BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

BUET

DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING

EEE 310 Project Report

Topic : Remote Patient Health Monitoring System

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Section : C2

Group Number : 03

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Abstract:

In this project, remote patient monitoring devices are used to record a patient's health data and this data on vital signs is then automatically compared to the upper and lower (threshold) values set by a physician. If the threshold value is breached, the RPM system at the healthcare facility triggers a notification that generates a warning message and alerts a physician that there is an abnormal situation. This notification to the doctor is sent through email. Through this project, healthcare providers can track a patient's health through the health data they receive electronically from the patient's health monitoring devices and, based on this data, can perform assessments and provide recommendations.

Introduction:

Remotely monitoring a patient's condition is a serious issue and must be addressed. Remote health monitoring systems (RHMS) in telemedicine refers to resources, strategies, methods and installations that enable doctors or other medical professionals to work remotely to consult, diagnose and treat patients. The goal of RHMS is to provide timely medical services at remote areas through telecommunication technologies. Through major advancements in technology, particularly in wireless networking, cloud computing and data storage, RHMS is becoming a feasible aspect of modern medicine. When incorporated in the management of chronic diseases, remote health monitoring has the potential to significantly improve quality of life for patients and so it should come as no surprise that this technology is growing increasingly popular. With the advent of the pandemic, many healthcare providers started tracking symptoms and vital signs of both coronavirus and non-coronavirus patients remotely. The future of remote patient monitoring looks promising indeed.

Objectives:

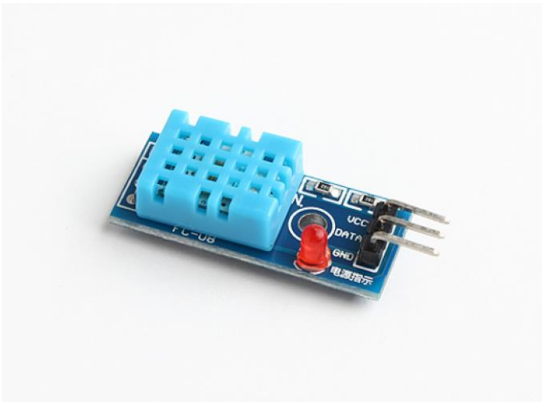
- Enable fast and remote healthcare monitoring.
- Implement an improved system based on advanced ICT allowing more efficient treatment and care with added possibilities offered by eHealth.
- Create a user friendly system, so the healthcare system will be equitable.
- Create a valuable information system enhancing the quality of life for everyone.
- Decrease human mortality by reliable easy-to-use and effective care system.
- Enable seamless adaptation between different kind of bio-sensors.
- Introduction in the clinical practice of a new e-health approach.
- Allow persons to be under constant monitoring of their physical conditions by healthcare professionals.
- Reduce geographical/physical boundaries as barriers for individuals seeking the best in Europe healthcare.
- Reduce working load on doctors and nurses.

Hardware Components:

DS18B20 (Body Temperature Sensor):

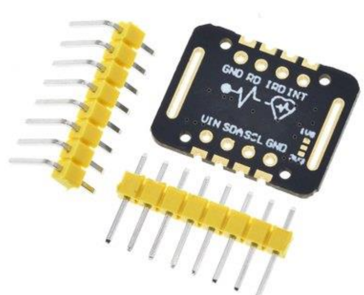
The DS18B20 is one type of temperature sensor. The communication of this sensor can be done through a one-wire bus protocol which uses one data line to communicate with an inner microprocessor. It can be used to measure temperature in the range of -67oF to +257oF or -55oC to +125oC with +-5% accuracy. The range of received data from the 1-wire can range from 9-bit to 12-bit. Because, this sensor follows the single wire protocol, and the controlling of this can be done through an only pin of Microcontroller. This is an advanced level protocol, where each sensor can be set with a 64-bit serial code which aids to control numerous sensors using a single pin of the microcontroller. this sensor gets the power supply directly from the data line so that the need for an external power supply can be eliminated. The applications of the DS18B20 temperature sensor include industrial systems, consumer products, systems which are sensitive thermally, thermostatic controls, and thermometers.

DHT11 (Temperature and Humidity Sensor):



The DHT11 is a commonly used Temperature and humidity sensor. The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values of temperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers. The sensor will come as a 4-pin package out of which only three pins will be used whereas the module will come with three pins. The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of ±1°C and ±1%.

MAX30102 (Pulse Oximetry and Heart-Rate Monitor Biosensor) :



The MAX30102 is an integrated pulse oximetry and heart-rate monitor biosensor module. It includes internal LEDs, photodetectors, optical elements, and low-noise electronics with ambient light rejection. The MAX30102 provides a complete system solution to ease the design-in process for mobile and wearable devices. The MAX30102 includes internal LEDs, photodetectors, optical elements, and low-noise electronics with ambient light rejection. This highly sensitive device operates on a single 1.8V power supply and a separate 5.0V power supply for the internal LEDs. Communication is through a standard I2C-compatible interface. This sensor can be shut down through software with zero standby current, allowing the power rails to remain powered at all times.

ESP8266 :

The ESP8266 is a low-cost Wi-Fi microchip, with built-in TCP/IP networking software, and microcontroller capability. It ennables microcontrollers to connect to 2.4 GHz Wi-Fi, using IEEE 802.11 bgn. It can be used with ESP-AT firmware to provide Wi-Fi connectivity to external host MCUs, or it can be used as a self-sufficient MCU by running an RTOS-based SDK.

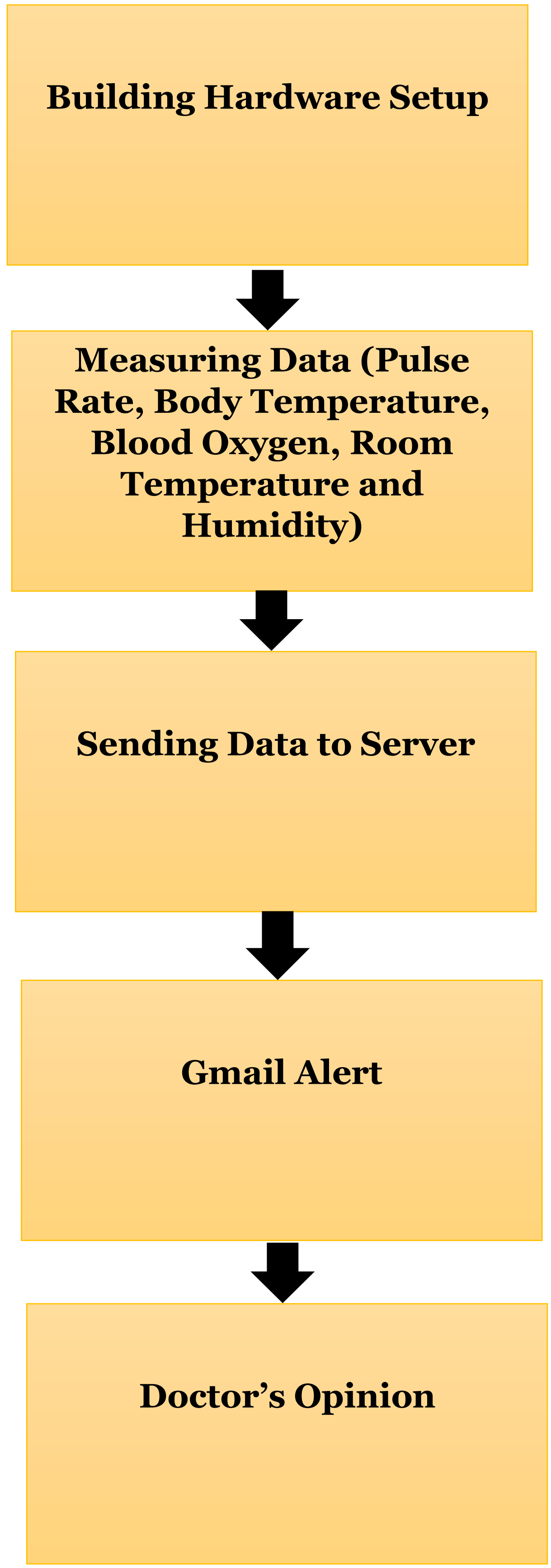
Jumper Wires:

Jumper wires are electrical wires with connector pins at each end. They are used to connect two points in a circuit without soldering. Jumper wires are used to modify a circuit or diagnose problems in a circuit. Further, they are best used to bypass a part of the circuit that does not contain a resistor and is suspected to be bad.

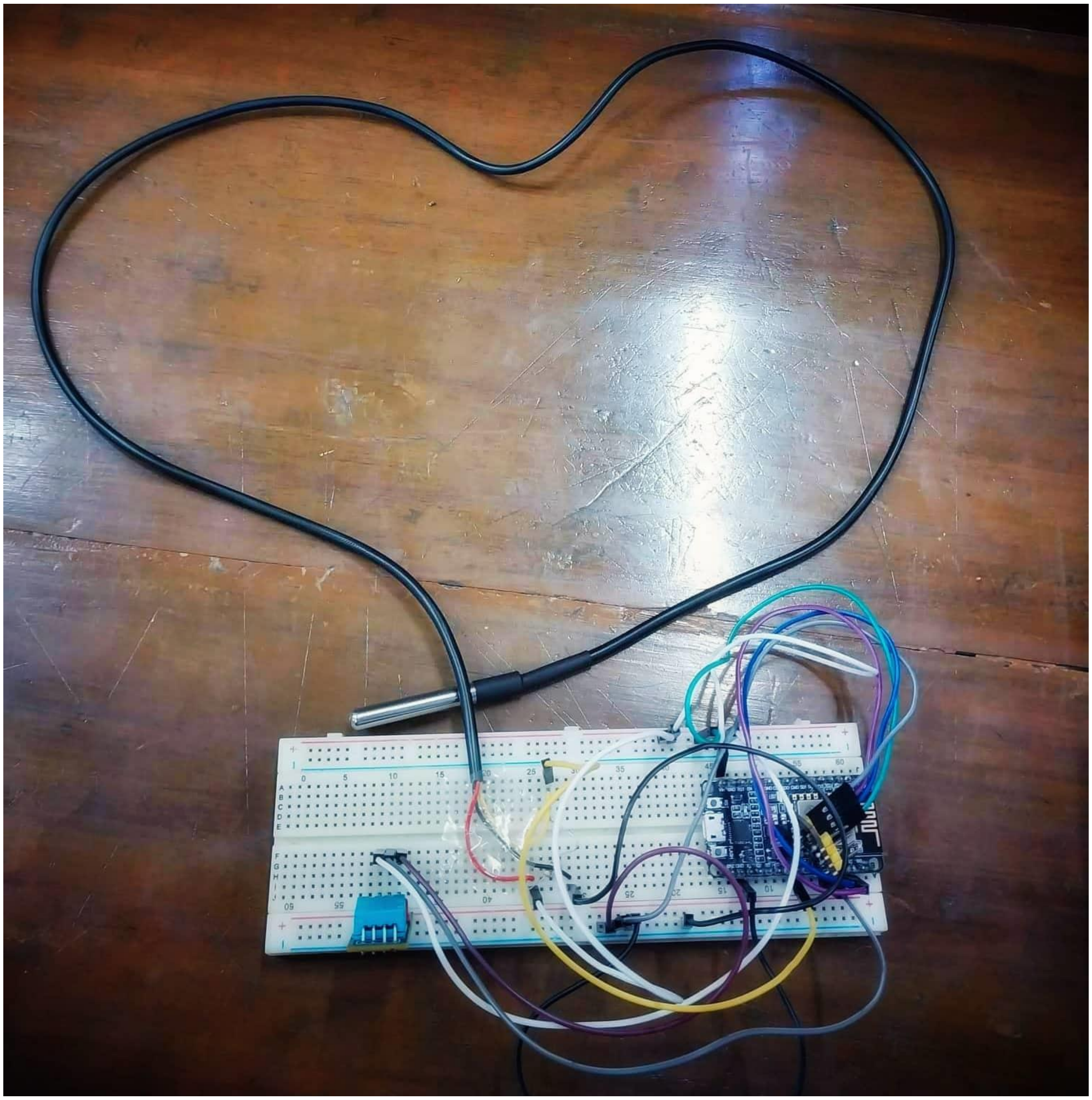
Breadboard:

A breadboard is used for building temporary circuits. It is useful to designers because it allows components to be removed and replaced easily. It is useful to build a circuit to demonstrate its action, then to reuse the components in another circuit.

Workflow:


Building Hardware Setup
Measuring Data (Pulse Rate, Body Temperature, Blood Oxygen, Room Temperature and Humidity)
Sending Data to Server
Gmail Alert
Doctor’s Opinion

Building Hardware Setup:



In this setup, pulse oximeter is connected with D2 and D3 pin of ESP8266 to measure heart rate and blood oxygen level. With D4 pin DHT11 is connected to measure room temperature and humidity. Finally D5 pin is connected to temperature sensor. A resistor of 4.7kohm is required in between Vin and data pin of temperature sensor.

Measuring Data:

The process of setting up a remote patient monitoring system starts with activating the patient health monitoring sensors.

```
 for (byte i = 0 ; i < bufferLength ; i++)
 {
   while (particleSensor.available() == false) //do we have new data?
   particleSensor.check(); //Check the sensor for new data
   redBuffer[i] = particleSensor.getRed();
   irBuffer[i] = particleSensor.getIR();
   particleSensor.nextSample(); //We're finished with this sample so move to next sample
 }
//calculate heart rate and SpO2 after first 100 samples (first 4 seconds of samples)
 maxim_heart_rate_and_oxygen_saturation(irBuffer, bufferLength, redBuffer, &spo2, &validSPO2, &heartRate, &validHeartRate);

 //dumping the first 25 sets of samples in the memory and shift the last 75 sets of samples to the top
 for (byte i = 25; i < 100; i++)
 {
   redBuffer[i - 25] = redBuffer[i];
   irBuffer[i - 25] = irBuffer[i];
 }
//take 25 sets of samples before calculating the heart rate.
 for (byte i = 75; i < 100; i++)
 {
/    while (particleSensor.available() == false) //do we have new data?
     particleSensor.check(); //Check the sensor for new data
    digitalWrite(readLED, !digitalRead(readLED)); //Blink onboard LED with every data read
    redBuffer[i] = particleSensor.getRed();
    irBuffer[i] = particleSensor.getIR();
    particleSensor.nextSample(); //We're finished with this sample so move to next sample
    Serial.print(F(", HR="));
    Serial.println(heartRate, DEC);
    Serial.print(F(", SPO2="));
    Serial.println(spo2, DEC);
 }
```

Max30102 provides heart rate and oxygen saturation. There is a red and IR LED and a photodetector. Oxygen in the hemoglobin can absorb IR ray. Deoxigenated oxygens absorb more red light while bloods with more sufficient oxygen absorb more IR light. Calculating the ratio between, it can measure oxygen level. Then bloods are pumped through veins in the finger, changes of reflected light creates an oscillating waveform. By calculating the wave, heart rate can be calculated.

```
void dhtRead()
{
  sensors_event_t event;
  dht.temperature().getEvent(&event);
  if (isnan(event.temperature)) {
    Serial.println(F("Error reading temperature!"));
  }
  else {
    //lcd.begin(16, 1);
    ///lcd.clear();
    //lcd.setCursor(0,0);
    //lcd.print("T=");
    //lcd.print(event.temperature);
    //lcd.print("C");
    Serial.print(F("Temperature: "));
    Serial.print(event.temperature);
    Serial.println(F("°C"));
    value_1 = event.temperature;
//    ThingSpeak.writeField(Channel_ID, Field_Number_1, value_1, myWriteAPIKey);
  }
  // Get humidity event and print its value.
  dht.humidity().getEvent(&event);
  if (isnan(event.relative_humidity)) {
    Serial.println(F("Error reading humidity!"));
  }
  else {
    Serial.print(F("Humidity: "));
    Serial.print(event.relative_humidity);
    Serial.println(F("%"));
    //lcd.setCursor(9,0);
    //lcd.print("H=");
    //lcd.print(event.relative_humidity);
    //lcd.print("%");
    value_2 = event.relative_humidity;
  }
}
```

DHT11 can measure room temperature as well as humidity. There is a humidity sensing capacitor. The change of capacitance occurs with the change of humidity.

```
Serial.print("Requesting temperatures...");
sensors.requestTemperatures(); // Send the command to get temperatures
Serial.println("DONE");

Serial.print("Body Temperature(C): ");
Serial.println(sensors.getTempCByIndex(0));
value_5 = 1.8*sensors.getTempCByIndex(0)+32;
```

Finally, we have measured body temperature using DH18B20.

After appropriate coding and proper hardware connection, sensors provide us the data.

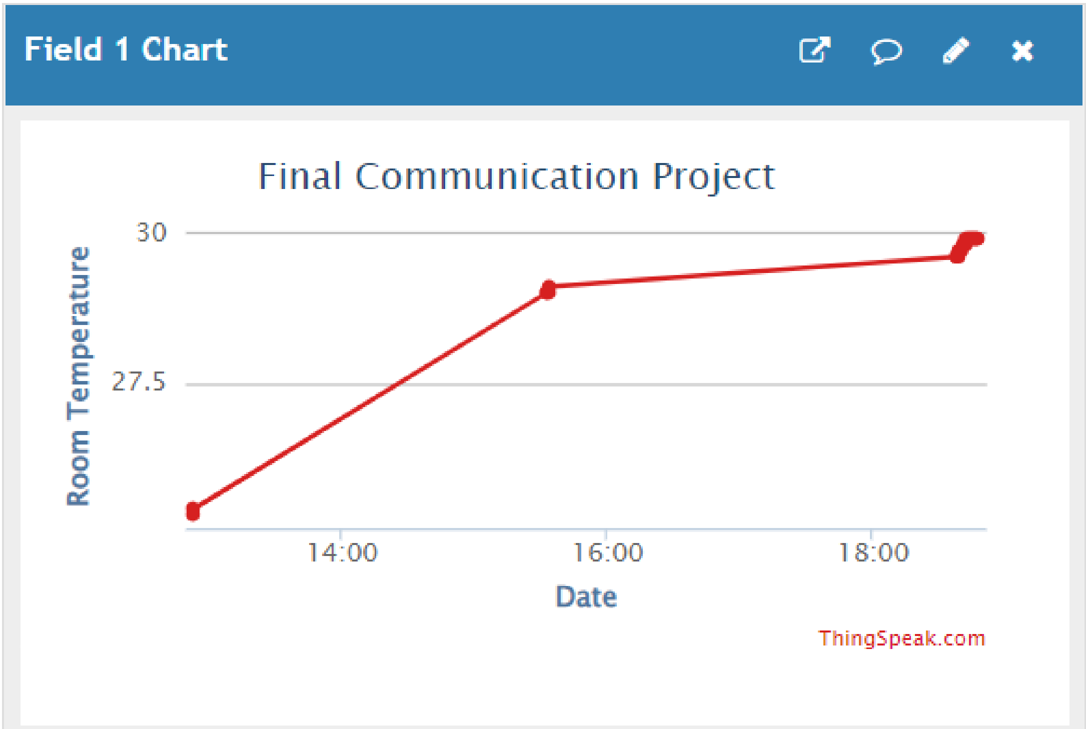
```
, SPO2=84
, HR=166
, SPO2=84
Temperature: 29.80°C
Humidity: 42.00%
Requesting temperatures...DONE
Temperature for the device 1 (index 0) is: 30.50
```

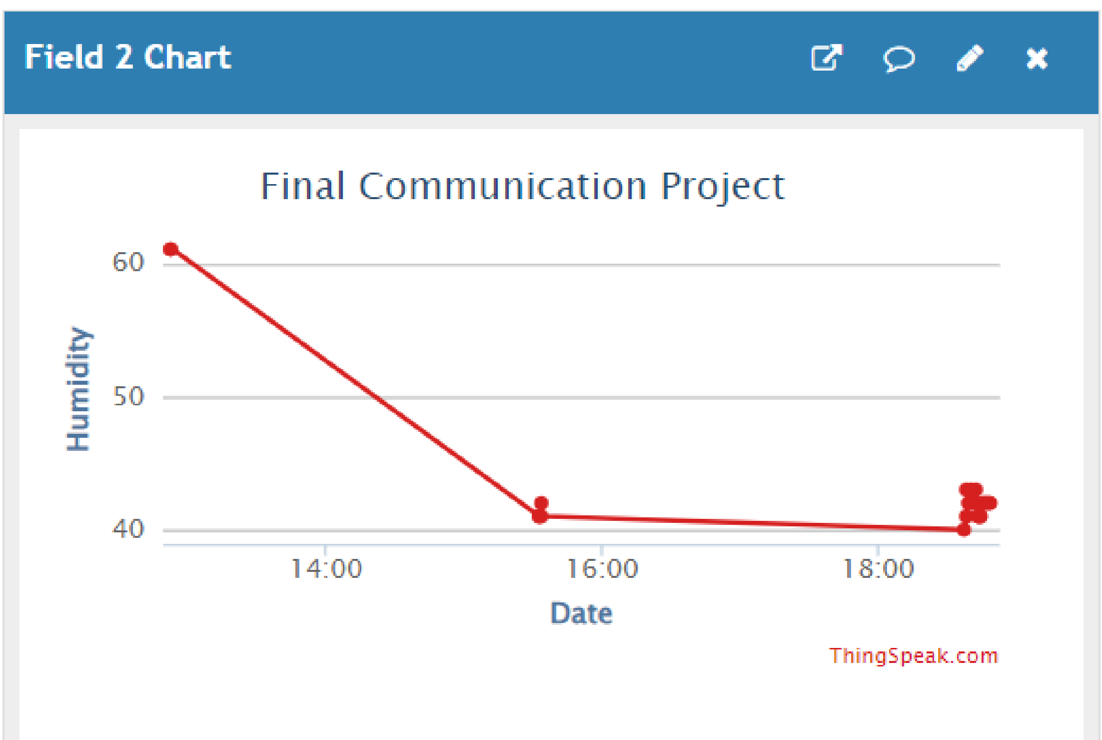
Sending Data to Server:

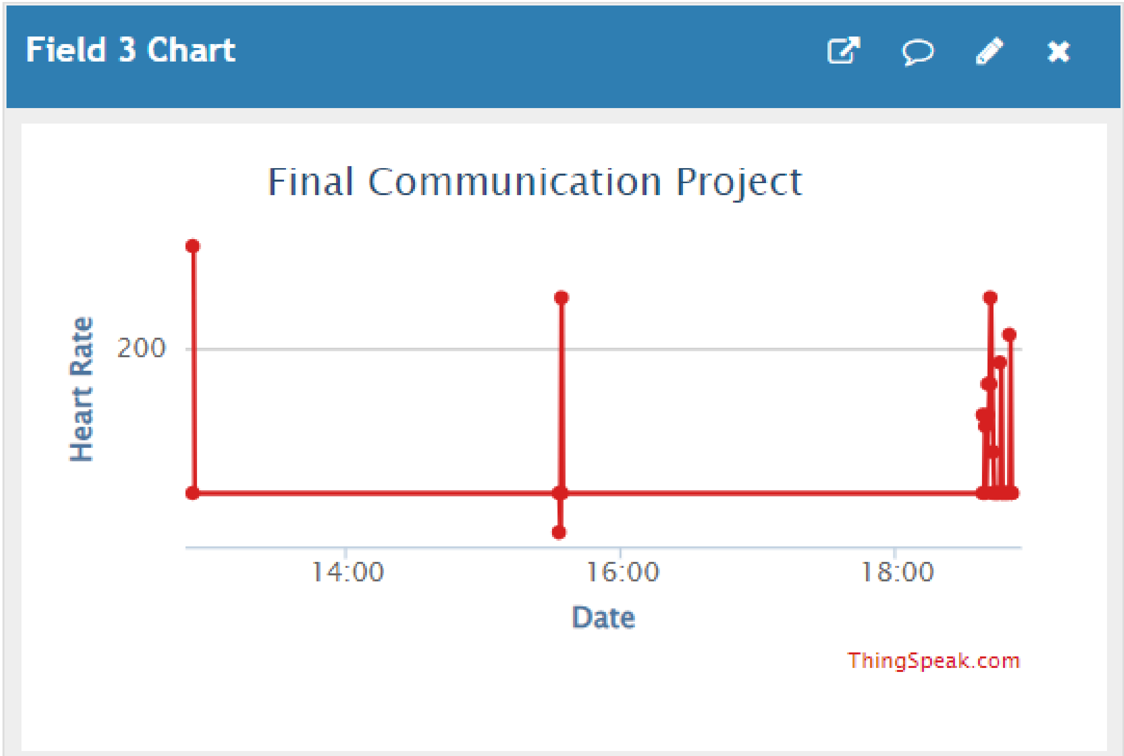
We created a channel on ThingSpeak and using its ID and Unique API keys on Arduino IDE, we have sent our data to ThingSpeak.

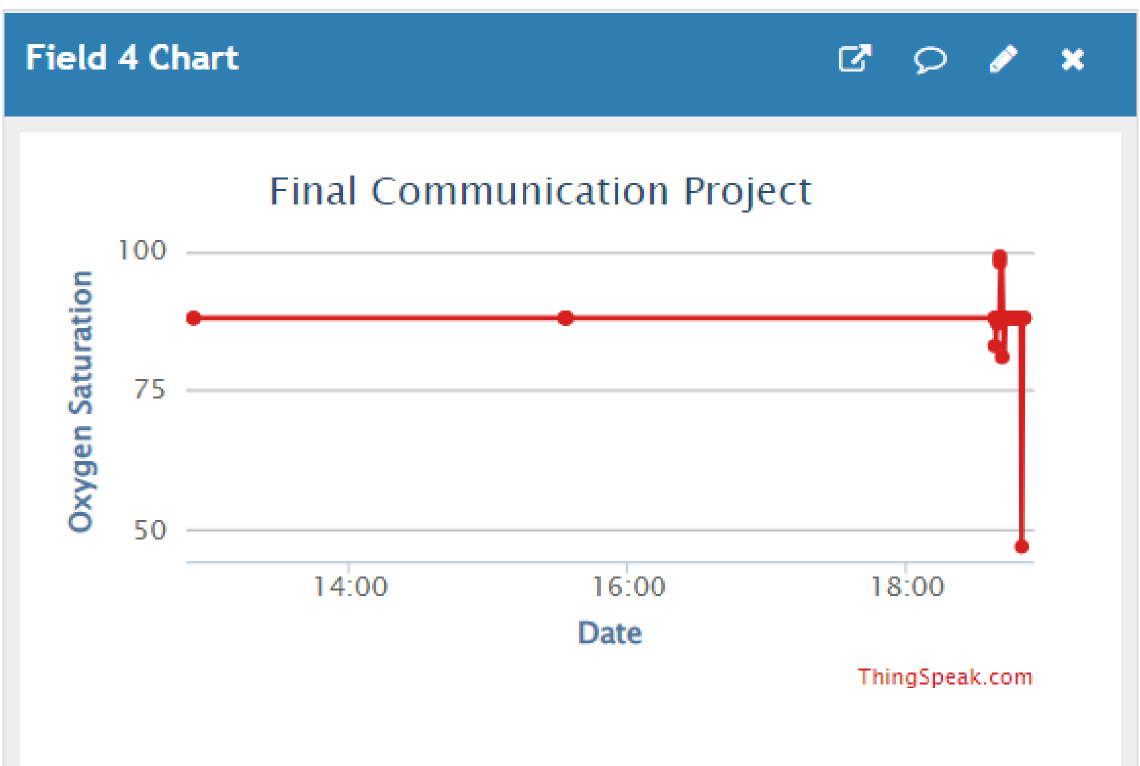
```
ThingSpeak.setField(1, value_1);
ThingSpeak.setField(2, value_2);
ThingSpeak.setField(3, value_3);
ThingSpeak.setField(4, value_4);
ThingSpeak.setField(5, value_5);
ThingSpeak.writeFields(Channel_ID, myWriteAPIKey);
```

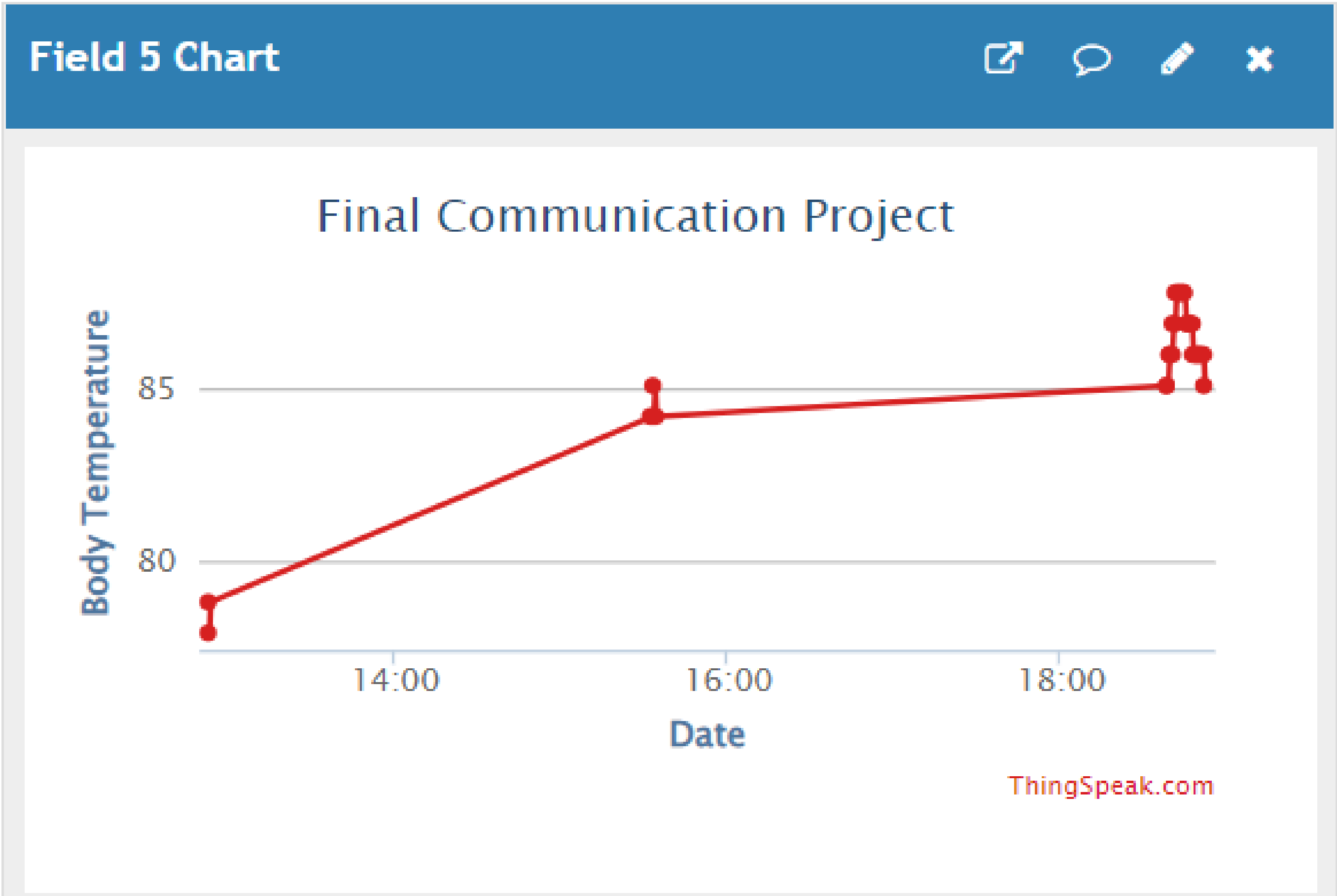
ThingSpeak Output:





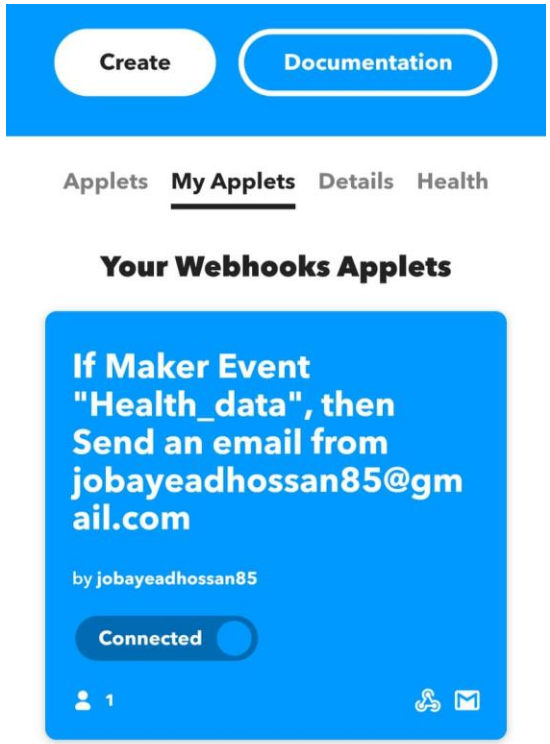

Field 3 Chart
Final Communication Project
Heart Rate
200
14:00
16:00
18:00
Date
ThingSpeak.com


Field 4 Chart
Final Communication Project
Oxygen Saturation
100
75
50
14:00
16:00
18:00
Date
ThingSpeak.com

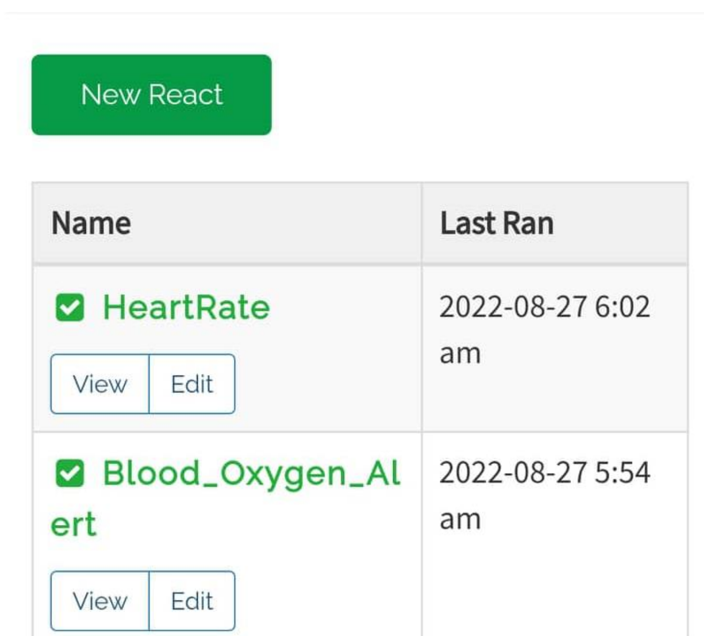


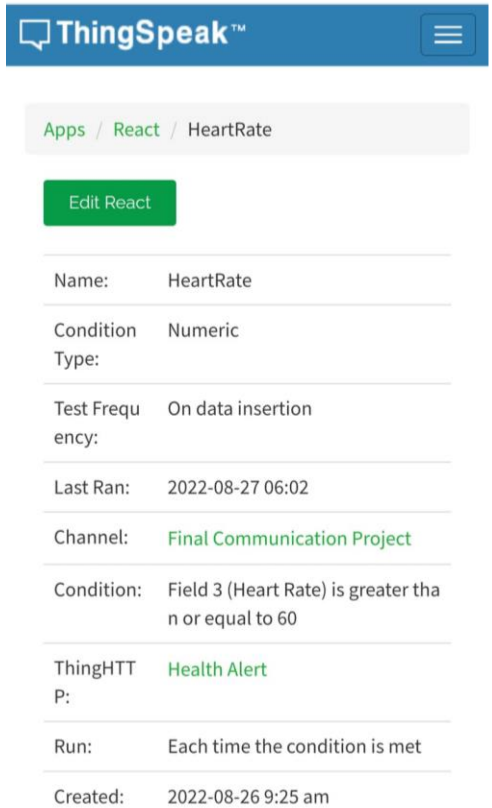
Gmail Alert:

For this, we have linked up IFTTT server with the ThingSpeak. Creating an applet on IFTTT, we created an event and decided how will we get alert. Then using it URL on ThingSpeak React, we decided when will we get alert. When any of our measured value goes out of this range, we will get notified.



We have set threshold <=88 for oxygen saturation and >=100 pm for heart beat.



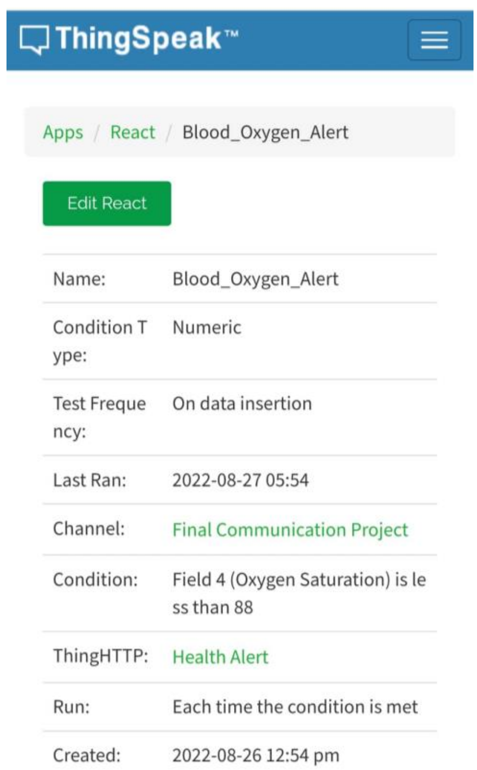


ThingSpeak™

Apps / React / HeartRate

Edit React

Name:	HeartRate
Condition Type:	Numeric
Test Frequency:	On data insertion
Last Ran:	2022-08-27 06:02
Channel:	Final Communication Project
Condition:	Field 3 (Heart Rate) is greater than or equal to 60
ThingHTTP:	Health Alert
Run:	Each time the condition is met
Created:	2022-08-26 9:25 am



ThingSpeak™

Apps / React / Blood_Oxygen_Alert

Edit React

Name:	Blood_Oxygen_Alert
Condition Type:	Numeric
Test Frequency:	On data insertion
Last Ran:	2022-08-27 05:54
Channel:	Final Communication Project
Condition:	Field 4 (Oxygen Saturation) is less than 88
ThingHTTP:	Health Alert
Run:	Each time the condition is met
Created:	2022-08-26 12:54 pm

If the threshold value is breached, the RPM system at the healthcare facility triggers a notification that generates a warning message and alerts a physician that there is an abnormal situation. This notification to the doctor is sent through email.

Doctor’s Opinion:

Once a notification has been triggered, the RPM system, nurses, or physicians send an alert to doctors if it is required. If the health data shows that a patient requires immediate medical attention, the relevant authorities are notified and immediate assistance is provided. However, if the data only indicates that only a change in the treatment is required, the physician can make the appropriate decision and communicate this information to the patient via various forms of communication like email, phone, or in-app notifications. The physician can also advise on how to prevent similar adverse events from happening again in the future.

Future Scope of Remote Patient Monitoring System:

RPM was already gaining popularity before the Covid-19 pandemic. However, the pandemic has certainly steered RPM into the mainstream of healthcare by accelerating the uptake of RPM as an effective way of delivering care while protecting patients from infection. Remote patient monitoring, monitors patients remotely with the help of modern technology is a big player in the field of healthcare because along with making lives easier it is also cost effective, time saving and most importantly acts as an early warning system by alerting whenever there are signs of health deterioration. Many Companies are leading this remote health virtual platforms with reference to this remote technology. Various facilities like telehealth, RPM systems have been provided by some leading companies like Medtronic, Resideo, Philips healthcare, PCL-Health. These companies not only provided digitized remote health tracking instruments, but also innovated these devices in a way to survive in cut-throat competition and deliver advanced quality care to each division of the population. According to Research and Markets, the global RPM systems market is projected to be worth over $1.7 billion by 2027, up nearly 128% from the $745.7 million opportunities the market currently represents

Benefits of RPM:

- Adjust medication dosing or treatment regularly to improve outcomes.
- Automate and respond to alerts while identifying worrisome trends or readings.
- Minimize associated hospitalizations by performing timely interventions as soon as message alerts indicate a problem.
- Monitor a patient's progress and adherence to the treatment program.
- Prioritize attention and resources on patients that need more support.
- Provide a holistic and comprehensive outlook of an individual's health.
- Reduce manual data collection and data entry, providing more for data analysis to improve clinical decisions.

Limitations of RPM:

Although the technology has many proven successes, its main flaws lie with the fact that remote health monitoring can heavily rely on patients taking an active role in their own health and some patients are more passive or forgetful than others. Wireless technologies are also not suitable for some rural areas, and some older patients may not know how to use modern technologies like apps. Any collected health information also needs to be encrypted and protected from hackers and some remote health monitoring technologies are very expensive.

Conclusion:

In this project, vital sign data is automatically compared to upper and lower (threshold) levels defined by a physician after being recorded by remote patient monitoring equipment. This system has the ability to improve the quality of care. Since RPM connects clinicians more directly (and virtually instantly) with relevant patient data, it can make their daily routines more efficient and eases the possibility of burnout resulting in obvious benefits to patient care. The patient is able to avoid the associated costs of an in-person visit when they receive care via RPM. Also, it can help reduce the burden of over-scheduled in person visits by allowing clinicians to provide some of that care virtually. It leverages a team-based care model that allows for provider flexibility. Monitoring can reduce hospitalization in the short term and prevent or delay complications from disease. This will enable patients to become more educated and be in charge of their health.