ISSN 2319-2720
Volume 7, No.2, April – June 2018
International Journal of Computing, Communications and Networking
Available Online at http://www.warse.org/ijccn/static/pdf/file/ijccn34722018.pdf
https://doi.org/10.30534/ijccn/2018/34722018

Health Monitoring System Using IoT and Raspberry Pi

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ABSTRACT

Now-a-days health problems like cardiac failure, lung failures & heart related diseases are arising day by day at a very high rate. Due to these problems time to time health monitoring is very essential. A modern concept is health monitoring of a patient wirelessly. It is a major development in medical arena. This project is based on the monitoring of the patient that is done by the doctor continuously without actually visiting the patient. Health professionals have developed a brilliant and inexpensive health monitoring system for providing more comfortable living to the people suffering from various diseases using leading technologies like wireless communications, wearable and portable remote health monitoring device. As a result, visits of doctors to the patients constantly are decreased as the information regarding patient's health directly reaches to doctor's monitor screen from anywhere the patient resides. Also, based on this, doctors can save many lives by imparting them a quick & valuable service. In this, IoT is becoming a major platform for many services & applications, also using Raspberry Pi not just as a sensor node but also a controller here.

This paper propose a generic health monitoring system as a step forward to the progress made in this department till now.

Keywords: IOT; Raspberry Pi; MQTT; Health Monitoring.

1. INTRODUCTION

In today's era, health problems are increasing day-by-day at a high pace. The death rate of 55.3 million people dying each year or 151,600 people dying each day or 6316 people dying each hour is a big issue for all over the world. Hence it is the need of hour to overcome such problems. We, therefore, proposing a change in technology by designing a system which included different sensors to receive information with respective human body temperature, heart rate etc. that will be undoubtedly further transmitted on an IoT platform which is accessible by the user via internet. An accessible database is created about patient's health history which can be further monitored & analyzed by the doctor if necessary. The data storage can be saved on the server permanently or can be reset via the software. This paper proposes a health monitoring system which is capable of detecting multiple parameters of our body such as temperature, heart rate & further transmitting this information on an IoT server through 2G/3G/4G GSM technologies. Also in case of emergency, automatically generating alerts will be sent to doctors and family members if any unusual activity is detected by or near the patient. A continuous record of body health parameters can be used to detect the disease in a more efficient manner. Now-a-days, people pay more attention towards prevention & early recognition of disease. In addition to it, new generation mobile phones technologies & their services provides an important impact on the development of network varieties (3G, Bluetooth, wireless LAN, GSM) etc. Various sensors have been used like pulse rate sensor and DHT22 temperature sensor is used to measure surface temperature of skin. Satisfactory work is done in health monitoring by using raspberry pi as well as IoT, but this paper gives embedded concept of both the platform. By using combination of these, the proposed structure will be more effective. In this paper, we investigated recent papers related to health monitoring systems & IoT. IoT is nothing but an advanced concept of ICT (Information Communication Technology). IoT is the interconnecting of devices and services that reduces human intervention to live a better life. This paper as showing the advancements in health care management technology, it would save patients from the future health problems that would arise and would also help doctors to take an appropriate measure or action at a proper time regarding patient's health.

2. RELATED WORK

The "Internet of things" - IOT is a concept and model consisting of sensors, actuators, and development boards interacting with each other connected over the internet without any human intervention resulting into a more intelligent system. In simple words, IOT refers to a network of objects all connected to the internet at the same time. The main principle of Internet of things (IOT) is that the objects/things i.e. sensor nodes identify, sense, process and communicate with each other [1]. IoT has a substantial influence in healthcare domain. Still, there are so many people who do not have access to

quality healthcare services, thus remote patient monitoring becomes a need. Presently Healthcare system is shattered with the lack of communication between the patients and the doctors. Thus to address this problem information technology becomes a need. Healthcare services can be improved a lot with IoT-enabled healthcare devices. By applying IoT concepts in healthcare, there is a great possibility of virtually saving the lives. E-health solutions based on IoT should provide worth information about health to the patients and the doctors can make better decisions irrespective of their patient's location [2]. IoT has already brought changes in various domains of health care like intelligent healthcare tools and devices, diagnostics and monitoring of patients, data storage, transfer, and collaborations. Till now several studies have been done in the healthcare domain of IOT, some researchers are monitoring the body temperature using an LM35 sensor which finds great use in power supplies, battery management, appliances etc. but not suitable for body temperature measurement [4]. For pulse rate measurement, some researchers are relying on android applications preinstalled in the smartphones. Application crashing is most frequent in android phones which make it unreliable. There are certain security issues in android devices, and serious problems may occur if this health-related data gets tampered [11].Performance of the camera, Proximity of flashing LED to the lens of camera and Algorithm involved in the extraction of the pulse rate are certain factors which can affect the reading of heart rate obtained by the smartphones so at the same time one can get different readings using different smartphones and it becomes rather difficult to trust the data received. Similarly, a thermistor is used by some people for body temperature measurement though it is meant to be used for industrial purposes and both LM35 as well as thermistor are not wearable [3].Thus, to solve these problems a system consisting of wearable temperature and pulse rate sensor along with Raspberry pi is designed. Once the data is received by the Raspberry pi board it will be sent to the IBM cloud i.e. Bluemix, the data stored in the cloud can be retrieved by the doctor.

3. PROPOSED SYSTEM

We, propose a change in sensors technology by designing a system which included different wireless sensors to receive information with respective human body temperature, blood pressure, saline level, heart rate etc. that will be undoubtedly further transmitted on an IoT platform which is accessible by the user via internet. An accessible database is created about patient's health history which can be further monitored & analyzed by the doctor if necessary. The data storage can be saved on the server permanently or can be reset via the software. This project proposes a health monitoring system which is capable of detecting multiple parameters of our body such as blood pressure, temperature, heart rate, ECG & further transmitting this information on an IoT server through 2G/3G/4G GSM technologies. Also in case of emergency, automatically generating alerts will be sent to doctors and family members if any unusual activity is detected by or near the patient. A continuous record of body health parameters can be used to detect the disease in a more efficient manner. Now-a-days, people pay more attention towards prevention & early recognition of disease. In addition to it, new generation mobile phones technologies & their services provides an important impact on the development of network varieties (3G, Bluetooth, wireless LAN, GSM) etc.

A. Design Of Proposed System

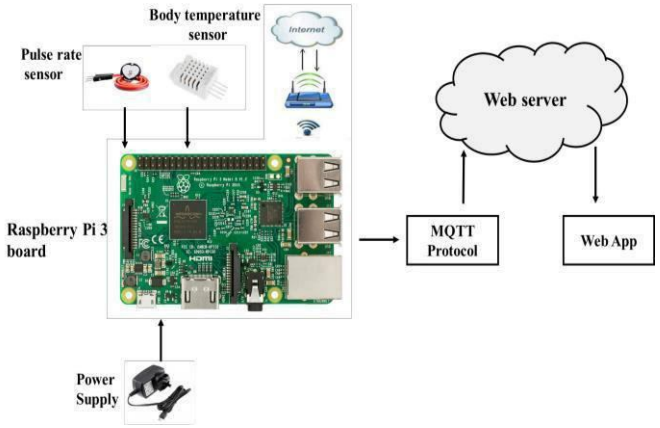

Figure3.a. System Architecture

B. User Profile Operations Module

This module provides the users of our project with a user interface to get access to our project. A user can create an account after which he will be able to access his/her account. Other operations a user can perform on his account are Login, Logout, Edit profile, Delete profile, change password, and retrieve password in case he/she forgotten.

The user then will be able to perform the configuration of MQTT. The end user will be provided with an interface where he/she can enter the IP address (host name) and port number of the mosquito server. Then portal then sends the request to the servlet layer to establish a TCP connection with the mosquito server which will be running on the Raspberry PI.

C. Body Temperature Module

Here, we will be implementing the human body temperature module. We will be using the DHT22 body temperature sensor for this purpose. The DHT22 sensor will be directly connected to the Raspberry PI and will be reading the human body temperature data every 3 seconds. The raspberry PI will then sends the data to the Mosquitto server installed which will eventually forward the temperature data to the web application module where the doctors will be able to monitor it from the remote geographical location. The DHT22 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use, but requires careful timing to grab data. The only real downside of this sensor is

you can only get new data from it once every 2 seconds, so when using the library, sensor readings can be up to 2 seconds old. Simply connect the first pin on the left to 3-5V power, the second pin to your data input pin and the rightmost pin to ground. Although it uses a single-wire to send data it is not Dallas One Wire compatible! If you want multiple sensors, each one must have its own data pin.

D. Heart Rate Module

Here, we will be implementing the human body temperature module. We will be using the pulse sensor for this purpose. The pulse sensor will be directly connected to the Raspberry PI and will be reading the human heart rate data every 3 seconds. The raspberry PI will then send the data to the Mosquitto server installed which will eventually forward the temperature data to the web application module where the doctors will be able to monitor it from the remote geographical location. Heart rate data can be really useful whether you're designing an exercise routine, studying your activity or anxiety levels or just want your shirt to blink with your heart beat. The problem is that heart rate can be difficult to measure. Luckily, the Pulse Sensor Amped can solve that problem! The Pulse Sensor Amped is a plug-and-play heart-rate sensor for Raspberry PI. It can be used by students, artists, athletes, makers, and game & mobile developers who want to easily incorporate live heart-rate data into their projects. It essentially combines a simple optical heart rate sensor with amplification and noise cancellation circuitry making it fast and easy to get reliable pulse readings. Also, it sips power with just 4mA current draw at 5V so it's great for mobile applications. Simply clip the Pulse Sensor to your earlobe or fingertip and plug it into your 3 or 5 Volt Arduino and you're ready to read heart rate! The 24" cable on the Pulse Sensor is terminated with standard male headers so there's no soldering required.

E. Patient Directory Module

In this module, the authorized doctors can register a new patient to the portal by providing the following information: patient name, patient email, patient mobile number, and the patient's unique topic name. The patient's unique topic name is the identifier used for a specific patient's data coming from the mosquito server. As soon as the doctor registered a new patient, an email will be triggered to the patients' mail id specified. The email will contain the link where the patients can access the read-only report. This read only report will contain all the advices provided by the doctors to him/her. However, the patient will not be given any write/delete permission to any data in the portal. In this module, the doctor will also be provided with an interface where he/she can see the list of all the patients added to the portal. The patient added by one doctor will be visible to all the other doctors since the privacy is made at the hospital level and not at the independent doctor's level. Every authorized doctor in the portal will have an access to remove the patient's record at any point of time. Once the patient's record have been removed by any of the doctor, that particular patient will no longer be having access to the read-only report.

F. Patient Health Data Module

In this module, every authorized doctors in the hospital portal will be provided with an interface where he/she can provide the medical advices to the patients based on the data gathered from the health sensors. The body temperature sensor will gather the body temperature data of each patients and stores it in the hospital portals' MySQL instance. Similarly the pulse rate sensor will gather the heart rate of each patients and stores it in the hospital portal's MySQL instance. The hospital portal will then read both the information from the MySQL instance and displays it in a web page whose access is given to each doctor. The doctor then will have to carefully monitor the data for each patient and provide the medical advice for them. The patient added by one doctor will be visible to another doctor and hence the advice can be given by any doctor of the hospital. As soon as the doctor provides a medical advice, an email will be triggered to the patient's mail ID notifying the patient regarding the advice.

G.Data Flow Diagram

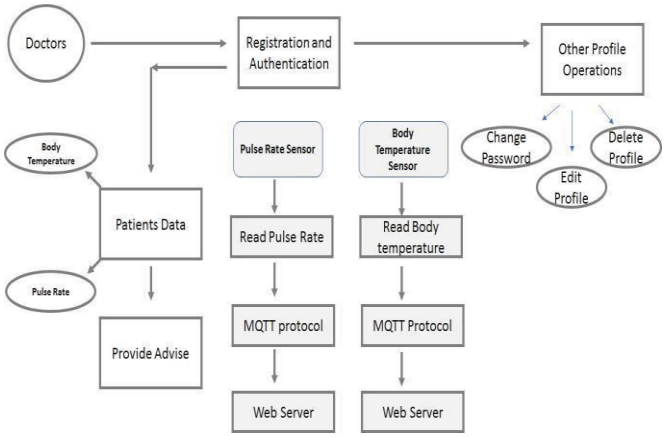

Figure3.G. Data flow diagram of the system.

4. MESSAGE QUEUING TELEMETRY TRANSPORT

The basic concepts of it is publish/subscribe and client/broker and its basic functionality is connect, publish, and subscribe. Also it has several good features like quality of service, retained messages, persistent session, last will and testament and SYS topics. MQTT decouples the space of publisher and subscriber. So they just have to know

hostname/ip and port of the broker in order to publish/subscribe to messages. The broker is able to store messages for clients that are not online. MQTT is also able to decouple the synchronization, because most client libraries are working asynchronously and are based on callbacks or similar model. So it won**'**t block other tasks while waiting for a message or publishing a message. But some libraries have synchronous APIs in order to wait for a certain message. MQTT is really the essence of pub/sub when using a client library and that makes it a light-weight protocol for small and constrained devices. MQTT protocol used at session layer in IoT protocol stack. In order to utilize IoT paradigm, interconnected devices need to communicate using lightweight protocols which do not need extensive use of CPU resources. For this, C, Python, Java and MQTT scripting languages are preferable choices used by IoT applications. MQTT Broker controls the distribution of information. It stores, forwards, filters and prioritizes public requests from the publisher client to the subscriber clients. Clients switch between publisher role and subscriber roles depending on the functionalities desired. So many MQTT brokers available now, like, Apache ActiveMQ, Apache Apollo, IBM Message Sight, JoramMQ, Mosquitto, RabbitMQ, HiveMQ, MQTT.js, Web sphere MQ, Solace Message Routers, mosca, etc. All are different in their feature; they can be setting as per our requirement. Some of them we can also implement additional features. MQTT makes small attempt to enable device-to-device data transfer, also separate the data to many recipients (Clients). Since it has a clear, compelling single application, MQTT is simple, offering few control options.It also doesn**'**t need to be particularly fast. In this context, **"**real time**"** is typically measured in seconds. The Publish/Subscribe model used in MQTT systems is very easily mapped to resource observers.

A. MQTT Header Format

The message header for each MQTT command message contains a fixed header with length of 2 bytes and an optional message-specific variable length header and message payload.

Table IV.A. MQTT Message Format

Bit	7	6	5	4	3	2	1	0
Byte 1	Message Type				DUP	QoS level		RETAIN
Byte 2	Message Length							

Byte 1 contains the Message type which is represented as a 4-bit unsigned value. There is 14 message type specified in 3.1 version of MQTT protocol. CONNECT (client request to connect to server), PUBLISH (publish message), PUBACK (publish acknowledgment), SUBSCRIBE (client subscribe request) are some of the message types. A detailed description of the message types can be found in protocol specifications DUP flag is set when the client the client or server attempts to re-deliver a PUBLISH, PUBREL, SUBSCRIBE or UNSUBSCRIBE message. This applies to messages where the value of QoS is greater than zero (0), and an acknowledgment is required. QoS flag indicates the level of assurance for delivery of a PUBLISH message. The QoS levels are described in next chapter. If RETAIN flag is set to true, normal MQTT message becomes retained message. The broker will restore last retained message with corresponding QoS for specific topic. Each client that subscribes to this topic pattern will receive the retained message immediately. The broker will save only one retained message per topic. Remaining length represents the number of bytes remaining within the current message, including data in the variable header and the payload.

5. CONCLUSION

The proposed system provides accurate, low power and low cost system for remote health monitoring of people. Self - monitoring is facilitated by the system as it is wearable. The system makes use of single board minicomputer Raspberry pi and IBM Blue mix cloud which further makes use of MQTT protocol for reliable services. Accuracy and cost of the system are equally emphasized by using appropriate sensors. Remote sensing wearability, accuracy, low power and low cost make our system reliable and effective. The system is addressing the society challenge of health monitoring of senior citizens from the comfort of their homes and this will help in improving the quality of life of citizens leading to a longer and a healthy life.

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