International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 05 Issue: 10 | Oct - 2021 ISSN: 2582-3930

IoT Based Air Pollution Monitoring System

Onkar Joshi[1], Pranav Garg[1], Vedant Modak[1], Dr Jagannath Nirmal[2], Dr Makarand Kulkarni[2]

[1,2]Department of Electronics Engineering, K.J. Somaiya College of Engineering, Mumbai 400077

Abstract—The industrial growth in the past few decades has been enormous. Humankind has used various resources and technologies to grow and develop. But with the growth of humanity on the technological front, a decline in our environmental quality has been observed. The most apparent degradation has been witnessed in the air quality. In the current scenario of a global pandemic (Covid-19), due to the country-wide lockdown, a change in the air quality has been observed in many parts of the country, especially the metropolitan cities. The motivation to see how much air quality has improved since the lockdown led to the inception of this idea, to work on an air quality monitoring system using the power of IoT. This paper gives an insight into how IoT and electronic components like MQ135, ESP8266, Arduino Uno can be incorporated to identify air quality index at places like schools, industries, hospitals, factories, etc. The model will be designed in a way that it will use a mobile application available through all operating systems for the consumer to view the air quality around the areas where the hardware is implemented as well as see the least polluted route between two paths using GIS software.

Keywords- *Firebase, Flutter, Internet of things (IoT), MQ-135 gas sensor, ThingSpeak IoT server, Wi-fi module ESP 8266.*

I. INTRODUCTION

Air Quality around the world has been worsening due to rapid urbanization and technological development. With the increase in the number of industries and number of cars owned per household, combined with the large per capita population of our country, citizens are facing the wrath of rapid urbanization. The Air Quality Index (AQI) of metropolitan cities, have been alarmingly high in the past decade.

A high AQI not only means that the air is not fit for breathing, it also means that the people who are breathing it are at the risk of catching diseases and forming harmful and health deteriorating conditions, which could be fatal. Industry workers, schools, government buildings, hospitals are some of the places where bad AQI could be dangerous. A healthy AQI would not only mean good air to breathe but it would prove to be beneficial for the country's growth.

We aim to apply our knowledge of IoT and Electronic Components to develop a product that could help monitor AQI. The whole process of detection, i.e., Dataset collection, Data Pre-processing, Model Development will be covered in this thesis explaining the basic hypothesis of each. A mobile application has been developed which is linked to the ThingSpeak IoT serve as well as the Firebase database. This is done so as to ease the process of monitoring the AQI in real time, and view the least polluted routes through GIS software.

The objective of this system is to provide real time AQI values with hardware deployment at various locations and using a mobile application to help consumer see this AQI value on their smartphone.

1.1 Air Quality Index

The concentrations of pollutants can be measured quite differently. If the AQI value is calculated hourly, then SO_2, NO_2, CO concentrations are measured as average per 24h, O_3 concentration is measured as average per hour and the moving average per 8h, $PM_{2.5}$ and PM_{10}concentrations are measured as average per hour and per 24h, where 2.5 and 10 refers to the tiny particles or droplets in air

that are 2.5 or 10 microns in width. If the AQI value is calculated per 24h, then SO_2, NO_2, C, $PM_{2.5}$ and PM_{10} concentrations are measured as average per 24h, while O_3 concentration is measured as the maximum 1h average and the maximum 24h moving average. The Indoor Air Quality Index (IAQI) of each pollutant is calculated according to a formula published by the Ministry of Ecology and Environment (MEP).

The score for each pollutant is non-linear, as is the final AQI score. Thus, an AQI of 300 does not mean twice the pollution of AQI at 150, nor does it mean the air is twice as harmful. The concentration of a pollutant when its IAQI is 100 does not equal twice its concentration when its IAQI is 50, nor does it mean the pollutant is twice as harmful. Below are some tables to better understand AQI.

Table I. AQI ranges.

Range	Index Value
0 - 50	Good
51 - 100	Moderate
101 - 150	Unhealthy for sensitive groups
151 - 200	Unhealthy
201 - 300	Very unhealthy
301 - higher	Hazardous

1.2 Air Quality Parameters

Air quality is a measure of how clean or polluted the air is. Monitoring air quality is important because polluted air can be bad for our health—and the health of the environment. Air quality is measured with the Air Quality Index, or AQI. The AQI works sort of like a thermometer that runs from 0 to 500 degrees. However, instead of showing changes in the temperature, the AQI is a way of showing changes in the amount of pollution in the air.
Some of the gases which are used in the measurement are-

- Carbon Dioxide (CO_2) – CO_2 is colourless, odourless gas and non-combustible gas. Moreover, it is considered under the category of asphyxiate gases that have capability of interfering the availability of oxygen for tissues. The concentration of CO_2 has increased due mainly to massive fossil fuels burning. This increase makes plants grow rapidly. The rapid growth of undesirable plants leads to the increased use of chemicals to eliminate them.
- Sulphur Dioxide (SO_2) - Sulphur Dioxide is a colourless gas, detectable by the distinct odour and taste. Like CO_2, it is mainly due to fossil fuels burning and to industrial processes.
- Nitrogen Dioxide (NO_2) – Nitrogen Dioxide is a brownish gas, easily detectable for its odour, very corrosive and highly oxidant. It is produced as the result of fossil fuels burning.
- Ozone (O_3)- This ozone layer is a good thing—it helps block us from the Sun's harmful radiation. However, ground level ozone is bad for human health. It is created when sunlight reacts with certain chemical emissions (for example nitrogen dioxide, carbon monoxide and methane).
- Temperature and humidity- Measurement of temperature is important for safety of people and affects our life skills. Greenhouse effect can be monitored by measuring temperature and comparing temperature changes from historical to present time especially since the industrial revolution using climate data.

1.3 IoT Based Approach

The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, all collecting and sharing data. Thanks to the arrival of super-cheap computer chips and the ubiquity of wireless networks, it's possible to turn anything, from something as small as a pill to something as big as an aero plane, into a part of the IoT. Connecting up all these different objects and adding sensors to them adds a level of digital intelligence to devices that would be otherwise unintelligent, enabling them to communicate real-time data without involving a human being. The Internet of Things is making the fabric of the world around us smarter and more

responsive, merging the digital and physical universes.

IoT has evolved from the convergence of wireless technologies, micro-electro mechanical systems (MEMS), micro services and the internet. The convergence has helped tear down the silo walls between operational technology (OT) and information technology (IT), allowing unstructured machine - generated data to be analysed for insights that will drive improvements.

1.4 Existing Models

The commercial meters available in the market are Fluke CO_{220} carbon monoxide meter for CO, Amprobe CO_2 meter for CO_2, ForbixSemicon LPG gas leakage sensor alarm for LPG leakage detection. The researchers in this field have proposed various air quality monitoring systems based on WSN, GSM and GIS. Now each technology has limited uses according to the intended function, as Zigbee is meant for users with Zigbee trans-receivers, Bluetooth. The GIS based system is designed, implemented and tested to monitor the pinpoints of air pollution of any area. It consists of a microcontroller, gas sensors, mobile unit, a temporary memory buffer and a web server with internet connectivity which collects data from different locations along with coordinates information at certain times of a day. The readings for particular locations are averaged in a closed time and space. The Global Positioning System (GPS) module is attached to a system to provide accurate representation of pollution sources in an area. The recorded data is periodically transferred to a computer through a General Packet Radio Service (GPRS) connection and then the data will be displayed on the dedicated website with user acceptance. As a result a large number of people can be benefited with the large scale implementation of this.

II. PROPOSED MODEL

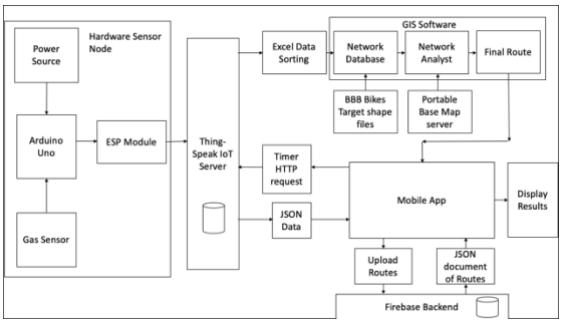

Fig.1 Proposed model flowchart

The proposed system will consist of a power source, an Arduino uno board, a wi-fi module ESP8266 and a gas sensor MQ-135 to measure the air quality. The wi-fi module will then send the data collected to the ThingSpeak IoT server for monitoring values in real time. Development of a mobile application will help the users see AQI values in real time.

2.1 Proposed Model Specifications

2.1.1 Hardware Specifications

1.Arduino

Fig.2 Arduino Uno Board [9]

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

2. ESP8266

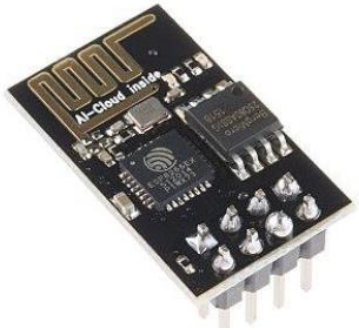

Fig.3 ESP8266 Board [10]

The ESP8266 is a low-cost Wi-Fi microchip, with a full TCP/IP stack and microcontroller capability. This small module helps microcontrollers like in our case Arduino UNO to connect to a wi-fi network and make simple TCP/IP commands. It provides capabilities for 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2), general- purpose input/output (16 GPIO), Inter-Integrated Circuit (I2C), analog-to-digital conversion (10-bit ADC), Serial Peripheral Interface (SPI), I2S interfaces with DMA (sharing pins with GPIO), UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2), and pulse-width modulation (PWM).

3. MQ 135

Pin No.	Pin Name
1	Vcc(+5V)
2	Ground
3	Digital Out
4	Analog out

Fig.4 MQ-135 Sensor [11]

The MQ-135 Gas sensors are used in air quality control equipment and are suitable for detecting or measuring of NH3, NOx, Alcohol, Benzene, Smoke, COx. The MQ-135 sensor module comes with a Digital Pin which makes this sensor to operate even without a micro- controller and that comes in handy when you are only trying to detect one particular gas. PPM of the gasses can be measured using the analog pin.

2.1.2 Software Requirements

1. ThingSpeak IoT Server

ThingSpeak is an open-source IoT application and API to store and retrieve data from things using the HTTP and MQTT 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.

The platform service that allows you to aggregate, visualize, and analyse live data streams. Once you send data to ThingSpeak from your devices, you can create instant visualizations of live data without having to write any code. With MATLAB analytics inside ThingSpeak, you can write and execute MATLAB code to perform more advanced pre-processing, visualizations, and analyses. ThingSpeak is an IoT application that collects data from things (sensors). it is an open source platform for the users and very popular among the internet of things experimenters. The main use of this application is to collect data from sensors and retrieve.

2. GIS

A GIS is a geographical information system which is used to work, manipulate, analyse all sort of geographical data which is spatial in nature. The data is referenced to locations on the globe. This information system is coupled with data called as attribute data which is tabular in nature. Attributes can be defined as an extra feature of the geographical data we work on. GIS is a geographical information system written in C++ and python is used to work with maps and geographical information maintained by the Environmental Research Institute.

III. IMPLEMENTATION

3.1 Hardware implementation

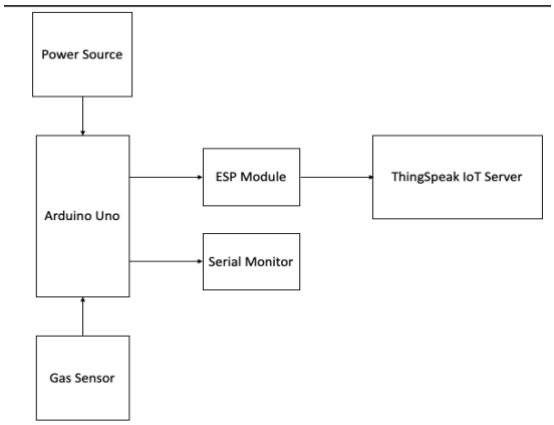

Fig.5 Hardware circuit flowchart

The Hardware is built using 3 components viz. Arduino, gas sensor and wi-fi module. Gas sensor and wi-fi module are connected with the help of jumper wires. The gas sensor senses the gases in the surrounding and gives the readings in PPM. According to the flow chart we can see the gas sensor writes the value to Arduino Uno, these readings can be seen on the serial monitor of Arduino application (explained below), along with the help of wi-fi module the values are seen on the ThingSpeak IoT server.

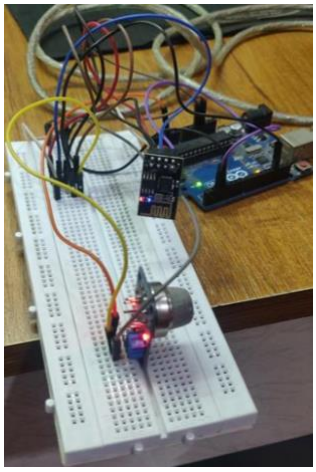

Fig.6 Hardware circuit

3.2 Software Implementation

1. Arduino IDE Software

Arduino software is an open-source software used to write, compile and upload the code directly onto any Arduino board. The installation of Arduino software requires a few easy steps that anyone can figure out from the Arduino website. After writing, compiling and uploading the code on the Arduino board we can see the results(gas sensor values) on the serial monitor based on the baud rate that has been defined in the Arduino code.

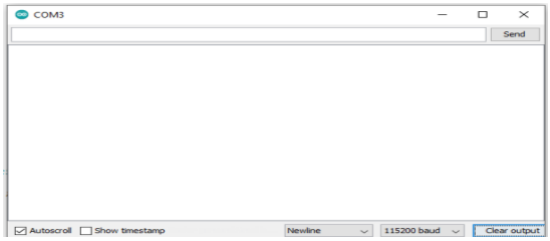

Fig.7 Serial monitor

2. ThingSpeak IoT server

A ThingSpeak IoT server is a cloud server wherein the values of the gas sensor obtained can be seen directly on to the server. ThingSpeak is an open-source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP and MQTT protocol over the Internet or via a Local Area Network.
Using ThingSpeak IoT server we get the read and write API keys which are used in Arduino code. The ThingSpeak IoT gives us the channel fields through which we can request the data for mobile app.

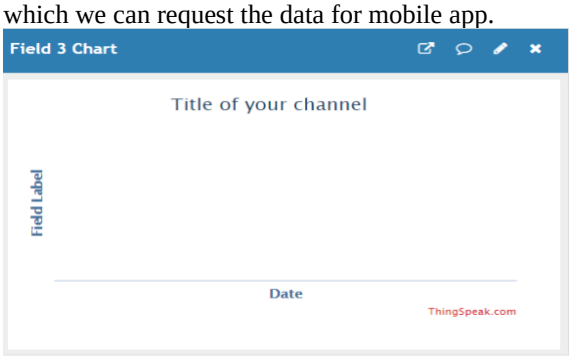

Fig.8 Field chart ThingSpeak

3. GIS Software

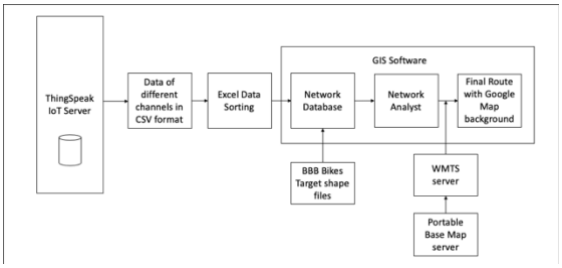

Fig.9 GIS flowchart

GIS is a geographical information system written in C++ and python is used to work with maps and

geographical information maintained by the Environmental Research Institute.

3.3 Mobile Application

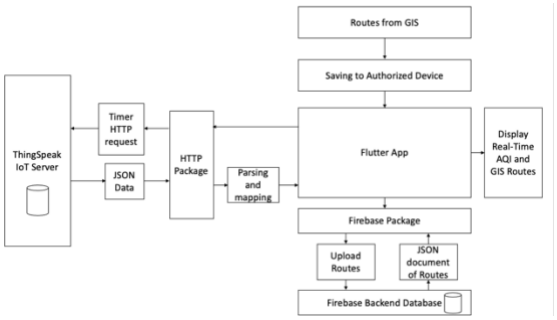

Fig.10 Mobile Application flowchart

1. Flutter:

Flutter is an open-source UI software development kit developed by Google. This allows the development of applications for Android, iOS, Linux, Mac, Windows, Google Fuchsia and the web from single codebase. The application built in this project has been made using this framework which provided us with multiple operating system compatibility. This framework also has various packages with which multiple tasks can be implemented like crud operations using HTTP and convert.

2. Dart:

Dart is an object oriented, class-based, garbage-collected language with C-style syntax. Dart can compile to either native code or JavaScript. It also provides with support interfaces, mixins, abstract classes, reifined generics, and type inference. It is the programming language which is used for the application development. It is the language which works with the Flutter Framework. It allowed us to create an application with multiple operating system compatibility.

3. Firebase:

Firebase is a backend as a service (BAAS), which provides a seamless integration with the Flutter framework. The integration is done with the firebase packages provided by Google. Firebase is a NoSQL database which stores the data in a JSON document rather than a schema. This allows the application to be deployed quickly and eases the scaling process. In the application the routes from GIS software were uploaded to the database of the Firebase backend and then through a read function the results were displayed in the app.

4. Mobile Application in the paper:

Mobile application has been developed with the help of Flutter framework. To display data on the app a request has to be made to the IoT server. For this exact purpose, a http get request has been made to the server's URL. The URL is specific for the channel to which the data has been sent from the Arduino device. The data received is in JSON format with multiple key value pairs. After the acquisition of data in the application, the data has to be parsed so to receive meaningful data from it. This is done by decoding and mapping the JSON data. The required key value pair which in this case is "field1" is extracted and the value (AQI) is displayed on the application's front page. To make the application work in real time, a timer HTTP get request is implemented. This is done by making the get request after every 5 seconds by creating a timer function which launches the get request after the specified time. This allowed us to acquire data from the IoT server in real time.

The application has also been used to upload as well as view the map routed achieved from the GIS software. Firstly, the route photo should be made available in a device with authorization to upload. This photo can then be uploaded to the Firebase database through an upload function and can be read in the routes section of the application. The database works in real time and can prove to be useful when scaling the application further.

IV. RESULTS AND DISCUSSIONS

4.1 ThingSpeak IoT Server

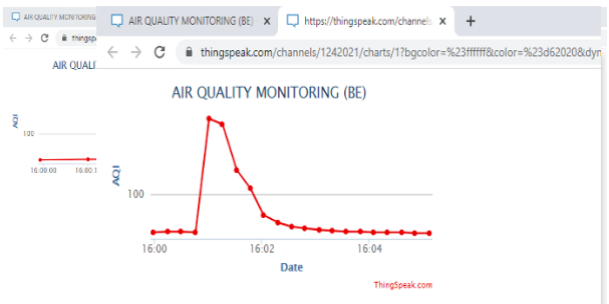

Fig.11 Real time data on ThingSpeak

4.2 Arduino

Fig.12 Readings on Serial Monitor

4.3 Mobile Application

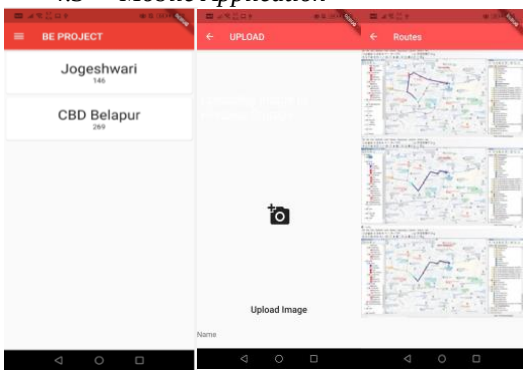

Fig.13 UI for mobile application

4.4 Applications and Benefits of the developed system

This system finds application at various places such as hospitals, factories, schools and colleges where continuous air quality monitoring can prove to be beneficial to the public. This developed system is better than the previously deployed systems because unlike Zigbee, it uses the power of IoT. The mobile application was also developed using flutter which works on different operating systems, giving user the freedom to download this application on various operating systems. Also, the air quality can be monitored from anywhere because it is present on an IoT server instead of local hosts. Furthermore, other models developed so far have not been made with a ready-to-market approach because most still use local hosts, whereas the proposed model in this paper uses IoT server and Firebase backend, which is scalable for market growth.

V. CONCLUSION

The proposed system uses a gas sensor to get the air quality in the surrounding area and send the data over a wi-fi module to the IoT server. Using flutter to develop a mobile application for various operating systems, we can view the AQI values on the application in real time. This system uses low cost material which makes it easy to deploy and affordable to implement. It will be useful in industries, hospitals, schools, and other public places where real time monitoring of air quality is necessary for the safety of the public as well as the environment.

ACKNOWLEDGEMENT

Research reported in this paper was supported by K. J. Somaiya College of Engineering, Vidyavihar Mumbai, A Constituent College of Somaiya Vidyavihar University.

VI. REFERENCES

[1] A New Method for Urban Travel Rout Planning Based on Air Homayoon Zahmatkesh, Mohsen Saber and Majid Malekpour University of Tehran, Department of Surveying and Geomatics, Iran.

[2] An Agent Based Traffic Regulation System Pollution Sensor Data for the Roadside Air Quality Control Abdelaziz El Fazziki, Djamal Benslimaney, Abderrahmane Sadiq, Jamal Ouarzaziz and Mohamed Sadgal_Computer Systems Engineering Laboratory, Cadi Ayyad University of Marrakech, Moroccoelfazziki@uca.ma,sadgal@uca.ma,abderrahmane.sadiq @ced.uca.mayLIRIS Laboratory, University of Claude Bernard Lyon 1, France

[3] INTELLIGENT NAVIGATION SYSTEM USING AIR QUALITY INDEX, Dept. of Computer Engineering Sinhgad College of Engineering, Pune, Maharastra, India. Prof. S.R. Hiray, Dept. of Computer Engineering Sinhgad College of Engineering, Pune, Maharastra, India.

[4] Providing interoperability for air quality in-situ sensors observations using GML technology *A. A. Alesheikh, A. K. Oskouei, F. Atabi and H. Helali* ,Department of GIS Engineering, Khajeh Nasir Toosi University of Technology, Tehran, Iran.

[5] Poonam Pal, Ritika Gupta, Sanajan Tiwari, Ashutosh Sharma. "IOT BASED AIR POLLUTION MONITORING SYSTEM USING ARDUINO".International Research Journal of Engineering and Technology (IRJET), Volume 5, Issue 10. e ISSN 2229-5518.

[6] Pattar Sunil Mahesh, Patil Bhushan Rajendra, Bodke Akshay Dnyaneshwar, Mr.Ulhas. A. Patil. "A SURVEY PAPER ON AIR POLLUTION MONITORING USING IOT". IJARIIE, Volume - 4 , Issue -6, 2018. ISSN(O)-2395-4396.

[7] Harsh N. Shah , Zishan Khan , Abbas Ali Merchant , Moin Moghal, Aamir Shaikh, Priti Rane. "IOT Based Air Pollution Monitoring System". International Journal of Scientific & Engineering Research. Volume 9, Issue 2, February-2018. e-ISSN: 2395-0056.

[8] Vijayakumar Sajjan, Pramod Sharma. "Research on an Iot Based Air Pollution Monitoring System".International Journal of

Innovative Technology and Exploring Engineering (IJITEE) , Volume-8, Issue- 9S2, July 2019. ISSN: 2278-3075.

[9] https://www.indiamart.com/proddetail/arduino-uno-r3-microcontroller-board-18159639973.html

[10] https://en.wikipedia.org/wiki/ESP8266

[11] https://components101.com/sensors/mq135-gas-sensor-for-air-quality