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# MEASUREMENT OF HEART RATE VARIABILITY FOR HYPERTENSIVE PATIENTS USING IOT

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## ABSTRACT

*The measurement of heart rate variability is a simple test that has been in existence for thousands of years due to the low-tech requirements for measurement. Heart Rate Variability (HRV) is determined by measuring the time gap between heart beats that varies as you breathe in and out. Heart rate (HR) is measured in terms of beats per minute. HRV monitoring is highly sensitive for highly risks linked with cardiovascular disease, Diabetic Mellitus disease and Hypertension patients. Measurement of HRV by using some parameters for such cases of high risk will useful in for providing adequate medical care at needed times. Our idea in the proposed system, HRV parameters are derived using Wireless Zigbee based pulse sensor and the care taker and doctor are intimated through Short Message Service in order to provide adequate medical help in case of emergency situations. At present there are no HRV monitoring systems that alarm the high risk hypertensive patients along with the aid of a remote doctor, the proposed system aims to achieve the same. The proposed system combines the dual benefits of Zigbee and Wi-Fi technology. This idea successfully fulfills all the ideal traits of a remote health monitoring system in terms of low-cost, long range, security, promptness and easy-to-use that serves in saving lives.*

***Keywords***: Internet of Things (IoT); Zigbee; Transport Level Security (TLS); Quality of service (QoS); HRV Parameters; Arduino; Message Queuing Telemetry Transport (MQTT). I

## 1. INTRODUCTION

With the rapidly growing need for timely medical services, the traditional method of treatment at the clinic or hospital more often falls short in accomplishing success with respect to emergency cases. The method is to sense life threatening risks prior to the actual happening sounds to be the need of the hour. An IoT based system for healthcare offers to be a vital solution in adjourning such a critical issues. An IoT is the inter-networking system of various real world objects has become a popular phenomenon. The healthcare industry is being revolutionized by breaking the traditional methods. Hypertension has become a serious disease that intimates as the path causes for major Cardiac mortality and Stroke mortality. Hypertension is a condition such that the blood pressure in the arteries of the body is higher than 120/80 mm Hg (more than 120 systolic and more than 80 diastolic). Major Risks events like Stroke or Heart attack related to Hypertension does not happen all of a sudden; rather it is a continued risk factor that results in such life threatening events. The parameter used in this

system that uncovers even dilates intricacies regarding health condition. The study of HRV enhances our understanding of physiological phenomenon, the actions of medications and disease mechanisms [8]. HRV parameters enable to be a predictor for cardiovascular disease risk [7]. Thus, the proposed system achieves to remote monitor as well as alert in critical situation based on the HRV parameters and Heart rate for borderline Hypertensive patients. The proposed system that is based on IoT shares the results of sensor data in terms of graph and manipulated HRV data to a remote medical practitioner through a web application. This system or methodology helps in following up the patient's condition without a hospital visit and to check the effectiveness of the treatment offered by the doctor. Recently, there are several standards and proprietary devices that support sensor networks [9]. Of all comparable standards, Zigbee are believed to be reliable standards. To capitalize the potential of such a dynamic system that is proposed here, the Quality of Service (QoS) and Security in wireless transmission of data needs to be taken care of. This is satisfied by the proposed system with the usage of a light-weight publish messaging protocol MQTT for IoT. Publish messaging paradigm is found much useful in remote monitoring systems. In a publish paradigm, the messages are published to an intermediate messaging broker and the subscriber shall obtain the required message from the broker by subscribing. A topic-based publish system (sub-categorical in publish/subscribe system) where the publisher publishes the messages to a topic (named logical channel) and the subscribers receive messages from a topic to which they are subscribed is used in the proposed system. The MQTT protocol for their well-known levels of QoS solves the QoS problem that was to be addressed. TLS, a cryptographic protocol analyses secured transferred data from remote patient to a Server at the doctor end alongside MQTT. There are no remote HRV analysis systems for hypertensive patients available to help doctors track the progression of the patient's condition and serve as an alert system prior to critical medical events

## 2. RELATED WORKS

In this system, it uses an IOIO microcontroller board that obtains ECG signals and sends it to the mobile device wirelessly using Bluetooth technology. In order to collect, store and transfer the ECG data, an android application is used. This also visualizes the data collected at the front-end. The data collection was saved as a binary file. The patient at the mobile device end was connected to the File Transfer Protocol server (FTP) via Filezilla to upload the files. The server also supports multiple user logins with authentication. The medical professional can download all the data of the patient which was uploaded from the FTP server for analysis of the patient's ECG waves. The unstructured binary files are uploaded via a FTP server and are stored in a file table. The file table helps to manage the files and the file metadata in a synchronized manner. This system incorporates a high level communication like machine to machine communication. The monitoring system of ECG and Temperature signals were implemented using Bluetooth technology. This technology uses an Arduino Uno board with ATmega328 microcontroller as data acquisition unit and for Analog/Digital conversion. An ECG acquisition takes place on a 3-lead module followed by filtering and amplification of acquired signals. The Data was transferred to a local device (Personal computer or Mobile phone) through Bluetooth technology. The Captured signals and the visualized signals are then sent to a remote database for storage which could be accessed by a web application deployed on server. A wireless channel of ECG transmission system that caters to monitor the health of old using a Personal Digital Assistant (PDA) phone had been developed. The system

consists of two ATmega328L microcontrollers namely Zigbee transmitter and Zigbee receiver. The transmitter end used to collect the data, stores in a Secure Digital (SD) card and transmits. The receiver sends collected data to a remote server for further processing. It helps to cope with sudden attacks of diseases by continuous monitoring. This system uses Bluetooth technology with sensor to transmit data to a smart phone. An application had been designed and used in the smart phone to transfer data to a remote server through Wi-Fi/3G for centralized monitoring. In the remote server end, a Lab VIEW based application shall do the necessary analysis on the obtained patient data especially heart rate over the entire long period of monitoring. An application shall also provide a window based look into the patient's condition from the obtained data. The physiological parameters monitoring system has been designed and developed in [4]. The system consists of heart rate sensor and temperature sensor to be worn by an at-risk person that is connected to a computer wirelessly. This device monitors as long as the data is logged into the system and sets up an alarm through the connected computer in the home when the parameters are found to be in risk level. MQTT protocol has been presented as the most widely applicable lightweight, fast communication, efficient protocol for IoT in [10]. It is found to reduce network traffic and minimizing transport overhead for dynamic communication in IoT according to the survey. It is completely found suitable for usage with constrained devices indulged in sensor networks. HRV had been monitored for hypertensive patients in the Indian population and is proved that HRV parameters are significantly reduced for hypertensive patients compared to normal, healthy subjects in [13]. The research involved hypertensive patient and normal subject to use HRV parameters for diagnosis of hypertension in [5]. An analysis of 30 normotensive and 30 hypertensive subjects have been performed and verified in [6]. The results concluded that the hypertensive condition could be well monitored and managed with the help of HRV time domain parameters which are drastically lowered compared to normotensive person. It is proved that HRV is a vital parameter for monitoring of Hypertension disease

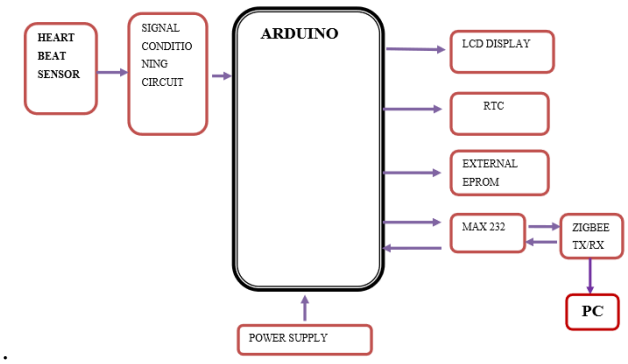


**Fig-1**:Architecture of Proposed System

An IoT based system in healthcare connected to a remote database or a remote server would serve for promptness in times of emergency, earlier diagnosis and prevention. The proposed system in this paper explains the design of low-cost, secured, scalable and efficient Remote HRV monitoring system.

## 3. ARCHITECTURE OF PROPOSED MODEL

3.1 Wireless Pulse Sensor Module

1) Wireless Pulse sensor: The Pulse sensor is used to detect the heart beat by the method of a Photoplethysmograph (PPG). Then PPG illuminates the skin optically and measures the pulse as a variation of resistance to the blood flow in the skin. The sensor could be attached to the finger/earlobe. The variation can be determined as a fluctuation in the analog values from the pulse sensor.

2) Zigbee Protocol: The use of Zigbee protocol in various health monitoring systems has become one of the most promising standards for short range wireless communication. There are lot of devices are incorporated with Zigbee standard, XBee is a 20-pin microcontroller made by digi that uses Zigbee protocol. An Operating voltage of 3.3V accounts required for the low-power consumption. There are three different roles that XBee could be assigned to in a network.

(i) Coordinator – It is available in every network as it takes care of the whole network. A network can have only one Coordinator.

(ii) Router – It is in relation with relaying data to the destination. Multiple routers may exist in a network.

(iii) End Point – Multiple end points may exist in network. XBees can able to act as any one of two modes, AT or API mode depending upon its use. The XBee that senses data should be set to AT mode and the one receiving shall be set to API mode. In our system, two XBees would be used.

**3.2 Intermediate Gateway Unit**

This unit is responsible for establishing a secured communicating channel for transmission of pulse data from pulse sensor module to the severs.

1) Arduino Uno: The Arduino Uno is a microcontroller board that is embedded with ATmega328 microcontroller. The board is used as a platform with sensor and associated networks for their 14 Digital pins and 6 Analog pins on them. An Arduino Uno board enabled with Zigbee through XBee and WiFi through ESP8266 is made to act as a gateway to the MQTT server from the Wireless Pulse sensor module. XBee act as coordinator shall receive data from pulse sensor module in the receiver end. Analog/Digital conversion is performed on the Arduino board. This data is formatted into JavaScript Object Notation (JSON) and it is ready for transfer to the MQTT server. Its light weighted nature and faster communication makes it highly suitable for data interchange scenario compared to XML format.

2) WiFi transmission with MQTT :

WiFi is the technology that can able to connect the devices to the internet via a wireless LAN network. The long range communication compared to other wireless technology in the IoT networks is available. It enables Arduino in the proposed system shall transfer the JSON formatted data to the MQTT server utilizing MQTT as the messaging protocol. Of various emerging protocols for connectivity of electronic, computing device and machine-2machine (M2M) communication such as AMQP (Server to Server), XMPP (Machine to Human) and DDS (Machine to Machine), MQTT v3.1.1 has now become an accepted standard for communication by Organization for the Advancement of Structured Information Standards (OASIS). QoS 1 (highest QoS for MQTT- “atmost once”) is used to properly make the data to reach the other end with acknowledgment messages between the sender and the receiver end.

MQTT protocol depends upon Transport Control Protocol (TCP) as transfer protocol where security is traded off. For secured channel of communication, we use TLS protocol with MQTT in the proposed system for secured channel of communication. TLS is a cryptographic protocol based upon a handshake mechanism comprising of data encryption with cipher texts meant for the MQTT server used. This certificate provided by the server is validated at client side. TLS protocol also specifies the type of certificates that must be exchanged for enhanced secured connectivity. The proposed system connects to port 8883 that is allocated for a secured MQTT connectivity.

## 4. IMPLEMENTATION AND RESULTS

4.1Result 1

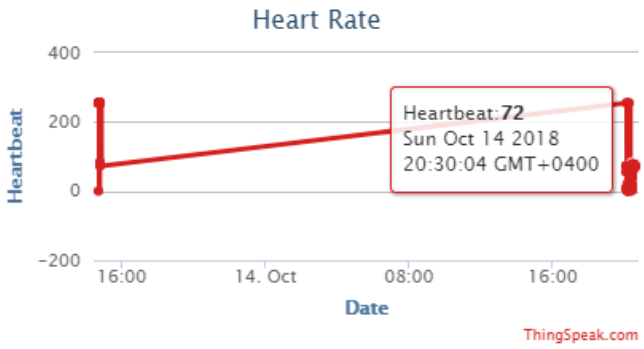


Fig. 4.1 Heart Rate of Normotensive patient

In the result 1, we measured the number of heart beats per second and it gives the result as 72 number of heart beats per second with accurate date and time which shows that patient is in normal condition as shown in the fig.4.1

4.2 Result 2

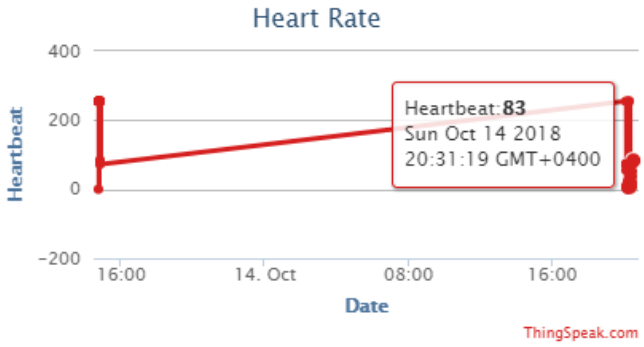


Fig. 4.2 Heart Rate of Normotensive patient

Inthe result 2, we measured the number of heart beats per second and it gives the result as 83 number of heart beats per second with accurate date and time for normotensive patient as shown in the fig.4.2

## 5. CONCLUSION

The research presented in this report describes about the real time heart variability monitoring and alerting system. A real time monitoring system was developed to evaluate the heart rate variability condition of the

patient. This consists of three modules: an electrode, hardware module and software were designed, developed, and validated to implement the proposed real time measurement and alertness of the heart variability. The Concept of remote monitoring the patient's condition is one among the various break-through in healthcare industry by IoT. There are various issues regarding power consumption, security in the wireless networks and efficiency in data interchange has proven to limit the usage of remote monitoring systems at large scale. The proposed system here has involved solving all limitations and is designed to be more reliable, low-cost, easy-to-use system for Hypertensive patients by combining the benefits of Zigbee and WiFi technologies. HRV monitoring for hypertensive patients will prove useful to provide adequate care to serious scenarios such as cardiac mortality and stroke mortality. The proposed system achieves the same. The proposed system is very helpful to monitor the HRV parameters for Hypertensive patients through a web application. The application is used to monitor the HRV parameters and provides results as graph. In case of emergency situations, the system intimates SMS to care taker and doctor to provide immediate medical help. The system was made to analyze the act on 3 normotensive and 3 hypertensive patients. The observation conclude that there is decrease in HRV time domain parameters beneath the normal range for hypertensive patients compared to normotensive person Thus, the proposed system successfully functions to monitor and provide insights regarding Hypertension condition.

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