IOT Device For Monitoring Humidity And Temperature using Bluetooth and WIFI Module

A THESIS

submitted in partial fulfillment of the requirements

for the award of the dual degree of

Bachelor of Science

in

Electrical Engineering And Computer Science

by

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April 2022

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CERTIFICATE

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April 2022
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ACKNOWLEDGEMENT

I would like to convey my heartfelt gratitude to Dr. Mitradip Bhattacharjee for devoting time from his hectic schedule to offer me with invaluable assistance, support, and encouragement in all parts of my research. His points of view have always been balanced, achieving a great mix between encouragement and constructive criticism. His insightful advice and comments greatly aided us in developing a concept from an idea. I've benefited greatly from his vast knowledge and expertise. I'm also grateful to my TAs Dayarnab Baidya and Kamalesh Tripathy from the EECS department for providing me with numerous resources and guiding me in developing a great research concept.

Bhargav Petla

ABSTRACT

Weather has always been a source of concern for everyone, and the current state of the climate, in particular, has made us recognise the need of having precise, reliable, and trustworthy sensors capable of anticipating changes in weather conditions over time. Portable weather monitoring tools that can be relied on for real-time alerting and reporting on changing environmental conditions are becoming increasingly important nowadays. To satisfy these needs, we created an efficient, small, and cost-effective weather system that uses the very dependable DHT11 sensor and the HC-05 Bluetooth module to provide us with crucial information about temperature and humidity. The DHT11 sensor provides excellent accuracy in temperature and humidity measurements, while the HC-05 Bluetooth module provides a higher data rate, greater range, and portability.

The other groundwork given in this using an Arduino UNO board, a DHT11 sensor, and an ESP8266 Wi-Fi module to send data to an open IoT-based API administration called ThingSpeak, where it is examined and transferred to the cloud, where it is displayed for end-users via API Web administration. The system's practicability is demonstrated by the experimental Results. Temperature monitoring is commonly used in several cycles, such as vehicle ventures, cooling, power plants, and other industries that require data to be saved and broken down. The main goal of this framework model is to make it as simple as possible for the client to see the current temperature.

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1. INTRODUCTION

Observing is seen as an essential component in dealing with changing environmental circumstances. Temperature and humidity monitoring are used to analyse and map biodiversity across wide areas, alerting to any changes in climate conditions. In practical processes, temperature measurement and control are also crucial [1]. Because of the vast range of temperatures being monitored and the measurement accuracy in a specified location, temperature transducers used in electrical tests are various. Humidity is the amount of water vapour present in a unit of air[2-4]. It is a critical feature of the air, both in terms of weather and bioclimatic conditions. In this project, we use an IoT-based system to monitor temperature and humidity, transfer data to an Android device, and map the data acquired. We seek reliable data transfer in today's world, and we may get it with the aid of wifi and Bluetooth modules[5],[9],[27]. Nowadays, wireless communication has evolved into a spectrum through which we can send an infinite number of data streams from one channel to the next. The system is made up of two parts: a transmitter and a receiver for sending and receiving data [7],[9]. We collect data using the DHT11 temperature and humidity sensor and transfer it to an android device via Bluetooth, in addition to transmitting data to Thingspeak through WIFI The DHT11 sensor is used to measure humidity. The DHT11 is a basic digital temperature and humidity sensor with a low price. It uses a capacitive humidity sensor and a thermistor to monitor the ambient air and generates a digital signal on the data. Although it is simple to operate, data collection needs precise timing[13]. The HC05 is a four-pin Bluetooth module that communicates with the Arduino board, is used in this project. This board was chosen because to its strong demand and market availability. The Bluetooth that we're using here is only good for a limited distance. i.e., data can be transferred from the Arduino to Android within this short range[14],[9],27]. The major medium for sending data can be served by the Bluetooth module, and the coding for manipulation is done in the Arduino software environment, which is a simple IDE environment used for uploading the sketches. Because of its high superior manifestation in the market compared to older operating systems, which are now obsolete due to modern-day motivation and technological innovation[1-3], android phones have a fairly efficient demand in the industry. We'll communicate data via the Arduino and Bluetooth module coupling, with the Android component acting as a receiver and the Arduino as a transmitter. In this situation, the default band rate, which is in the range of 9600[6], is used for data transmission and reception.

Temperature and humidity are also obtained as input readings via monitoring sensor DHT11, and the data sensing output is supplied to a distant cloud storage open IoT API ThingSpeak via the ESP8266Wi-Fi module. With the help of ThingSpeak, MATLAB does data analysis and develops a trigger[33-35]. The produced application is a low-cost, cost-effective system that enables the creation of a comprehensive IoT application including various operations, including sensing and wireless transmission to the cloud, as well as information extraction from the cloud via the developed application.

2. MATERIALS AND METHODS

2.1 Hardware Materials

2.1 Arduino Uno Board:

The Arduino Uno board is at the heart of the project and is in charge of all of the primary operations. It is easily interfaced with the DHT11 sensor and the Bluetooth module due to its robustness and open source nature[1]. This board includes serial communication capabilities for displaying received data on a PC, as well as an Integrated Development Environment for simpleprogramming[3].

Fig-1 Arduino Uno Board

2.2 Breadboard:

With the use of connecting wires and various interface techniques, the Breadboard is utilised to link the hardware samples with it. The breadboard is needed to connect the Arduino's peripherals and the Bluetooth module in this project.

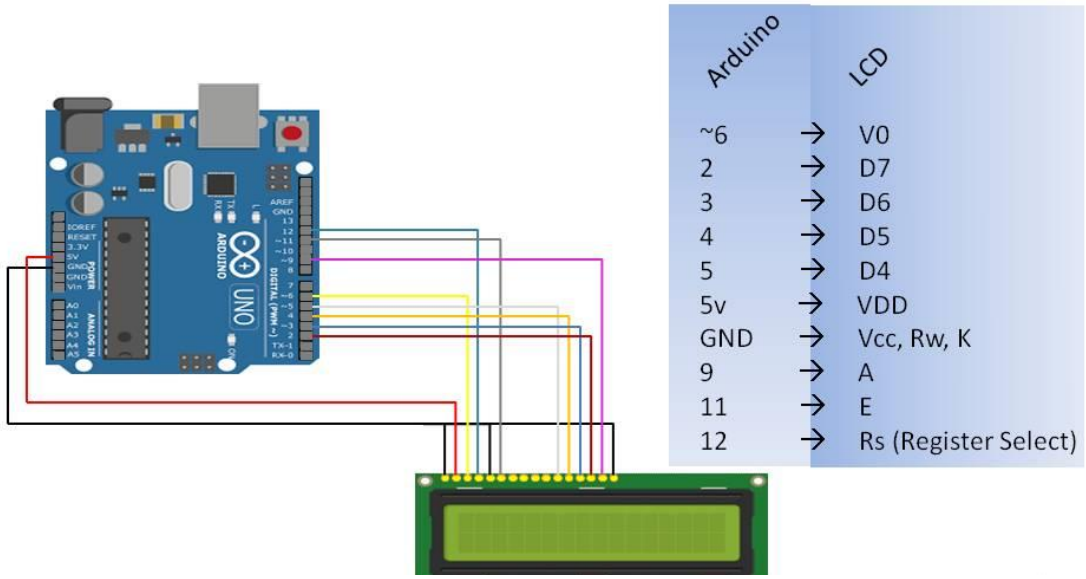
2.3 Connecting wires:

The connecting cables link the Arduino to the Bluetooth module and vice versa. The Arduino board is mounted on the breadboard, and the Arduino's receiver module is linked to the Bluetooth module to provide a high-end, dependable, and efficient way of communication[2]. The Arduino board's connecting ends are attached to the Bluetooth module's, and the connection pieces are described in methodology.

The various components used to connect between the Arduino board and the Bluetooth module are listed later on.

2.4 LCD display:

If present a backlight, there are 16 pins total in a 16x2 LCD; if no backlight, there are 14 pins total. The backlight pins maybe pleased or off. There are immediately eight dossier pins (7-14 or D0-D7), two capacity supply pins (1&2 or VSS&VDD or GND&+5v), a tertiary attach for contrast control (VEE-controls in what way or manner dense the personalities concede possibility convene), and three control pins (RS&RW&E) in the 14 pins..



2.5 Digital Humidity Temperature Sensor(DHT11):

The DHT11 is a temperature and humidity sensor that outputs a measure temperature and humidity signal. It guarantees that the amount acquired is of excellent stability and establishment on account of its unique digital modules and temperature and humidity noticing electronics. The sensor is containing a resistive wet component sense and an NTC temperature weighing ploy that is connected to a extreme-conduct 8-bit microcontroller[1-4]. Fast response, depressed power devouring, and cheap are all benefits of the DHT11 sensor. It also has the ability to avoid interfering signals and can transfer data over vast distances. A distinct wire two-habit relation is used for ideas and synchronisation middle from two points the microcontroller unit and the DHT11 sensor, that demands a single transport dossier format[6-7].The sensor transmits information in 40-bit packets. The sensor has two modes of operation: low power consumption mode and operating mode[5]. The start signal indicates that the device is switching from low to high power mode. Following the completion of the start signal, the sensor delivers a response signal including information about the relative temperature and

humidity[26]. The sensor utilised in the Bluetooth-located meteorological station is a three-attach piece accompanying Vcc, Data, and Ground (GND)[11],[20]. The Data attach is related to the Arduino board's A0 attach, while the Vcc attach is related to the Arduino board's 5V attach. The sensor sends hotness and moisture readings to the Arduino board, that are therefore presented on a sequential monitor through sequential ideas[14]

Specification Title	DHT11
Humidity Range	20-90% RH
Humidity Accuracy	±5% RH
Temperature Range	0-50 °C
Temperature Accuracy	±2% °C
Operating Voltage	3V to 5.5V
Reading rate	One reading/second

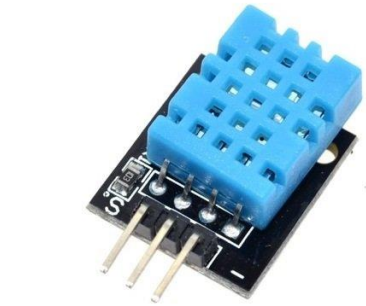


Fig-2 Digital Humidity Temperature sensor

2.6 HC-05 Bluetooth Module

HC-05 The Bluetooth Module HC-05, as illustrated in Figure 3, is a Bluetooth module that works on the Serial Port Protocol premise (SPP). This module was created with wireless serial connection in mind[2]. This piece has a brimming 2.4GHz transmission device for receiving and baseband, in addition to Bluetooth V2.0 EDR (Enhanced Data Rate) 3Mbps timbre. It utilises a CSR Bluecore 04-External distinct chip Bluetooth method accompanying CMOS electronics and AFH (Adaptive Frequency Hopping Feature)[9-12]. The Bluetooth module is

utilised because of its inexpensive cost, low power consumption, and long range, which allows the user to access the weather station from a long distance. -80dBm is the sensitivity of the Bluetooth module. It makes use of a UART interface with persumable baud rates. The most common baud rate is 36800, and the data packet contains 8 bits of data, 1 stop, and no parity bits[15]. There are two fads of movement for these Bluetooth modules: master and slaver device. When a device with an even number (HC-04) is removed from the manufacturer, it can be configured as a master or slaver, but it cannot be converted to the other mode. However, for devices with odd numbers, such as the HC-05, the user can utilise AT commands to set the mode to master or slave. The HC-05 Bluetooth module was used in this project, and it works in slave mode[9],[15],[18]. The RX and TX pins of the HC-05 are connected to the TX and RX pins of the Arduino board, individually. For appropriate transmission and reception between the Arduino and the Bluetooth Module, a potential divider circuit is utilised to decrease the Arduino 5V potential to 3.3V. We must ensure that the Bluetooth module's baud rate is synchronised with that of the Arduino in order to avoid data loss and ensure appropriate connectivity.

Specification Title	DHT11
Frequency	2.4GHz ISM band
Emission power	≤4dBm, Class 2
Sensitivity	≤-84dBm at 0.1% BER
Supply Voltage	+3.3V to 6.0 V
Supply Current	30mA
Working temperature	-20 ~ +75Centigrade

Fig-3 HC-05 Bluetooth Module

2.7 Wifi Module

Arduino UNO interfaces at the output with Wi-Fi module ESP8266 to post sensor readings from DHT11 to the opensource cloud ThingSpeak. It's a cheap Wi-Fi semiconductor crystal that involves the whole TCP/IP stack. It runs on 3.3V, which is supplied by the Arduino UNO in our system[18-20]. The AT commands are used to setup the module, and it requires the needed sequence to be used as a client. The module may be used as a client or a server. When it connects to Wi-Fi, it receives an IP address, which the module uses to communicate over the Internet. We attached our ESP8266 module to an Arduino UNO and programmed it to setup the ESP8266 Wi-Fi module as a TCP client and send data to the ThingSpeak server, that is an open IoT manifesto for visualising and analysing live dossier from sensors.

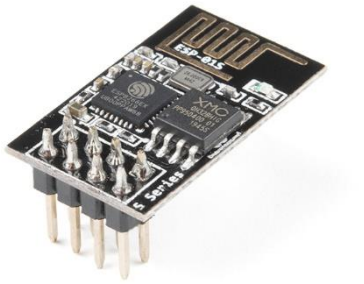


Fig-4 ESP8266 Wifi module

Specification Title	ESP8266
Working Voltage	3.3V
Maximum IO Driving Power IMAX	12 mA
Maximum IO Voltage Level VMAX	3.6V
Current Consumption	100mAmp

2.2 Software Materials

2.8 Android Interface

The data acquired in the form of temperature and humidity is displayed using an Android interface in this project. It's a Bluetooth-enabled communication app. It enables Android

smartphones to connect to any Bluetooth device that supports the Serial Port Profile[6]. This facilitates data transfer between the two platforms. The data in the form of temperature and ambient humidity is shown on an Android mobile phone in this project[9]. The key benefit of utilising this programme is that it provides a user-friendly interface that eliminates any ambiguity for the user, as seen in Figure 6[15]. The device and incoming data are configured using distinct colours on the interface. According to the range, the data to be delivered or shown is highlighted.

2.9 Thingspeak

ThingSpeak is a free connected to the internet help that admits you to draw and store sensor dossier in the cloud and constitute IoT requests [11]. ThingSpeak Webservices offers apps for analysing and visualising dossier as drawings or as MATLAB rule. ThingSpeak is fit taking dossier from a sort of fittings instruments, containing Arduino, Raspberry Pi, BeagleBone Black, and so forth. A channel is ultimate fundamental component of Thingspeak, and it has dossier fields, region fields, and rank fields. ThingSpeak has existed widely utilised in a sort of IoT-connected tasks [12,13].

2.3 Method

2.10 Bluetooth Model

System Model:

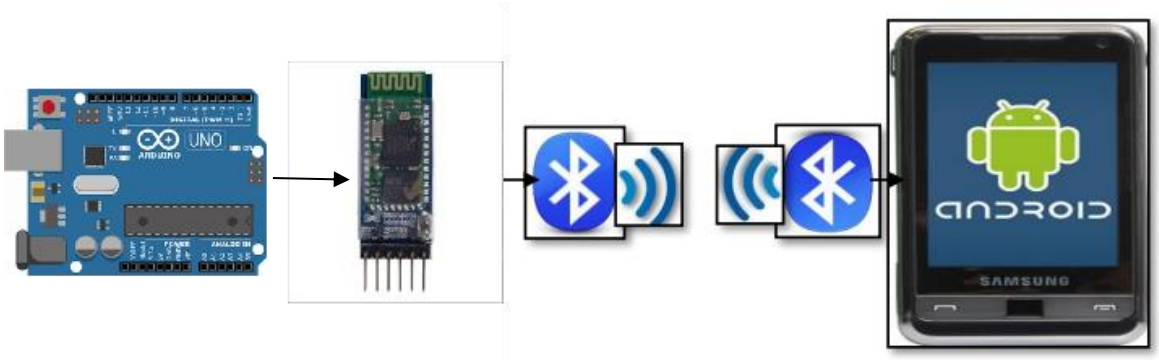


Fig-5 system model

The Internet of Things is a very hopeful concerning details progress that aims to correct existence by joining smart sensors and smart ploys that ideas over the WWW network. With IOT, all of the supplies we use in our common lives can be regulated and listened. In the IoT, sensors are used to complete the most of processes. The sensors are placed at strategic locations, and they transform raw physical data into digital signals that are sent to the control

center[18]. As a result, we can use the internet to monitor changes in the environment from anywhere in the globe. This system's design will be built on the context of real-time activities and processes[14], [20], [30]. Security in the IoT is now undergoing an amazing development, with a lot of security research employing IoT. Some algorithms that may be used to IoT include Tripple Transposition Key, Base64, Blowfish, and many more, with symmetric cryptography methods being the most prevalent use[32]. The DHT 11 sensor, Arduino UNO R3, 1x16 LCD, I2C LCD, HC-05, and MIT APP[24] were used to create a humidity and temperature detection prototype. The major element to detect the sensor using DHT 11 is a thermistor type NTC (Negative Temperature Coefficient) to measure the temperature and an 8-bit microcontroller that processes both sensors and sends the data to the pin output in a single-wire bi-directional format[22] and Figure 19,20 shows the complete approach on the proposed humidity and temperature sensing prototype using an android app through bluetooth HC-05.

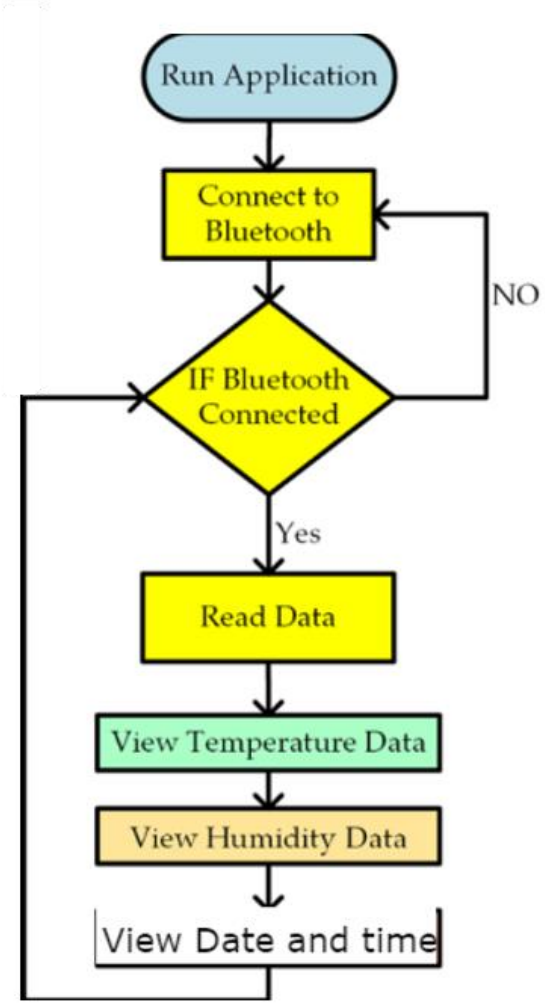


Fig-6 Software Architecture

Hardware Representation:

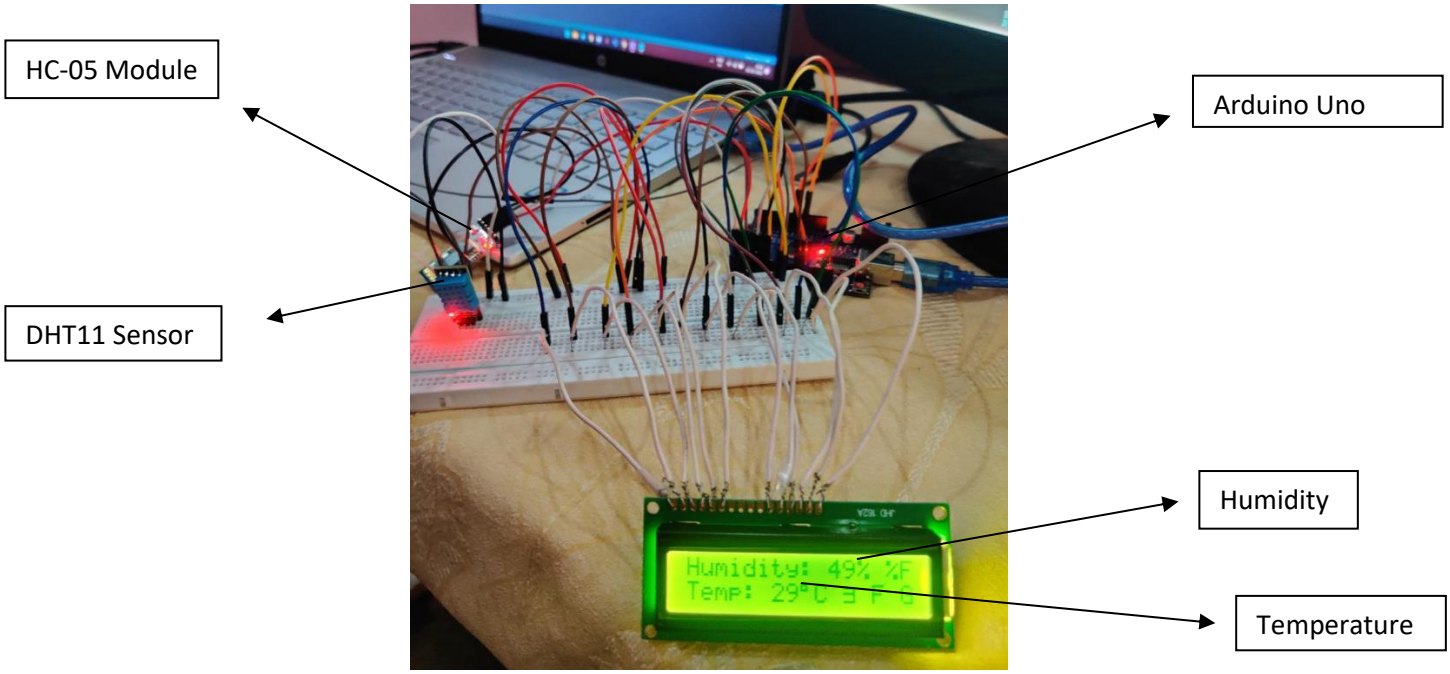


Fig-7 Bluetooth Experiment Setup.

How to connect Arduino to android:

Step-1 connect bluetooth Step-2 open app and click connect Step-3 click on HC-05

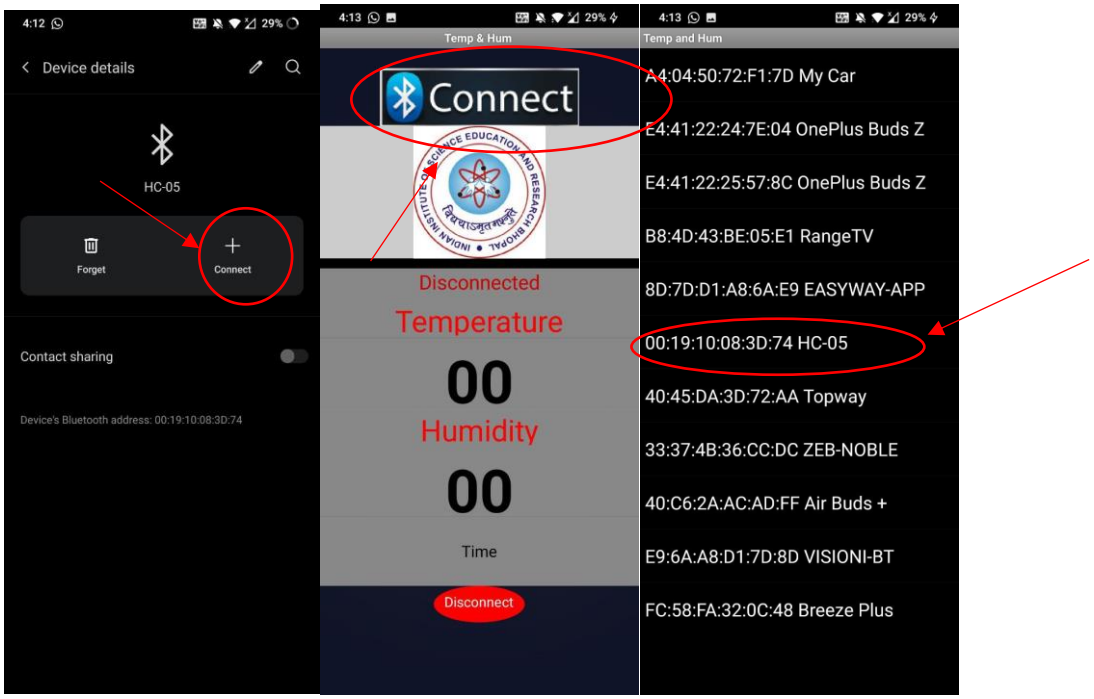


Fig-8 Bluetooth connection in Android app.

2.11 Wifi model

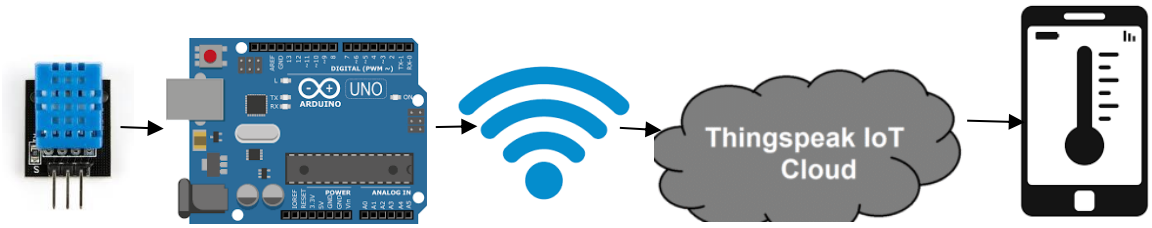


Fig – 9 Wifi system model

Arduino collects dossier from sensors and sends it to the cloud. After examining the hardware pieces, assimilation can be done at a later stage. Initially, AT commands were used in a desired pattern to start the system in order to make it user-friendly. As a result, the ESP8266 Wi-Fi Module is top-secret as a TCP/IP customer. The sensor dossier from DHT11 is rescued using program that calculates temperature and moisture calculations.We employ IoT analytics once the data has been updated in the cloud (like ThingSpeak to aggregate, visualise and analysis of live streams). ThingSpeak creates an immediate display of recently updated data in the cloud. Through the WIFI module, IP is utilised to transport data to the cloud. After establishing an API connection using ThingSpeak, a key known as API key is used to view the results via a channel. As a result, before saving and showing the data in the channel, we must first write the APIkey.

Initial Setup

Experiment

Sign in to ThingSpeak (If you already have an account, just login with your id and password.) Visit make an account, go to www.thingspeak.com. If you forbiddance have an account still, make use of the sign up alternative and enter using your facts. After that, double-check your email address.

Create a new channel using the New Channel option once you've created your account. After that, give the material to be posted on that channel a name and a title. We've labelled it as WIFI temperature and humidity. In Fields 1 and 2, we must now add the characteristics temperature and humidity, respectively. If we want to add another attribute as a field and write the data

description, we may utilise the box next to the Field choice. Click the save channel button to store your information.ThingSpeak employs a unique API Key to locate the data storage location and traverse the activity when it is invoked. Press the API key Button on the ThingSpeak site to upload DHT11 data with a unique API key.Click on “API **.** The Arduino Uno is designed by Arduino.cc and based on the Microchip ATmega328P microprocessor. The board is made up of a number of digital and analogue input/output pin sets that may be linked to various shields and circuits. The board has 14 digital and 6 analogue pins that are flexible when linked to ArduinoIDE through a type B USB connection. The Aurdino board can receive voltages ranging from 7 to 20 volts, although it is only powered by a 9-volt external power supply, comparable to the Arduino Nano and Leonardo.

The DHT11 sensor and NodeJS Arduino are used to establish a dampness and hotness boundary. As demonstrated above, news about dampness and hotness is brought to NodeMCU's mathematical attach 1 through sensor. Temperature and moisture calculations are recorded in the cloud from bud repeatedly utilizing an ESP8266 Wi-Fi piece. As a result, the hotness and moisture can be optically shown on ThingSpeak in the cloud. The sequential traffic is place the Arduino board and the calculating ideas. The data bits are intercepted using Node JS and then placed in a short-term buffer, which is subsequently reassembled using wild cards and it. A serial port is being used to communicate between the Arduino board and the computer. NodeJS is used to capture data bits arriving from the Arduino serial port and store them in a temporary buffer, which is then reformatted with pre-defined patterns (wild-cards) and sent to the cloud in a non-parallel manner via the HTTPS protocol. As a result, the temperature and humidity may be visually shown on ThingSpeak in the cloud.

Hardware Representation

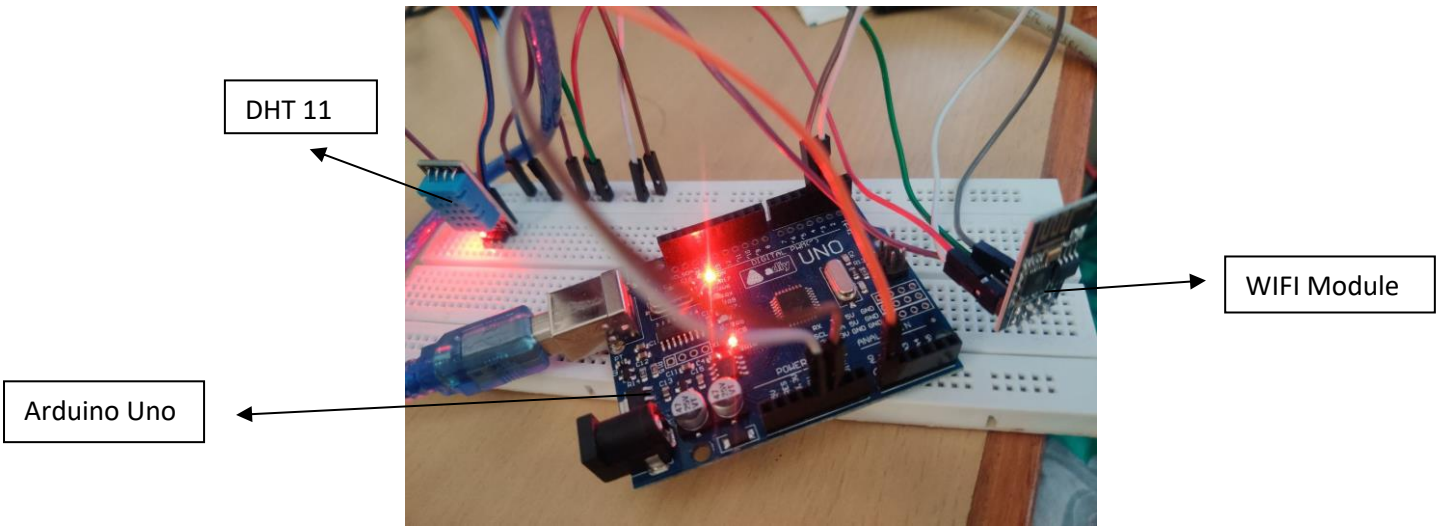


Fig – 10 Wifi Experiment setup

If the DHT library is not already installed in the Arduino IDE, go to Sketch→Includelibrary→Managelibraries→Install DHT Sensor library after saving it. Then, using the Arduino IDE, compile and update the application. Note: Wifi modem and internet connection should be operating correctly code, the Temperature and Humidity data are stored on ThingSpeak, and we can see it graphically in your channel's private window.

3. RESULTS AND DISCUSSION

3.1 Bluetooth Results

At IISER Bhopal, the Bluetooth-based weather station was put to the test. The sensor collected data on the lab's humidity and temperature, which was shown on the serial monitor screen of the Arduino, as seen in Fig11. As seen in Fig. 12, the data is also shown on the android smartphone utilising the MIT application via the HC-05 Bluetooth module**.**

Serial Monitor output:

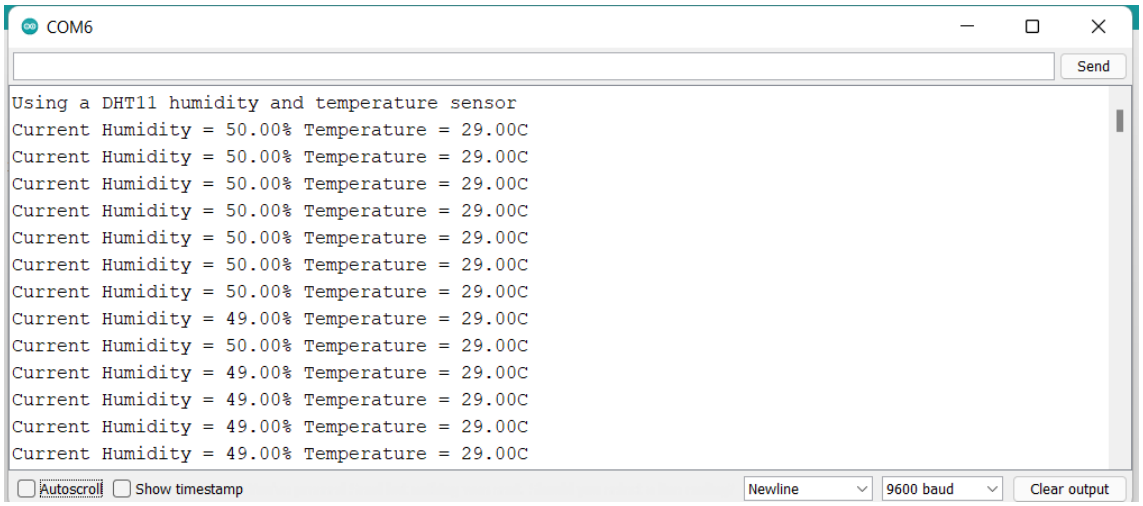


Fig-11 Serial Output

Android Output:

Fig-12 Android app output

The DHT11 measures the encircling air accompanying a capacitive humidity sensor and a thermistor and outputs a mathematical signal, while the HC 05 communicates in sequential. The Arduino Bluetooth piece sends sequential dossier to the Android app, that is destined to sustain it. The Arduino Bluetooth piece, in another way, transmits and accepts dossier through the Bluetooth piece's TX attach (Connected to the RX attach of the Arduino). The law uploaded to the Arduino compares and justifies the dossier taken.

3.2 WIFI Results

Figures depict the overall design of the environmental monitoring system. The design that was employed is depicted in the image, which depicts the integration of all hardware components when in operation. The Arduino IDE is used to connect DHT11 and ThingSpeak. ThingSpeak is used to view the sensed data. The experiment's findings are displayed here, namely, the data requested by the user is displayed via a mobile application and a graphical representation of humidity and temperature records.

Tabular representation of Temperature and Humidity

The data in the table below is a sample of temperature and humidity measurements taken at various time intervals using the DHT11 sensor. The information is sent to the ThingsSpeak cloud, where it is automatically turned into a graph, as seen in the subsequent result. This tabular data was collected from the ThingsSpeak cloud service's JSON object file. The purpose of this article is to obtain this information via the Internet. In practise, this configuration may be used in conjunction with other home sensing applications to remotely initiate an action depending on patterns seen in the measurements.

Table 1: Temperature and Humidity readings

created_at		Temperature	Humidity
2022-04-10 03:15:49 UTC		32	19
2022-04-10 03:16:37 UTC		32	23
2022-04-10 03:17:14 UTC		32	23
2022-04-10 03:18:16 UTC		32	23
2022-04-10 03:18:42 UTC		32	23
2022-04-10 03:19:09 UTC		32	22
2022-04-10 03:19:47 UTC		32	23
2022-04-10 03:20:23 UTC		32	23

2022-04-10 03:21:11 UTC	32	23
2022-04-10 03:21:29 UTC	32	18
2022-04-10 03:22:00 UTC	32	18
2022-04-10 03:22:54 UTC	32	22
2022-04-10 03:23:10 UTC	32	22
2022-04-10 03:23:26 UTC	33	23
2022-04-10 03:24:39 UTC	32	21
2022-04-10 03:25:51 UTC	33	21
2022-04-10 03:26:27 UTC	33	21
2022-04-10 03:27:17 UTC	32	20
2022-04-10 03:28:18 UTC	32	19

Graphical Record of Temperature Monitoring

The data of temperature observed over a magnitude is proved in Figure 13. The diagram depicts temperature alternatives over a 10-minute ending. The graph describes the relation between temperature and time.

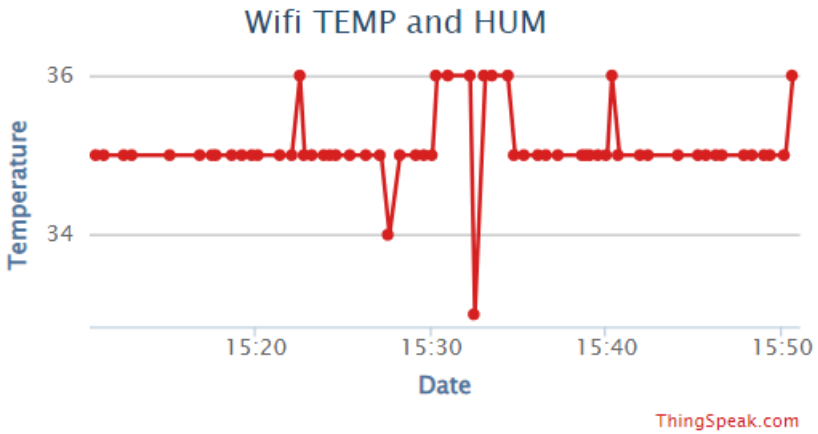


Figure 13:Record of Temperature Monitoring

The data of humidity recorded throughout time is displayed in Figure 14. The diagram depicts humidity alternatives over a 10-minute ending. The graph describes the relation between humidity and time.

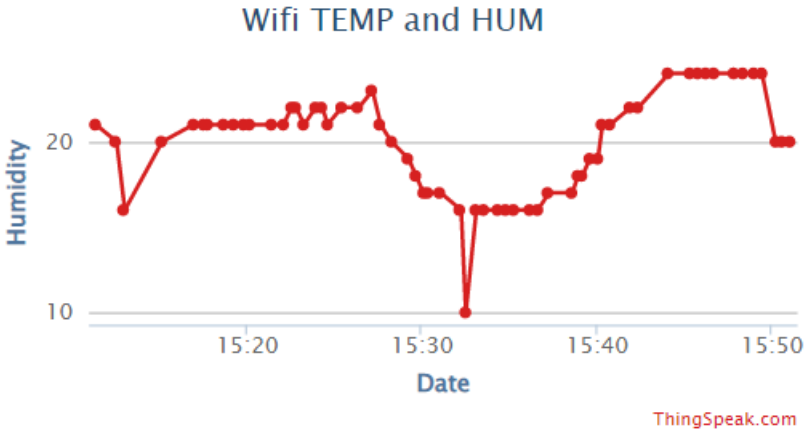


Figure 14:Record of Humidity Monitoring

4. CONCLUSIONS

Finally, the ThingSpeak IoT on Real Time Room Condition Monitoring System has been successfully constructed, demonstrating an option to simplifying the room monitoring procedure. The Temperature and moisture sensor utilised in this arrangement can discover two together temperature and humidity and broadcast the dossier through bluetooth to the ThingSpeak principle's site and a smartphone request. Furthermore, the system's remote-access capability made it easy for users, particularly room administrators, who could monitor the room from anywhere provided they were connected to the internet. As a result, building this system is a key step in understanding the creation and deployment of IoT applications, and it serves as a basis for many helpful advances in this area.

BIBLIOGRAPHY

[1]Ahmad, Y. A., Surya Gunawan, T., Mansor, H., Hamida, B. A., Fikri Hishamudin, A., & Arifin, F. (2021). On the evaluation of DHT22 temperature sensor for IoT application. *2021 8th International Conference on Computer and Communication Engineering (ICCCE)*. https://doi.org/10.1109/iccce50029.2021.9467147

[2] W. (1980). MONITORING LONG-TERM TEMPERATURE AND HUMIDITY. *ICCM Bulletin*, *6*(1), 36–42. https://doi.org/10.1179/iccm.1980.6.1.006

[3]Debele, G. M., & Qian, X. (2020). Automatic room temperature control system using arduino UNO r3 and DHT11 sensor. *2020 17th International Computer Conference on Wavelet Active Media Technology and Information Processing (ICCWAMTIP)*. https://doi.org/10.1109/iccwamtip51612.2020.9317307

[4]DHT11 temperature & humidity sensor features a temperature & humidity sensor complex with a calibrated digital signal output. (2015). Mouser Electronics. https://www.mouser.com/datasheet/2/758/DHT11-Technical-Data-Sheet-Translated-Version-1143054.pdf

[5]IoT based temperature and humidity monitoring system over ThingSpeak using arduino UNO and ESP8266. (2019). IOT Design PRO. https://iotdesignpro.com/projects/temperature-humidity-monitoring-over-thingspeak-using-arduino-esp8266

[6]Irawan, Y., Wahyuni, R., -, M., Fonda, H., Luthfi Hamzah, M., & Muzawi, R. (2021). Real time system monitoring and Analysis-Based internet of things (IoT) technology in measuring outdoor air quality. *International Journal of Interactive Mobile Technologies (iJIM)*, *15*(10), 224. https://doi.org/10.3991/ijim.v15i10.20707

[7]Jenila, R., Pappa, C. K., & Supraja, C. (2022). A smart and precision agriculture system using DHT11 plus FPGA. *Machine Learning and Autonomous Systems*, 579–589. https://doi.org/10.1007/978-981-16-7996-4_42

[8]Nayyar, A., Puri, V., Nguyen, N. G., & Le, D. N. (2018). Smart surveillance robot for Real-Time monitoring and control system in environment and industrial applications. *Advances in Intelligent Systems and Computing*, 229–243. https://doi.org/10.1007/978-981-10-7512-4_23

[9]Temp & humidity DHT11, weather monitoring in mobile app. (2020). Arduino Project Hub. https://create.arduino.cc/projecthub/tehcwan_canel/temp-humidity-dht11-weather-monitoring-in-mobile-app-57b5ac

[10]Vallabh, B., Khan, A., Nandan, D., & Choubisa, M. (2021). Data Acquisition Technique for Temperature Measurement Through DHT11 Sensor. *Algorithms for Intelligent Systems*, 547–555. https://doi.org/10.1007/978-981-15-6707-0_53

[11]Vij, A., Vijendra, S., Jain, A., Bajaj, S., Bassi, A., & Sharma, A. (2020). IoT and machine learning approaches for automation of farm irrigation system. *Procedia Computer Science, 167,* 1250–1257. https://doi.org/10.1016/j.procs.2020.03.440

[12]Wu, Q., Zhang, G., & Yan, L. (2016). Temperature and humidity sensor research based on monobus technology. *Proceedings of the 2015 4th National Conference on Electrical, Electronics and Computer Engineering*. https://doi.org/10.2991/nceece-15.2016.31

[13]Margret Sharmila, F., Suryaganesh, P., Abishek, M., & Benny, U. (2019). Iot based smart window using sensor dht11. *2019 5th International Conference on Advanced Computing & Communication Systems (ICACCS)*. https://doi.org/10.1109/icaccs.2019.8728426

[14] T. Listyorini and R. Rahim, "A prototype fire detection implemented using the Internet of Things and fuzzy logic," World Trans. Eng. Technol. Educ., vol. 16, no. 1, pp. 42–46, 2018.

[15] J. Suyono, A. Sukoco, M. I. Setiawan, S. Suhermin, and R. Rahim, "Impact of GDP Information International Journal of Pure and Applied Mathematics Special Issue 2489 Technology in Developing of Regional Central Business (Case 50 Airports IT City Development in Indonesia)," in Journal of Physics: Conference Series, 2017, vol. 930, no. 1.

[16] N. Nasrudin, I. Agustina, A. Akrim, A. S. Ahmar, and R. Rahim, "Multimedia educational game approach for psychological conditional," Int. J. Eng. Technol., vol. 7, no. 2.9, pp. 78–81, 2018.

[17] R. Rahim et al., "Internet based remote desktop using INDY and socket component," Int. J. Eng. Technol., vol. 7, no. 2.9, pp. 44–47, 2018.

[18] R. Rahim, D. Hartama, H. Nurdiyanto, A. S. Ahmar, D. Abdullah, and D. Napitupulu, "Keylogger Application to Monitoring Users Activity with Exact String Matching Algorithm," J. Phys. Conf. Ser., vol. 954, no. 1, p. 012008, 2018.

[19] B. J. Morse, N. L. Gullekson, S. A. Morris, and P. M. Popovich, "The development of a general Internet attitudes scale," Comput. Human Behav., vol. 27, no. 1, pp. 480–489, 2011.

[20] R. Khan, S. U. Khan, R. Zaheer, and S. Khan, "Future internet: The internet of things architecture, possible applications and key challenges," in Proceedings - 10th International Conference on Frontiers of Information Technology, FIT 2012, 2012, pp. 257– 260.

[21] Y. Wang and Z. Chi, "System of wireless temperature and humidity monitoring based on Arduino Uno platform," in Proceedings - 2016 6th International Conference on Instrumentation and Measurement, Computer, Communication and Control, IMCCC 2016, 2016, pp. 770–773.

[22] T. Liu, "Digital Humidity and Temperature sensor," Adfruit, pp. 1–5, 2016.

[23] J. L. Nguyen, J. Schwartz, and D. W. Dockery, "The relationship between indoor and outdoor temperature, apparent temperature, relative humidity, and absolute humidity," Indoor Air, vol. 24, no. 1, pp. 103–112, 2014.

[24] D-robotics UK, “Temperature Sensor DHT 11 Humidity & Temperature Sensor,” D-Robotics, pp. 1– 9, 2010.

[25] . R. et al., “Automatic Blood Pressure Detector Using Arduino to Measure Blood Pressure in Indonesian People Age 19-27 Years Old,” Int. J. Eng. Technol., vol. 7, no. 2.5, pp. 115–118, Mar. 2018.

[26] U. Khair, H. Fahmi, S. Al Hakim, and R. Rahim, “Forecasting Error Calculation with Mean Absolute Deviation and Mean Absolute Percentage Error,” J. Phys. Conf. Ser., vol. 930, no. 1, p. 012002, Dec. 2017.

[27] A. S. Ahmar et al., “Implementation of the ARIMA(p,d,q) method to forecasting CPI Data using forecast package in R Software,” J. Phys. Conf. Ser., vol. 1028, no. 1, p. 012189, Jun. 2018.

[28] A. S. Ahmar et al., “Modeling Data Containing Outliers using ARIMA Additive Outlier (ARIMA AO),” J. Phys. Conf. Ser., vol. 954, no. 1, 2018.

[29] E. Kartikadarma, T. Listyorini, and R. Rahim, “An Android mobile RC4 simulation for education,” World Trans. Eng. Technol. Educ., vol. 16, no. 1, pp. 75–79, 2018.

[30] Z.-H. Qian and Y.-J. Wang, “IoT technology and application,” Tien Tzu Hsueh Pao/Acta Electron. Sin., vol. 40, no. 5, pp. 1023–1029, 2012.

[31] M. U. Farooq and M. Waseem, “A Review on Internet of Things (IoT),” Int. J. Comput. Appl. (0975 8887), vol. 113, no. 1, pp. 1–7, 2015.

[32] H. Boujezza, H. Kaffel-Ben Ayed, and L. Azouz Saodane, “Protection of IoT transaction using IDKEM based on three-pass protocol countermeasure,” 2017 13th Int. Wirel. Commun. Mob. Comput. Conf. IWCMC 2017, pp. 423–428, Jun. 2017

[33]. KarthikKrishnamurthi, SurajThapa, LokeshKothari, Arun Prakash, March 2015, “Arduino Based Weather Monitoring System”, International Journal of Engineering Research and General Science Volume 3, Issue 2.

[34]. DebrajBasu, GiovanniMoretti, Gourab Sen Gupta, Stephan Marsland, “Wireless Sensor Network Based Smart Home: Sensor Selection, Deployment and Monitoring”.

[35]. Setu Garg, Akash Chaudhary, Akash Pradhan, Heena Sharma, “THE ROLE OF ZIGBEE TECHNOLOGY IN WEATHER MONITORING SYSTEM”,International Journal of Advanced Research in Electrical,Electronics and Instrumentation Engineering, Vol. 2,Issue 5, May 2013.