured to a finger or earlobe. It measures the oxygen saturation level in blood. Normal oxygen saturation levels are between 95 and 100 percent. Low oxygen saturation levels below 90 percent can cause cells to be strained and damaged. Pulse oximeter is used to monitor the health conditions of a patient with problems that affect blood oxygen levels such as anaemia, heart attack, heart failure etc.

2) Arduino Uno Rev3: Arduino Uno Rev3 is adopted as the microcontroller board. It is based on ATmega328P. Arduino consists of 14 digital input/output pins, 6 analog inputs and a 16 MHz quartz crystal. It also supports USB connection, power jack, ICSP header and a reset button. The components of the sensing unit are integrated to the Arduino board.

3) ESP8266 WiFi Module: ESP8266 Wi-Fi Module is an economical Wi-Fi microchip. Its integration with TCP/IP protocol stack allows microcontroller to access Wi-Fi. This is integrated onto the Arduino board.

4) User Database: The database stores medical information given by the user (patient) during account registration. This information includes medication details such as frequency, dosage etc. Verified contacts of the user are notified of these details for patient care.

B. Working of the System

Arduino Uno Rev3 is connected with the components of the sensing unit, ESP8266 WiFi Module, and is powered by an external battery. The sensors are attached onto the patient's body. The system proposed will work as a real-time monitoring system.

According to the adjustments such as time interval between each reading made in the application, the readings of the sensors are recorded by the application and displayed. In case an emergency event is triggered, the application will send a notification and alarm the user and contacts of the situation. The mobile application will also provide an interface which notifies the user and the contacts of the medication that needs to be taken, according to the time specified. The application records these details and sends it to the database accordingly.

C. Application Design

The application is designed using Sketch on an iOS layout. The app plays the following purposes:

- Fig.3 depicts the user onboarding screen of the app.
- Fig.4 shows the medication along with information specified by the user, such as dosage, time to be taken and other instructions.
- Fig.5 presents the sensor reports on heart rate and blood pressure
- Fig.6 presents the past sensor reports on oxygen, heart rate and blood pressure, indicating the last recorded time. This is viewed by dragging down the screen.
- Fig.7 shows the calendar view of medical events.
- Fig.8 displays the contact information of caretakers and medical professionals. The user provides the level of access accordingly.

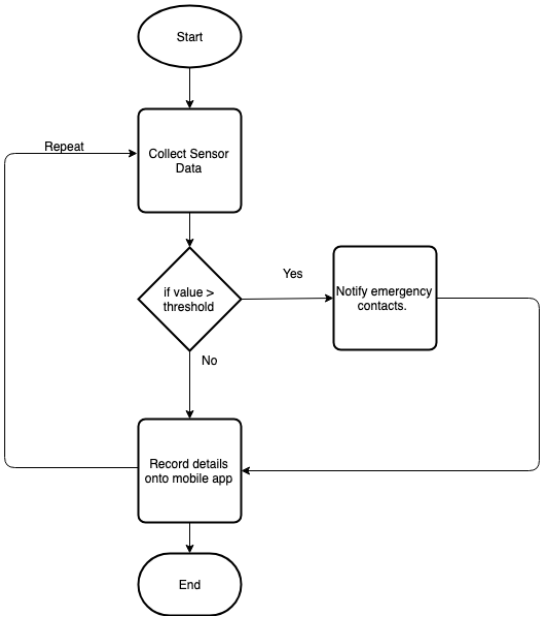

Fig. 2. Process Flow Diagram representing working of proposed system

D. Implementation

Using React Native, the proposed medical application, Genki, was implemented. It is derived from the Japanese word 元気 (Hiragana: げんき), meaning to be " healthy / good health / full of spirit".

The application works as follows:

- Under "Contacts" navigation in Fig.9, the emergency contacts are displayed and can be notified in case of an emergency event.
- Under "Home" navigation in Fig. 10, the readings of the different sensors will be updated in real-time and displayed. Medical reminders can also be added.

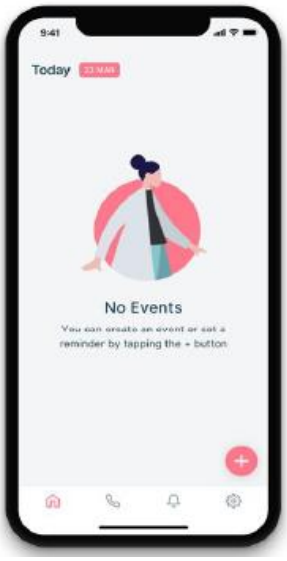

Fig. 3. User Onboarding

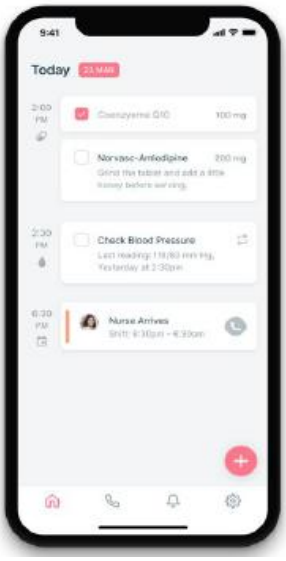

Fig. 4. Medication Reminders

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

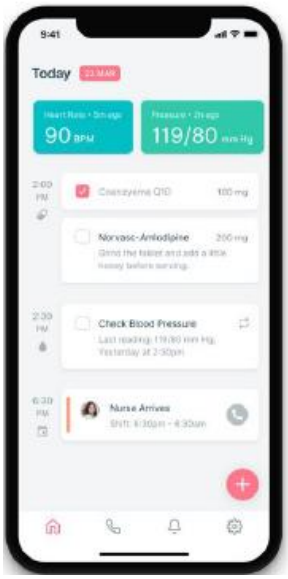

Fig. 5. Sensor Reports

Fig. 6. Expanded Report

Fig. 7. Calendar View

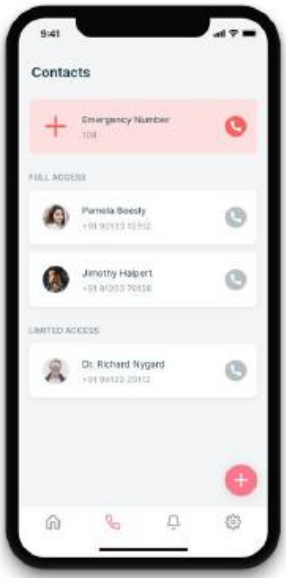

Fig.8. Emergency Contacts

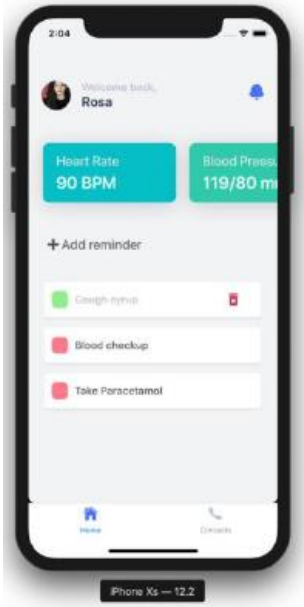

Fig. 9. Home Screen

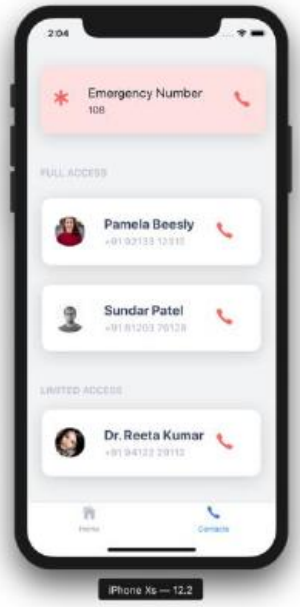

Fig. 10. Contacts Screen

IV. RESULT ANALYSIS

The special motivation for creating this proposed system design was to develop a process that would track the health vitals through the various sensors, thereby monitoring the health status of the patient in real-time. This would thereby enable the respective caretakers to examine the patient's recovery status and accordingly prescribe recommendations. The implementation of the application provides restricted functionalities. However, the limited time constraint was solely responsible for the restricted functionalities of the proposed system. Future work will look into the actual implementation of the proposed system and recording of results. The application can be further expanded to other devices.

V. CONCLUSION

This paper elaborated on the design of a real-time health monitoring system using Internet of Things (IoT). In the proposed work, the system is integrated with sensors that records the medical condition of the patient in real-time. The parameters that are measured are blood pressure, electrocardiogram (ECG), pulse rate and oxygen saturation (SpO_2). A mobile application is designed to store the medical information of the user. This includes details regarding the user's medication such as dosage, frequency etc. The user can also add contacts as caretakers. These contacts will be notified of the medication to be taken at the respective time as well as the event of any health parameter being over the threshold value. The primary objective of the paper was to introduce a simplified version of medical report details to the user, which would otherwise only be understood by doctors and medical staff. The priority was to develop a system that can be made available to the community for post-operative and post-surgery recuperation. This thereby reduces the expenses of repeated follow-up visits and post-operative expenses.

REFERENCES

1. Ghosh, A.M., Halder, D. and Hossain, S.A., 2016, May. Remote health monitoring system through IoT. In 2016 5th International Conference on Informatics, Electronics and Vision (ICIEV) (pp. 921-926). IEEE.
2. Wu, T., Redouté, J.M. and Yuce, M., 2019. A Wearable, Low-Power, Real-Time ECG Monitor for Smart T-shirt and IoT Healthcare Applications. In Advances in Body Area Networks I (pp. 165-173).
3. Krishnan, D.S.R., Gupta, S.C. and Choudhury, T., 2018, June. An IoT based Patient Health Monitoring System. In 2018 International Conference on Advances in Computing and Communication Engineering (ICACCE) (pp. 01-07). IEEE.
4. Kumar, S. and Pandey, P., 2018, March. A Smart Healthcare Monitoring System Using Smartphone Interface. In 2018 4th International Conference on Devices, Circuits and Systems (ICDCS) (pp. 228-231). IEEE.
5. Aziz, K., Tarapiah, S., Ismail, S.H. and Atalla, S., 2016, March. Smart real-time healthcare monitoring and tracking system using GSM/GPS technologies. In 2016 3rd MEC International Conference on Big Data and Smart City (ICBDSC) (pp. 1-7). IEEE.
6. Zulkifli, N.S.A., Harun, F.C. and Azahar, N.S., 2012, January. Centralized heart rate monitoring telemetry system using ZigBee wireless sensor network. In Proceedings of 2012 IEEE-EMBS International Conference on Biomedical and Health Informatics (pp. 265-268). IEEE.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

7. Watthanawisuth, N., Lomas, T., Wisitsoraat, A. and Tuantranont, A., 2010, May. Wireless wearable pulse oximeter for health monitoring using ZigBee wireless sensor network. In ECTI-CON2010: The 2010 ECTI International Confernce on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology (pp. 575-579). IEEE.
8. Mahgoub, M.T.A., Khalifa, O.O., Sidek, K.A. and Khan, S., 2015, September. Health monitoring system using Pulse Oximeter with remote alert. In 2015 International Conference on Computing, Control, Networking, Electronics and Embedded Systems Engineering (ICCNEEE) (pp. 357-361). IEEE.
9. Fajar, M.Z., Hadiyoso, S. and Rizal, A., 2017, September. An interfacing digital blood pressure meter with arduino-GSM module for real-time monitoring. In 2017 International Conference on Control, Electronics, Renewable Energy and Communications (ICCREC) (pp. 98-102). IEEE.
10. Reddy, A.N., Marks, A.M., Prabaharan, S.R.S. and Muthulakshmi, S., 2017, March. IoT augmented health monitoring system. In 2017 International Conference on Nextgen Electronic Technologies: Silicon to Software (ICNETS2) (pp. 251-254). IEEE.
11. Kioumars, A.H. and Tang, L., 2011, November. Wireless network for health monitoring: heart rate and temperature sensor. In *2011 Fifth International Conference on Sensing Technology* (pp. 362-369). IEEE.
12. Zulkifli, N.S.A., Harun, F.C. and Azahar, N.S., 2012, February. XBee wireless sensor networks for Heart Rate Monitoring in sport training. In *2012 International Conference on Biomedical Engineering (ICoBE)* (pp. 441-444). IEEE.

AUTHORS PROFILE

S. Aarthi, Assistant Professor (O.G.) at Department of Computer Science Engineering, SRM Institute of Science and Technology, Chennai. Areas of interest include Object Oriented Analysis and Design, Software Engineering.

R. Gayathri, 3rd year B. Tech Computer Science student at SRM Institute of Science and Technology, Chennai. Areas of interests are UI/UX Designing, Front-End Development.