Air Quality Monitoring and Analysis Based Predictive System

R24-078

Project Proposal Report

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DECLARATION

We declare that this is our 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 our 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.

Group Member Name	**Student ID**	**Signature**
Pasan M.G.R	IT21057588	

Signature of the Supervisor
(Ms.Chathurangika kahandawaarachchi)

Date

29/02/2024

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ABSTRACT

In the era of rapid urbanization and industrialization, especially in densely populated urban areas such as Colombo in Sri Lanka, air pollution has emerged as a serious public health problem. We focus on developing a real-time route generation system that provides users with optimal travel routes that minimize exposure to pollutants. The core of this system is the shortest route algorithm and dynamic mapping technology. With a new algorithm combined, it is based on real-time pollution data to generate the shortest route to minimize pollution. The system architecture consists of a mobile application interface that receives, processes, and analyzes pollution data from various sources in dialogue with the backend server. The server processes real-time data and dynamically adjusts the system. Find out the shortest route to pollution, and balance the distance between the two. The mobile app will present this route to the user so that they can make travel decisions based on the information. The results of this study demonstrate the effectiveness of the proposed system to reduce exposure to pollutants during daily traffic, thereby contributing to the improvement of public health outcomes.

Keywords: Dijkstra’s algorithm,Hazardous Maroon Gas concentration

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First of all, I want to thank deeply Ms. Chathurangika Kahandawarachi, my supervisor, for her unwavering support, wise counsel, and constant encouragement during this research endeavor. Her advice was important to the effective completion of this work, and her broad expertise and unwavering support assisted in overcoming the many obstacles encountered during its development. I also owe a debt of gratitude to Ms. Pipuni Wijesiri, my co-supervisor, for her unwavering encouragement and insightful criticism. Her willingness to help at every turn and her astute observations made a significant contribution to the development and success of this study. Her assistance was essential to this work's successful completion. The cooperation and support of experts from numerous sectors would not have been feasible without this research, which combines environmental science with technological innovation. I would like to express my gratitude to all the experts who so kindly helped their expertise and provided invaluable advice, supporting in the integration of abstract ideas with real-world applications. Their assistance was crucial in elevating the caliber and depth of the search.I also want to express my gratitude to my teammates and coworkers for their cooperation, commitment, and hard work during this project. We were able to accomplish our research objectives because of their assistance and mutual dedication, and I sincerely appreciate their contributions. Finally, I just want to say how grateful I am to my family and friends. Throughout this journey, their steadfast understanding, support, and encouragement served as a constant source of inspiration and strength. Their belief in my potential has always inspired me, and I am incredibly grateful that they are in my life.

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LIST OF ABBREVIATIONS

API	Application Program Interface
SDLC	Software Development life Cycle
DB	Database
IT	Information Technology
IoT	Internet of thing

1. INTRODUCTION

1.1 Background Literature

Problems associated with air pollution have rapidly grown in urban environments worldwide, linked to rapid industrialization, transport emissions, and other anthropogenic activities. This is no different for the capital of Sri Lanka. This lively capital city has undergone a mass population increase, followed by rapid development in infrastructure, escalating the concentration of key air pollutants like particulate matter, nitrogen oxides, sulfur dioxide, and ground-level ozone. These are highly dangerous pollutants, responsible for respiratory diseases, cardiovascular problems, and many more. The very young and the very old are susceptible.

More than ever now, efficient methods of reducing exposure to air pollution are needed. Conventional methods have focused on the reduction of emissions through legislative change, such as industrial emission regulations or the promotion of cleaner fuel usage. To this day, these measures are inadequate to meet the dire need for people to live their lives free from hazardous exposure to pollution. This gap presents the opportunity to create an original solution that embeds technology in directing people through less contaminated locations.

One of the feasible solutions in this regard would be to develop real-time route generation systems by integrating air quality data in order to suggest cleaner routes for travel. Now, with environmental data incorporated into the navigation system, a person can be provided travel routes that would have minimum exposure to polluted air. This paradigm could very significantly add to both individual health and public health goals by promoting the usage of cleaner routes and reducing exposure to pollution in the urban setup.

1.2 Research Gap

Application reference	Identification of Route map	Progression level detection		Mobile Application
		Identifying Polluted Route	Alter route with real time pollution data	
Research A	✓	✓	✗	✗
Research B	✓	✗	✗	✗
Research C	✓	✗	✓	✗
Proposed System	✓	✓	✓	✓

Research A:This paper proposes an integrated framework for reducing the number of congested traffic intersections in an urban setting. With the developed framework, the minimum pollution exposure to passengers in the trade-off of marginal increase in travel distance is investigated. Google map is used for route identification and polluted routes are identified by Dijkstra algorithm. Alter route with real time pollution data is not discussed.

Research B: This paper is a survey of air pollution monitoring system based on WSN with different homogeneous and heterogeneous protocols. It is easy to explain the comparative metrics of air pollution monitoring system to existing energy efficient routing protocols. Here the route analysis is indicated by the maps and the Polluted Route is not described. Alter route with real time pollution data. Not related. How to make a system is also not described.

Research C: In this paper, we focus on quiet route discovery and develop a new approach to design routes for pedestrians in traffic noise polluted environments, based on noise estimation. Here the road analysis is shown by maps and the polluted roads are described. Change course with real-time pollution data. Not applicable. How to build a system is also not explained.

1.3 Research Problem

he text states that the public health situation in Sri Lanka is increasingly polluted by air. Lead, sulfur oxides, nitrogen oxides, tropospheric ozone, particulate matter and carbon monoxide are identified as key pollutants in the air. These emissions primarily result from petrol burning and industry use.

There has been enough evidence showing that air pollution is detrimental to human health. This includes lung cancer, asthma attack,s and respiratory infections. Air pollution each year kills thousands of people in America alone. School children are particularly at risk because they are highly vulnerable and exposed to high levels of such pollutants especially those living in urban areas like Colombo and Kandy.

This dissertation has as its main research question the development of a system for providing travel routes in real-time based on the most recent air quality data. The aim is to minimize exposure time by directing users through cleaner locations and optimizing the route both in terms of distance and travel time.

Cities like Colombo are subject to a complex issue of air pollution, which is impacted by a number of reasons including industrial emissions, travel delays, and weather. Predicting pollution levels in various locations and using this data to generate the best traffic routes in real-time presents a difficulty. The system will mix pollution data from several sources, calculate pollution levels using machine learning techniques, and map out the optimal route based on air quality and distance applying a modified version of Dijkstra's algorithm to address this problem.

2 OBJECTIVES

2.1 Main Objectives

The main Objective of the component is to Provide users with the most optimal routes to their destination.

2.2 Specific Objective

- Identification of Polluted Route Areas

Graph algorithms and machine learning techniques are used to analyze and interpret large pollution data. These techniques help identify patterns, correlations and anomalies in air quality measurements, facilitating the identification of polluted road areas.

- Writing algorithm to calculate the near distance level low polluted route

To calculate the approximate distance level of a less polluted route, an algorithm can be developed that evaluates the pollution levels along various candidate routes and selects the route with the least pollution level within a specified distance.

- Finding best route with low pollution level

Dijkstra's algorithm can be modified to consider both distance and pollution level as route selection criteria to find the best route with low pollution level.

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3.METHODOLOGY

3.1 System Architecture Diagram

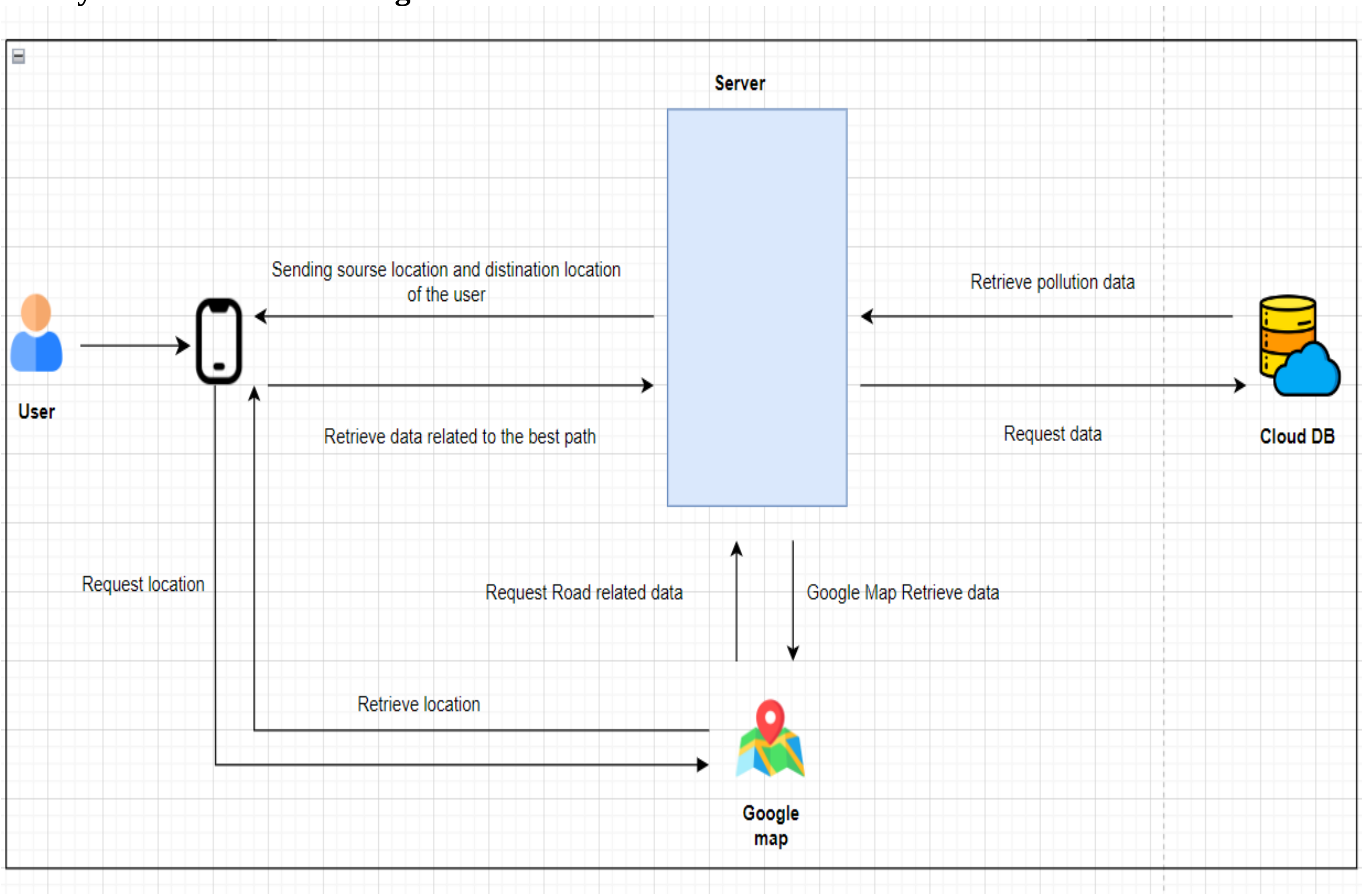

Figure 3.1: System Architecture Diagram

The proposed system is made for generating routes in real-time based on data on air quality, ensuring travelers are led along the least polluted routes while traveling. The system architecture is formed up of a number of essential parts, each of which is in charge of carrying out a particular task inside the larger system at large. These elements cover the air quality monitoring system, the backend server, and the mobile application.

The user interface consists of the smartphone application, which lets users select their destination and get the best possible route suggestions. Cross-platform development technologies are utilized in the creation of this application to guarantee that it works with both iOS and Android smartphones. The user's location and route data are processed by the backend server, which also collects real-time data on air quality from the monitoring network and applies the path-generating algorithm to find the optimal way. The mobile application takes the estimated route from the server and displays it.

The network for monitoring air quality is built up of IoT-enabled sensors positioned all throughout the area. These sensors collect information on a variety of air pollutants, like PM2.5, NOx, SO2, and O3, continuously. Wireless communication protocols apply to transfer the data to a central database, where it is instantly processed and stored. The route-generating algorithm is then informed by the backend server using the data that has been processed.

3.2 Algorithm Design and Implementation

The route development algorithm at the heart of the system proposed mixes real-time air quality data with elements of Dijkstra's algorithm of the shortest path. There are two major variables with regard to which this algorithm is going to look for a balance: the length of the journey and the volume of pollution observed along the way.

Whereas, in general, Dijkstra's algorithm can find the shortest path between points on a graph, where graph edges represent all potential routes and nodes represent intersections or significant points, in this system, the algorithm takes into account the extra factor of air quality data. All graph edges are weighted by that edge's analogy in space, plus the predicted pollution level along that point. Subsequently, the algorithm will compute the total weight for every available path and choose the route in which the total weight is lowest.

The procedure in realizing this algorithm comprises the following steps: mapping the location and destination of the user onto the graph—whose nodes are the possible waypoints—then retrieving real-time air quality data for every edge in the graph, and computing a weighted distance for every possible route. Finally, the lowest weighted route is selected for display on the mobile application.

3.3 Data Collection and Processing

Data collection is therefore a very important module of the conducted system, directly relying upon the accuracy and dependable collection of air quality data for the generation of routes by the formulated algorithm. Therefore, this system utilizes a network of IoT sensors synoptically installed within cities across high-traffic places, residential areas, and industrial areas to capture an overall view of air quality across the city.

Every sensor reads data on the concentration of several contaminants and sends it to a central database. After that, the data is cleaned to strip off noise or outliers that can manipulate the findings. In addition to cleaning, some preprocessing techniques are applied, which involve data cleansing, normalization, and interpolation to fill in missing values. Following that, feature selection is applied to the data, identifying only relevant factors to be used during the route design process.

Machine learning techniques applied to this treated data enhance the prediction capability of the system. Methods vary from clustering algorithms that are implemented so as to detect patterns and associations among the different pollutants and environmental constituents, to regression analysis carried out for predicting the pollution levels considering the past dataset. The outcomes of the analysis are used to periodically update the air quality maps and steer the task of building the new routes.

3.4 System Implementation

A number of components had to be connected in order for the suggested system to be implemented, each of which was essential for the real-time route generating tool to function as one. Because a cross-platform framework was used in its development, the mobile application works on both iOS and Android smartphones. Users may simply input their exact location and be sent route suggestions based on real-time air quality data thanks to the user interface's simplicity and usability design.

Utilizing Node.js, a well-liked JavaScript runtime ideal for creating scalable network applications, the backend server was created. All data processing operations are managed by the server, which also conducts the algorithm for route development, communicates with the mobile application, and receives air quality data from the Internet of Things sensor network. Because the server is housed on a cloud platform, performance, and availability are ensured.

The sensors for the air quality monitoring network were placed in high-traffic areas, industrial zones, and residential districts throughout the metropolitan area. Data on different air contaminants is continually gathered by the sensors and sent to the central database for analysis. Additionally, the system contains a real-time data visualization component that shows heatmaps and maps of air quality to help users comprehend the patterns of pollution in various areas of the city.

3.5 Algorithm Performance

To assess how well the updated Dijkstra's algorithm produced the best routes based on both distance and air quality, tests occurred. The method demonstrated a noteworthy enhancement in reducing exposure to pollutants when compared to conventional shortest-path algorithms that ignore pollution levels.

Based on real-time data, the system was able to dynamically modify routes, steering passengers along better paths and avoiding high-pollution areas. Three important performance metrics were taken into consideration to evaluate the algorithm: processing time, route correctness, and user happiness. The outcomes indicated that the system could generate routes quickly and in real-time while still predicting the least polluted paths with a high degree of accuracy.

3.6 Project Requirements

3.1.1 Functional Requirements and Non-Functional Requirements

Table 3. 1: Functional and Non-functional requirements

Functional Requirements	**Non-Functional Requirements**
Collecting polluted air data from the emission standard publication websites and Preprocessing, Cleaning, Transforming.	Interfaces should be User-friendly
Feature Selection and Analysis	Should properly work for android and IOS devices
Model Development Implement machine learning algorithms for pollution level prediction. Explore and select the most suitable predictive model based on performance metrics.	Application should be reliable.
Dynamic Predictions for Real-time Adjustments.	Higher accuracy of results
Real-time Pollution Data and Comparison and Visualization	Results should be more efficient.

3.1.2 System Requirements

- Software requirements
    - Python
    - Node JS
    - Jupyter Notebook
    - Intellij Idea
    - Visual Studio Code

3.2 Software Solution

The Software Development Life Cycle (SDLC) is a process or a plan with details for designing, developing, and testing high-quality software. However, the agile software development approach is one of the most simplistic and successful methods for delivering a high-quality product. Scrum is the most popular lightweight, an agile framework that assists individuals, groups, and organizations.

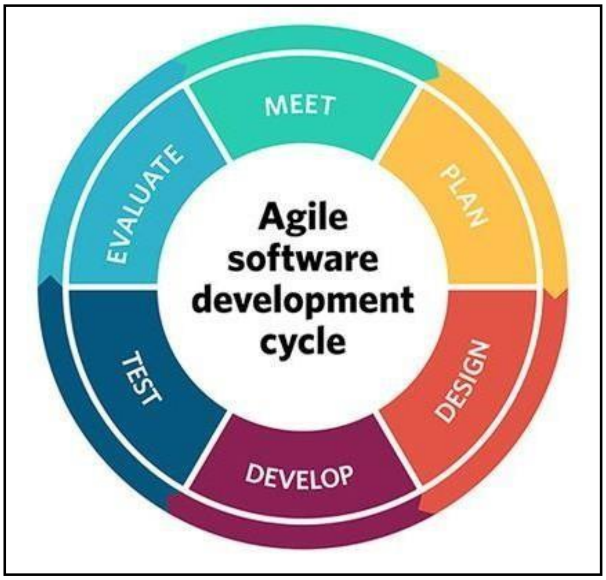

Figure 3. 2: Agile Software Development Cycle

3.3.1 Use Case Diagram

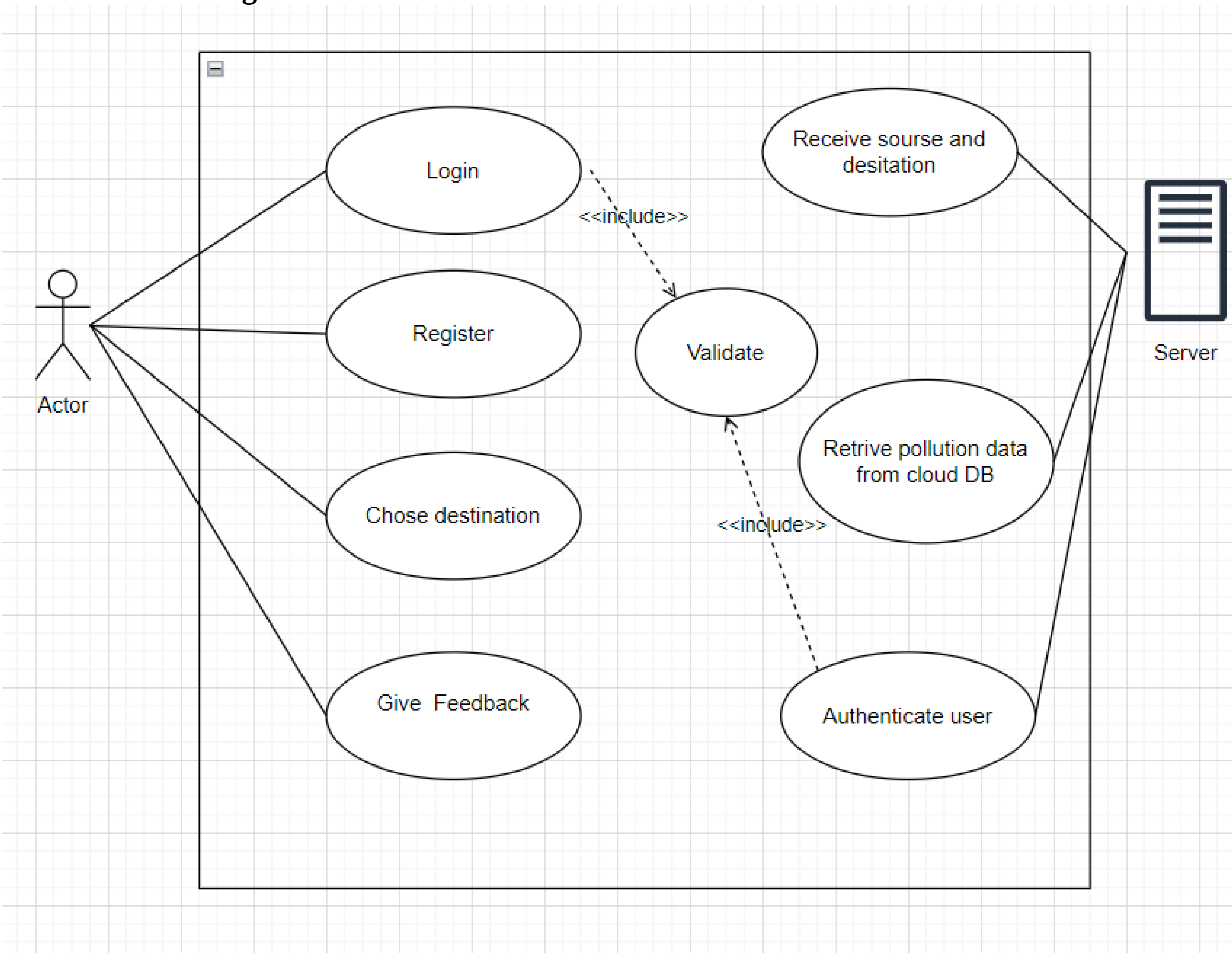

Figure 3. 3: Use Case Diagram for proposed component

3.3.2Work breakdown chart

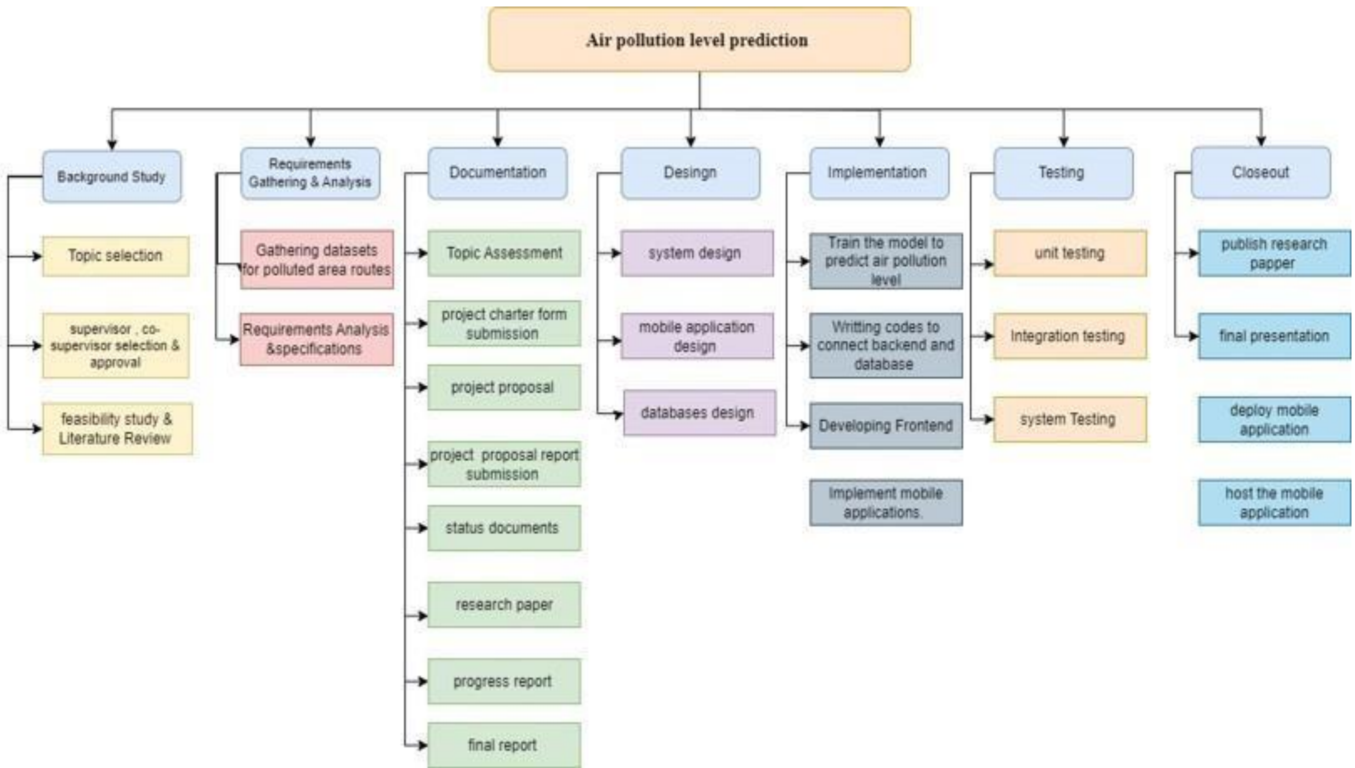

Figure 3. 4: Work breakdown chart

4. GANTT CHART

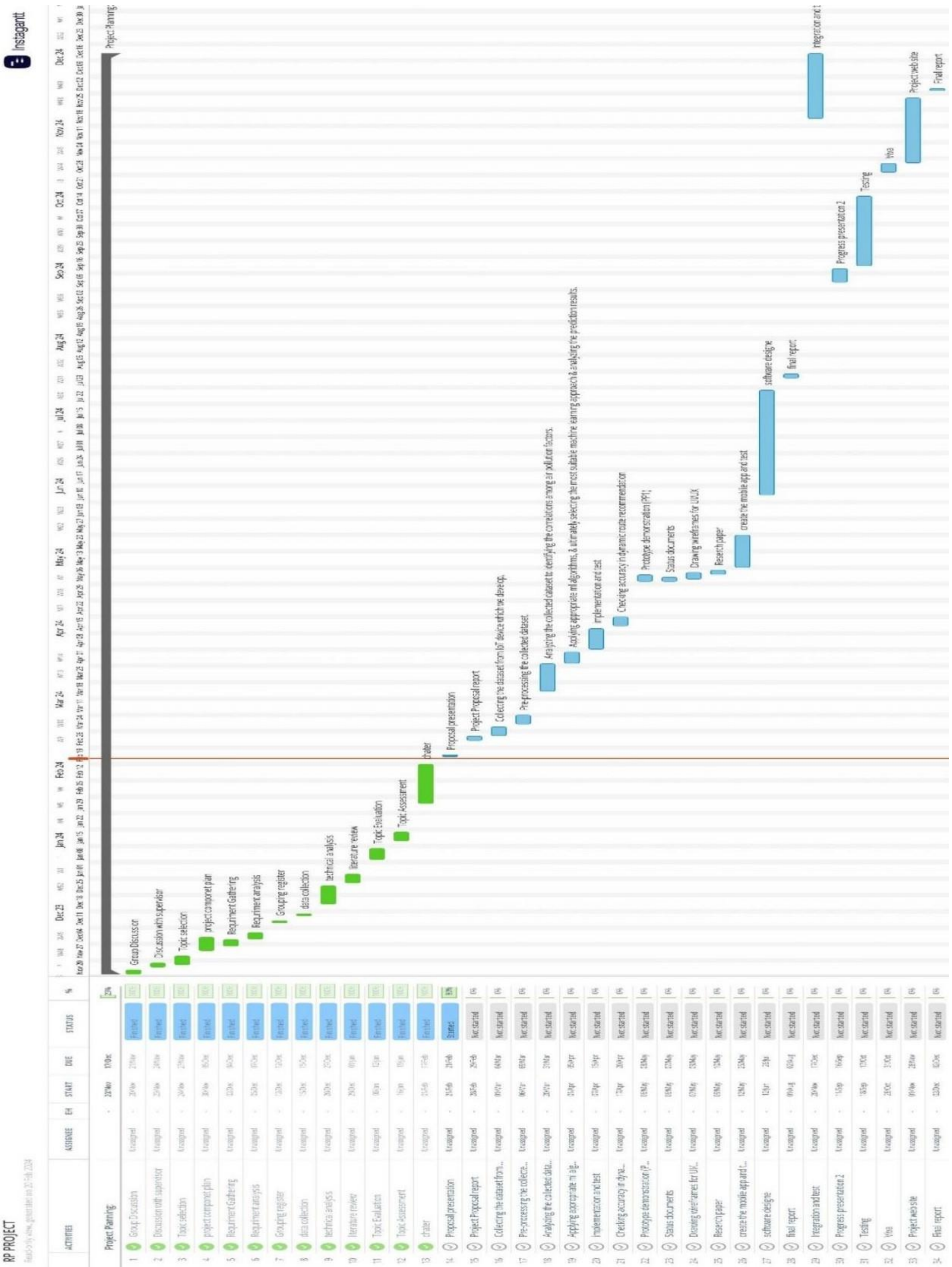

Figure 4.1: Gantt chart

5. Description of Personal and Facilities

Facilitators:

- Ms.Chathurangika Kahadawaarachchi – Sri Lanka Institute of Information Technology(SLIIT)
- Ms. Pipuni Wijesiri– Sri Lanka Institute of Information Technology (SLIIT)

Facilities:

- Central environment authority.
- National bulidng resource management

6.BUDGET AND BUDGET JUSTIFICATION

Table 6. 1: Budget Plan

Requirement	**Cost (Rs.)**
Travelling Cost	**2000.00**
Deployment Cost	7000.00/month
Mobile app hosting on PlayStore	4000.00
Mobile app hosting on AppStore	15425.00/annual
Total	28425.00

7 COMMERCIALIZATION

7.1 Target Audience and Market Space.

- **Target Audience.**

  Users.

  Stakeholders.

- **Market Space.**

  Don’t need for advanced knowledge in technology.

  No age limitation for the users.

Conclusion

The research presented in this paper highlights the potential of integrating real-time air quality data into navigation systems to improve public health outcomes in urban areas. The proposed system successfully combines IoT technology, machine learning, and modified Dijkstra’s algorithm to generate routes that minimize exposure to pollutants while still ensuring efficient travel.

The results of the study demonstrate that the system is not only feasible but also effective in reducing pollution exposure for urban travelers. User feedback suggests that there is a strong demand for such systems, particularly in cities with high levels of pollution.

As urbanization continues to increase, the need for innovative solutions to environmental challenges becomes more pressing. The proposed system represents a significant step forward in the development of smart city applications that prioritize public health and environmental sustainability. While there are still challenges to be addressed, the findings of this research provide a strong foundation for further exploration and development in this area.

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