HEALTH MONITORING OF PATIENT USING BODY SENSORS

M. Karunakar Reddy[1], S.Naseem Taj[2], B.Harinadha Reddy[3], G.DelliBabu[4], P.Hareesha Reddy[5]
[1,2,3,4,5]Electronics and Communication Engineering, Aditya College of Engineering, Madanapalle

Abstract

The world of medical science is an emerging area that has accelerated with new technologies and this is the time when the vision of "The internet of things (IoT)" has turned into reality. IoT can play a significant role in healthcare domain by managing chronic diseases at one end as well as preventing diseases on the other hand. People demand more care at reduced clinical costs, remote health monitoring (using IoT) is one of the possible solutions to this demand. Remote health monitoring can be best utilized provided the device is wearable to facilitate self- monitoring. In this paper, we propose a system for monitoring of pulse rate, body temperature (vital body parameters) of the person with dedicated sensors along with Raspberry pi and IoT. A system is wearable and also supports remote health monitoring. Remote Health monitoring is attained by storing the collected data to Bluemix cloud, this data can be retrieved by the doctor for analysis anywhere and any aberrancy will be timely detected.Bluemixuses MQTT(Message Queuing Telemetry Transport) protocol. Along with remote monitoring and wearability of system, accuracy and cost cannot be ignored.A perfect tradeoff between accuracy and cost of the system is accomplished by choosing appropriate sensors which are DS18B20 (temperature sensor) and KG011 (heart rate sensor). The pulse rate and temperature of a person at different time instants are measured by the sensors. The readings are shown in the form of graphs at IBM Watson IoT platform.

Keywords: Healthcare System, Internet of Things, Arduino UNO, Raspberry pi, cloud computing, IBM Bluemix cloud service.

I. INTRODUCTION

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. The proposed system will be really helpful in reducing a person's unnecessary visits to a doctor since the person's health monitoring is done on a real-time basis. Apart from this the diseases can be timely detected and treated; errors will be reduced as the data is stored at cloud automatically without human intervention.In section II research gaps have been discussed along with possible solutions to them. Section III provides the details of existing literature. The complete details of the proposed system are described in Section IV -VI. The readings of measured parameters (temperature and heart rate) with the help of graphs are shown in Section VII. Section VIII concludes the paper along with the future scope of the study.

II. MOTIVATION

The health monitoring system proposed in this paper focuses on healthcare domain ofIoT.We can provide good healthcare support to the people especially senior citizens at their homes with the intervention of latest technologies like IoT. Some authors have already proposed health monitoring system using temperature and pulse rate sensors but the sensors [3] used are not wearable. Those who have made the use of wearable sensors [6] have not emphasized on storing the health -related data on the cloud be accessed by the medical personnel, which in turn does not fulfill the aim of remote health monitoring. Some authors [3] have made use of cloud computing for remote health monitoring but the sensors used are neither wearable nor reliable due to their low accuracy. And the systemswhich used wearable and accurate sensors are expensive and at the same time data storage and its access are also limited to the site of personnel, monitoring the health.

By reviewing these systems authors found that all the systems are lacking in its quality in one and another way. Thus authors proposed a system which provides a better tradeoff between wearability, accuracy, power and cost. Also, the remote access of data is taken into consideration, since proposed system automatically stores the data in IBM Bluemix cloud which can be accessed by any legitimate person. To the best knowledge of authors, no such system is proposed till date which considers all the factors (wearability, accuracy etc.).The proposed system will also save time as well as efforts which people put in traveling to hospitals and standing in long queues. By facilitating the people to use such kind of technologies, they will be able to get quality healthcare services at the comfort of their homes and the medical personnel can take required action if any aberrancy is found.

III. RELATED WORK

Kumar et al [3] monitor the temperature of the body using thermistor and heart rate of a person using Infrared transmitter and receiver using a raspberry pi board and the results are displayed on the Lx terminal of raspberry pi.

Hasmah Mansor et al [4] focused on the measurement of body temperature using an LM35 temperature sensor. LM35 sensor is interfaced with Arduino UNO board. Afterward, a website using SQL database format is created which will be used for storing the data received by Arduino. A patient can access the website by a login.

Mohammed S. Jasses et al [5] focused on monitoring body temperature and pulse rate of a person using a raspberry pi. The main idea of the paper is based on the integration of wireless health sensor network and cloud computing. Amazon EC2 cloud service provided by Amazon Web Service is used for storing the data.

Mathan Kumar et al[6] implemented a remote patient telemonitoring system using android technology. LM35 and ppm sensors are interfaced with PIC16F887A microcontroller and data is sent to an android based mobile application via Bluetooth and GSM module.

Nitin P. Jain et al [7] monitors patient's pulse rate, temperature and blood pressure using ATMEGA 32. RS232 interface along with GSM module is used for serial communication with external peripheral. All the parameters are continuously sent to the doctor.

IV. SYSTEM ARCHITECTURE

The design part consists of mainly two sections:-

- Hardware architecture
- Software architecture

A. Hardware Architecture

It includes Temperature sensor, pulse rate sensor, Arduino UNO, Raspberry pi 2 model and ESP8266 Wifi shield.

1) Arduino UNO

Arduino Uno is an open source design based on the Atmega 328P. Arduino has 14 digital I/O pins.Out of these 6 can be used for PWM outputs, clock of 16 MHz , an easy interface with USB, 32Kb of flash memory which is used for storing the codes ,c ,an ICSP header for directly interfacing Arduino board as a serial device and a reset button to reset the stored programs on the chip[8]. An Analog to Digital Converter (ADC) plays a key role in converting analog values into digital numbers. On the Arduino board, these pins have an 'A' in front of their label (A0 through A5) to indicate these pins can read analog voltages. The inbuilt ADC of Arduino is a 10-bit converter that can detect 1024 distinct analog values. This means that it will map input voltages between 0 and 5 volts into integer values between 0 and 1023.

2) NODE MCU

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the dev kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson,and spiffs.

3) KG011-Heartbeat Sensor

The heartbeat sensor is based on the principle of photoplethysmography. The blood volume changes through any organ of the body due to which the light intensity also changes through the vascular region/organ.The rate of heart pulses decide the rate of flow of blood volume and since light is absorbed by blood, the heart beat pulses are equivalent to signal pulses. The timing associated with the pulses is more important in the case where the pulse rate is to be monitored.

Working of a Heartbeat Sensor:

The heartbeat sensor consists of an Infrared LED and a photodiode(light detecting resistor) to detect the pulse of the finger. On one side infrared LED is present whereas on the other side photodiode is present. When the light source illuminates the tissue, the reflected rays are being captured by the photodiode [3]. The output of the detector is an electrical signal which basically gives the number of pulses counted by the sensor.This pulse rate sensor is shown in fig. 2 has the following features –LED for the heartbeat indication, Digital output, Compact in size with the operating voltage of +5 V DC.

Fig. 2. KG011 Heartbeat Sensor

1) DS18B20-Temperature Sensor

DS18B20 is a digital sensor or a thermo probe that employs DALLAS DS18B20. This temperature sensor can easily communicate with other devices because of its unique one wire interface. With the conversion time of just 750 milliseconds, it can convert temperature to a 12-bit digital word. This thermo probe draws power from the data line, and it doesn't require any external power supply.It has a stainless steel probe head which makes it suitable for measurement in the harsh or wet environment. The sensor is shown in fig. 3. has the following technical specifications- Power Supply Range of 3.0 V to 5.0 V, Storage Temperature Range of -55°C to +125°C (-67F to +257F), Operating Temperature Range of -55°C to +125°C (-67F to +257F) with accuracy of ±0.5˚C, over the range of -10°C to+85°C. It has RJ11/RJ12, 3P-2510 connector.

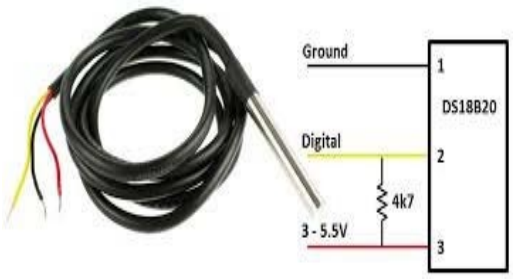

Fig. 3. DS18B20 Temperature Sensor

B. Software Architecture

It includes Integrated Development Environment (IDE), Node-Red and MQTT protocol.

1) Integrated Development Environment

IDE acts as a base for Arduino hardware which is not dependent on the platform. Any programming language can be chosen to write Arduino programs.. IDE is a powerful platform for programmers, project development professionals and researchers to develop projects on various sensors and Arduino projects.

Arduino IDE is an open source design/software which is originated from the Integrated Development Environment for the programming languages Processing and Wiring projects. It can run on Windows, Linux based operating system as well as MAC OS. It was developed for the people with less knowledge of electronics. IDE is incorporated with features like highlighting the syntax, searching-replacing text, brace matching, cutting-pasting and automatic indenting and programs can be compiled and uploaded to the Arduino board by a simple click mechanism [8]. A text console, message area, and toolbar for common functions are some of its key features. A program written for Arduino using IDE is called a "sketch". To organize the code languages like C and C++ are supported by the Arduino IDE.

2) Node-RED

Node –RED is an open source, very fundamental and easy to use programming tool for IOT. It is a visual programming tool that helps IoT developers to integrate hardware devices,APIs, and online services in a new and an interesting mannerSince Node-RED run time includes node.js, it can be run at the edge of a network on the Hardware like Raspberry pi or in the cloud. A built-in library of Node-RED consisting of over thousand flows and nodes enable the users to make connections to all kinds of devices and services. Flows can be deployed to a light-weight runtime by the IoT developers.

3) MQTT protocol

MQTT (Message Queuing Telemetry Transport) is a low bandwidth, a lightweight protocol which was developed in 1999 for connecting different devices and applications together especially for the machine to machine communication (M2M). Unlike HTTP protocol which uses request/response architecture, MQTT protocol follows publish/subscribe architecture. It provides great flexibility to the clients to connect as a publisher, subscriber or both. By using this protocol, the user gets connected to MQTT broker which is solely responsible for all the messages being transmitted and received. Node-RED is used to transmit the data from sensor tag to the cloud.

V. METHODOLOGY

Personal health monitoring systems must be handy hence they need to be lightweight, low powered and small in size. The system consists of cheap-yet-serviceable, small microcontroller board Arduino UNO and powerful Single board minicomputer Raspberry Pi [8]. As shown in fig 1. our system has DS18b20 one wire temperature sensor and Pulse rate sensor which are used to measure body temperature and pulse rate of a person. Pulse sensor whose output is analog in nature is interfaced to A0 pin of Arduino board whereasDS18B20 whose output is digital is connected to digital pin 2 of the board. Arduino is connected to the Raspberry pi via USB cable. Raspberry pi is poweredwith a power supply of 3.3V, 1.55A. Whenever our Raspberry pi is connected to the internet, our visual programming tool i.e. Node-RED gets automatically started. There is several nodes available in the Node-red library for use by the IoT developers out of which Serial -In node is being used to get the data coming from Arduino board. Debug node is connected to the Serial node and the data will start coming in the debug tab. Once our device i.e. Raspberry pi gets registered at the IBM Bluemix the values of the pulse rate and body temperature sensed by the sensors will be transmitted from the raspberry pi to the cloud. Thus all the data gets stored in the cloud which can be accessed by the doctors by login id/password. On the other hand, a user can log into his/her mobile application and can check all parameters within the android based application by GUI and cloud.

VI. EXPERIMENTAL SETUP

Experimental setup for our system has been shown in Fig. 4. The sensors are connected to the Arduino board and raspberry pi is connected via USB cable to the board.

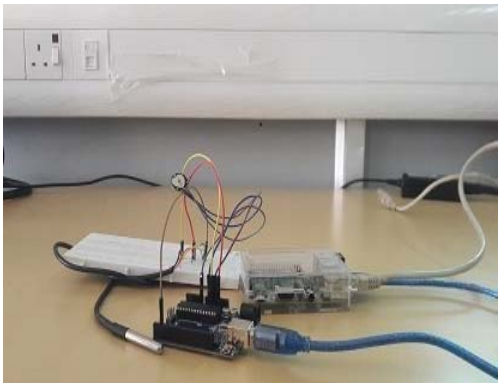

Fig.4. Experimental Setup

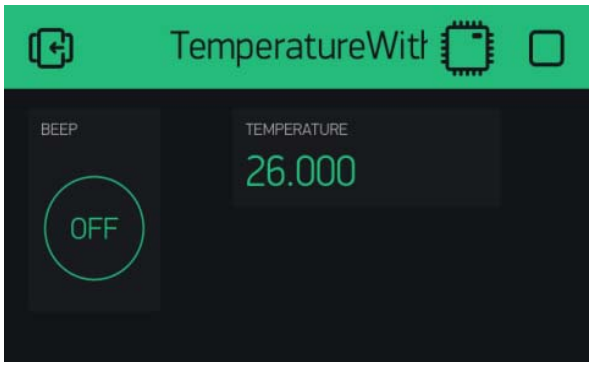

Fig 5 Temperature monitoring using Blink app

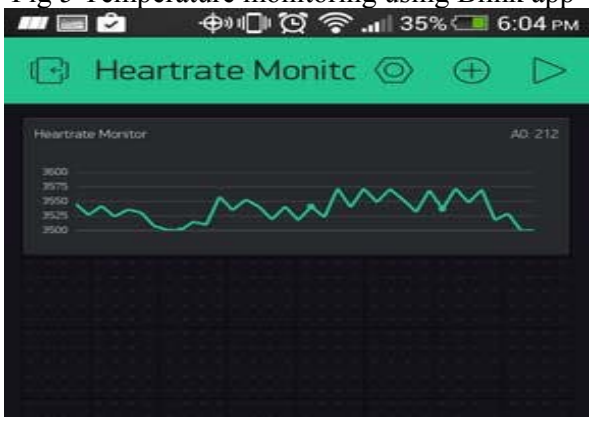

Fig 6 Heartbeat monitoring by using Blynk app

VII. RESULTS

The flow drawn in our visual programming tool i.e Node-RED has been shown in Fig. 5.Device-Centric analytics on the IBM Watson IoT platform has been shown in Fig 6.

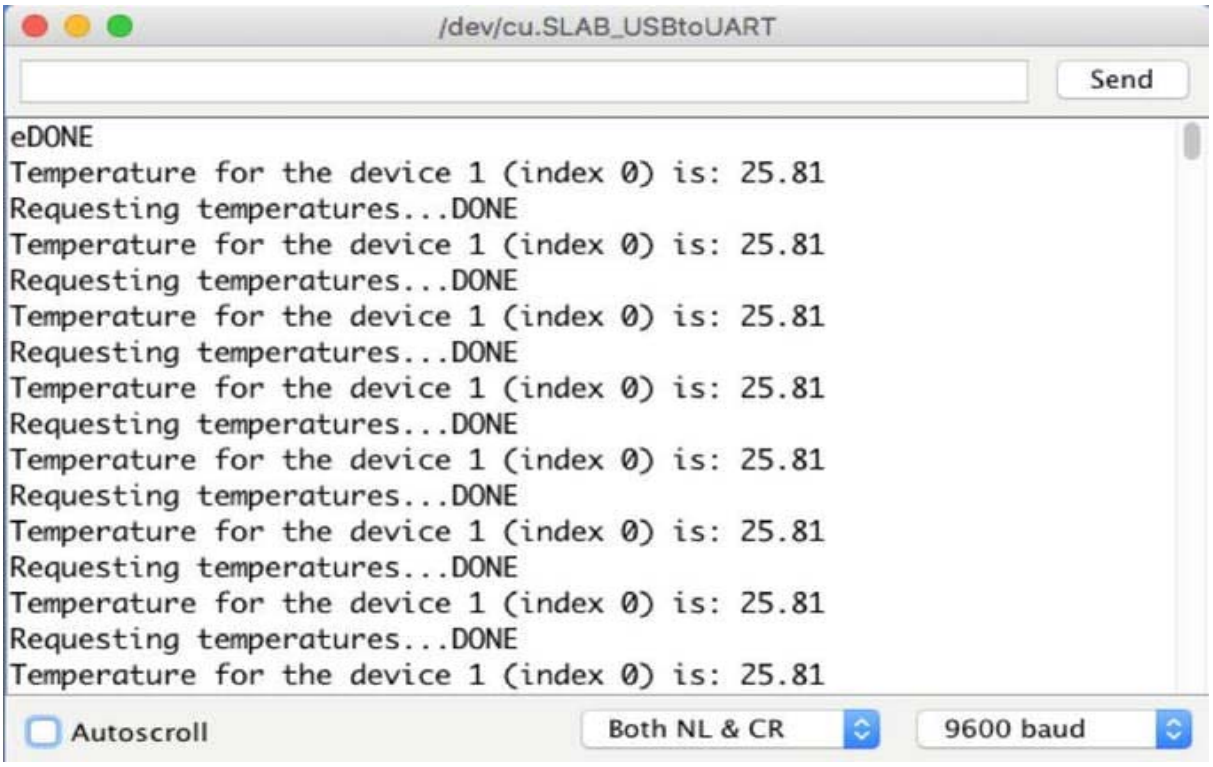

Fig 7 Temperature measurement in computer display

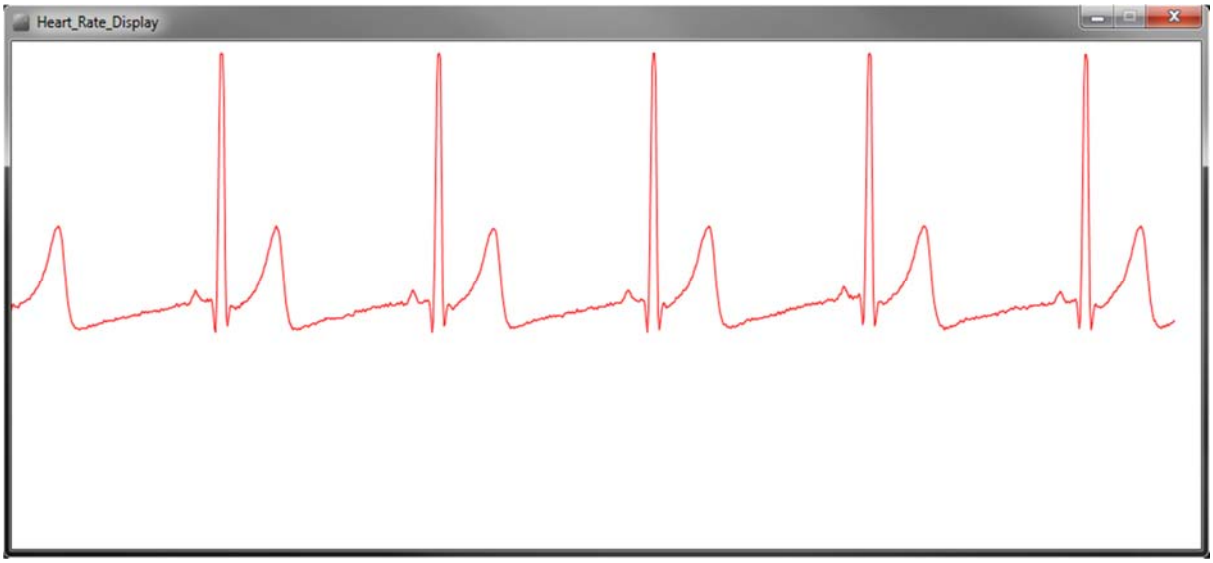

Fig 8 heart beat monitoring in computer display

The graphs can be generated automatically on the dashboard of IBM Watson platform for both the parameters i.e temperature and pulse rate of a person measured at different time instants.

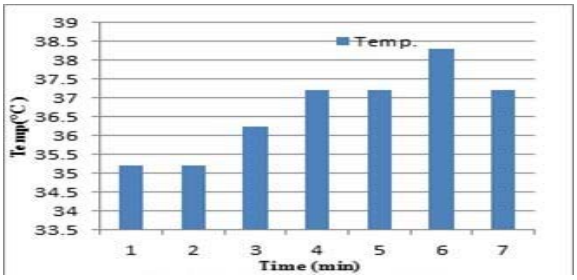

Fig 9 Variation of temperature with time

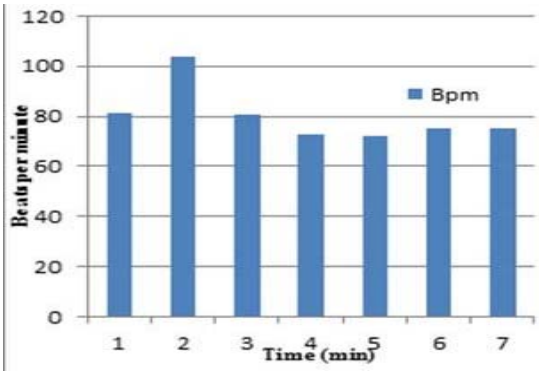

Fig 10 Variation of Heartbeat with time

One of those values for both the temperature and pulse rate has been shown in fig. 9. Dashboard presentation looks very attractive because of the different block designs available on IBM Watson platform.

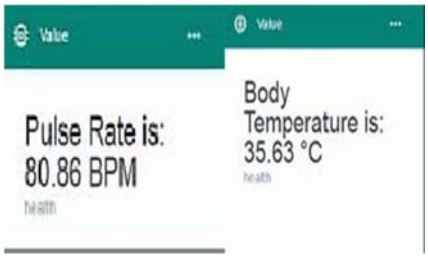

Fig. 9. Dashboard parameters

VIII. CONCLUSION AND FUTURE WORK

The proposed system provides accurate, low power and low cost system for remote health monitoring of people. Self - monitoring is facilitatedby the system as it is wearable. The system makes use of single board minicomputer Raspberry pi and IBM Bluemix 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

By adding blood pressure sensor, ECG sensor, Respiration sensor the system can turn into a complete health monitoring system. The network systems have to ensure that the data generated by the IoT devices should be accessed only by the authenticated individuals by involving security controls like authentication by ID and password.

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