

# Embedded Internet of Things (IoT) Environmental Monitoring System Using Raspberry Pi

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## Abstract

**Background:** Measuring and monitoring the temperature and humidity levels in a computer laboratory is crucial for ensuring the safety of the facility and the comfort of those using it. The latest technology for collecting this data is the Internet of Things (IoT), which uses sensors to monitor these parameters remotely. **Aim:** This paper presents an IoT system that assesses the temperature and humidity levels in a computer laboratory using a Raspberry Pi single-board computer and a DHT11 sensor. **Method:** The major contribution of this research is it utilizes the ThingSpeak Cloud database which provide the result faster within the shortest interval time which improve the temperature and humidity values more than the traditional Message Queue Telemetry Transport (MQTT). The DHT11 sensor captures the temperature and humidity data, which is then uploaded to the servers in real-time. This allows laboratory managers and decision-makers to monitor the laboratory's condition through a web portal or a mobile application installed on their Android or iOS devices from anywhere. **Results:** The results show that the ThingSpeak Cloud database provides the result of the temperature as to 31.5°C and the relative humidity 74.8%.

**Keywords:** Embedded, Internet of Things (IoT), Environmental Monitoring, Raspberry Pi

## 1. Introduction

The Internet of Things (IoT) involves embedded devices that communicate with both the real world and the internet using sensors and actuators, enabling stable and remote communication. Recent technological advancements have led to exponential growth in the IoT market, and as a result, issues related to the physical sensing environment, connectivity, security, and power are no longer significant challenges (Chong et al., 2023; Jadhav et al., 2016).

The IoT has the potential to create a more hospitable world for humanity, promoting lifestyle changes and providing better service quality in areas such as air quality control, traffic and parking regulation, energy consumption management, and building construction (Nasution et al., 2019).

Given the critical state of the global environment and the various parameters, such as population growth and industrialization, that affect its quality and have socio-economic impacts on humans, continuous and automatic environmental monitoring is essential to track changes and implement appropriate measures (Apurva Ajay Mohite, 2021).

Humidity and temperature are two of the most important tracking metrics in IoT applications, whether for outdoor purposes such as air-quality control and irrigation or indoor applications such as intelligent houses and smart buildings (Md. Zahidul Islam et al., 2021). These parameters are critical features of the objects being monitored and are readily available and easy to use with sensors. Monitoring typically takes place through a user interface, such as a web or smartphone application, with various examples available (Deshmukh & Shinde, 2016; Yanshori et al., 2022).

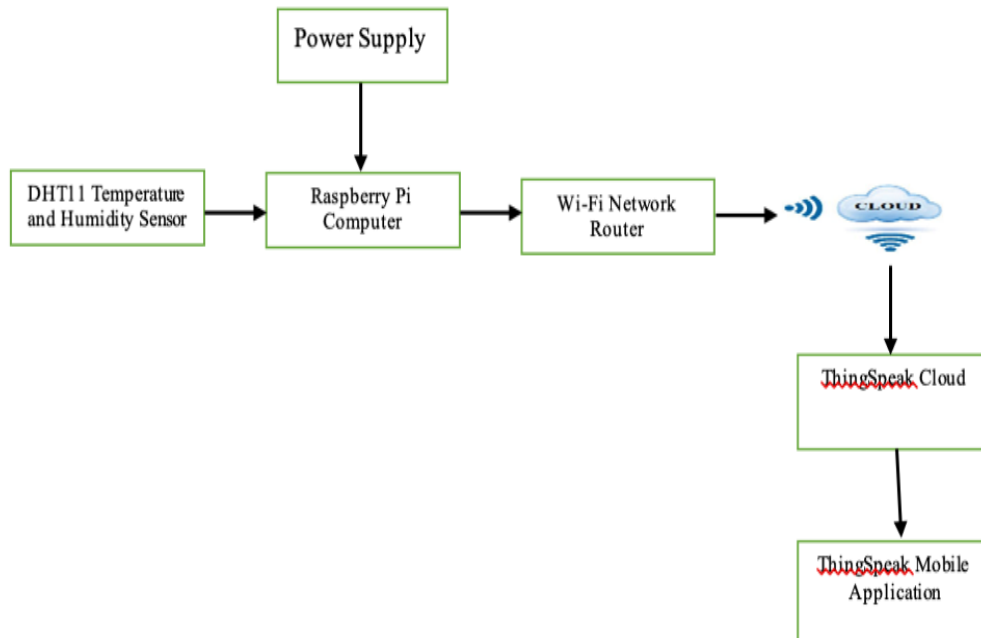
In this experiment, the humidity and temperature of the laboratory are measured in Realtime and shown using raspberry pi. The essential aim of the paper is to utilize ThingSpeak Cloud database which provides the results faster more than the traditional MQTT (Grgić et al., 2016). to get the result faster and within the shortest time interval to measure the laboratory humidity and temperature and know a certain level when the temperature may cause damage to the laboratory equipment. DHT11 sensor is used in this project, the sensor consists of features of measuring temperature and humidity, the sensor is very cheap, since it reads not only from a sensor but also stores cloud information and is connected by Raspberry Pi to web and other applications like a smartphone.

## 2. Methodology

Raspberry Pi with the DHT11 sensor were used in this project for monitoring of temperature and humidity of Computer laboratory. With the Wi-Fi connector, Raspberry Pi connects to the Internet and sends the readings from DHT11 (Temperature and Humidity sensor) to Thing Speak cloud database and the processed information would be monitored via web and mobile application.

### 2.1. System Hardware Architecture

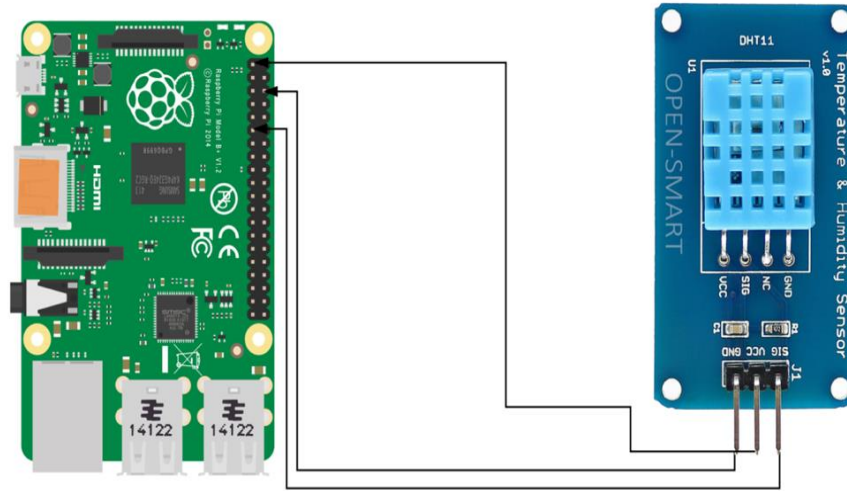
The diagram below shows the entire System 's architecture. The connection of sensor and raspberry pi, power supply, network router, and ThingSpeak Realtime database is shown in figure 1



**Figure 1:** The Hardware Architecture of the System

## 2.2 The Connection of the System

Figure 2 shows how DHT 11 Temperature and Humidity sensor connected to Raspberry PI Model B.



**Figure 2:** Raspberry Pi model B and DHT 11 sensor Connection

## 2.3 DHT11 Temperature and Humidity Sensor

The DHT11 is a popular humidity and temperature sensor. The sensor has an NTC for temperature and an eight-bit microcontroller for the normal data output of temperature and humidity. The sensor is also easy to use and also easy to attach to other microcontroller systems.

Sensors can calculate temperatures between 0 and 50 °C and humidity between 20 and 90 percent with  $\pm 2^{\circ}\text{C}$  and  $\pm 5$  percent range. If you want to test this range, this sensor might be the right option for you.

## 2.4 Raspberry Pi

Raspberry Pi, the UK-Raspberry Pi Foundation to inform and enable computer education in schools and developing countries, is a cost-effective computer-sized credit card. Sunlight Raspberry Pi. Several open-source groups since the founding have contributed thousands, close to Raspberry Pi, to open-source software, operating systems and many other small form factor computers (Ms. Kshitija Tanaji Kamble et al., 2022)

## 2.5 ThingSpeak IoT Cloud database

The ThingSpeak™ software is an IoT analytics tool for aggregating, accessing, and reviewing live cloud data sources. ThingSpeak automatically shows the data submitted to ThingSpeak through your computers. You will run online analyzes and process data as it comes with the opportunity to implement MATLAB® in ThingSpeak. ThingSpeak is also used to develop and show IoT structures involving study.

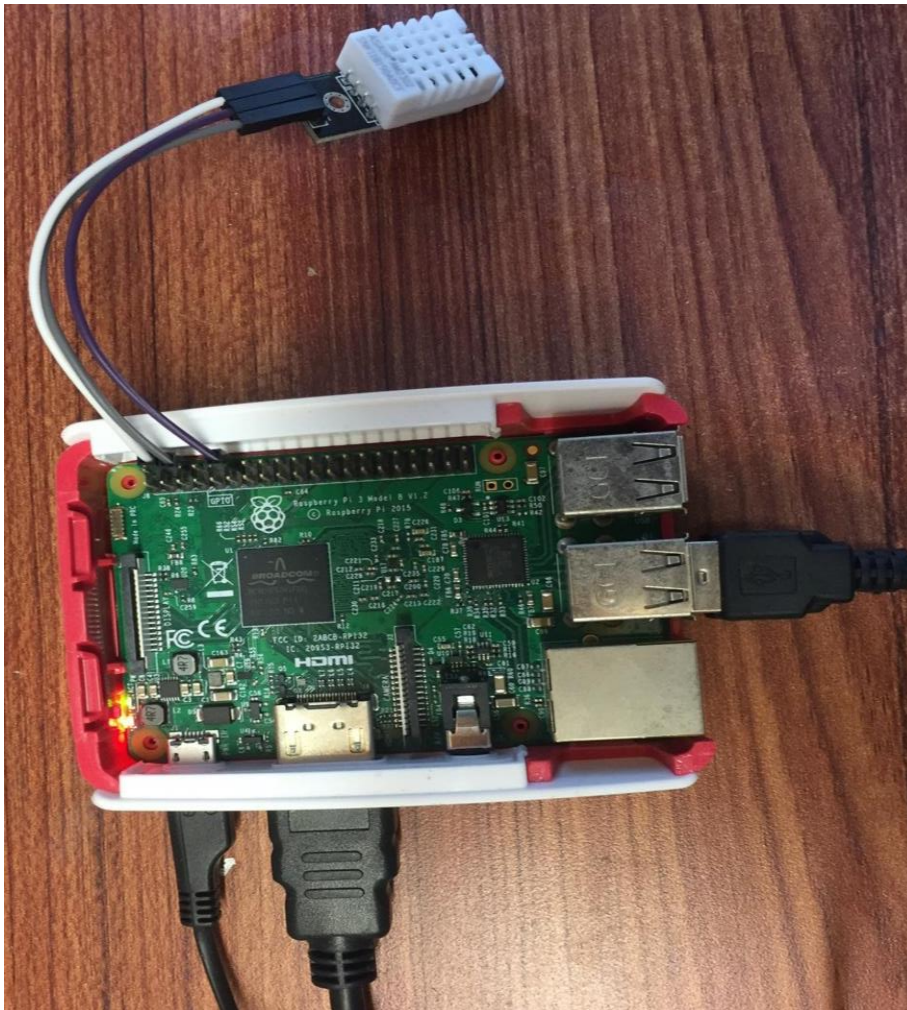
You may directly transfer data to ThingSpeak using a Rest API or MQTT from any Internet-connected computer. Cloud-to-cloud integrations also allow ThingSpeak data to access Things through LoRaWAN® and 4G/3G smartphone connections via device Network, Senet, the Lebelium Meshlium Gateways and Particle.io.

## 2.6 System Configuration

Through loading the Raspbian Operating System on the memory card, the following procedures are followed for the configuration of the Raspberry Pi.

1. Image of Raspbian software was downloaded from the official website with the size of approximately 2.6 GB in the form of Zip form.
2. SD memory card formatter was downloaded from the internet to format the memory card for the installation of images of operating system into the memory card.
3. Balena Etcher software was installed on my PC MacBook Air to mount the image on my 8 GB memory card
4. Memory card was removed from my laptop and inserted to Raspberry Pi.
5. After insetting power supply and connecting Key Board mouse and Monitor, I was able to get the graphical user interface on the screen.
6. Python was pre-installed in the Raspbian Package.
7. Libraries of Temperature and Humidity Sensor was updated in the operating system.
8. VNC software was also installed and the system was accessed through iPhone 6 Smart Phone wireless Hot-Spot.
9. Pi is ready to use through Remote Access

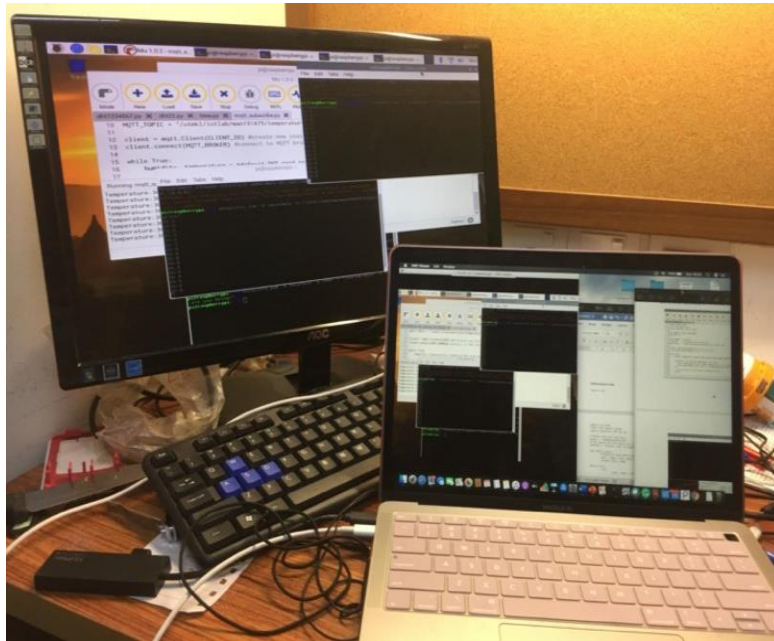
### 3. Results



**Figure 3** Connection of the Raspberry Pi

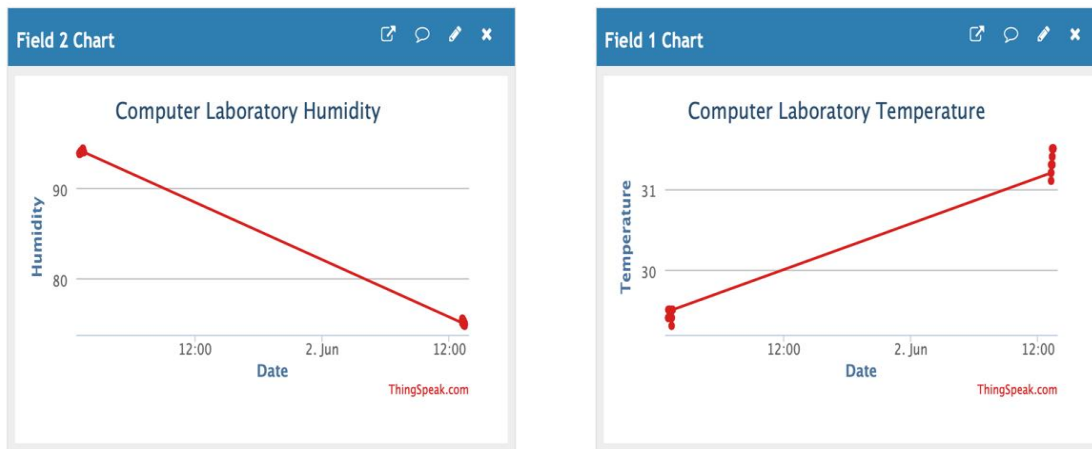
Figure 3 shows the different connection from power supply of the Raspberry pi to DHT11 Temperature and Humidity Sensor for the system.





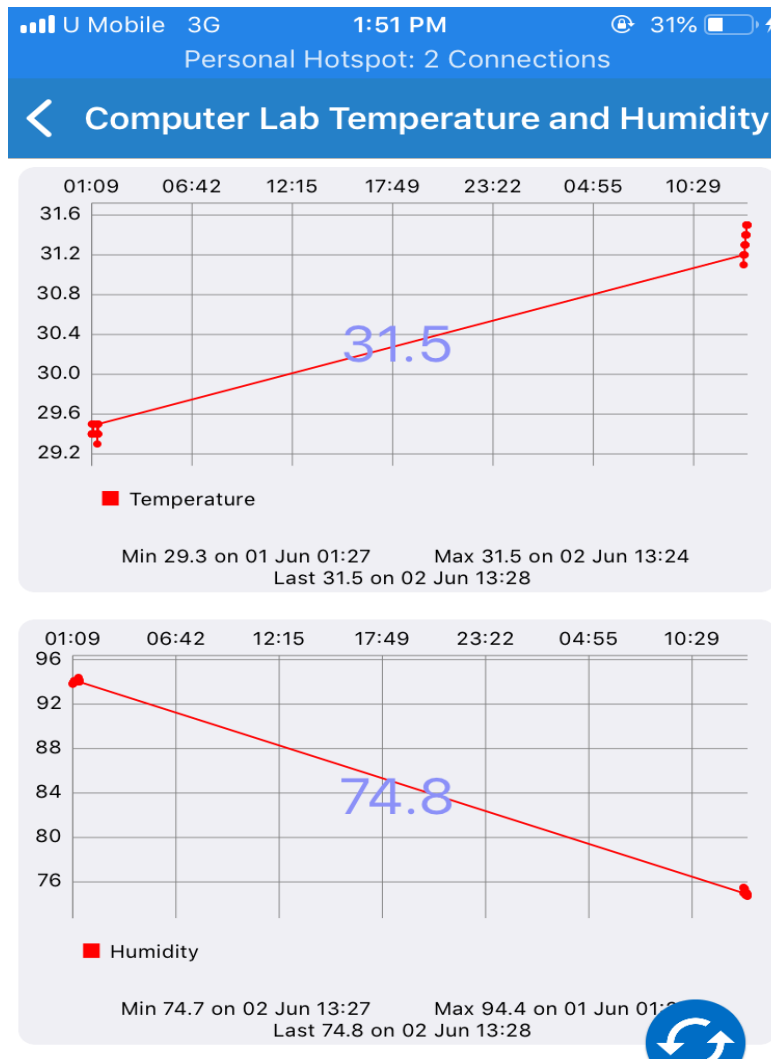
**Figure 4** Picture of the System during Programming and Configuration

The above picture, Figure 4, shows the computers while configuring and programming the system for temperature and the humidity for the mini laboratory.



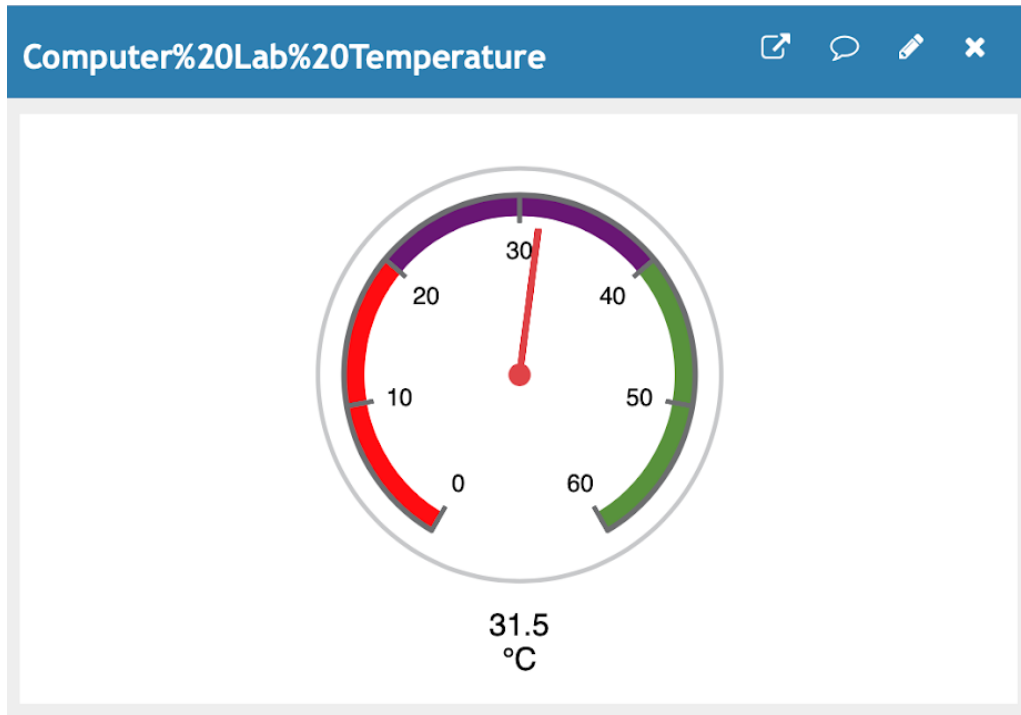
**Figure 5:** Laboratory Temperature and Humidity web Result during the day

Figure 5 is a large-scale graph of Temperature and Humidity from ThingSpeak database as Humidity is inversely proportional to the temperature during the day as the temperature increases the humidity decreases and vice versa.



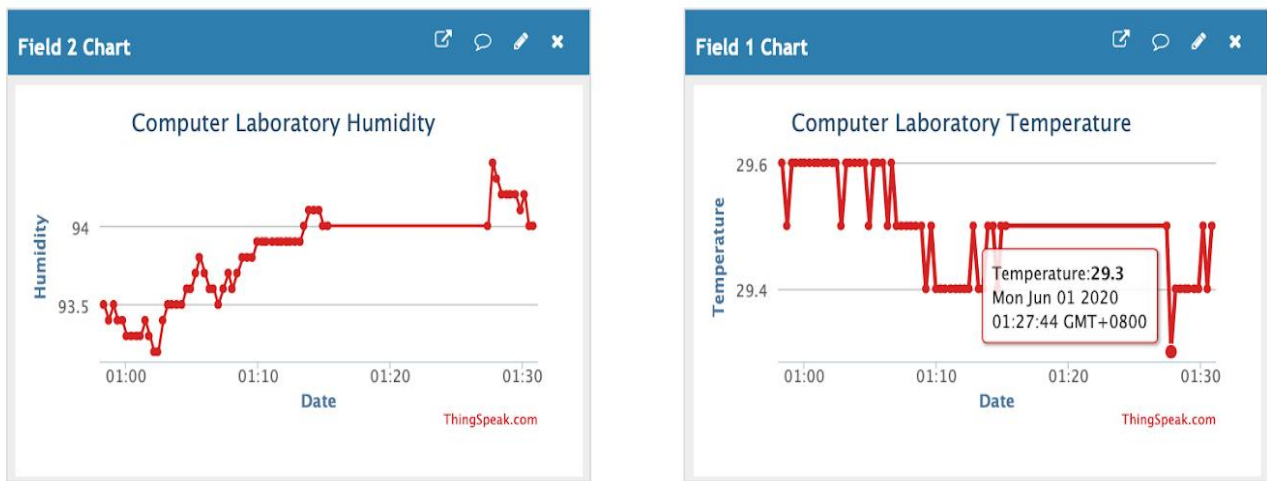
**Figure 6:** Laboratory Temperature and humidity Result from mobile app during the day

Figure 6 is a large-scale graph of Temperature and Humidity from ThingSpeak mobile phone application as shown from the graph the Humidity is inversely proportional to the temperature during the day as the temperature increases to 31.5°C the humidity decreases to 74.8% and vice versa.



**Figure 7:** Laboratory Temperature clock from the web

Figure 7 shows the Temperature clock that would help the user to check the Temperature from the web application from any device.



**Figure 8:** Laboratory Temperature and Humidity web Result during the night

Figure 8 shows the small-scale graph of Temperature and Humidity result of the lab from web application during the nighttime.

### 3.2 Discussion and Analysis

The above figure 5 shows the large scale of temperature and humidity of a computer laboratory during the daytime and figure which explains the relationship between temperature and the humidity of the laboratory as the temperature decreases the humidity of the lab increase and vice versa. Figure 7 shows the laboratory temperature clock from the web portal which will assist the user to see the temperature from the clock at the web portal. While figure 6 shows the small-scale graph of temperature and humidity result of the laboratory during the night with very high humidity about 94.0% and Temperature of 29.5°C at the point selected by the arrow. This would give the managers and decision-makers of the laboratory find out the modalities and know how to control the level of the relative humidity of the laboratory during the night for the safety of the facilities of the lab.

### 4. Conclusion

Embedded Internet of Things (IoT) Environmental Monitoring System with Raspberry Pi for Computer laboratory was developed using Raspberry pi 3 Model B for the measurement of temperature and humidity of the computer laboratory. This will assist in monitoring the temperature of the laboratory via a website as well as the mobile phone Android or iOS application of the laboratory managers for the good functioning of the laboratory facilities as well as the comfort of the people using the laboratory. Despite the low cost of the system, the system is very reliable and will function with efficiency and will help in saving the budget of the laboratory management. The most advantage of the system was very secure, reliable and the temperature of the laboratory can be monitored from anywhere provided you are connected to the internet. Another advantage of the system can be used for other purposes like Temperature monitoring of an Industry or Home temperature monitoring system.

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