Health Monitoring System Based on IoT

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Bachelor of Engineering
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by

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Certificate

This is to certify that, the dissertation titled

"Health Monitoring System Based on IoT "

is a bonafide work done by

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and is submitted in the partial fulfillment of the requirement for the degree of

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in
Electronics and Telecomunication Engineering
to the
University of Mumbai.

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Certificate of Approval by Examiners

This is to certify that the dissertation entitled ”**Health Monitoring System Based on IoT**” is a bonafide work done by **Fahad Ansari, Faizan Shaikh, Deepak Gupta, Touqueer Khan** under the guidance of **Asst. Prof. Mazhar Malagi**.

This dissertation has been approved for the award of **Bachelor’s Degree in Electronics and Telecommunication Engineering**, University of Mumbai.

Examiners :

Signature	Signature

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Abstract

Since the population of the world is ageing rapidly, how to provide appropriate healthcare to the elderly and unwell people becomes an important issue and draws high attention from medical, academic and industrial fields of the society.

The Internet of Things (IoT) drives the evolution of the Internet, and is regarded as a great potential to improve quality of life for the surging number of elderly people significantly. As Android operating system gains immense popularity nowadays, it is a trend to make use of it for the wider access of IoT utility.

This report presents a health monitoring system prototype based on IoT, with the increasing use of sensors by medical devices, remote and continuous monitoring of a patients health. This network of sensors and other mobile communication devices, referred to as the Internet of Things for Medical Devices (IoT-MD), is poised to revolutionize the functioning of the healthcare industry.

List of Figures

1.1 Overview of IoT 1
1.2 Overview of Project 4

3.1 Block Daigram 7
3.2 Arduino Uno 8
3.3 ESP8266 12
3.4 LM35 14
3.5 Basic Centigrade Temperature Sensor (2 C to 150 C) 15
3.6 HRM-2511E as a transmission PPG probe 16
3.7 PPG components shown not to scale 17
3.8 HRM-2511E pulse sensor circuit 18
3.9 Arduino IDE example 19
3.10 ThingSpeak Platform App 20
3.11 Creating channel on ThingSpeak 21
3.12 Creating Fields 22
3.13 Send data to the ThingSpeak.com 23
3.14 Generation of Channel ID and API Key 23
3.15 ThingSpeak Field Chart 24
3.16 Configuring PushingBox.com 25
3.17 Configuration of ThingHttp 26
3.18 Creating field for Threshold values 27
3.19 Setting Threshold value for Body Temperature 27
3.20 Setting Threshold value for Low Pulse Rate 28
3.21 Setting Threshold value for High Pulse Rate 28

Contents

Abstract iv

List of Figures v

1 Introduction 1
- 1.1 Introduction 1
- 1.2 What is Internet of Things (IoT) ? 2
- 1.3 Problem Statement 3
- 1.4 Project Overview 3

2 Literature Survey 5

3 Hardware and Software 7
- 3.1 Block Diagram 7
- 3.2 Hardware Components Description 8
  - 3.2.1 Arduino 8
  - 3.2.2 Wi-Fi Module (ESP8266) 12
  - 3.2.3 Temperature Sensor 14
  - 3.2.4 Heartbeat Sensor 16
- 3.3 Software Description 18
  - 3.3.1 Arduino IDE 18
  - 3.3.2 ThingSpeak 20
  - 3.3.3 PushingBox 25

4 Advantages and Limitations 29
- 4.1 Advantages of m-IoT 30
- 4.2 Limitations 31

5 Future Application 32

6 Conclusion 36

7 Bibliography 37

Chapter 1

Introduction

1.1 Introduction

Figure 1.1: Overview of IoT

Health is one of the global challenges for humanity. According to the constitutions of World Health Organization (WHO) the highest attainable standard of health is a fundamental right for an Individual. To keep individuals healthy an effective and readily accessible modern healthcare system is a prerequisite. A modernized healthcare system should provide better healthcare services to people at any time and from anywhere in an economic and patient friendly manner. Recent advances in the design of Internet-of-Things (IoT) technologies are spurring the development of smart systems to support and improve healthcare- and biomedical-related processes.

In a health care monitoring system it is necessary to constantly monitor the patients physiological parameters. For example a pregnant woman parameters such as blood pressure (BP) and heart rate of the woman and heart rate and movements of fetal to control their health condition.

This paper presents a monitoring system that has the capability to monitor physiological parameters from multiple patient bodies. In the proposed system, sensors has attached on patient body to collect all the signals and sends them to the base station. The attached sensors on patients body are able to sense the heart rate, blood pressure and so on. This system can detect the abnormal conditions, issue an alarm to the patient as well as physician.

1.2 What is Internet of Things (IoT) ?

The Internet of Things or IoT is the internetworking of physical devices, vehicles (also referred to as ”connected devices” and ”smart devices”), buildings and other itemsembedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data.

The Internet of Things (IoT) is also referred an integrated information network of future Internet where physical and virtual things with identities, physical attributes and intelligent interfaces are seamlessly connected. It connects a large number of information and communication systems, in which people interact with information and communication technologies in support of business processes.

The Internet of Things may be a hot topic in the industry but its not a new concept. In the early 2000s, Kevin Ashton was laying the groundwork for what would become the Internet of Things (IoT) at MITs AutoID lab. Ashton was one of the pioneers who conceived this notion as he searched for ways that Proctor and Gamble could improve its business by linking RFID information to the Internet. The concept was simple but powerful. If all objects in daily life were equipped with identifiers and wireless connectivity, these objects could be communicate with each other and be managed by computers. In a 1999 article for the RFID Journal Ashton wrote:
”If we had computers that knew everything there was to know about thingsusing data they

gathered without any help from us – we would be able to track and count everything, and greatly reduce waste, loss and cost. We would know when things needed replacing, repairing or recalling, and whether they were fresh or past their best. We need to empower computers with their own means of gathering information, so they can see, hear and smell the world for themselves, in all its random glory. RFID and sensor technology enable computers to observe, identify and understand the worldwithout the limitations of human-entered data."

According to Cisco Internet Business Solutions Group (IBSG), the Internet of things is regarded as the first real evolution of the Internet, and will lead to many applications with revolutionary potential for improvement of peoples way of life, work and entertainment. Wireless broadband is seen as a prerequisite of IoT development, and it allows a wide range of different types of objects to benefit a lot from network connection. Experts estimate that the IoT will consist of almost 50 billion objects by 2020.

1.3 Problem Statement

To monitor the health of a patient using sensors and informing to the doctors about the ongoing problems via internet by sending email .

1.4 Project Overview

Imagine a scenario where a patients medical profile, vital parameters, and dialysis machine inputs are captured with the help of medical devices attached to his body. The patient does not even have to move from facility to facility to receive treatment. Rather, he can get his dialysis done with the help of a portable/home machine designed for the purpose.

Data gathered from this device is analyzed and stored, and the aggregation from multiple sensors and medical devices helps make informed decisions in a timely manner. Caregivers can monitor the patient from any location and respond appropriately, based on the alert received. Advanced treatment of this nature can drastically improve a patients quality of life.

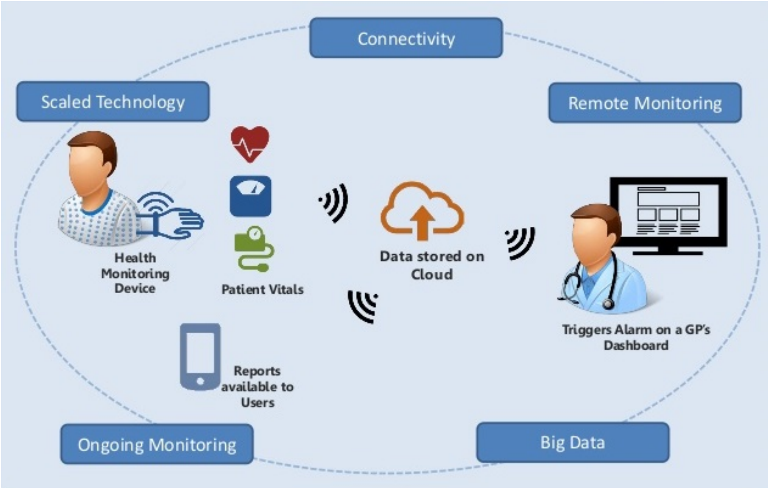

Figure 1.2: Overview of Project

Sensors has attached on patient body to collect all the signals and sends them to the base station. The attached sensors on patients body are able to sense the heart rate, blood pressure and so on. This system can detect the abnormal conditions, issue an alarm to the patient and send a SMS or e-mail to the physician.

Chapter 2

Literature Survey

- **A Hospital Healthcare Monitoring System Using Wireless Sensor Networks(WSN), J Health Med Inform ISSN: 2157-7420 JHMI, an open access journal, Volume 4 Issue 2 1000121:**
  In the proposed system, a coordinator node has attached on patient body to collect all the signals from the wireless sensors and sends them to the base station. The attached sensors on patients body form a wireless body sensor network (WBSN) and they are able to sense the heart rate, blood pressure and so on.

- **An IoT-Aware Architecture for Smart Healthcare, IEEE INTERNET OF THINGS JOURNAL, VOL. 2, NO. 6, DECEMBER 2015 :**
  This paper propose a smart hospital system (SHS), which relies on different, yet complementary, technologies, specifically RFID, WSN, and smart mobile, interoperating with each other through a Constrained Application Protocol (CoAP)/IPv6 over low-power wireless personal area network(6LoWPAN)/representational state transfer (REST) network infrastructure.

- **Artificial Intelligence in Medical Diagnosis, International Journal of Applied Engineering Research, ISSN 0973-4562 Vol.7 No.11 (2012) :**
  This paper discusses about the application potential of artificial intelligence in medical diagnosis. The fuzzy expert system has been presented specific to liver disease diagnosis.

- **The Internet of Things for Medical Devices -Prospects, Challenges and the Way Forward, Ashok Khanna Business Head UK, EU and Major Accounts, Life Sciences (EIS),TATA CONSULTANCY SERVICES :**
  The IoT-MD provides an environment where a patients vital parameters get transmitted by medical devices via a gateway onto secure cloud based platforms where it is stored,aggregated and analyzed. It helps store data for millions of patients and perform analysis in real time, ultimately promoting an evidence-based medicine system.

Chapter 3

Hardware and Software

In this chapter explains about the hardware as well as software involves in this system. The proposed system the patients physiological signals are acquired by the sensors attached on the patient body, and are then transmitted to the remote base-station and also a PC for storing and analyzing. Let us understand this process with the help of block diagram, working and each component description.

3.1 Block Diagram

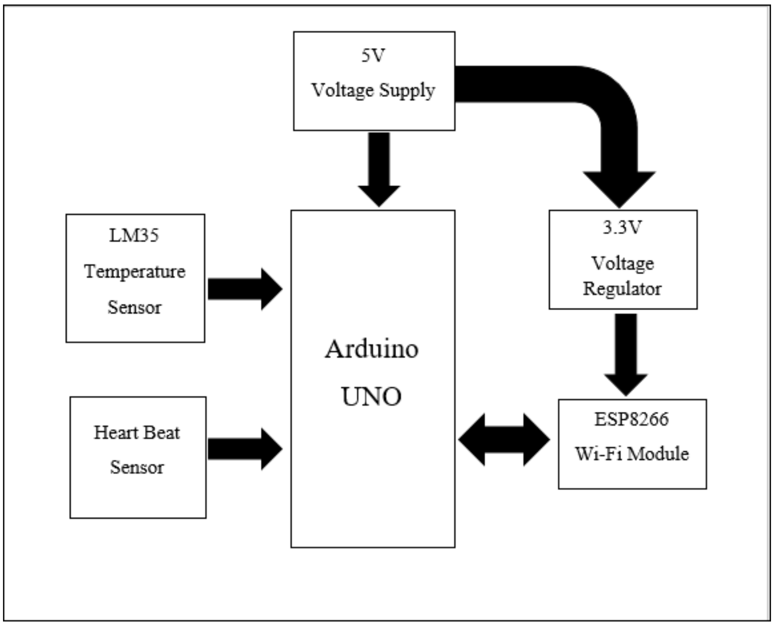

Figure 3.1: Block Daigram

A 5V voltage supply is used power to the processsor i.e Arduino UNO and the same power is given to the 3.3V voltage regulator. The output from this voltage regulator is used to power the Wi-Fi module. The sensors we have used are connected to the processor i.e Arduino UNO. In this project we have use two sensors, one is LM35 the temperature sensor and other is the heartbeat sensor.With the help of this block diagram one can develop a protoc-type for remote health monitoring system.

3.2 Hardware Components Description

3.2.1 Arduino

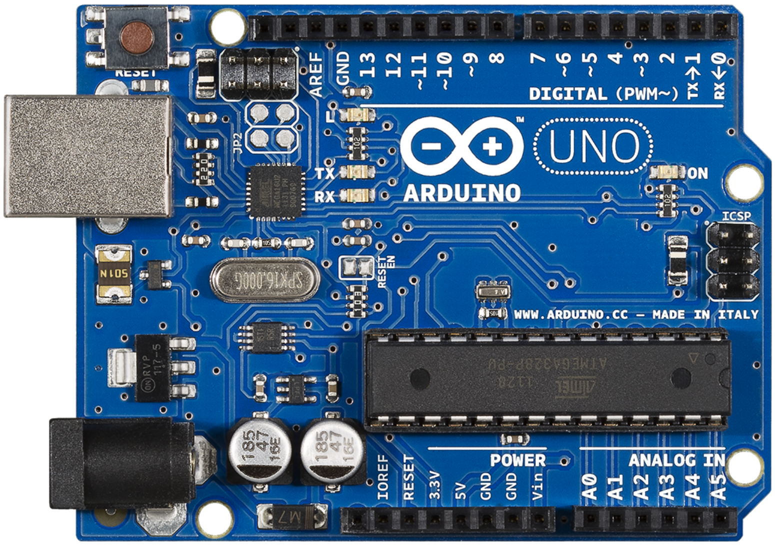

Figure 3.2: Arduino Uno

Arduino is an open-source prototyping platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on a LED, publishing something online. We can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so we use the Arduino programming language (based on wiring), and the Arduino Software (IDE), based on Processing.

Arduino can interact with buttons, LEDs, motors, speakers, GPS units, cameras, the internet, and even your smart-phone or your TV! This flexibility combined with the fact that the Arduino software is free, the hardware boards are pretty cheap, and both the software and hardware are easy to learn has led to a large community of users who have contributed code and released instructions for a huge variety of Arduino-based projects. There are many varieties of Arduino boards (explained on the next page) that can be used for different purposes. Some boards look a bit different from the one below, but most Arduinos have the majority of these components in common:

- **Power (USB / Barrel Jack)**

  Every Arduino board needs a way to be connected to a power source. The Arduino UNO can be powered from a USB cable coming from your computer or a wall power supply (like this) that is terminated in a barrel jack. In the picture above the USB connection is labelled-(1) and the barrel jack is labelled- (2). The USB connection is also how you will load code onto your Arduino board.

- **Pins (5V, 3.3V, GND, Analog, Digital, PWM, AREF)**

  The pins on your Arduino are the places where you connect wires to construct a circuit (probably in conjuction with a breadboard and some wire. They usually have black plastic headers that allow you to just plug a wire right into the board. The Arduino has several different kinds of pins, each of which is labeled on the board and used for different functions.

- **GND (3):**

  It is used as short for ground. There are several GND pins on the Arduino, any of which can be used to ground your circuit.

- **5V (4) and 3.3V (5):**

  As you might guess, the 5V pin supplies 5 volts of power, and the 3.3V pin supplies 3.3 volts of power. Most of the simple components used with the Arduino run happily off of 5 or 3.3 volts.

- **Analog (6):**

  The area of pins under the Analog In label (A0 through A5 on the UNO) are Analog In pins. These pins can read the signal from an analog sensor (like a temperature sensor) and convert it into a digital value that we can read.

- **Digital (7):**

  Across from the analog pins are the digital pins (0 through 13 on the UNO). These pins can be used for both digital input (like telling if a button is pushed) and digital output (like powering an LED).

- **PWM (8):**

  You may have noticed the tilde ( ) next to some of the digital pins (3, 5, 6, 9, 10, and 11 on the UNO). These pins act as normal digital pins, but can also be used for something called Pulse-Width Modulation (PWM). We have a tutorial on PWM, but for now, think of these pins as being able to simulate analog output (like fading an LED in and out).

- **AREF (9):**

  It stands for Analog Reference. Most of the time you can leave this pin alone. It is sometimes used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins. Reset Button. Just like the original Nintendo, the Arduino has a reset button (10). Pushing it will temporarily connect the reset pin to ground and restart any code that is loaded on the Arduino. This can be very useful if your code doesnt repeat, but you want to test it multiple times. Unlike the original Nintendo however, blowing on the Arduino doesn't usually fix any problems.

Power LED Indicator

Just beneath and to the right of the word UNO on your circuit board, theres a tiny LED next to the word ON (11). This LED should light up whenever you plug your Arduino into a power source. If this light doesnt turn on, theres a good chance something is wrong. Time to re-check your circuit!

TX/RX LEDs

TX is short for transmit, RX is short for receive. These markings appear quite a bit in electronics to indicate the pins responsible for serial communication. In our case, there are two places on the Arduino UNO where TX and RX appear once by digital pins 0 and 1, and a second time next to the TX and RX indicator LEDs (12). These LEDs will give us some nice visual indications whenever our Arduino is receiving or transmitting data (like when were loading a new program onto the board).

Central Integrated Circuit

The black thing with all the metal legs is an IC, or Integrated Circuit (13). Think of it as the brains of our Arduino. The central IC on the Arduino is slightly different from board type to board type, but is usually from the ATmega line of ICs from the ATMEL company. This can be important, as you may need to know the IC type (along with your board type) before loading up a new program from the Arduino software. This information can usually be found in writing on the top side of the IC.

The Atmega328 has 32 KB of flash memory for storing code (of which 0,5 KB is used for the bootloader); It has also 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library). If you want to know more about the difference between various IC's, reading the datasheets is often a good idea. The voltage regulator (14) is not actually something you can (or should) interact with on the Arduino. But it is potentially useful to know that it is there and what its for.

The voltage regulator does exactly what it says it controls the amount of voltage that is let into the Arduino board. Think of it as a kind of gatekeeper; it will turn away an extra voltage that might harm the circuit. Of course, it has its limits, so dont hook up your

Arduino to anything greater than 20 volts.

3.2.2 Wi-Fi Module (ESP8266)

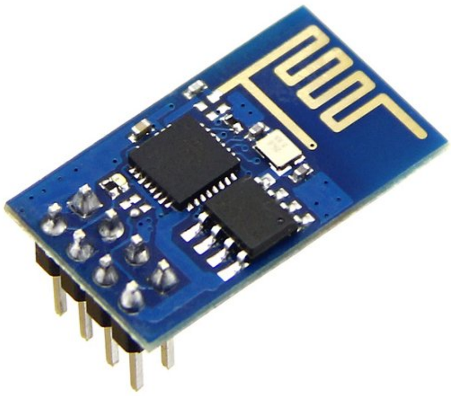

Figure 3.3: ESP8266

The ESP8266 WiFi Module is a self contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your WiFi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much WiFi-ability as a WiFi Shield offers (and thats just out of the box)! The ESP8266 module is an extremely cost effective board with a huge, and ever growing, community.

Features of ESP8266

- 32-bit RISC CPU: Tensilica XtensaL106 running at 80 MHz*
- 64 KiB of instruction RAM, 96 KiB of data RAM
- External QSPI flash: 512 KiB to 4 MiB* (up to 16 MiB is supported)
- IEEE 802.11 b/g/n Wi-Fi
- Integrated TR switch, balun, LNA, power amplifier and matching network
- WEP or WPA/WPA2 authentication, or open networks
- 16 GIPO pins
- SPI
- IS interfaces with DMA (sharing pins with GPIO)
- UART on dedicated pins, plus a transmit-only UART can be enabled on GPIO2
- 10-bit ADC

This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area.

3.2.3 Temperature Sensor

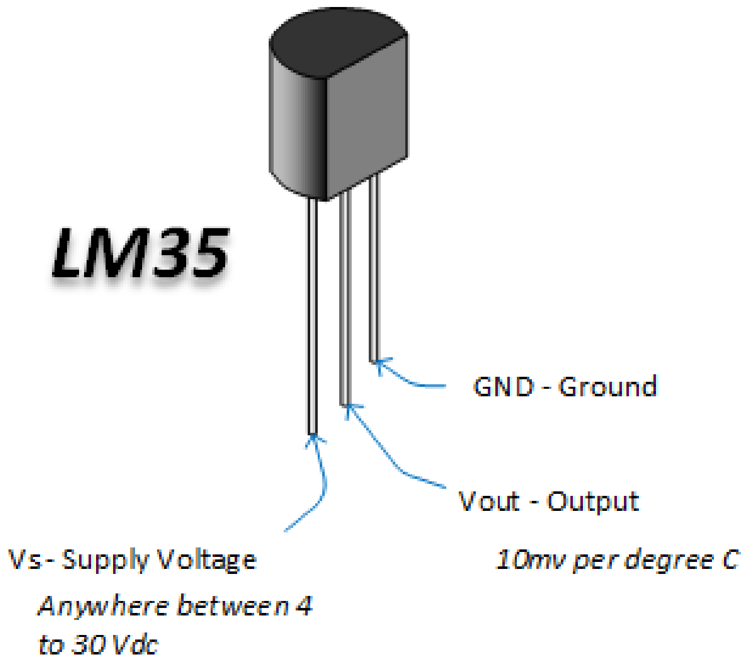

Figure 3.4: LM35

The LM35 series are precision integrated circuit LM35 temperature sensors, whose output voltage is linearly proportional to the temperature in Celsius (Centigrade). The LM35 sensor thus has an advantage over linear temperature sensors, calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient centigrade scaling. The LM35 sensor does not require any external calibration or trimming to provide typical accuracies of C at room temperature and C over a full -55 to +150C temperature range. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. As it draws only 60 A from its supply, it has very low self-heating, less than 0.1C in still air.

Features of LM35

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/C Scale Factor
- 0.5C Ensured Accuracy (at 25C)
- Rated for Full 55C to 150C Range
- Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming

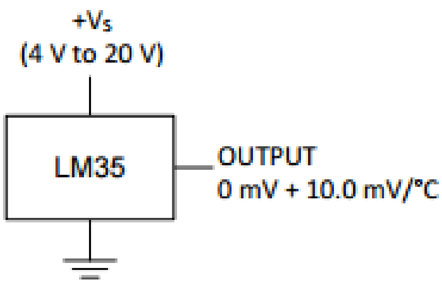

Figure 3.5: Basic Centigrade Temperature Sensor (2 C to 150 C)

- Operates from 4 V to 30 V
- Less than 60-A Current Drain
- Low Self-Heating, 0.08C in Still Air
- Non-Linearity Only C Typical
- Low-Impedance Output, 0.1 for 1-mA Load

3.2.4 Heartbeat Sensor

The Heart Beat sensor is based on the principle of photoplethysmography (PPG) which is a non-invasive method of measuring the variation in blood volume in tissues using a light source and a detector. Since the change in blood volume is synchronous to the heart beat, this technique can be used to calculate the heart rate. Transmittance and reflectance are two basic types of photoplethysmography. For the transmittance PPG, a light source is emitted in to the tissue and a light detector is placed in the opposite side of the tissue to measure the resultant light. Because of the limited penetration depth of the light through organ tissue, the transmittance PPG is applicable to a restricted body part, such as the finger or the ear lobe. However, in the reflectance PPG, the light source and the light detector are both placed on the same side of a body part. The light is emitted into the tissue and the reflected light is measured by the detector. As the light doesnt have to penetrate the body, the reflectance PPG can be applied to any parts of human body. In either case, the detected light reflected from or transmitted through the body part will fluctuate according to the pulsatile blood flow caused by the beating of the heart. The sensor body is built with flexible Silicone rubber material that helps to keep the sensor tightly hold to the finger.

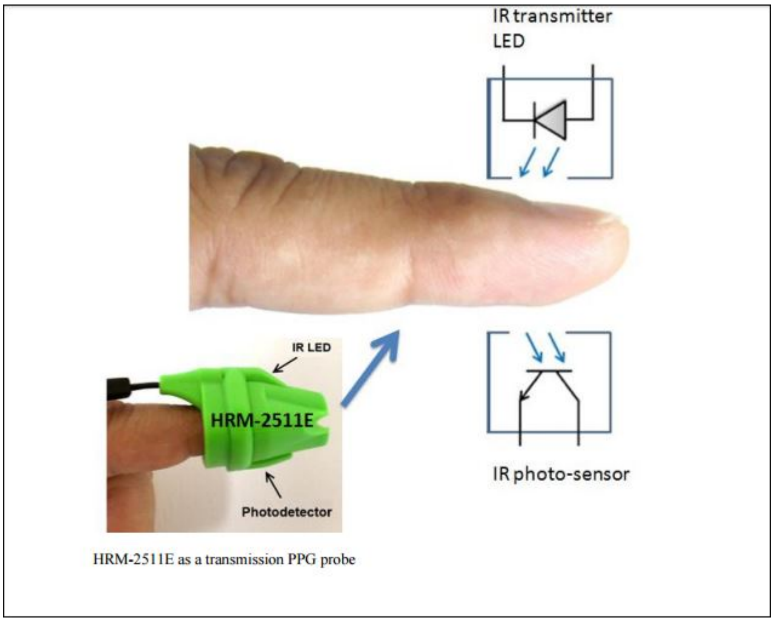

Figure 3.6: HRM-2511E as a transmission PPG probe

Inside the sensor case, an IR LED and a photodetector are placed on two opposite sides and are facing each other. When a fingertip is plugged into the sensor, it is illuminated by the IR light coming from the LED. The photodetector diode receives the transmitted light through the tissue on other side. More or less light is transmitted depending on the tissue blood volume. Consequently, the transmitted light intensity varies with the pulsing of the blood with heart beat. A plot for this variation against time is referred to be a photoplethysmographic or PPG signal.

The PPG signal consists of a large DC component, which is attributed to the total blood volume of the examined tissue, and a pulsatile (AC) component, which is synchronous to the pumping action of the heart. The AC component, which carries vital information including the heart rate, is much smaller in magnitude than the DC component. A typical PPG waveform is is much smaller in magnitude than the DC component. A typical PPG waveform is shown in the figure below (not to scale).

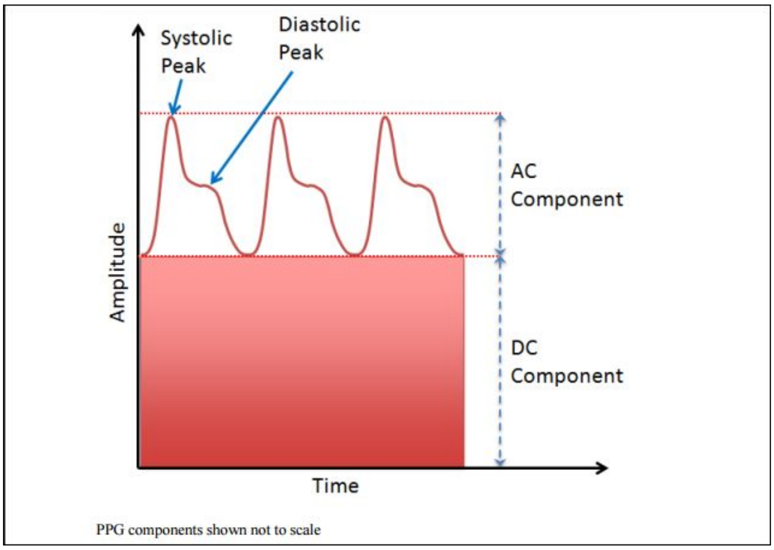

Figure 3.7: PPG components shown not to scale

The two maxima observed in the PPG are called Sytolic and Diastolic peaks, and they can provide valuable information about the cardiovascular system (this topic is outside the scope of this article). The time duration between two consecutive Systolic peaks gives the instantaneous heart rate. The following circuit shows the ON/OFF control scheme for the infra-red light source inside HRM-2511E. Note that the Enable signal must be pulled high in order to turn on the IR LED. The photodetector output (VSENSOR) contains the PPG signal that goes to a two-stage filter and amplifier circuit for further processing.

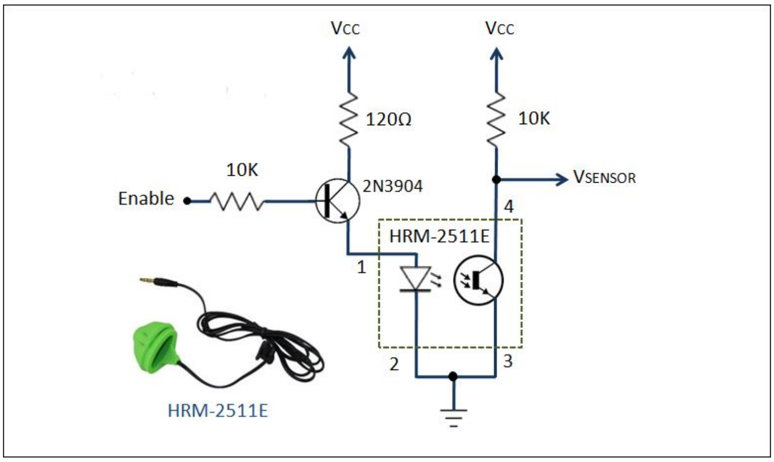

Figure 3.8: HRM-2511E pulse sensor circuit

3.3 Software Description

3.3.1 Arduino IDE

A program for Arduino may be written in any programming language for a compiler that produces binary machine code for the target processor.The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software. This software can be used with any Arduino board. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio.

The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It includes a code editor

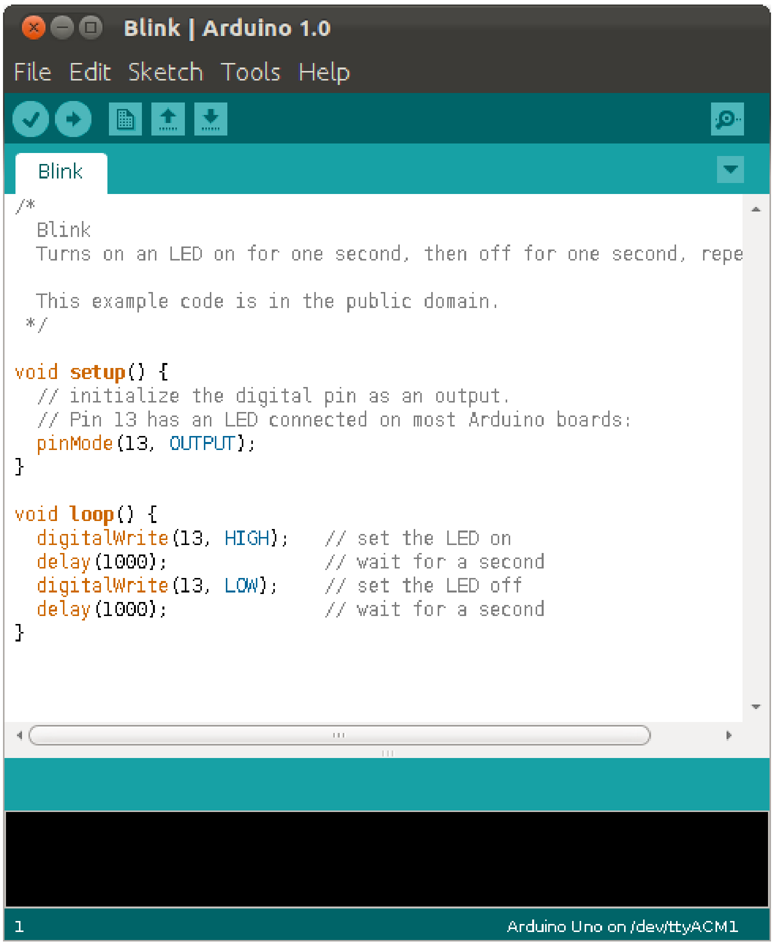

Figure 3.9: Arduino IDE example

with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus.

A program written with the IDE for Arduino is called a sketch. Sketches are saved on the development computer as text files with the file extension .ino. Arduino Software (IDE) pre-1.0 saved sketches with the extension .pde .

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU tool chain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

3.3.2 ThingSpeak

According to its developers, ”ThingSpeak is an open source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. ThingSpeak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates”.

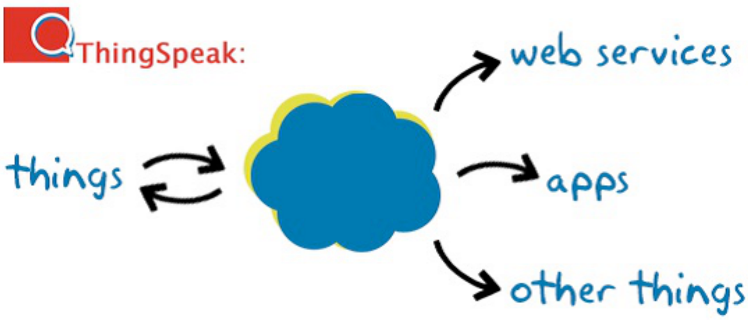

Figure 3.10: ThingSpeak Platform App

ThingSpeak was originally launched by ioBridge in 2010 as a service in support of IoT applications. ThingSpeak has integrated support from the numerical computing software MATLAB from Mathwork. Allowing ThingSpeak users to analyze and visualize uploaded data using Matlab without requiring the purchase of a Matlab license from Mathworks.

Features of ThingSpeak :

- Open API
- Real-time data collection
- Geo-location data
- Data processing
- Data visualizations
- Device status messages
- Plugins ThingSpeak can be integrate with, Arduino, Raspberry Pi, ioBridge/ RealTime.io, Electric Imp, Mobile / Web Applications, Social Networks and Data Analytics with MATLAB.

Procedure for ThingSpeak :

Step 1 : Create a channel

1. Sign In to ThingSpeak using either your MathWorks Account or ThingSpeak account, or create a new MathWorks account.

2. Click Channels >MyChannels.

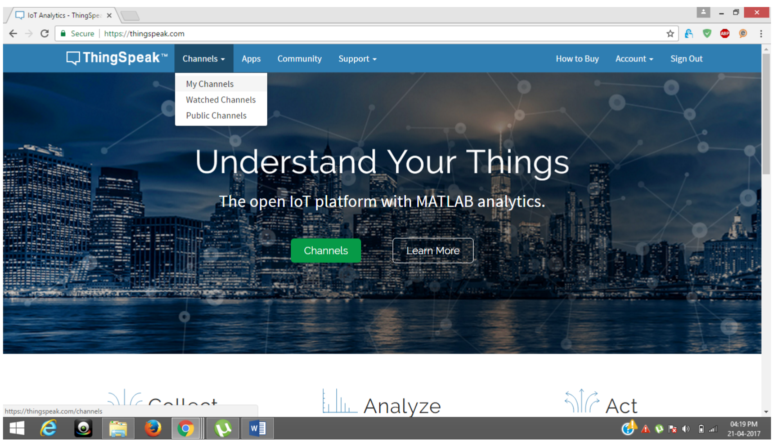

Figure 3.11: Creating channel on ThingSpeak

3. On the Channels page, click New Channel.

4. Check the boxes next to Fields 12. Enter these channel setting values:

- Name: PROJECT
- Field 1: Body Temperature
- Field 2: Heart-Rate

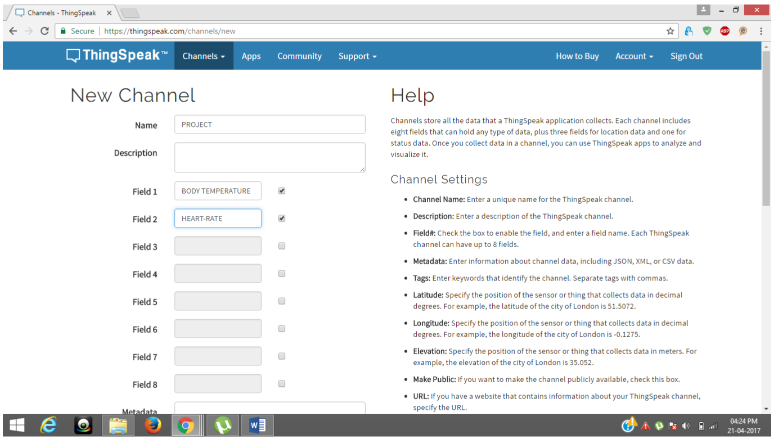

Figure 3.12: Creating Fields

5. Click Save Channel at the bottom of the settings.

You now see these tabs:

- **Private View:**This tab displays information about your channel that only you can see.
- **Public View:** If you choose to make your channel publicly available, use this tab to display selected fields and channel visualizations.
- **Channel Settings:** This tab shows all the channel options you set at creation. You can edit, clear, or delete the channel from this tab.
- **API Keys:** This tab displays your channel API keys. Use the keys to read from and write to your channel.

- **Data Import/Export:** This tab enables you to import and export channel data. Your channel is available for future use by clicking Channels >My Channels.

Step 2: How to send data to the ThingSpeak

Sending data to ThingSpeak is extremely easy. Decide what action you wanted to take and add that action command line in your coding precisely. Please make sure to add your respective Channel ID and API key.

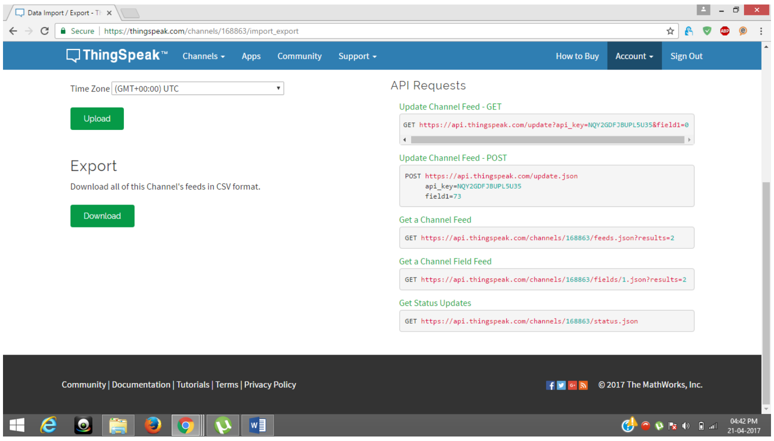

Figure 3.13: Send data to the ThingSpeak.com

Step 3: Find channel ID and API key

You can find your channel ID just below the channel title (PROJECT in my case) and Your API Keys in the API Keys.

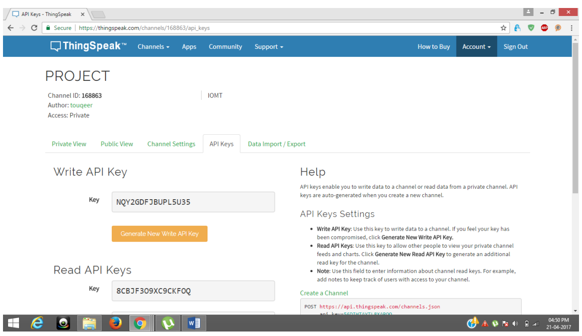

Figure 3.14: Generation of Channel ID and API Key

ThingSpeak Field chart visualization

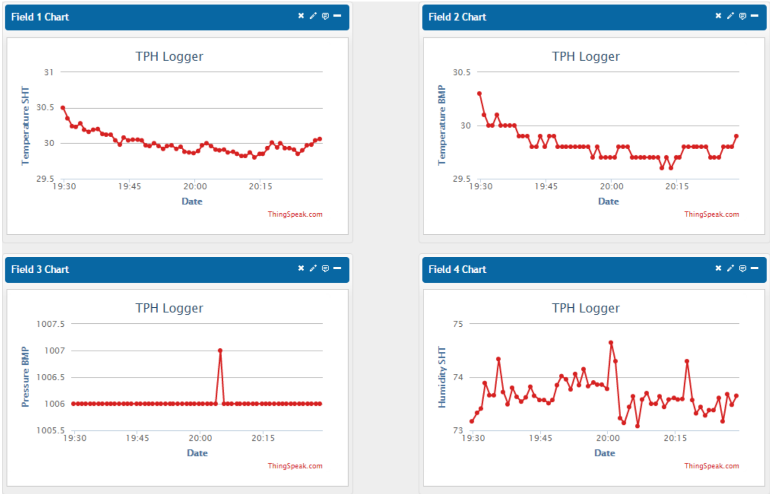

Figure 3.15: ThingSpeak Field Chart

3.3.3 PushingBox

PushingBox is a cloud that can send notifications based on API calls. From one request, you can send several notifications like a Push, a Tweet, an Email... All this in real time. PushingBox has only one API that you can trigger by HTTP request (GET/POST) or Email.

1. Configure a pushingbox.com scenario

2. Login to PusingBox with your Google login account (In our case it will be person email id to whom we wanted to send the data)

- Title: Patient HEALTH Monitoring
- subject: Patient Health Information: ALERT!!!!!
- body: Body Temperature : $temp$ Pulse Rate : $pulserate$ (you can add an note too in the body section)

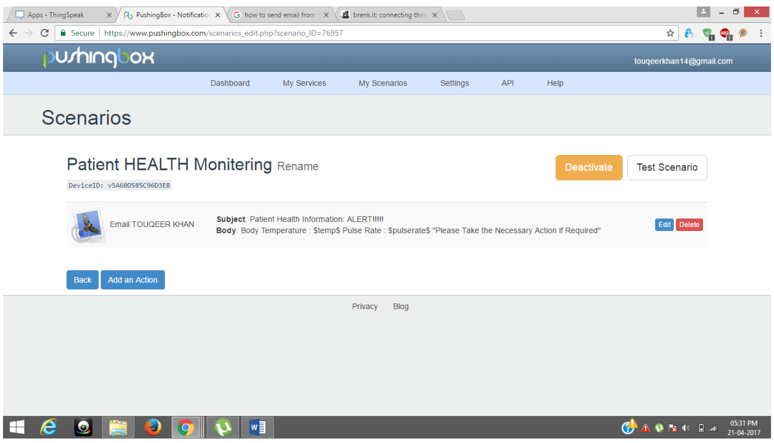

Figure 3.16: Configuring PushingBox.com

3. To Configure ThingSpeak

Now configure a ThingHttp - action on thingspeak.com. We can find ThingHttp in the **APPs** >**Action** section of THINGSPEAK Website

- Name: Patient Health Information
- url: http://api.pushingbox.com/pushingbox
- method: POST
- Content Type: application/x-www-form-urlencoded
- HTTP Version: 1.1

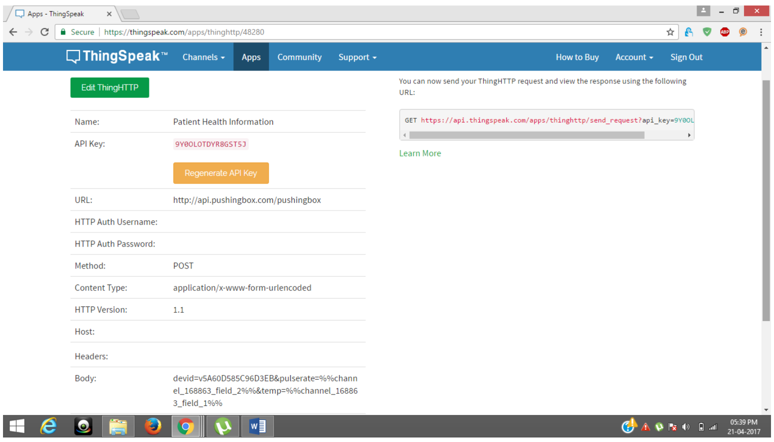

Figure 3.17: Configuration of ThingHttp

4. To configure the Threshold values

Go to **Thingspeak.com**>**APPs** >**Action** section into the **REACT**,open it and configure

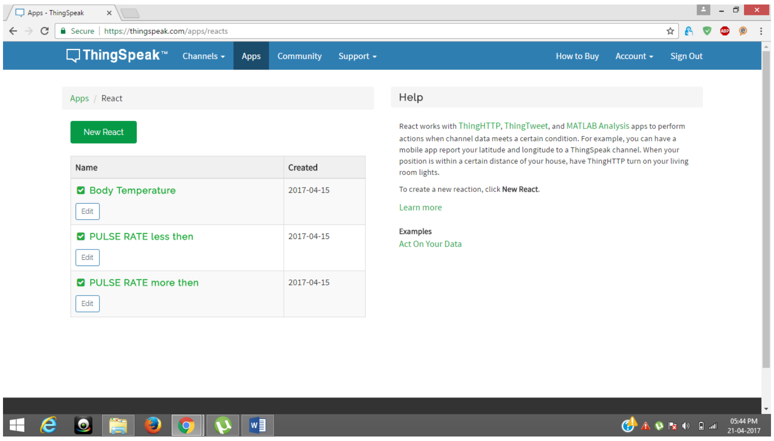

Figure 3.18: Creating field for Threshold values

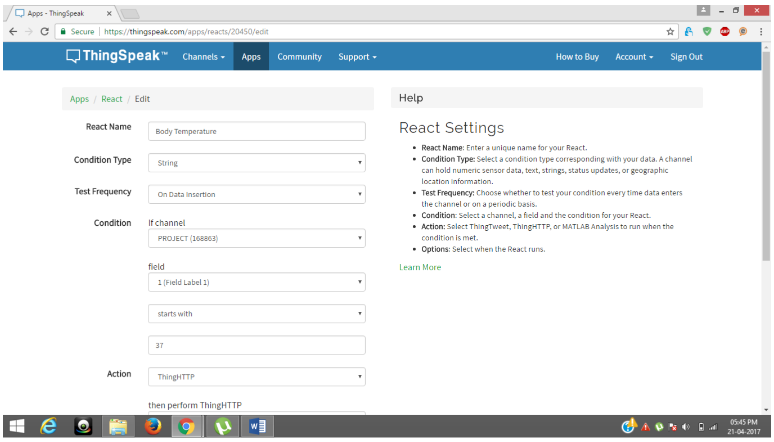

Figure 3.19: Setting Threshold value for Body Temperature

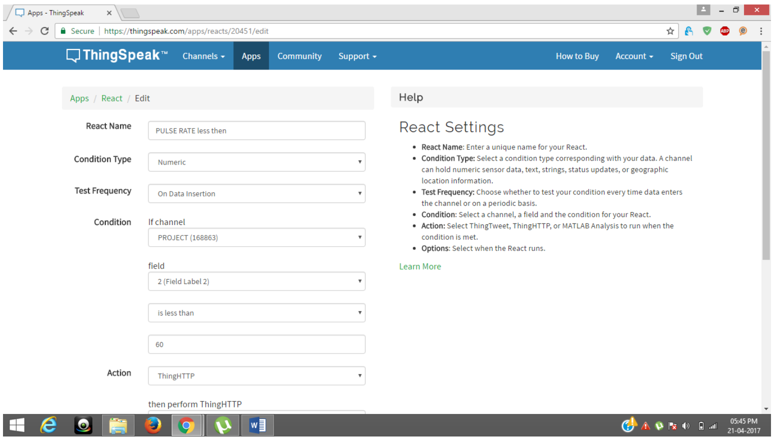

Figure 3.20: Setting Threshold value for Low Pulse Rate

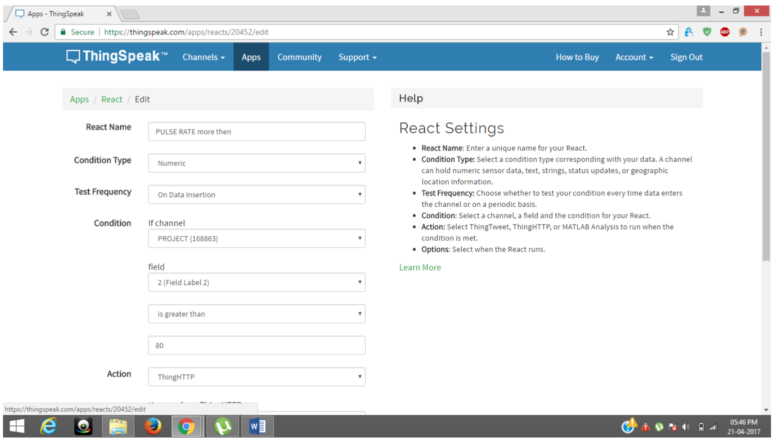

Figure 3.21: Setting Threshold value for High Pulse Rate

Chapter 4

Advantages and Limitations

Unlocking the Potential of IoT-MD connected to the medical devices and associated IoT technologies will primarily be used to achieve the following capabilities:

- Access real time visibility of the patient's condition, his/her activities, context and physiological parameters
- Monitor compliance to prescribed treatment, diet and exercise regimes
- Provide feedback and cues to patients, family members, doctors and caregivers in order to implement corrective action
- Leverage high performance computing for real time feedback and use evidence-based medicine for better patient outcome Remote monitoring of patients leads to more effective and timely treatment, leading to better management of health. In addition, patients (and their relatives) are empowered by getting greater visibility into their actual health conditions, enabling them to play an active role in controlling and influencing their treatment.

4.1 Advantages of m-IoT

Lowered cost of care: By leveraging IoT-MD systems, the health of patients can be monitored on a real time basis, avoiding unnecessary doctor visits. Home care is possible, further reducing hospital stay. Caregivers can address common use cases and reach out to doctors only when needed.

Improved patient outcomes: By referring to a comprehensive knowledge base compiled from previous disease outbreaks and proven research, caregivers and doctors can use evidence-based medicine for improved patient outcomes. The real-time information can help provide timely care and address issues at an early stage.

Real time disease management: In a connected healthcare environment with continuous remote monitoring, patients can get treated proactively before their condition worsens. This not only helps patients' health, but also reduces the cost of care. The focus is shifted from 'treatment' to 'wellness'.

Improved quality of life: For the critically ill, pediatric and aged populations, IoT-MD offers an easier life. The elderly can live independently at any location of their choice while getting their medical condition monitored. Improved user experience: For patients as well as caregivers, IoT-MD makes it possible to have a richer and more intimate engagement with each other. Automation of data collection makes it possible to collect data accurately, on time and with minimal human intervention. All stakeholders receive better visibility with respect to the patient's condition, progress and outcomes of treatment. Automation of engagement also allows better compliance to prescribed treatment regimes.

4.2 Limitations

Scale, data volume and performance: As the quality and accuracy of medical devices improve, more applications will be developed for an expanding user base. The amount of data that needs to be ingested, stored and analyzed will also increase exponentially. Some medical devices will need to store high resolution data, and some will generate multimedia output such as high resolution images and videos. This will lead to a typical Big Data problem where the sheer volume and velocity of data ingested will make standard architectures and platforms inadequate. In other cases, some applications may demand more stringent real-time performance than what is ordinarily possible using standard internet technologies. Applications and the database backend must be seamlessly scaled up as operations become more complex.

Flexibility and evolution of applications: As newer analytics, techniques, algorithms, use cases and business models evolve, advanced medical devices with improved capabilities will be created. Newer applications and software components need constant upgrades by specialists with specific technology and medical domain skills.

Data privacy: Data collected from medical devices is sensitive and must be protected from unauthorized access. It should be used only for the specific purpose for which the patient/user allowed that data to be collected. Policies to share medical data with authorized persons and applications must be strictly followed, and data securitization be given utmost importance.

Need for medical expertise: The diagnosis and transmission of medical data to healthcare providers is governed by regulations. The inability to interpret data captured by medical devices, with patients trying to diagnosis themselves based on an incorrect understanding, can lead to major risks. Every diagnosis and prognosis bases itself not only on current observations made by devices, but on the history and the health profile of the individual patient. Diagnosis and detection of alert conditions is aided by automated decision support systems where rules/decision trees are provided by trained physicians, customized for each condition and patient.

Chapter 5

Future Application

Real Time Location Services

Through IoT, doctors can use real time location services and track the devices used for treating patients. Medical staff may sometimes keep the devices in out-of-sight areas which makes them difficult to find when another medical staff comes on the scene.

Medical apparatus and devices like wheelchairs, scales, defibrillators, nebulizers, pumps or monitoring equipment can be tagged with sensors and located easily with IoT. Apart from real time location services, there are IoT devices that help in environmental monitoring as well (checking the refrigerator temperature, for example).

Predicting the Arrival of Patients in PACU

With the intervention of Internet of Things, clinicians can predict the arrival of patients who are recuperating in the Post-Anesthesia Care Unit (PACU). They can also monitor the status of patients in real time.

Hand Hygiene Compliance

There are hand hygiene monitoring systems that would detect the degree of cleanliness in a healthcare worker. According to the Center for Disease Control and Prevention in the United States, about one patient out of every 20 gets infections from lack of proper hand hygiene in hospitals. Numerous patients lose their lives as result of hospital acquired infections.

The interactions in the hand hygiene monitoring systems are done in real time and if a clinician comes near a patients bed without washing his hands, the device would start buzzing. And thats not all. The information about the healthcare worker, his ID, time and location will all be fed into a database and this information would be forwarded to the concerned authorities.

Tighten Budgets and Improve Patient Journey

The healthcare industry has to keep a watchful eye on the budget and at the same time have updated infrastructure to provide better patient experiences. Thanks to the seamless connection between devices that IoT has made possible, it is now possible for the medical staff to access patient information from the cloud as long as they are stored in there.

The goal is to provide quality medical care to patients, and by spending a small amount on IT infrastructure, hospitals can provide good care to patients at affordable rates. IoT aims to provide better patient journey by:

- Room lighting through personal control
- Communicate to family and friends through email services
- Immediate attention to patient needs

Remote Monitoring

Remote health monitoring is an important application of Internet Of Things. Through monitoring, you can give adequate healthcare to people who are in dire need of help. Every day, lots of people die because they do not get timely and prompt medical attention. With IoT, devices fitted with sensors notify the concerned healthcare providers when there is any change in the vital functions of a person.

These devices would be capable of applying complex algorithms and analyzing them so the patient receives proper attention and medical care. The collected patient information would be stored in cloud. Through remote monitoring, patients can significantly reduce the length of hospital stay and perhaps, even hospital re-admission.

This kind of intervention is a boon to people living alone, especially seniors. If there is any interruption in the daily activity of a person, alerts would be sent to family members and concerned health providers. These monitoring devices are available in the form of wearables too.

Focus on the Research Side of Healthcare

Protein research and composition analysis benefits from Internet of Things. Through IoT, researchers are able to analyze the accuracy of the equipment, and it rewards them by shortening their workflow through quantitative and reproducible analysis of proteins.

When an infinite array of devices is connected, the healthcare industry is able to provide scalable solutions to its patients. A number of healthcare apps providing cutting-edge personalized solutions are released to them. Here are a few of them:

- **Medication Dispensing Device by Philips** so patients will not miss a dose anymore; perfect for elderly patients.
- **Niox Mino by Aerocrine** for routine measurements of Intric Oxide in a patients breath.

- **UroSense by Future Path Medical** for catheterized patients to check their core body temperature and urine output.
- **GPS SmartSole** this is a shoe-tracking wearable device for dementia patients who have the habit of forgetting things.

Chapter 6

Conclusion

M-IoT will drastically change the face of healthcare monitoring and treatment outcomes. By providing personalized and optimized services, it will promote a better standard of living.

With the wide use of internet this work is focused to implement the internet technology to establish a system which would communicate through internet for better health. Internet of things is expected to rule the world in various fields but more benefit would be in the field of healthcare. Hence present work is done to design an IOT based smart healthcare system using a processor.

Nations across the world are struggling to improve patient care and m-IoT provides a timely and cost-effective response to this critical imperative. Moreover, recent developments in sensor, internet, cloud, mobility and big data technologies have led to affordable medical devices and connected health programs, vastly increasing the potential of IoT-MD to influence further changes.

Chapter 7

Bibliography