AIR QUALITY MONITORING AND ANALYSIS BASED PREDICTIVE SYSTEM

Project ID:2024-078

Project Proposal Report

RIMAS.M.J.M

B.Sc. (Hons) Degree in Information Technology Specialized in Information Technology

Department of Information Technology

Sri Lanka Institute of Information Technology
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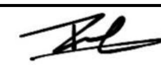
DECLARATION

I declare that this is my own work, and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name	Student ID	Signature
RIMAS.M.J.M	IT21003714	

Signature of the Supervisor (Chathurangika Kahandawaarachchi) ....

Date ....

ABSTRACT

Sri Lankan's everyday life is negatively impacted by the significant air pollution crisis that the country is currently confronting. The number of people who die because of pollution is rising. The primary cause of Sri Lanka's ambient air pollution is emissions from vehicles. Air pollutants are many, the most important are Particulate Matter (PM), Carbon Dioxide (CO2), CH4 etc. which is found in the ambient air. Now it has begun a major environmental health problem that affects people. In this issue we are introduced to make an IOT Based Air Pollution Monitoring System in which we will monitor the Air Quality of pollution level. The overall work is categorized into three sections. One is e IoT based air quality monitoring system, sever-side (DB) and mobile application Arduino UNO, MQ7 And MQ4 sensors were used to (CH4) and (CO) gases in the air respectively, The ESP8266 Wi-Fi module is used to transmit the sensor data to the database in every one-minute and. These are the devices we are using in this system. Finally, when the air quality goes down beyond a certain level, means when there are enough harmful gases present in the air like (CO2), (CO), (NO_X). It will show the air quality in PPM on the mobile phone notification so that we can monitor it very easily. In this IOT device, you can monitor the pollution level from anywhere using your mobile application. The proposed system offers a low-cost, highly portable, and easily maintainable solution, by providing real-time air pollution levels.

Keywords: Air quality monitoring, Wireless Sensor Networks, Internet of Things (IoT), Low-Cost Sensor, Vehicle, monitoring system, smart city

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LIST OF ABBREVIATIONS

IoT	Internet of things
CEA	Central Environmental Authority Sri Lanka
DMT	Department of Motor Traffic
PPM	Gas concentration
TCP	Transmission Control Protocol
UI	User Interface
API	Application Program Interface
SDLC	Software Development Life Cycle
DB	Database
CO	Carbon Monoxide
IT	Information Technology

1. INTRODUCTION

1.1 **Background Literature**

Approximately two thirds of the world's population suffer from poor air quality [1]. The quality of the air we breathe, or air quality, is an extremely valuable resource that ought to be available to all. According to the most current World Health Organization data, over half of the world's population lives in significantly air-polluted metropolitan areas, but nearly none of them are aware of how clean the air is where they live.

Air pollution has a significant impact on the quality of life and public health. Monitoring air pollution is significant for raising public awareness and improvement in human health and sustainable urban environments [3]. Our environment has been affected by air pollution due to the increased population, industries, and traffic on the roads. Worldwide, air pollution, both indoor and outdoor, has reached dangerous levels with health problems that affect people in both developed and developing countries. Ambient air pollution in both cities and rural areas was estimated to cause 4.2 million premature deaths worldwide per year in 2016[]. The main source of ambient air pollution in Sri Lanka is vehicular emissions. When considering outdoor air pollution, emissions caused by the combustion process from motor vehicles, solid fuel burning, and industry are the common sources of outdoor air pollution. Approximately 24000 people died including children of air pollution in Sri Lanka. Air pollutant levels were significantly higher in the premises of the urban school as compared to the rural school. According to the population in Sri Lanka, school children are the most effective group which exposed to high levels of pollutants exaggerated by overcrowding of major schools in cities, especially in Colombo and Kandy.

While there are many different types of air pollutants, particulate matter (PM), carbon dioxide (CO2), carbon monoxide (CO), ground-level ozone (O3), nitrogen oxides (NOx), and sulfur oxides are the most significant. (So_x) and Lead (Pb), both of which are present in surrounding air. Which pollutant particulate materials (PM2.5 or PM10) can cause several kinds of respiratory, cardiovascular diseases and blood diseases. Medical studies have shown that PM2.5 can be easily absorbed by the lung, and high concentrations of PM2.5 can lead to respiratory disease or even blood diseases [2].

Table 1.1 Criteria Pollutants and their health and environmental effects

Pollutant	Most relevant Health Effects
Carbon Monoxide(CO)	Aggravation of angina pectoris; decreased exercise tolerance; risk of foetuses
Lead (Pb)	Impaired blood formation ; infant development effects
Nitrogen Dioxide (NO_2)	Aggravation of respiratory disease; atmospheric discoloration
Particulate Matter (PM_{10} and $PM_{2.5}$)	Aggravated asthma; coughing; painful breathing; chronic bronchitis; decreased lung function; Premature death in heath and lung patients
Ozone (O_3)	Decreased Pulmonary function; surrogate for eye irritation
Sulphur Dioxide (SO_2)	Wheezing, shortness of breath, chest tightness; premature deaths

Air pollution has both acute and chronic effects on human health, affecting a few different systems and organs in recent years. Pollution has had a direct influence on human health. To rising levels of noise and air pollution, people are more susceptible to different health issues.

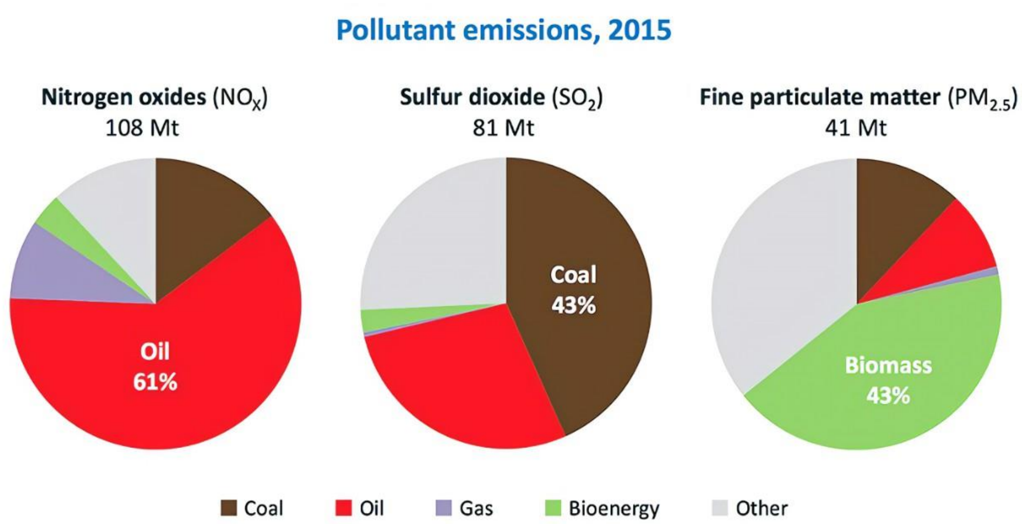
(Muthukumar S. et al., 2018) [15]. Growing industrialization and urbanization are the main contributors to noise and air pollution. The primary factors that harm both human health and the environment (Janeera D.A. et al., 2021) [23]. Monitoring and limiting such emissions are crucial.

Monitoring contamination using traditional methods was time-consuming and ineffective (Bhuvaneswari T. et al., 2020) [18]. With the development of technology, quick and effective pollution monitoring has been developed in the Internet of Things (IoT) (Nižetić S. et al., 2020; Abid M.A. et al., 2022) [21]. With the aid of many sensors, it allows data exchange between the internet, electrical and electronic appliances, and people. IoT is successful because it is affordable, effective, and feasible (Sasikumar A. et al., 2023) [16]. Pollutants from cars, vehicles, and buses are causing an increase in environmental issues, which is why asthma attacks and respiratory illnesses are on the rise. The only traffic is responsible for

50% of the carbon monoxide in the air (Rakhonde M.A. et al., 2018) [19]

Table 1.2 Status of air pollution due to vehicle emissions in Colombo

Pollutant	Grand mean concentration	Range
TSP	404 μg/m3 (g h)	100-700 μg/m3 (g h)
Pb	0.415 μg/m3 (g h)	0.01-2.0 μg/m3 (g h)
CO	4.0 ppm (3 hr)	2.25 ppm
SO_2	0.019 ppm (3 hr)	0.0045-0.054 ppm
THC	2.7 ppm (3 hr)	2-5 ppm
NMHC	0.83 ppm (3 hr)	0.2-3.00 ppm
CH_4	1.9 ppm (3 hr)	1.8-2 ppm



Source: Masters and Ela, 2015

Figure 1.1 Summary of responses Criteria Pollutants and their health and environmental effects.

To tackle this issue, research topic suggests an air quality monitoring and analysis based predictive system is proposed IoT air quality monitoring devices. A novel Internet of Things-based air quality monitoring devices System has been proposed to monitor the air pollution level. The main contributions are in this section the whole system consists of three main parts. IoT based air quality monitoring hardware system, the second part is the server backend, and the third part is the front-end mobile application. This IoT based air quality monitoring hardware system is fixed at suitable urban, open areas to monitor the ambient air quality of these regions [10]. This hardware system uses an Arduino Uno, MQ4, and MQ7 sensors were used to measure Methane (CH4) and Carbon Monoxide (CO) gases in the air respectively board and esp8266 Wi-Fi module used to transmit the sensor data to the database in every one minute of time interval to make the device more real in time. The location of the device is identified using a predefined terminal number to the places where the devices implemented. Instead of using a GPS senor Wi-Fi module to transmit the information packet to the MongoDB database. The sensor data received from the air quality monitoring device is processed and stored in the database, but that sensor data cannot be stored in the database directly. So, the server back-end must be built using NodeJS language and then the sensor data passes through the server back-end to the database. The mobile application gets real-time air quality information by accessing the database and displays. The proposed system offers a low-cost, highly portable, and easily maintainable solution, by providing real-time air pollution levels. A key benefit of this approach is raising public awareness, which aids elderly, children, and those with respiratory conditions.

Most pollution monitoring methods used today monitor and consider a variety of vehicles emissions. This section is an overview of a few recent methods used to monitor and detect the air pollution level.

In 2021, Gautam, A., et al., proposed an embedded system utilizing sensors and IoT technology to monitor and control air pollution on a global scale. The system prototype, based on Raspberry Pi, incorporates sensors and actuators to achieve this goal. Additionally, a website was developed to remotely monitor gas levels. The results indicate successful testing and implementation of the entire system.

In the year 2022, Rauniyar, A., and colleagues introduce an innovative car emissions monitoring system for smart cities, based on the Internet of Things (IoT) technology. This system enables infrastructure managers and analysts to perform real-time monitoring of vehicle noise and pollution sensor data. To analyze the collected data, artificial intelligence (AI) algorithms are employed, which effectively categorize the emission sources into three levels: high, medium, and normal emitters. Furthermore, the researchers aim to develop a comprehensive software solution that can seamlessly integrate with the existing intelligent transport systems in smart cities. [25].

In the year 2020, Kaivonen, S. and Ngai, E.C.H., along with their colleagues, proposed the utilization of wireless sensors installed on public vehicles to monitor air pollution in real-time. These sensors, when combined with the data collected from stationary sensors and Uppsala's single ground-level monitoring station, provide additional measurements. Consequently, the quality of data and communication within the system has been evaluated through various experiments [26].

In 2020, Zhang, D. and Woo, S.S. introduced a strategy to develop the air quality pattern within a particular region by employing both mobile and stationary IoT sensors integrated into the vehicles that patrol the area. The comprehensive assessment covers the entire spectrum of air quality in the neighboring regions. The effectiveness of the proposed method in accurately gauging and predicting air quality through the application of diverse machine learning algorithms and real-time data illustrates its efficiency. The outcomes reveal that the forecasting and monitoring of air quality in a smart city context is effective and shows potential [23].

In 2020, Jo, J., et al., proposed an IoT-driven Smart-Air system for effective air quality monitoring and real-time data transmission to a web server using LTE technology. The system comprises an LTE modem, pollutant tracking sensors, and a microprocessor. Users could monitor air quality through the web server from any location at any given time. Furthermore, the web server can store all data in the cloud, enabling users to access resources for further analysis of outdoor air quality [27].

In 2022, Kumar, A., et al., proposed an Internet of Things (IoT) solution aimed at monitoring vehicle emissions. The sensors of the Arduino Uno are utilized to monitor the quantity of pollutants emitted from the vehicle's exhaust system. Additionally, a Raspberry Pi is employed in the prototype for the purposes of monitoring and control. In this system, an audible warning is issued to the vehicle user via a buzzer, and in case of non-compliance, a penalty notice is issued to the user and subsequently sent to their email address [24].

In the year 2022, Asha, P., et al., proposed the ETAPM-AIT model, which involves the monitoring of eight pollutants (NH_3, CO, NO_2, CH_4, CO_2, $PM_{2.5}$, temperature, and humidity) through an IoT-based sensor array. The sensor array is responsible for measuring the levels of pollutants and transmitting this data to a cloud server for further analysis via gateways at intervals of 5, 15, 30, and 60 minutes. Following the completion of simulation analysis, the results are scrutinized utilizing artificial intelligence methodologies [17].

Existing monitoring techniques require laboratory analysis and have poor accuracy and sensitivity. Consequently, better vehicle monitoring methods are required. To overcome the above drawbacks, a novel of IoT- air quality monitoring devices has been proposed in this system.

Table 1.3 Summary of Literature review

Author	Application	Techniques	Remark
Rauniyar, A., and colleagues	IoT-based car emissions monitoring system for smart cities	Reacts, a PostgreSQL database	85.2% of the vehicles were classified as normal emitters, 7.1% were medium emitters, while 7.7% of the vehicles were classified as high emitter vehicles
Kaivonen, S. and Ngai, E.C.H	real-time air pollution monitoring using wireless sensors on public transport vehicles	Python scripts, MongoDB, JSON, HTTP API, PHP	
Zhang, D. and Woo, S.S.	air quality pattern in the area using both moving and fixed IoT sensors mounted in the vehicles	mobile and stationary IoT sensors integrated into the vehicles	machine learning algorithms and real-time
Kumar, A	IoT-based system for monitoring vehicle pollution	proposed an Internet of Things (IoT) solution aimed at monitoring vehicle emissions	
Asha, P., et	IoT enabled environmental toxicology for air pollution monitoring using AI techniques	Artificial Algae Algorithm	model, which involves the monitoring of eight pollutants (NH3, CO, NO2, CH4, CO2, PM2.5, temperature, and humidity) through an IoT-based sensor
JunHo Jo	IoT-driven Smart-Air system for effective air quality monitoring and real-time	AWS server, PHP, MySQL, IoT-based, JavaScript, web server developed for Android OS	

1.2 **Research Gap**

Background Literature shows that a few research projects done previously aimed to Monitoring air pollution is significant for raising public awareness and improvement in human health and sustainable urban environments. Kaivonen, S. and Ngai, E.C.H., et al. was proposed real-time monitoring of air pollution in public cars [6]. that have been conducted to measure air quality based on IoT or wireless sensor networks. The data from the stationary sensors and Uppsala's only ground-level monitoring station are supplemented by measurements from the sensors on public transportation vehicles. The experiments have led to an evaluation of the data and communication quality of the system. Similarly in 2021, Gautam, A., et al proposed an Internet of Things (IoT)-enabled sensor-based embedded system to control and monitor air pollution produced worldwide [8]. built on the Internet of Things, an embedded system prototype using sensors and actuators is built on Raspberry Pi. Additionally, a website is designed to monitor gas levels virtually anywhere. A little over two years ago, the Internet of Things-based solution to track automobile pollution. The sensors on the Arduino Uno monitor the quantity of pollutants originating from vehicle exhaust. Additionally, a Raspberry Pi is used by the prototype for control and monitoring. The buzzer in this car will alert the user, and if they disregard it, a challenge is filed against them and forwarded to their mail ID. Eight pollutants—NH3, CO, NO2, CH4, CO2, PM2.5, temperature, and humidity—are measured using an Internet of Things-based sensor array, according to Asha, P., et al.'s 2022 proposal for the ETAPM-AIT model. The pollutant level is calculated by the sensor array and sent to the cloud server for analysis via gateways. 15 minutes, 30 minutes, and 60 minutes. After the simulation analysis is finished, the AI method is used to review the results. put into practice Current monitoring methods are inaccurate and sensitive, and they need to be analyzed in a lab. Therefore, more advanced vehicle monitoring techniques are needed. This system has a novel set of IoT-based air quality monitoring sensors that have been presented to address the disadvantages. This IoT consists of three primary components, an Internet of Things (IoT)-based hardware device for monitoring air quality, a server backend, and a front-end mobile application. A monitoring hardware system is installed in appropriate urban open places to track the quality of the surrounding air.

To measure methane (CH_4) and carbon monoxide (CO) gases in the air, respectively, this hardware system uses an Arduino Uno, MQ4, and MQ7 sensors. An esp8266 Wi-Fi module is fixed for transmitting the sensor data to the database once every minute, making the device more realistic in real time. A predetermined terminal number is used to identify the device's position at the locations where it is implemented. Wi-Fi module is used to send the data packet to the MongoDB database rather than a GPS sensor. Though it cannot be directly recorded in the database, the sensor data that is received from the air quality monitoring device is processed and stored there. Thus, NodeJS must be used in the construction of the server back-end, through which the sensor data is routed to the database. The mobile application uses displays and database access to obtain real-time information on air quality. The suggested system provides real-time air pollution readings and hence presents an affordable, highly portable, and readily maintainable alternative. It is important to use the following method to monitor and identify air pollution to increase public awareness, enhance human health, and create more sustainable urban environments.

Table 1.2 Summary of Research Gap

Product Reference	**Research A**	**Research B**	**Research C**	**Proposed System**
Real-time Monitoring: of air quality	✓	✓	✕	✓
Mobile application platform	✓	✓	✕	✓
Real time notification regarding our air pollution concentration level every one minute	✕	✕	✕	✓

1.3 Research Problem

A major gap in the field of Air Pollution Monitoring System in Sri Lanka is the focus of the research. challenge addressed in this work. The passage brings attention to the notable problem of air pollution, specifically in Sri Lanka, which presents a grave danger to the well-being of the public. Numerous harmful substances, such as Particulate Matter (PM), Carbon Dioxide (CO_2), Carbon Monoxide (CO), Ground-level Ozone (O_3), Nitrogen Oxides (NO_x), Sulfur Oxides (So_x), and Lead (Pb), have been identified as significant factors contributing to air pollution [7]. These pollutants primarily originate from sources like motor vehicles, fuel combustion, and industrial operations.

The adverse impacts on health caused by air pollution, including respiratory infections, asthma, and even lung cancer, have been extensively documented. Each year, a considerable number of fatalities are linked to air pollution. School children, being more susceptible and exposed to elevated levels of pollutants, face a heightened risk, particularly in urban regions such as Colombo and Kandy.

Recognizing the urgency of the situation, the passage proposes an innovative solution a real-time air quality monitoring and analysis system. This system aims to monitor ambient air quality, provide optimal routes with minimal pollution levels, generate heatmaps for easy identification of air quality in specific areas, and predict future air quality trends.

The prototype of this system utilizes gas sensors, an Arduino Uno board, and a Wi-Fi module. These sensors collect real-time air pollution level data, which is then transmitted to an information processing center using IoT technology. The data is. In essence, this proposed system represents a proactive approach to addressing the air pollution crisis in Sri Lanka by leveraging IoT technology and predictive analytics to monitor, analyze, and mitigate the adverse effects of air pollution on public health and well-being.

The following research was question was identified related to.

1. How can an IoT-based air quality monitoring system be designed and implemented to effectively monitor and analyze air pollution levels, particularly due to vehicle emissions?
2. How can gas sensors, Arduino Uno board, and Wi-Fi module be integrated to develop a functional air quality monitoring prototype?

2. OBJECTIVES

2.1 **Main Objectives**

The dangers of air pollution, its health impacts, and the need for solutions, particularly focusing on Sri Lanka. It has significant negative impacts on human health, causing respiratory, cardiovascular, and blood diseases. The main sources of air pollution include vehicular emissions, solid fuel burning, and industry. School children in Sri Lanka are particularly vulnerable to air pollution due to overcrowding in Colombo. By presenting these facts and statistics, the paragraph aims to raise awareness about the urgency of addressing air pollution, especially in Sri Lanka, and its detrimental effects on human health.

The objective of this study is to investigate a passage proposal. an **IoT-based air quality monitoring system** to address air pollution concerns. This system uses **sensor-equipped devices** placed in urban areas to collect real-time air quality data on gases like methane and carbon monoxide. This system offers a low-cost, portable, and easily maintained solution to raise public awareness and benefit health-sensitive individuals.

2.2 **Specific Objectives**

front-end Mobile Application Development

- Develop a mobile application interface for users to access real-time air quality information, including route suggestions, heatmaps, and air quality predictions.
- Implement interactive map visualization features to display air quality data and facilitate user-friendly navigation.

Development of Air Quality Monitoring Hardware System:

- Design and implement an IoT-based hardware system capable of real-time monitoring of ambient air quality using MQ4 and MQ7 gas sensors.
- Integrate Arduino Uno board and ESP8266 Wi-Fi module to enable wireless transmission of sensor data to the server backend.

Sensor Calibration and Data Processing:

- Calibrate MQ4 and MQ7 sensors to convert analog readings into accurate gas concentration values (PPM) using predefined calibration curves.
- Develop algorithms for sensor data processing to ensure accurate measurement and interpretation of air quality parameters.

User Awareness and Accessibility:

- Evaluate the usability and accessibility of the air quality monitoring system, ensuring that it meets the needs of diverse user groups, including individuals with respiratory diseases, children, and the elderly.

1. Develop an IoT-based air quality monitoring hardware system capable of real-time data collection and transmission.
2. Implement algorithms for sensor calibration and data processing to ensure accurate measurement of air pollutants.
3. Design and implement a server backend for storing, processing, and managing real-time sensor data.
4. Evaluate the accuracy and effectiveness of the system in predicting air quality levels and suggesting routes with minimal air pollution.

3. METHODOLOGY

3.1 System Architecture Diagram

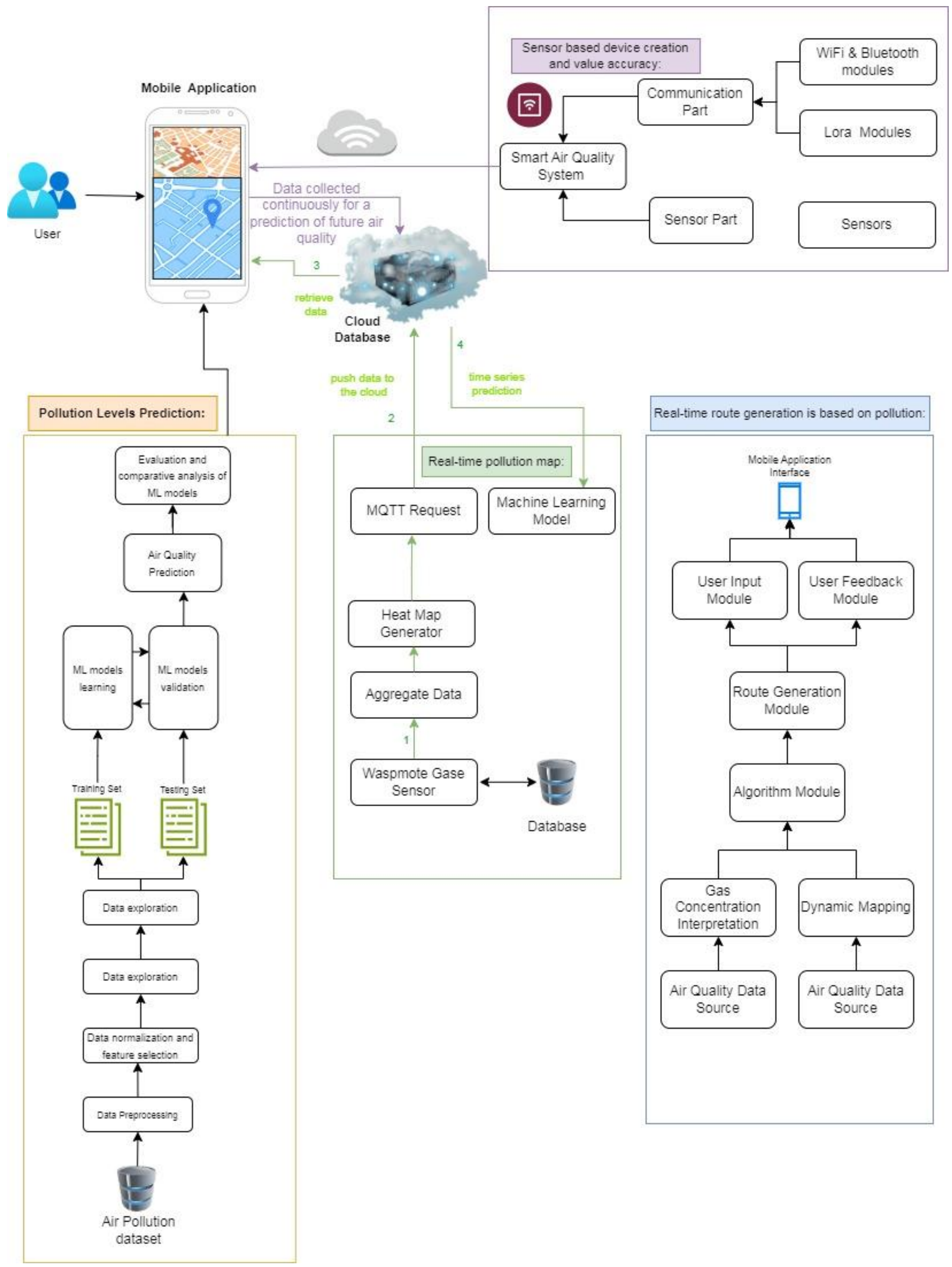


Figure 3. 1 System Architecture Diagram

Figure 3. 2 Sensor based device creation and value accuracy Architecture Diagram

As shown in Figure 3.2, Air pollution is a significant global environmental health concern affecting both developed and developing countries. In Sri Lanka, air pollution poses a grave danger to public health, primarily due to emissions from motor vehicles, industrial activities, and solid fuel burning the methodology for implementing an IoT-based air quality monitoring system involves several steps, including planning, hardware and software setup, data collection, processing, and analysis. Here's a detailed outline of the methodology Identify the objectives of the air quality monitoring system, such as real-time monitoring, data analysis, and prediction Define the scope of the project, including the target locations for monitoring and the pollutants to be measured Select appropriate sensors for measuring air pollutants, such as particulate matter (PM), carbon dioxide (CO2), carbon monoxide (CO), etc. Install the sensors at strategic locations in urban and rural areas to capture representative air quality data Set up microcontroller boards (e.g., Arduino Uno) and Wi-Fi modules (e.g., ESP8266) to interface with the sensors and transmit data. Implement a server backend using Node.js and MongoDB to receive, store, and process the sensor data. Upon receiving the sensor data, process it to convert analog readings into concentration values for each pollutant. Create a front-end web or mobile application for users to access real-time air quality information and visualization. The proposed IoT-based air quality monitoring system aims to provide real-time air quality information, mitigate the adverse effects of air pollution, and raise public awareness. the system will contribute to improved public health and environmental sustainability in Sri Lanka

3.2 **Project requirements**

3.2.1 Functional Requirements and Non-Functional Requirements

Table 3. 1 Functional and Non-Functional Requirements

Functional Requirements	Non-Functional Requirements
1. Data Collection and Processing • it should process the sensor data to convert analog readings into gas concentration values. • The system should collect real-time data from the air quality monitoring system.	• Should have high security
2. Mobile Application Integration • The system should provide real-time air quality information to the mobile application. • The mobile app should access the database to retrieve air quality data for display	• Should properly work as a mobile cross platform application. • Interfaces should be more user-friendly.
3. Database Interaction • The system must interact with the MongoDB database to store sensor data.	• Usability
4. Implement algorithms for sensor calibration and data processing to ensure accurate measurement of air pollutants	• Reliability

1. **Software Requirements**

Software requirements are:

- React Native
- MongoDB
- Note-JS
- Postman Api
- Arduino IDE
- Visual Studio Code

.

2.Personnel Requirements

To enhance the quality, knowledge, continuation, and integrity of the research the following are the required personnel.

- Department of Motor Traffic
- Central Environmental Authority Sri Lanka

3.3 **Software Solution**

The software solution for an IoT-based air quality monitoring system involves several components working together to collect, process, analyze, and visualize air quality data. Below is a high-level overview of the software components and their functionalities.

System Components:

- Hardware: Arduino Uno board, ESP8266 Wi-Fi module, MQ4 and MQ7 gas sensors.
- Software: Arduino programming for data processing, MongoDB for data storage, Nodejs for server backend.
- Mobile Application: Front-end interface for accessing real-time air quality information.

Phases of the Proposed Approach

Data Collection:

- Gather data from IoT air quality monitoring devices. This data should include sensor readings for various air pollutants such as particulate matter (PM), carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), etc. Ensure the data is labeled accurately.

Model Deployment:

- Deploy the trained model to the IoT devices or a cloud-based server for real-time predictions.
- Implement mechanisms for model updates and maintenance to ensure continued accuracy and reliability.

deployment and Field Testing:

- Deploy the IoT-based air quality monitoring system in target locations (e.g., urban areas, industrial sites, schools).
- Install sensors and IoT devices according to predefined deployment plans and sensor networks.

The software development life cycle that is being recommended is the agile scrum technique. Scrum is an iterative software development technique built on the agile concepts of the Agile Manifesto [4]. Scrum may also be defined as a lightweight development methodology that provides total transparency and rapid adaptability [4]. Agile enables quick component changes in response to shift requirements throughout the implementation stage because of the characteristics. The adjustments will be effectively facilitated by the application of the agile scrum approach. Consequently, the recommended course of action will be implemented in compliance with the framework by enabling prompt adaptation and continuous modifications.

Figure 3. 2 Agile Methodology [14]

3. Requirement Gathering and Analysis

- **Survey Results**

  A survey was conducted to obtain needs from the target audience. Based on the survey results, the primary criteria were determined. According to the survey findings, the misunderstandings and misleading aspects of the stakeholders were obvious, identifying the necessity of the suggested solution for the country.

4. Feasibility Study

Feasibility Analysis is the process of determining whether a project is worth doing.

- **Technical Feasibility**

  To successfully complete the project the advanced knowledge in NodeJS, react native, use of external libraries, data fetching from external APIs, methodologies are needed.

- **Economic Feasibility**

  The Due to the project's constraints, it was necessary to use more trustworthy and priced resources to ensure reliability and cost-effectiveness. Budgetary restrictions thus had an impact on the selection of components and materials. The suggested sub-component is expected to operate without issue or malfunction, emphasizing dependability, excellent performance, and cost. In terms of component needs and resource requirements, the project aims for minimal costs.

- **Schedule Feasibility**

  The suggested subcomponent must be finished within the specified time range, producing outcomes with more accuracy, and closely following the schedule that has been established. Not to mention, the final product presentation should take place by the appointed timeframe.

- **Operation Feasibility**

  A designated member oversees each stage of the software life cycle, with an emphasis on the requirement analysis phase. Ensuring that the finished product meets the needs specified by the consumers is the goal, with a focus on user-centric design.

3.3.3 Design

- **flowchart and IoT device**

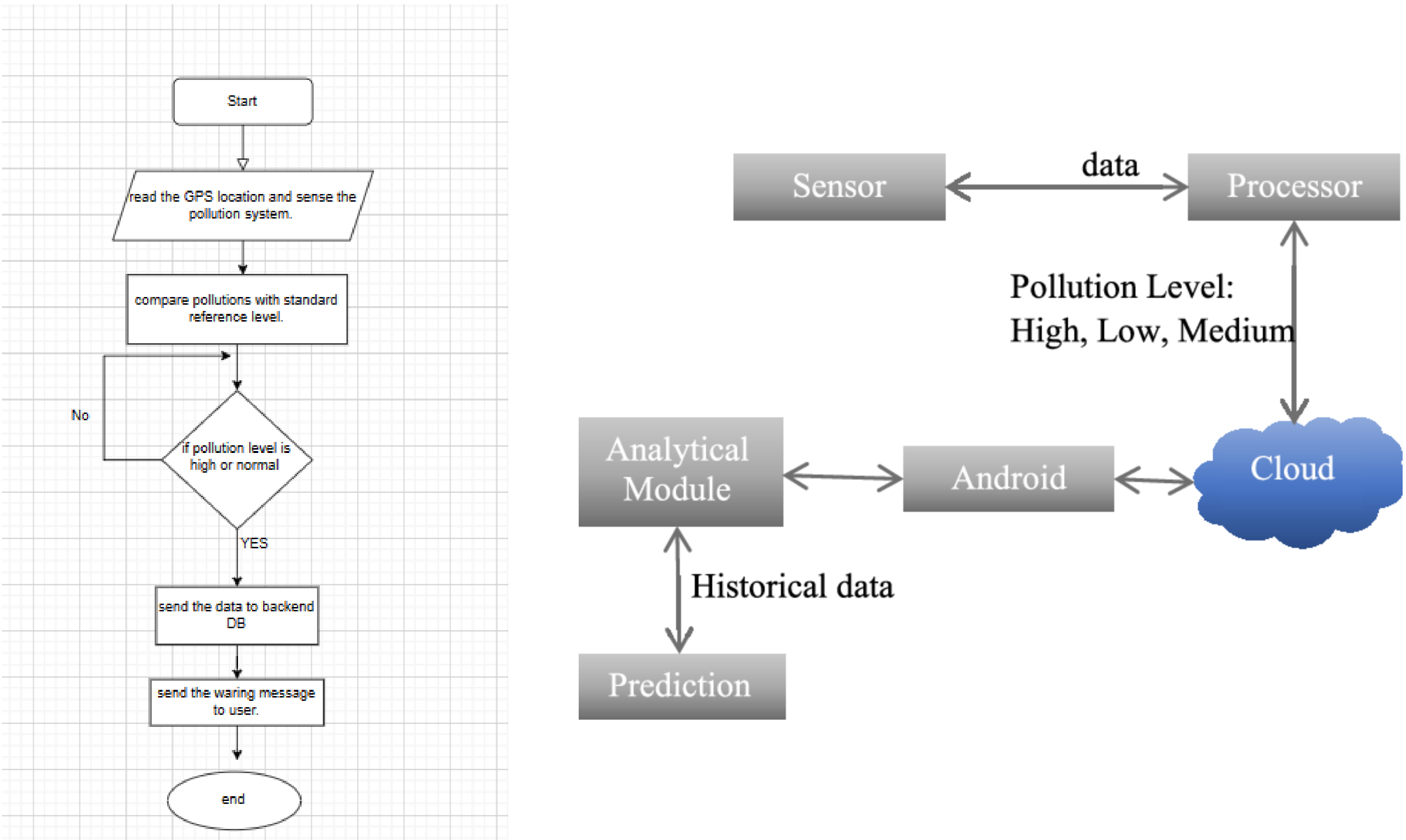
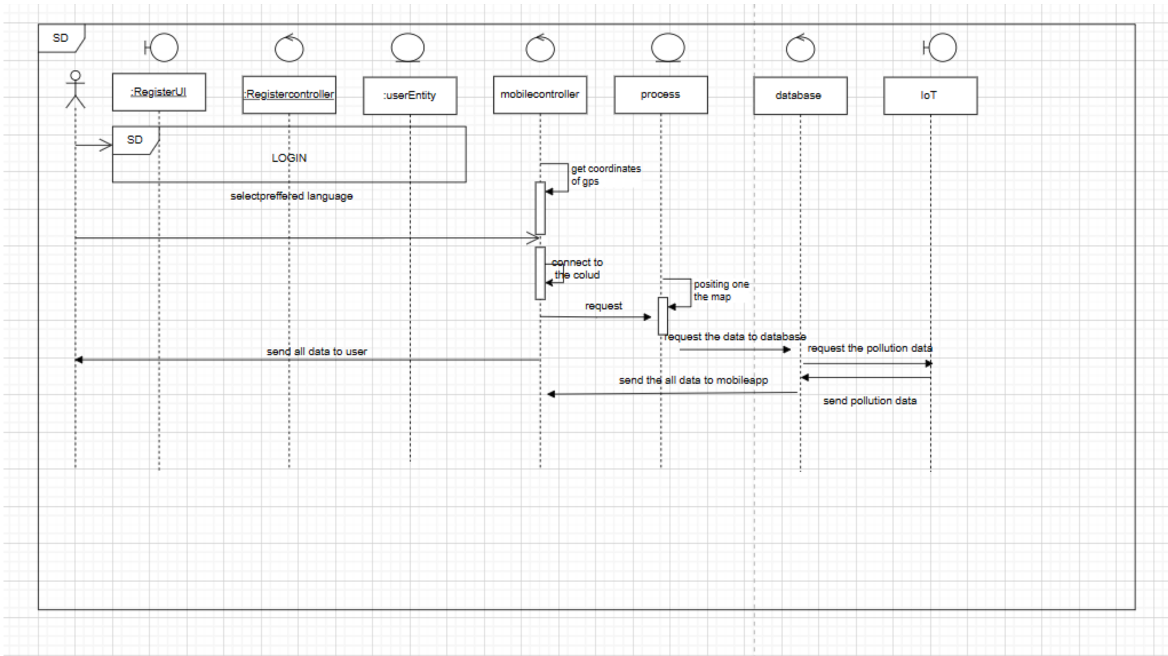


Figure 3. 3 Overall flowchart and IoT device architecture

Figure 3.3 overall flowchart and IoT device architecture diagram indicates the external and internal actor functional and technical overview.

- **sequence diagram and Block diagram.**



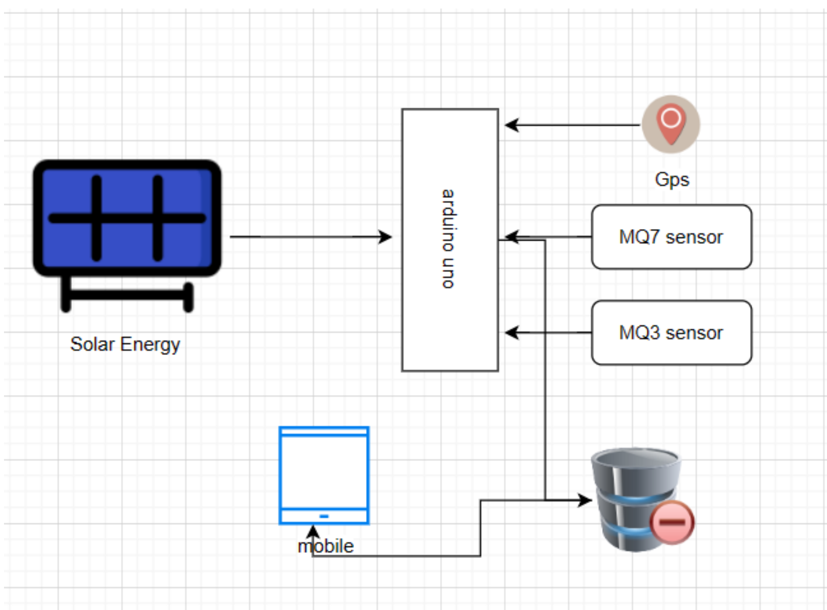


Figure 3. 4 1.1.1.1 sequence diagram and Block diagram

The figure 3.4 sequence diagram and Block diagram depict the technical interactions with the IoT system.

3.3.3.4 Dataset

To achieve the goals, both primary and secondary data were collected. Primary data was collected to the IOT device. Air quality data was obtained from both the Central Environmental Authority (CEA) and the National Building Research Organization (NBRO). Data was obtained for CO, NO2, SO2, and PM10 pollutants from CEA, as well as SO2 and NO2 from NBRO. These two institutes conduct direct measurements of the air contaminants listed above, making them the main sources of data.

3.3.3.4 Work Breakdown Structure

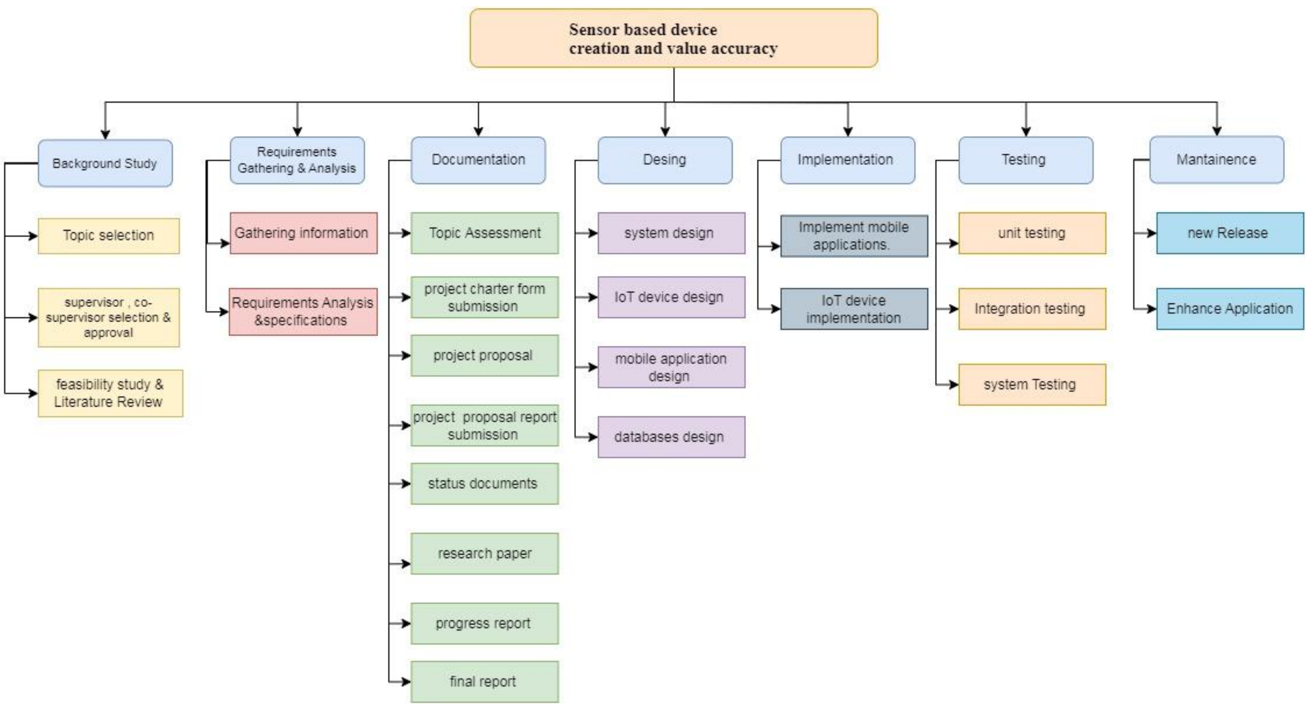


Figure 3. 5 Work Breakdown Structure

3.3.3.5 High Fidelity Diagram

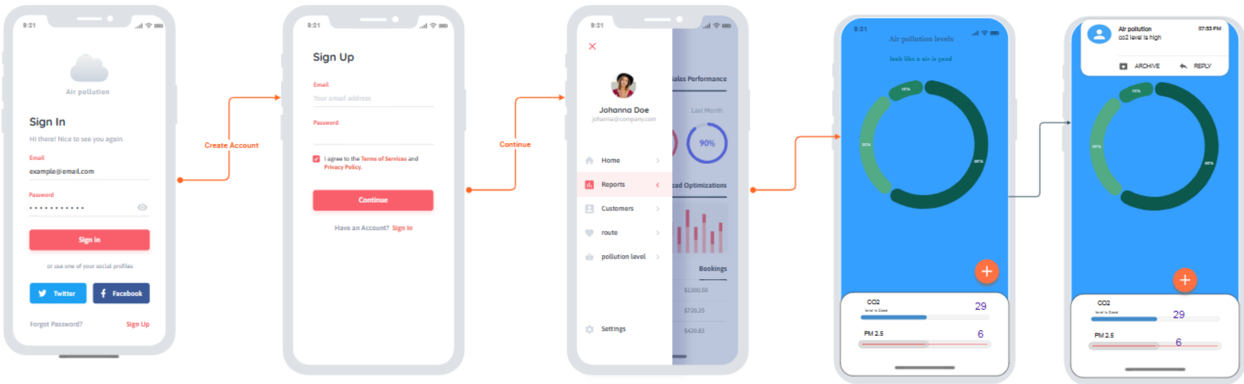


Figure 3. 6 High fidelity diagrams for information sharing to crowd.

2. Implementation

The proposed system should comply with the development of the gathered requirement as given below,

- When the sensor finds a high reading for particulate matter or carbon monoxide identification, the mobile app notifies the registered email addresses via email.
- Gather historical and current forecast air pollution consternation data based on the GPS using.
- The carbon monoxide emission rate in parts per million can be found by using the Android application.
- The mobile app provides a user-friendly interface for viewing air pollution levels and route maps.

The above functionalities will be integrated so that stakeholders can get a view through a mobile app.

- **Mobile Application**

Depending on the user's level, the suggested mobile application will have different user perspectives. According to the results of the poll, the mobile application will support English, Sinhala, and Tamil, among other three languages. Users can view high or low levels of air pollution concern. The program itself will be used to extract the meta data. The target audience will be presented with the application in two versions: a commodity version and a premium version that includes more functionality. Push alerts on the amount of air pollution and the application will be sent to users even when they are not using it. Reminders every day

- **Database Handling**

Cloud. MongoDB will be used to store data for the mobile platforms. It is an auto-scaling document database for mobile apps that saves, syncs, and queries information. The Wi-Fi module sends sensor data to the database every minute, enhancing the device's real-time capabilities. Data cannot be saved in a database directly. So, the backend must be constructed using the NodeJS language, and the sensor data travels through the server back-end to the database.

- **External Libraries and APIs**

    - **Cloud MongoDB API**

      MongoDB Cloud Messaging is a free service that establishes a secure and battery-efficient connection between the server and devices, allowing users to send and receive messages and notifications on iOS, Android.

    - **Sensor Libraries:**

    - Arduino Libraries: Arduino platforms often use various sensor libraries to interface with sensors such as MQ-series gas sensors, particulate matter (PM) sensors.

    - Raspberry Pi Libraries: Similar to Arduino, Raspberry Pi may utilize Python libraries to interact with sensors and acquire data.

3.Testing (Track and Monitor)

The program will be tested in the appropriate phases as unit, integration, system, and user acceptability testing.

4 GANTT CHART

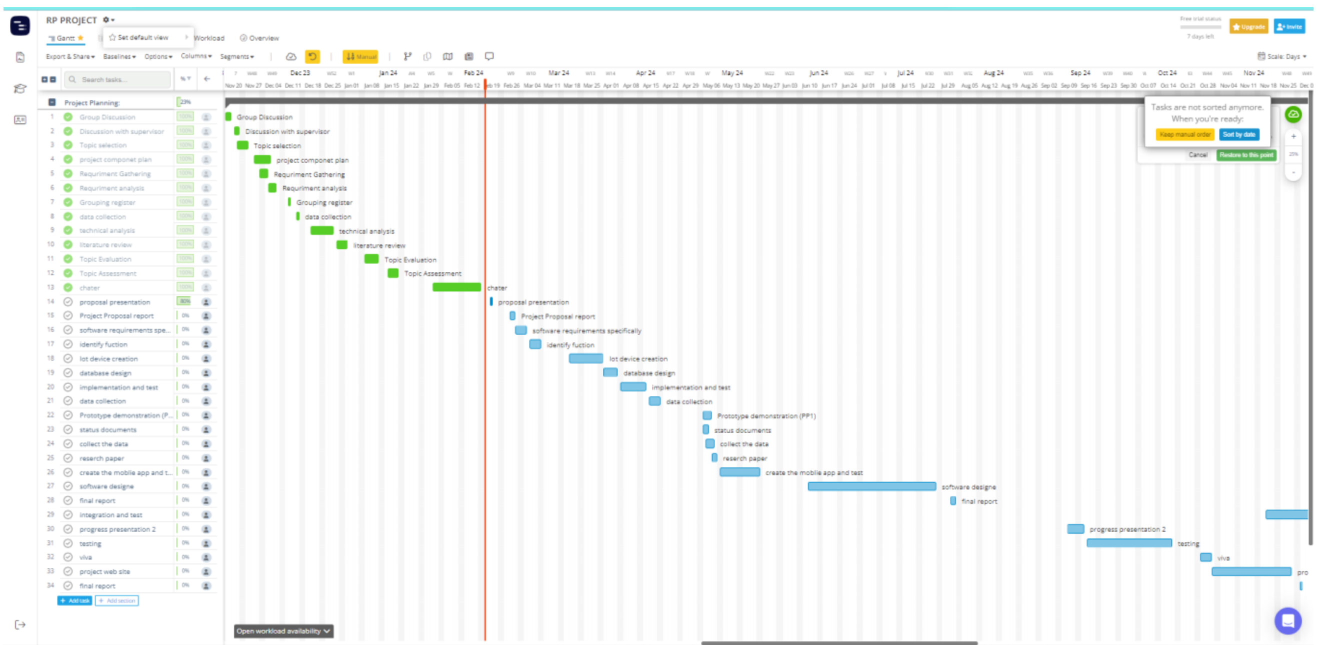


Figure 4. 1 Gantt Char

5 DESCRIPTION OF PERSONAL AND FACILITIES

Facilitators:

- Guidance and support from supervisor, co-supervisor, and lecturers
- Ms. Chathurangika Kahandawaarachchi Sri-Lanka-Institute of Information Technology

Facilities:

- Central Environmental Authority Sri Lanka (CEA)
- Department of Motor Traffic (DMT)
- National Building Research Organization (NBRO)

6 BUDGET AND BUDGET JUSTIFICATION

The estimated budget contains subscription costs, deployment costs, database costs and hosting costs.

Table 5. 1 Budget of the Air pollution IoT devices

Feature	Price
MQ4, and MQ7 sensors	1250/-
Deployment Cost	6073/-
Arduino Uno board	2950/-
MongoDB database	Free
Mobile App -Hosting on Play Store	4898/-
GPS module	1,790/-
esp8266 Wi-Fi module	395/-
16X2 LCD, Breadboard	800/-
Travel cost	3000/-
Total	21088/-

7. COMERCIALIZATION

The proposed software solution for air pollution level has significant business potential for market analysis and a well-rounded marketing plan. Identify potential customers such as homeowners, schools, businesses, and government agencies concerned with air quality.

1. SaaS Model:

The Software as a Service (SaaS) approach emerges as a powerful model for predicting air pollution levels. Its advantages lie in scalability, accessibility, and cost effectiveness, aligning with the contemporary trend of delivering applications over the internet. Eliminating maintenance costs and hardware expenses, the SaaS model provides a steady revenue stream through one-time costs or monthly subscriptions.

Developing a SaaS (Software as a Service) model for an air quality monitoring device IoT solution involves providing a cloud-based platform that offers ongoing services and functionalities to users. Here's a breakdown of how you can implement a SaaS model for your air quality monitoring device.

- **Data Storage and Processing**: Store air quality data collected from devices in a scalable and reliable database. Implement data processing pipelines to analyze and aggregate the data, enabling users to gain insights into air quality trends and patterns.

- **Device Onboarding and Management**: Develop tools for users to onboard their air quality monitoring devices onto the platform seamlessly. This may involve providing APIs or SDKs for device integration and management, as well as configuring device settings remotely.

2. Mobile Application with Ad-Based Revenue

Developing a smartphone application with integrated adverts is a profitable opportunity, especially with real-time air pollution data. Advertisers gain from this strategy since it actively engages people around the clock.

Ad revenue may be a substantial source of income, especially with a huge user base. Introducing a subscription model to eliminate adverts boosts income and benefits both consumers and advertisers.

6.1 Target Audience and Market Space

- **Target Audience**
    - schoolchildren.
    - Government bodies
    - Environmental air pollution agencies

- **Commercial Buildings**: Businesses and organizations operating in commercial spaces, such as offices, schools, hospitals, and retail stores, may use IoT air quality monitoring devices to maintain a comfortable and healthy outdoor environment for occupants.
- **Marketing Channels**: Online platforms, social media
- **Promotions:** Launch promotions, free trial periods,

- **Market Space**
    - No need for advanced knowledge in technology.
    - No age limitation for users.
    - User friendly interface easy to user

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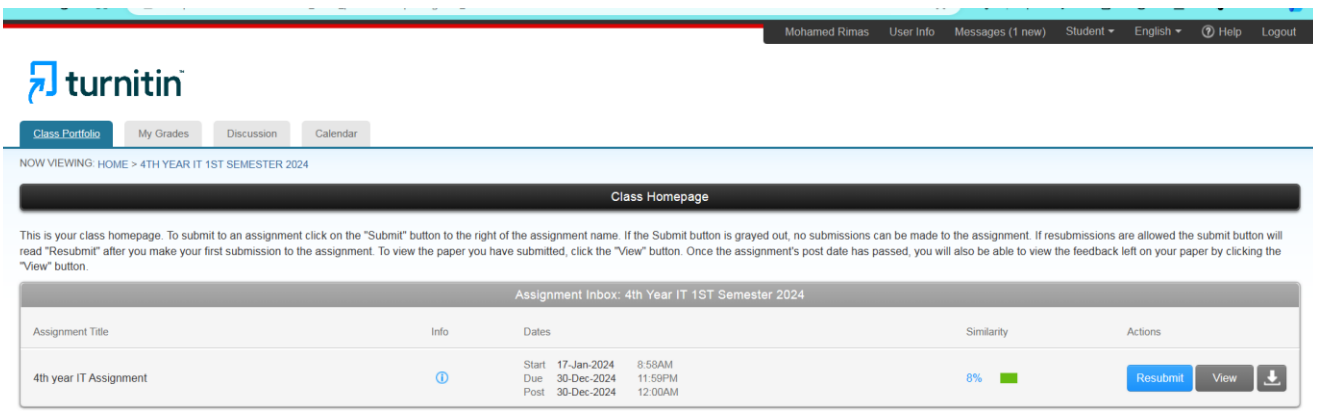
9. APPENDICES

- Plagiarism Report



Appendix 1

National Ambient air quality Standards

Pollutant	Averaging time	Maximum Permissible level	
		µg/m-3	ppm
Particulate Matter – PM_{10}	Annual	50	
	24 hr	100	
$PM_{2.5}$	Annual	25	
	24 hr	50	
Nitrogen Dioxide (NO_2)	24 hr	100	0.05
	8 hr	150	0.08
	1 hr	250	0.13
Sulphur Dioxide (SO_2)	24 hr	80	0.03
	8hr	120	0.05
	1 hr	200	0.08
Ozone (O_3)	1 hr	200	0.10
Carbon Monoxide (CO)	8 hrs	10,000	9.00
	1 hr	30,000	26.00
	anytime	58,000	50.00

Source: Central Environmental Authority