Department of Computer Science

University of Gujrat

EnviroCast: Smart Environment Monitoring System

Session: BSCS 2020-2024

Project Advisor: Dr. Abdur Rehman

Submitted By

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STATEMENT OF SUBMISSION

This is to certify that Meerab Irfan Roll No. 20021519-009, Hassan Tahir Roll No. 20021519-083 and Sheraz Ahmed Roll No. 20021519-100 has successfully completed the final year project named as EnviroCast: Smart Environment Monitoring System under my supervision at the Department of Computer Science, University of Gujrat, to fulfill the requirement of the degree of **BS in Computer Science**.

_____
Project Supervisor

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Chairperson
Department of Computer Science

Acknowledgement

We truly acknowledge the cooperation and help make by **Dr. Abdur Rehman** Assistant Professor, Department of Computer Science, University of Gujrat. He has been a constant source of guidance throughout the course of this project. We are also thankful to our friends and families whose silent support led us to complete our project.

Date: 25th-June 2024

Abstract

EnviroCast: Smart Indoor Environment Monitoring is a comprehensive system that monitors indoor and outdoor parameters like LPG, CO, NH3, CO2, Smoke, Temperature, Humidity, and Dust (PM2.5) particles. Utilizing IoT technology, advanced sensors, data processing, and machine learning, it provides real-time insights and predictive analytics to enhance air quality management. The user-friendly mobile app, developed with Flutter, offers seamless access to critical data and includes 7-day outdoor air quality forecasts, covering temperature, AQI, CO, NO2, O3, SO2, PM2.5, and PM10. EnviroCast empowers users by raising awareness and providing actionable data to improve health and comfort. The project outlines key modules, advantages, challenges, and future enhancements to deliver a robust smart environment management solution.

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Chapter 1: Project Feasibility Report

1.1. Introduction

EnviroCast is a Mobile-based application designed to empower individuals with comprehensive air quality information, both indoors and outdoors. This innovative system leverages the power of Internet of Things (IoT) technology, Machine Learning (ML), and a user-friendly interface to address the growing concern of air pollution.

EnviroCast seamlessly connects with various sensors to provide users with real-time data on critical indoor air parameters like smoke, dust particles, harmful gases (LPG, CO, NH3, CO2), Humidity, and temperature. This empowers users to make informed decisions about their indoor environment, ensuring optimal health and comfort.

It goes beyond real-time data by utilizing advanced MULTISTEP 1D CNN models. Trained on historical data, these models provide highly accurate forecasts for outdoor air quality parameters like temperature, AQI (Air Quality Index), CO (Carbon Monoxide), and various other pollutants (NO2, O3, SO2, PM2.5, PM10) for the next 7 days.

EnviroCast is an air quality monitoring and prediction system designed to address the growing concern of air pollution. Additionally, EnviroCast integrates weather data to provide a holistic view of environmental conditions. This project aims to empower individuals to manage their health proactively by raising awareness and providing actionable data through a mobile application.

1.2. Project/Product Feasibility Report

1.2.1. Technical Feasibility

The technical feasibility of implementing the EnviroCast system involves evaluating the readiness and capability of the technology required for its successful deployment. This section assesses the key technical aspects that determine whether the system can effectively monitor and forecast indoor air quality, integrate with existing infrastructure, and provide reliable data to users.

IoT Technology: At the core of the EnviroCast system is its use of Internet of Things (IoT) technology. This includes hardware (sensors), software, connectivity, and data processing components working together to collect and analyze environmental data in real-time.

Sensor Integration: The system incorporates various sensors to measure indoor parameters such as smoke, dust particles, harmful gases (LPG, CO, NH3, CO2), Humidity, and temperature. Sensors like MQ5, MQ7, MQ135, DHT11, and GP2Y101AU0F sensors are integrated seamlessly to provide accurate data.

Data Processing: The data collected from the sensors is processed efficiently to derive meaningful insights. This involves data preprocessing techniques to clean and normalize the data, ensuring it is suitable for analysis and prediction.

Machine Learning Algorithms: Machine learning algorithms are critical for predictive analytics. These algorithms process historical data to forecast future environmental conditions, providing users with valuable insights. The accuracy and reliability of these models is ensuring the system's effectiveness.

Real-Time Data Analysis: The system is capable of real-time data analysis to provide immediate feedback on indoor air quality. This includes efficient data streaming and processing capabilities to handle continuous data flow from multiple sensors.

User Interface: The EnviroCast system relies on the Flutter framework to develop an intuitive mobile application for data visualization and user interaction. The user interface is designed to present data clearly and provide actionable insights in a user-friendly manner.

Connectivity: Reliable connectivity is crucial for the continuous operation of the EnviroCast system. The sensors and processing units are connected to a central system for data aggregation and analysis. This is achieved through Arduino Uno, ESP8266 Wi-Fi Module, Firebase, and other suitable communication protocols.

Technical Expertise: Finally, it is essential to mention that the project team possesses the necessary technical expertise to develop and maintain the EnviroCast system. This includes skills in sensor integration, data processing, machine learning, mobile application development, and system maintenance.

All these technical aspects are satisfied so the EnviroCast system can be developed and deployed successfully, providing users with a reliable and effective solution for indoor and outdoor environment monitoring and forecasting.

1.2.2. Operational Feasibility

The operational feasibility of EnviroCast involves ensuring it meets service requirements, It is easy to operate and maintain, and its usability and acceptability by users is high. The system delivers real-time data and predictive analytics for indoor air quality, ensuring ease of operation through an intuitive interface. Usability testing and user feedback refine the system, while demonstrating health benefits and regulatory compliance validate its acceptability. Seamless integration with existing infrastructure and scalability ensures operational efficiency.

1.2.3. Economic Feasibility

The economic feasibility of the EnviroCast project involves analyzing the cost and benefit of the system.

Sensors and Hardware: Calculated cost of acquiring and purchasing sensors like MQ5, MQ7, MQ135, DHT11, and GP2Y101AU0F, Arduino Uno, ESP32Wi-Fi Module, and any required hardware is affordable and within the project member's budget.

Software Development: Estimated expenses associated with developing or customizing the software for prediction, forecasting better user interaction, and all other software requirements are also affordable.

Energy Consumption: The energy consumption of the monitoring system and estimated electricity costs for operation is not high and within the budget.

By conducting all these comprehensive economic feasibility analyses, the EnviroCast project is determined to be economically feasible.

1.2.4. Schedule Feasibility

The project's modular architecture allows for parallel development of various components, facilitating faster implementation. Moreover, potential risks and challenges have been identified and addressed, contributing to a proactive approach to risk management. With a clear project roadmap and a commitment to meeting milestones, the project EnviroCast exhibits strong schedule feasibility.

1.2.5. Specification Feasibility

Specification feasibility for the EnviroCast project involves evaluating the clarity and definiteness of the system requirements and assessing the scope boundaries.

Clarity of Requirements: All requirements for EnviroCast are clear, well-defined, and aligned with the project objectives. This includes conducting thorough requirements analysis and documenting requirements in a detailed and unambiguous manner. Clear requirements facilitate effective communication between the development team and project manager and help prevent misunderstandings or misinterpretations during the project lifecycle.

Definiteness of Requirements: In addition to clarity, the definiteness of requirements is evaluated. This ensures that requirements are specific, achievable, and measurable. Each requirement is clearly defined and quantifiable to enable accurate estimation, implementation, and validation.

Scope Boundaries: Another aspect of specification feasibility is defining the scope boundaries of the project. This ensures the features, functionalities, and deliverables that are included within the scope of EnviroCast, as well as those that are explicitly excluded are identified and clear. Establishing clear scope boundaries helps prevent scope creep and ensures that the project remains focused on delivering the essential features and functionalities within the defined constraints of time, budget, and resources.

By evaluating the clarity and definiteness of requirements and defining clear scope boundaries, the specification feasibility of the EnviroCast project is ensured, laying a solid foundation for successful project execution and delivery.

1.2.6. Information Feasibility

Assess the feasibility of obtaining, processing, and managing the information required for EnviroCast. We have ensured the availability of reliable data sources for air quality monitoring and weather forecasting by evaluating the capabilities of data processing and analysis techniques to derive meaningful insights from the collected data. We have considered factors such as data accuracy, timeliness, and scalability to ensure the effectiveness of the system in providing accurate and actionable information to users. The feasibility of information is assessed regarding its completion, reliability, and meaningfulness All the information regarding the project is on hand and assessed according to the planned activities. The output of each step is tested according to the expected result to ensure its reliability.

1.2.7. Motivational Feasibility

Motivational feasibility for EnviroCast involves assessing stakeholder enthusiasm, commitment, and motivation to support the system's deployment and use. This includes evaluating clients' or users' motivation to perform tasks promptly and correctly for EnviroCast. Assess their willingness to engage, adhere to maintenance schedules, and respond to alerts. Measure their enthusiasm and commitment to ensuring effective system operation and maintenance, engaging stakeholders, providing training and support, fostering communication and feedback, and recognizing and incentivizing stakeholders. By ensuring strong stakeholder motivation, EnviroCast has gained support for successful implementation and adoption.

1.2.8. Legal & Ethical Feasibility

The project undertaken meets all legal and ethical requirements. We are owned to develop the application that is both professional and ethical. All the terms and conditions are applied. our app and device data will be kept confidential. We assess the legal and ethical implications of implementing EnviroCast and ensuring compliance with relevant laws and regulations governing data privacy, security, and environmental monitoring. Address ethical considerations such as data transparency, consent, and fairness in data collection and usage. Implement safeguards to protect user privacy and confidentiality while promoting transparency and accountability in data handling practices.

1.3. Project/Product Scope

EnviroCast focuses on monitoring and predicting indoor and outdoor air quality parameters in real-time. It includes monitoring temperature, humidity, smoke, dust particles, harmful gases (LPG, CO, NH3, CO2) concentrations indoors, and providing outdoor air quality forecasts for the next 7 days. The system integrates IoT, ML, and Flutter for data delivery via a mobile app. Scope involves sensor hardware development, data processing algorithms, machine learning models, and user interface design. Continuous monitoring, maintenance, and updates ensure system reliability and effectiveness. Managing scope involves iterative development, and prioritizing requirements based on priority, effort, and risk. These systems provide real-time data on air quality, help identify sources of pollution, and support regulatory compliance.

1.4. Project/Product Costing

The EnviroCast project involves several components, each contributing to the overall cost. Below is the detailed breakdown of the project/product costing:

- Mq5 Sensor: 340 Rs
- Mq7 Sensor: 340 Rs
- Mq135 Sensor: 340 Rs
- Dust Sensor: 1500 Rs
- DHT11 Temperature Sensor: 250 Rs
- Arduino Uno: 1900 Rs
- ESP32: 1500 Rs
- Breadboard + Jumper Wires: 700 Rs

- 16x2 lcd: 400Rs
- Adapter: 300Rs
- Circuit base: 2000Rs

Total Cost:

340+340+340+1500+250+1900+1500+700+400+300+2000 = 9570 Rs

The total cost for the EnviroCast system components amounts to 12000 Rs. This budget covers all necessary hardware components for monitoring and forecasting indoor air quality, ensuring accurate and reliable performance, other cost consider is the project development cost. The cost of development is primarily the cost of the efforts involved and the documentation cost.

1.5. Task Dependency Table

Activity ID	Name of Activity	Immediate Predecessor
A	Proposal	None
B	Define project objectives and scope	Task A
C	Conduct requirements gathering	Task B
D	Develop sensor hardware	Task C
E	Design data processing algorithms	Task C
F	Implement machine learning models	Task E
G	Design user interface	Task C
H	Develop mobile application	Task G
I	Integrate IoT technology	Task D, Task E
J	Perform system testing	Task C, D, E, G, H
K	Deploy EnviroCast system	Task J
L	Monitor system performance	Task K

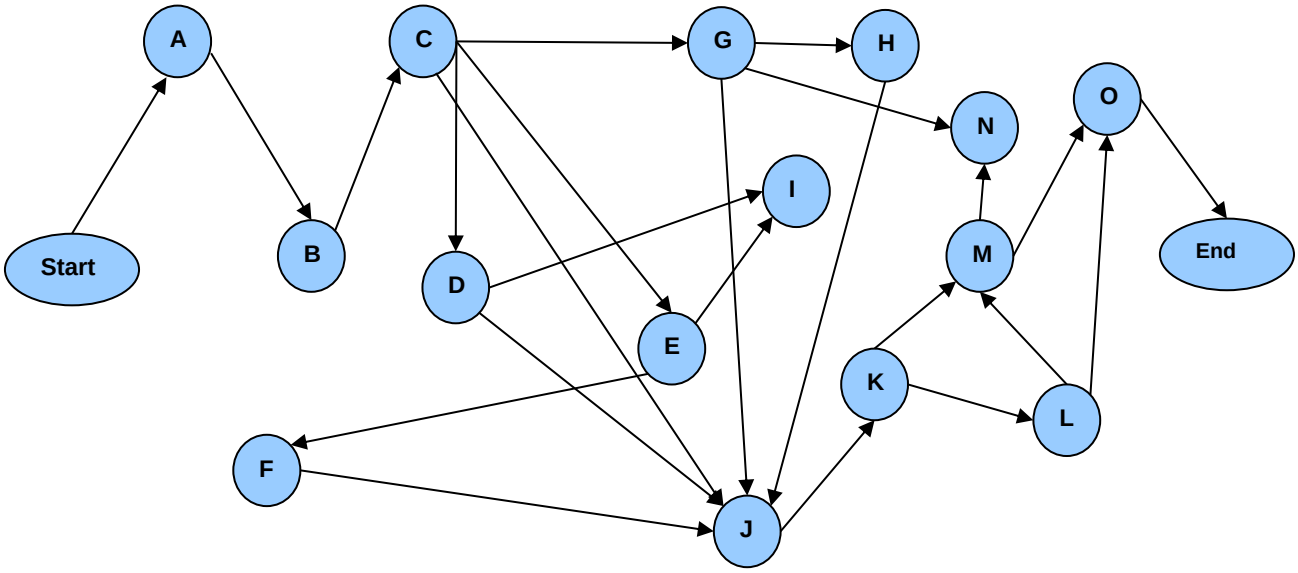
M	Prepare Project Documentation	Task K, Task L,
N	Create Project Presentation	Task G, Task M
O	Review and Finalize Documentation	Task L, Task M,

(TABLE # 1.1 Task Dependency Table)

1.6. CPM - Critical Path Method

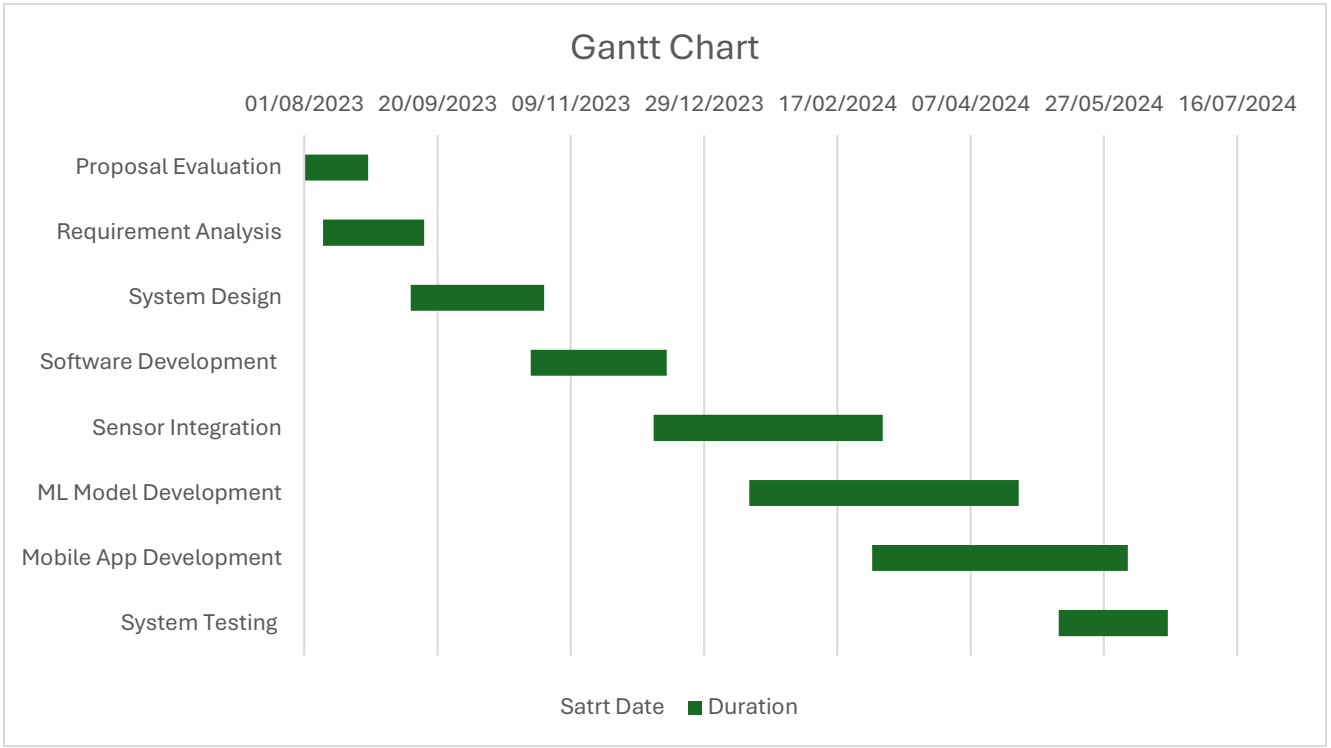
Activity ID	Name of Activity	Immediate Predecessor	Duration (days)
A	Proposal	None	8
B	Define project objectives and scope	Task A	10
C	Conduct requirements gathering	Task B	15
D	Develop sensor hardware	Task C	30
E	Design data processing algorithms	Task C	15
F	Implement machine learning models	Task E	101
G	Design user interface	Task C	25
H	Develop mobile application	Task G	95
I	Integrate IoT technology	Task D, Task E	86
J	Perform system testing	Task C, D, E, G, H	25
K	Deploy EnviroCast system	Task J	10
L	Monitor system performance	Task K	15
M	Prepare Project Documentation	Task K, Task L	30
N	Create Project Presentation	Task G, Task M	10
O	Review and Finalize Documentation	Task L, Task M,	15

(TABLE # 1.2 Critical Path Method



(Figure # 1.1, Network Diagram of above activities)

1.7. Gantt chart



(TABLE # 1.3: Gantt chart)

1.8. Allocation of Members to Activities

Activity ID	Activity	Meerab	Hassan	Sheraz
A	Project Proposal	✓	✓	✓
B	Define project objectives and scope	✓	✓	✓
C	Conduct requirements gathering	✓	✓	✓
D	Hardware Procurement			✓
E	Design data processing algorithms		✓	
F	Implement machine learning models		✓	
G	Design user interface	✓		
H	Develop mobile application	✓		
I	Integrate IoT technology			✓
J	Perform system testing	✓	✓	✓
K	Deploy EnviroCast system	✓	✓	✓
L	Monitor system performance	✓	✓	✓
M	Prepare Project Documentation	✓		
N	Create Project Presentation	✓		
O	Review and Finalize Documentation	✓		

(TABLE # 1.5: Members Activity Table)

1.9. Tools and Technology with reasoning

IoT Sensors (Mq5, Mq7, Mq135, Dust Sensor, DHT11)**:**
Reasoning: These sensors are crucial for collecting accurate real-time data on air quality parameters such as smoke, gases, dust particles, and temperature. The data collected by these sensors form the backbone of the monitoring system, providing the necessary inputs for further processing and analysis.

Arduino Uno:
Reasoning: Arduino Uno is used for interfacing with various sensors. It provides a cost-effective and flexible platform for collecting and processing sensor data. Its open-source nature and extensive community support make it a suitable choice for rapid prototyping and development.

ESP32:
Reasoning: ESP32 is chosen for its powerful microcontroller capabilities, including built-in Wi-Fi and Bluetooth. This allows for seamless wireless data transmission from sensors to the cloud or local servers, facilitating remote monitoring and control.

Flutter Framework:
Reasoning: Flutter is used for developing mobile applications due to its cross-platform capabilities. It enables the creation of a user-friendly and visually appealing interface that works on both iOS and Android devices, ensuring broader accessibility and user engagement.

Python:
Reasoning: Python is employed for data processing and machine learning. Its extensive libraries and frameworks, such as Pandas, NumPy, and Scikit-learn, allow efficient data handling, analysis, and the development of predictive models to forecast air quality.

Machine Learning Algorithms:
Reasoning: Machine learning algorithms are integral for predictive analytics. They analyze historical data to predict future air quality trends, enabling proactive measures to be taken to ensure a healthy indoor environment.

Mobile App Development Tools (e.g., Android Studio):
Reasoning: While Flutter is the primary framework, tools like Android Studio are used for platform-specific testing and optimization, ensuring the app performs well across different devices.

Version Control (Git, GitHub):
Reasoning: Version control systems like Git and platforms like GitHub are essential for collaborative development. They help manage changes in the codebase, facilitate collaboration among team members, and maintain a history of code changes.

Breadboard and Jumper Wires:
Reasoning: These are used for prototyping and testing the sensor connections and configurations before finalizing the circuit design. They provide a flexible platform for building and modifying circuits without soldering.
By leveraging these tools and technologies, EnviroCast aims to deliver a robust and reliable system for monitoring and forecasting indoor air quality, enhancing the health and comfort of users in various indoor environments.

1.10. Vision Document

EnviroCast aims to revolutionize indoor air quality management by providing a comprehensive system that monitors and forecasts key environmental parameters such as temperature, humidity, air quality index (AQI), and dust particles. Leveraging advanced IoT sensors, data processing, and machine learning, EnviroCast delivers real-time insights and predictive analytics through an intuitive mobile application. This empowers homeowners, facility managers, educational institutions, and healthcare facilities to proactively manage indoor air quality, enhancing health, comfort, and productivity. The system is designed to integrate seamlessly with existing infrastructure, ensuring ease of use and continuous operation. By addressing the growing concern of indoor air pollution, EnviroCast aims to create healthier and more comfortable indoor environments, ultimately improving quality of life.

Stakeholders Involves:
Homeowners: To ensure a healthy living environment for their families.
Facility Managers: To maintain optimal indoor air quality in commercial and public buildings.
Educational Institutions: To provide a safe and comfortable environment for students and staff.
Healthcare Facilities: To monitor and control air quality to prevent health issues.
Environmental Researchers: To gather and analyze data for studies on indoor air pollution.

Goals and Objectives:
Develop a comprehensive system: To monitor and forecast room temperature, humidity, AQI, and dust particles.
Provide real-time data: Deliver accurate and timely information on indoor air quality.
Implement predictive analytics: Use machine learning models for short-term and long-term air quality predictions.
Enhance user experience: Design an intuitive mobile application for easy access to data and insights.

Future Directions:
Expand Sensor Capabilities: Integrate additional sensors for monitoring other indoor pollutants.
Enhanced Predictive Models: Improve machine learning algorithms for more accurate and comprehensive predictions.
Scalability: Adapt the system for larger and more complex indoor environments.

User Feedback Integration: Continuously improve the system based on user feedback and evolving needs.
EnviroCast aims to revolutionize indoor air quality management by leveraging advanced sensor technology, data processing, and machine learning. By providing real-time monitoring and predictive analytics, EnviroCast empowers users to create healthier and more comfortable indoor environments, ultimately enhancing quality of life and productivity.

1.11. Product Features/ Product Decomposition

1. Real-Time Monitoring
Temperature and Humidity Sensors: Continuously monitor indoor temperature and humidity levels using DHT11 sensors.

Air Quality Sensors: Measure AQI using gas sensors (MQ5, MQ7, MQ135) to detect pollutants such as LPG, CO, NH3, CO2 etc.

Dust Sensors: Track dust particles using specialized dust sensors.

2. Predictive Analytics
Machine Learning Models: Utilize machine learning algorithms like MULTISTEP 1D CNN to forecast air quality parameters for the next 7 days.

Data Processing: Analyze collected data to provide insights and trends over time.

3. Mobile Application
User Interface: Develop an intuitive and user-friendly mobile application using the Flutter framework.

Data Visualization: Present real-time and forecasting data through easy-to-understand charts and graphs.

Alerts and Notifications: Send alerts and notifications for critical changes in air quality or other environmental parameters.

4. Hardware Components
MQ5, MQ7, MQ135 Sensors: Detect various harmful gases.

Dust Sensor: High-precision dust sensor for measuring dust.

DHT11 Sensor: For temperature and humidity data collection.

Arduino Uno and ESP32: For sensor integration and data transmission.

Breadboard and Jumper Wires: For circuit assembly and sensor connections.

16x2 lcd: This display module is useful for showing sensor readings.

Adapter: to provide a stable and suitable power supply to the components of the circuit.

Circuit base: to organize and secure the components of an electronic circuit.

5. Software Components

Flutter Framework: For mobile application development.

Android Studio: For mobile application development.

Python: For data processing and machine learning model development.

Jupiter Notebook: For data processing and machine learning model development.

Collab: For data processing and machine learning model development.

Chapter 2: Software Requirement Specification (For Object Oriented Approach)

2.1 Introduction:

The rapid advancement of smart technologies has led to a critical need for innovative environment management systems. The proposed "EnviroCast" system aims to address this need by offering real-time monitoring and predictive analytics for temperature, humidity, AQI, and dust particles. By integrating advanced sensors, machine learning algorithms, and user-friendly interfaces, the project seeks to enhance indoor comfort, health, and energy efficiency. This proposal sheds light on the project's historical context, introduces its core modules, discusses potential advantages and drawbacks, and outlines the path towards future advancements.

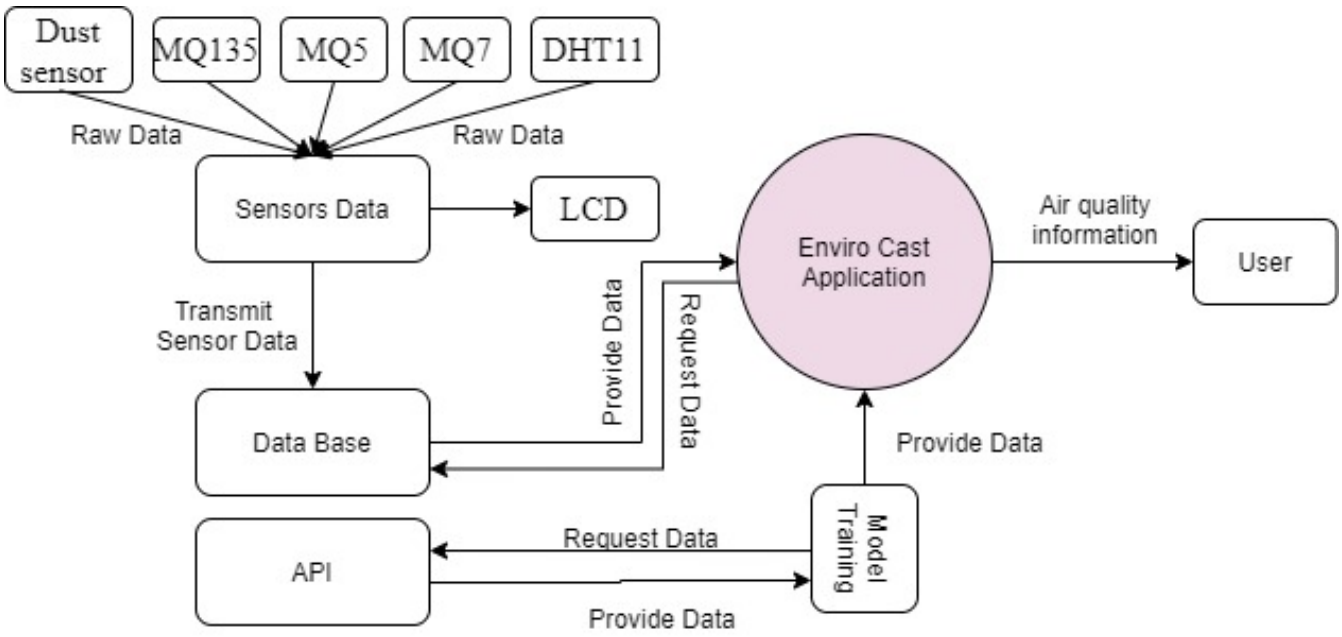
2.2 Systems Specifications

The following are the clauses for describing the system specifications.

2.2.1. Identifying External Entities

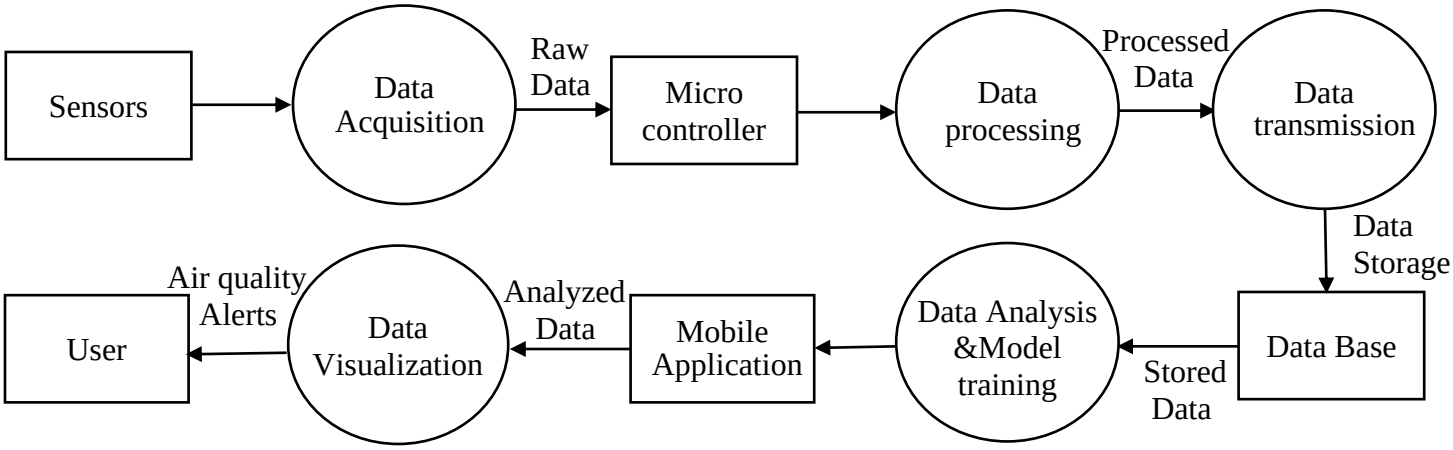
- Users: the people who will be using the application to monitor the environment.
- Organization/ Stakeholders: Individuals or groups interested in accessing air quality information. They interact with the system to view air quality data, reports, or receive alerts about pollution levels.
- Sensor Devices: These are external devices that measure air quality parameters such as smoke, gases (like CO2, NH2, LPG), temperature, humidity, etc. They provide real-time data to the system.
- Mobile Applications: these interfaces act as external entities for users to interact with the system.

2.2.2. Data Flow Diagram (Functional Model):



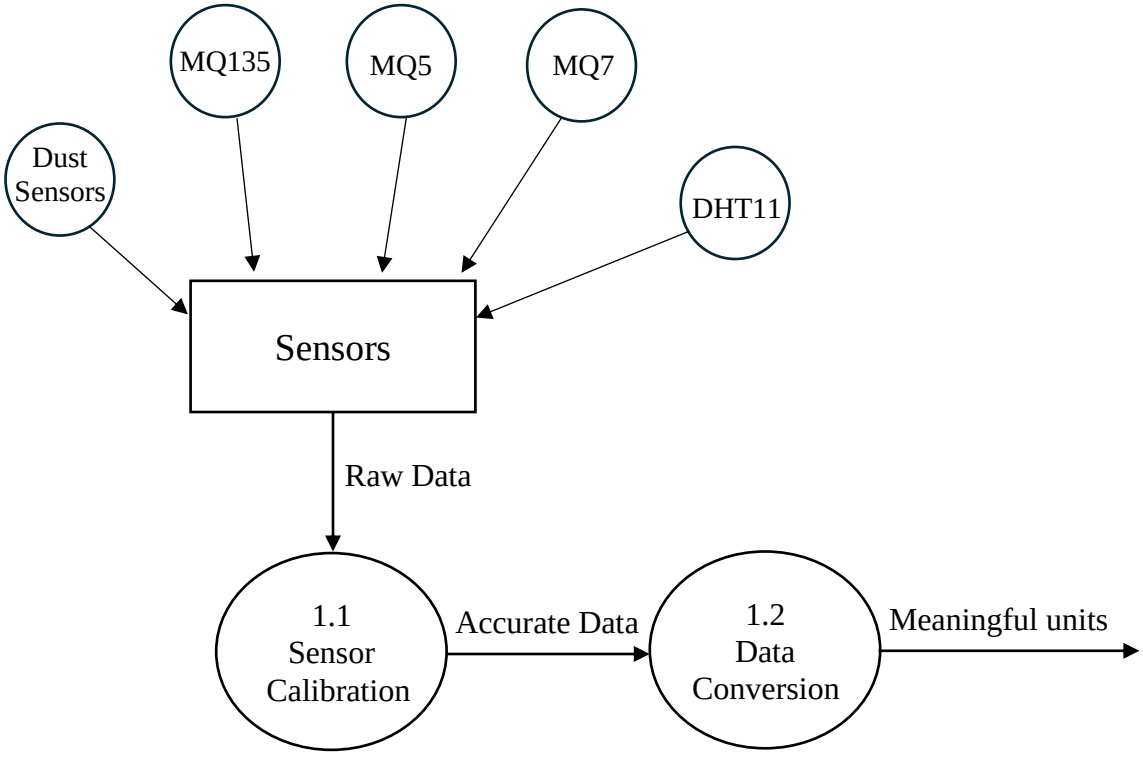
(Figure # 2.1, Context Level Data Flow Diagram)

Level 1 DFD

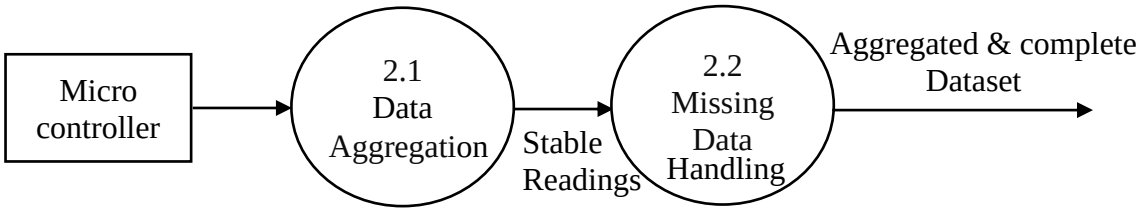


Level 2 DFD

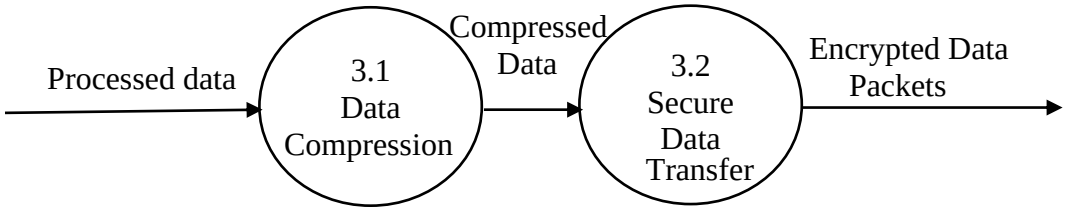
2.2.2.1. Sensor Data Acquisition:



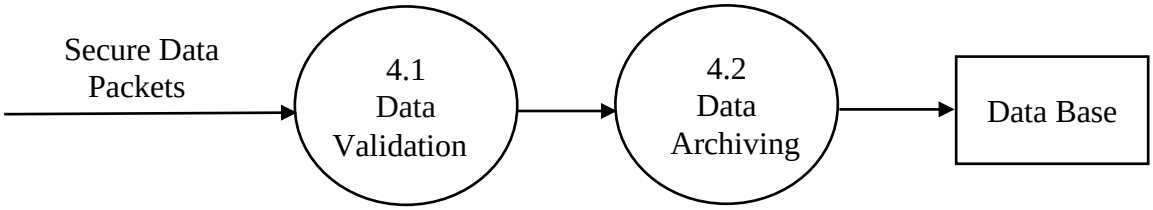
2.2.2.2. Data Processing:



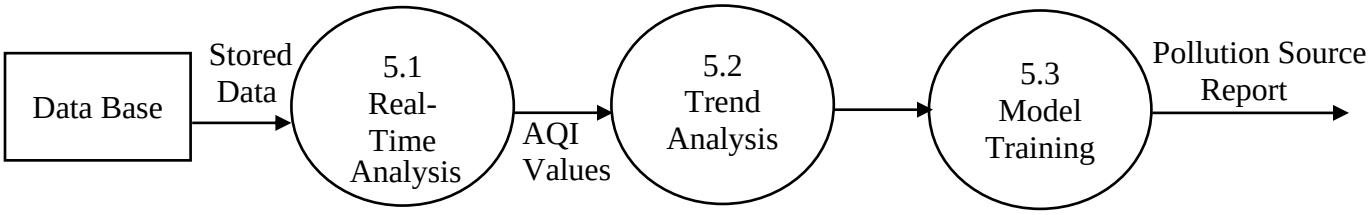
2.2.2.3. Data Transmission:



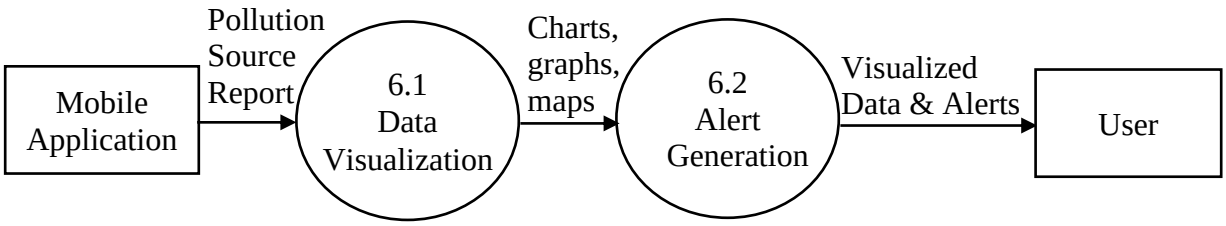
2.2.2.4. Data Storage:



2.2.2.5. Data Analysis &Model Training:



2.2.2.6. Data Visualization and Notification:



2.2.3. Capture "shall" Statements:

Para No #	Initial Requirements
1	The system shall integrate various sensors, including Dust sensor GP2Y101AU0F, MQ5, MQ7, MQ135, and DHT11, to measure distinct air quality parameters.
2	It shall ensure proper calibration and accuracy of sensors for precise data collection.
3	The system shall implement secure communication protocols for real-time transmission of air quality data.
4	It shall provide real-time access to air quality data, enabling users to view trends, receive alerts, and visualize data in a user-friendly manner.
5	It shall ensure the accuracy, reliability, and stability of sensor data.
6	System shall ask the user to provide the permission to access the location
7	System shall allow user to browse through weather ans air condition data
8	System shall allow user to view indoor data
9	System shall allow user to browse through outdoor data
10	System shall allow user to view Forecast data
11	The system shall be designed to be scalable, allowing for the addition of more sensor nodes or features in the future.
12	The system shall provide alerts to the user

(TABLE # 2.1: Capture "shall" Statements)

2.2.4 Allocate Requirements:

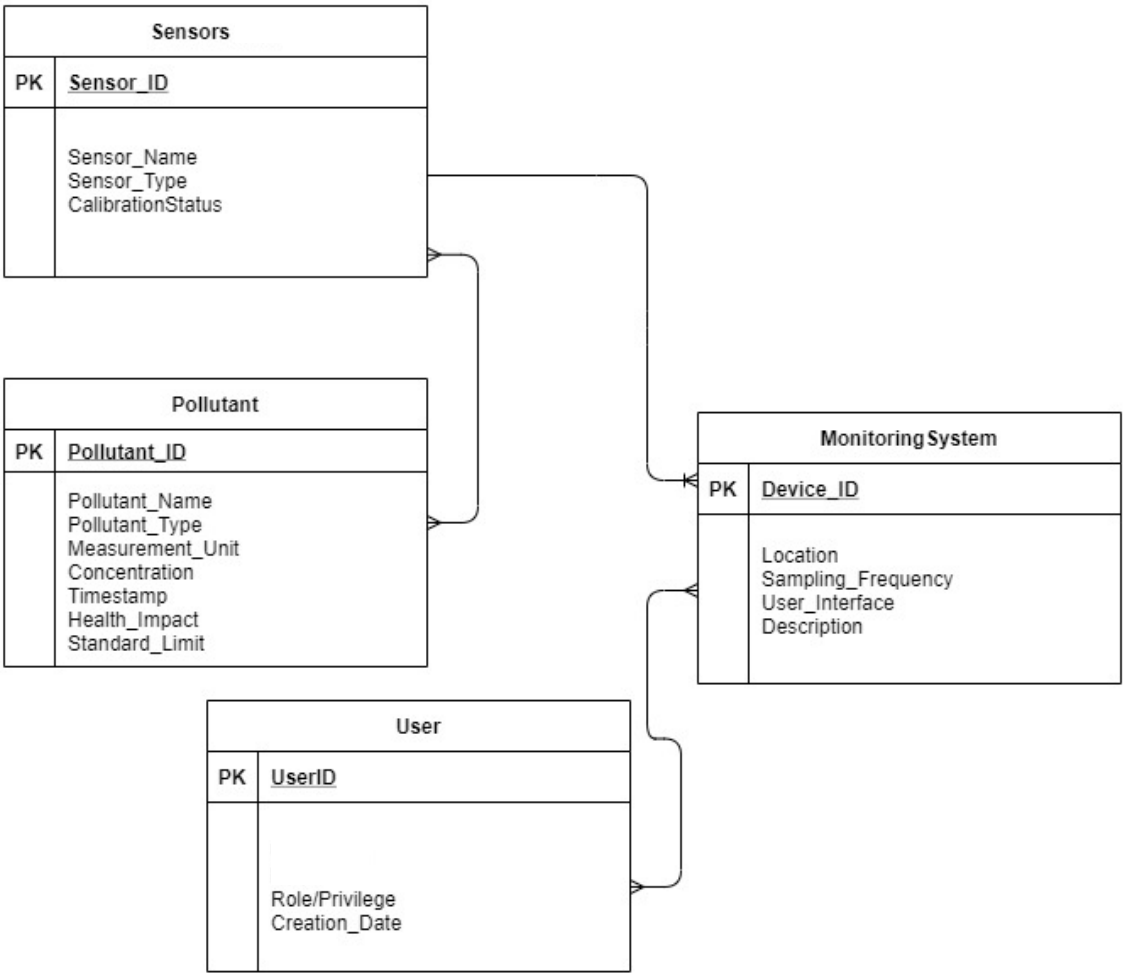
Para No #	Initial Requirements	Use Case Name
1	The system shall integrate various sensors, including Dust sensor GP2Y101AU0F, MQ5, MQ7, MQ135, and DHT11, to measure distinct air quality parameters.	UC_ ManageSensors
2	It shall ensure proper calibration and accuracy of sensors for precise data collection.	UC_ ManageSensors
3	The system shall implement secure communication protocols for real-time transmission of air quality data.	UC_ ManageData
4	It shall provide real-time access to air quality data, enabling users to view trends, receive alerts, and visualize data in a user-friendly manner.	UC_Real_ Time_Data
5	It shall ensure the accuracy, reliability, and stability of sensor data.	UC_Train_ ML_Model
6	System shall ask the user to provide the permission to access the location	UC_Sattion Report
7	System shall allow user to browse through weather and air condition data	UC_Real_ Time_Data
8	System shall allow user to view indoor data	UC_View IndoorData
9	System shall allow user to browse through outdoor data	UC_View OutdoorData
10	System shall allow user to view Forecast data	UC_View ForcastData
11	The system shall be designed to be scalable, allowing for the addition of more sensor nodes or features in the future.	UC_ ManageSensors
12	The system shall provide alerts to the user	UC_Generate Alerts

(TABLE # 2.2: Allocate Requirements)

2.2.5. Entity Relationship Diagram:

Entities and Attributes:

Monitoring System:
Attributes: DeviceID (Primary Key), Location, Sampling_Frequency, User_Interface, Description
Sensors:
Attributes: SensorID (Primary Key), Type, CalibrationStatus
Pollutants:
Attributes: PollutantID (Primary Key), Pollutant_Name, Pollutant_Type, Measurement_Unit, Concentration, Timestamp, Health_Impact, Standard_Limit
User:
Attributes: Username, Password, Email, Role/Privilege, Last_Login, Creation_Date



(Figure # 2.2: Allocate Requirements)

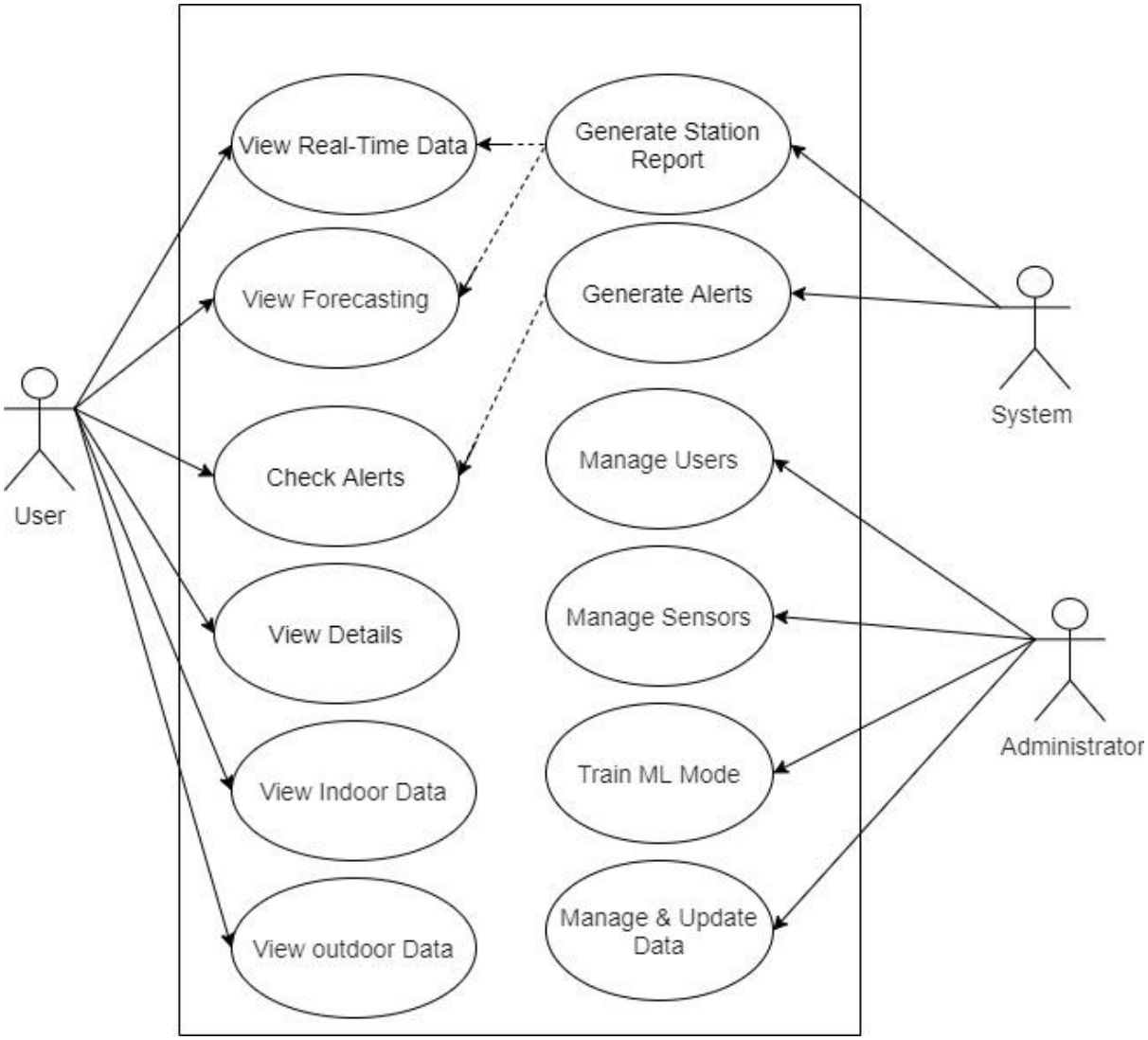
2.3. Existing Systems / Literature Review:

Here is an explanation about the Existing Systems defined below.

2.3.1. Existing System

Several existing systems and projects are currently operational, albeit limited in scope, as they exclusively manage singular pollutants or parameters. These systems typically forecast data about a single pollutant, resembling the functionality of Weatherbit, which exclusively displays, manages, and forecasts data for a single day. Conversely, our proposed system demonstrates an enhanced capacity, capable of interfacing with many pollutant sensors. Notably, it possesses the capability to forecast data for a span of seven days, exhibiting superior accuracy and a reduced margin for errors.

2.4. Usecase Diagram of Project:



(Figure # 2.3: Use Case Diagram)

2.4.1. Usecase Description

UC_Real_Time_Data	
Use Case Name	UC_ **Real_Time_Data**
Use Case ID	UC_01
Primary Actor	User
Secondary Actor	System
Dependency	Station Report
Description	User can view the real time data about weather and air pollution
Basic Flow	• Open Envirocast Application • Click on Weather Button or Air Condition Button
Pre-Conditions	User must Install app and give Location permission
Extension	None

(TABLE # 2.4.1: Real Time Data)

UC_ViewForecasting	
Use Case Name	UC_ **ViewForecasting**
Use Case ID	UC_02
Primary Actor	User
Secondary Actor	System
Dependency	Station Report
Description	User can view the future air condition
Basic Flow	• Open Envirocast Application • Click on Air Condition • Click on Outdoor Button • Click on any parameter to see Forecast Button
Pre-Conditions	User must Install app and give Location permission
Extension	None

(TABLE # 2.4.2: Forecasting)

UC_ViewDetails	
Use Case Name	UC_ **ViewDetails**
Use Case ID	UC_03
Primary Actor	User
Secondary Actor	System
Dependency	None
Description	User can view the Detailof the air condition
Basic Flow	• Open Envirocast Application • Click on Outdoor Button then click on specific air feature to see the detail
Pre-Conditions	User must Install app and give Location permission
Extension	None

(TABLE # 2.4.3: Details)

UC_CheckAlerts	
Use Case Name	UC_ **CheckAlerts**
Use Case ID	UC_04
Primary Actor	Users
Secondary Actor	System
Dependency	GenerateAlerts
Description	User can get alerts related to their poor environment and pollution
Basic Flow	• Get the alerts
Pre-Conditions	User must Install app and give Location permission
Extension	None

(TABLE # 2.4.4: Alerts)

UC_ViewIndoorData	
Use Case Name	UC_ **ViewIndoorData**
Use Case ID	UC_05
Primary Actor	User
Secondary Actor	None
Dependency	None
Description	User can view the Indoor air condition
Basic Flow	• Open Envirocast Application • Click on Air Condition
Pre-Conditions	User must Install app
Extension	None

(TABLE # 2.4.5: IndoorData)

UC_ViewOutdoorData	
Use Case Name	UC_ **ViewOutdoorData**
Use Case ID	UC_06
Primary Actor	User
Secondary Actor	None
Dependency	None
Description	User can view the Outdoor air condition
Basic Flow	• Open Envirocast Application • Click on Air Condition • Click on Outdoor Button
Pre-Conditions	User must Install app and give Location permission
Extension	None

(TABLE # 2.4.6: OutdoorData)

UC_SattionReport	
Use Case Name	UC_ **StationReport**
Use Case ID	UC_07
Primary Actor	System
Secondary Actor	None
Dependency	None
Description	Display and generate the reports and data to users
Basic Flow	• Get the data from the sensors • Apply the Machine Learning models • Generate forecasting
Pre-Conditions	Sensors integration and Machine Learning Model
Extension	View Real_Time_Data and Forecasting

(TABLE # 2.4.7: SattionReport)

UC_GenerateAlerts	
Use Case Name	UC_ **GenerateAlerts**
Use Case ID	UC_08
Primary Actor	System
Secondary Actor	None
Dependency	None
Description	Generate Alerts to warn the user about their poor environment and pollution
Basic Flow	• Get the data from the sensors • Apply the Machine Learning models • Generate reporsts and forecasting • Generate the alerts
Pre-Conditions	Sensors integration and Machine Learning Model
Extension	Check_Alerts

(TABLE # 2.4.8: GenerateAlerts)

Chapter 3: Design Document (For Object Oriented Approach)

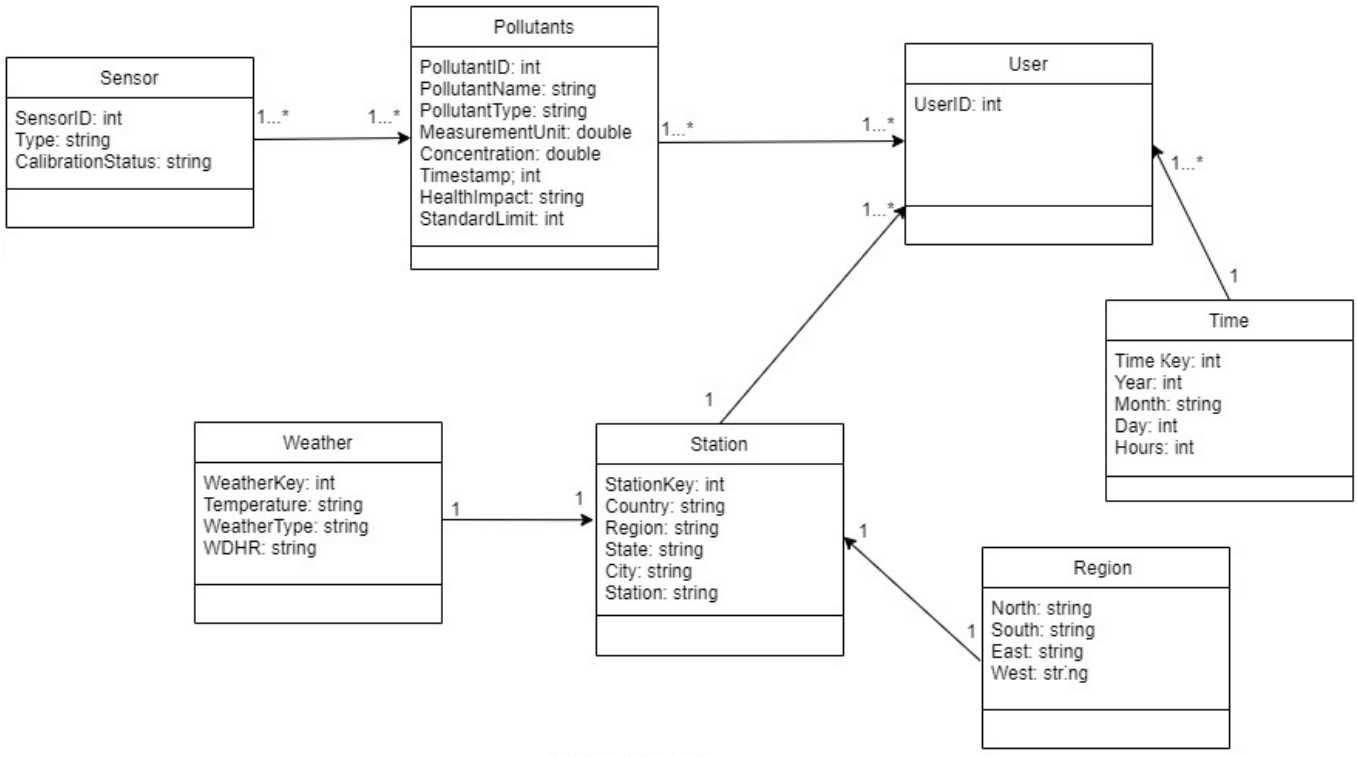
3.1. Introduction:

This deliverable is all about the software design. In the previous deliverable, analysis of the system is completed. So, we understand the current situation of the problem domain. Now we are ready to strive for a solution for the problem domain by using object-oriented approach. Following artifacts must be included in the 3rd deliverable.

1. Domain Model
2. Design Class Diagram
3. Sequence Diagram
4. State Chart Diagram
5. Collaboration Diagram

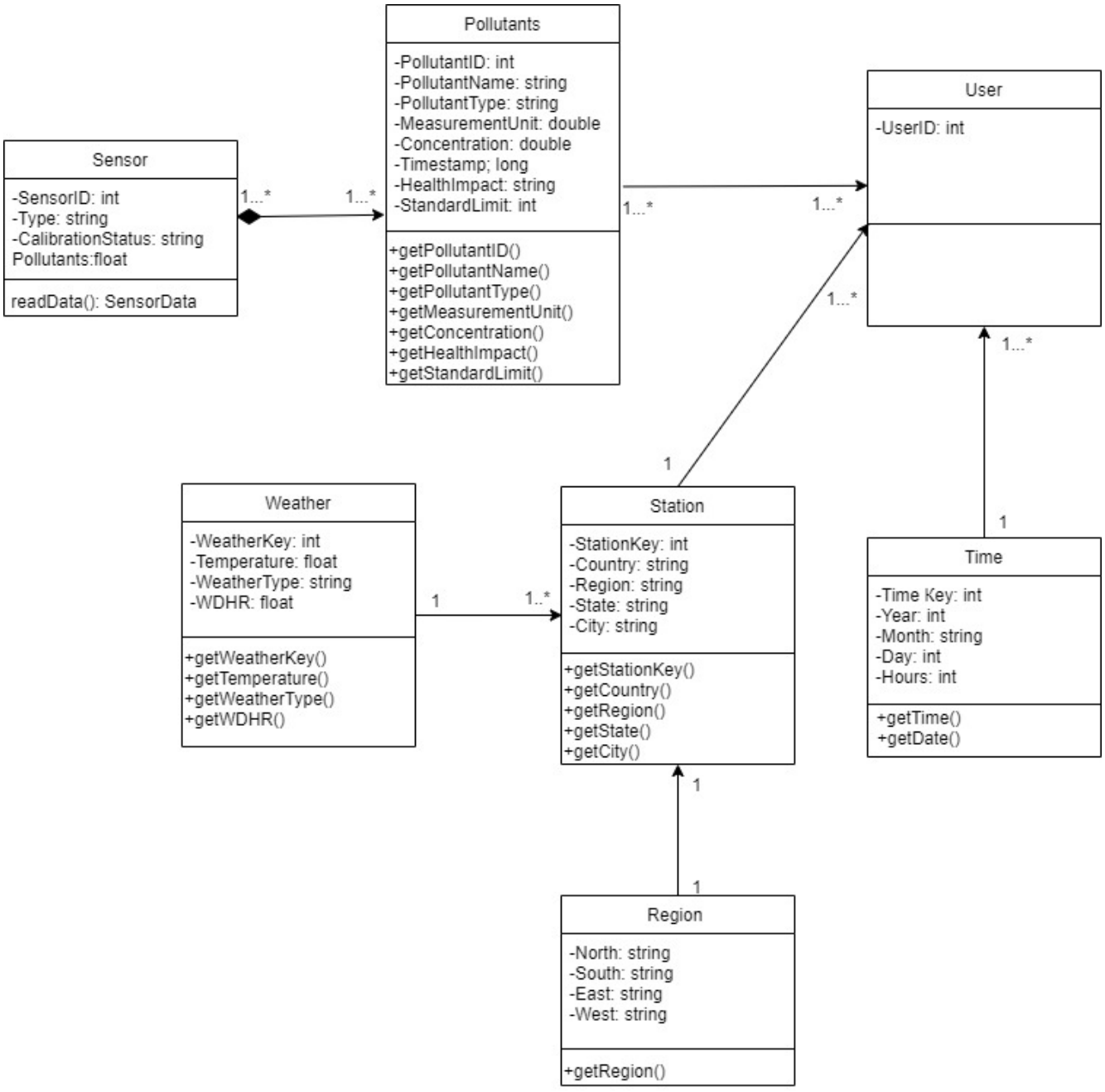
Now we discuss these artifacts one by one as follows:

3.2. Domain Model



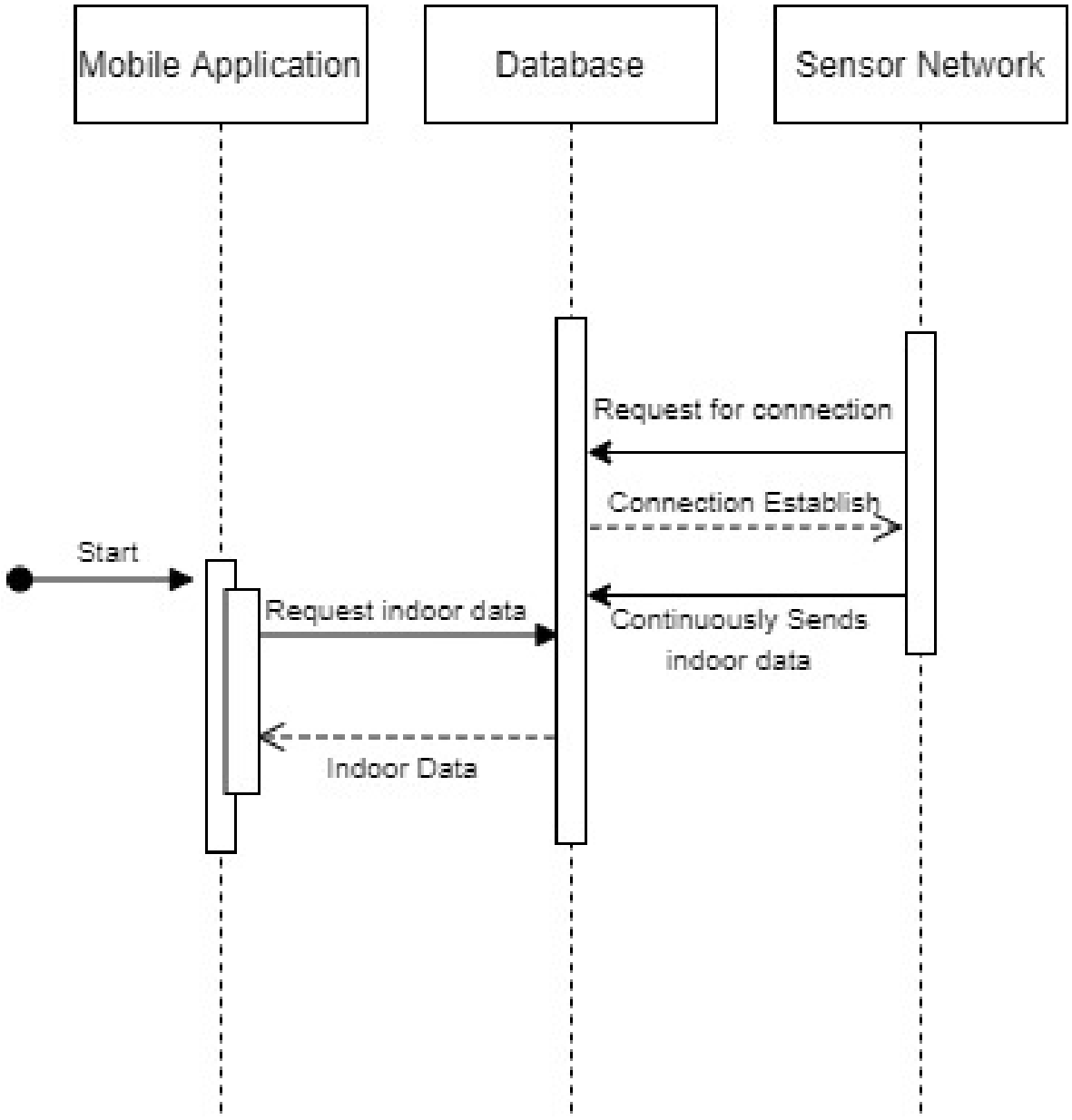
(Figure # 3.1: Domain Model Diagram)

3.3. Design Class Diagram

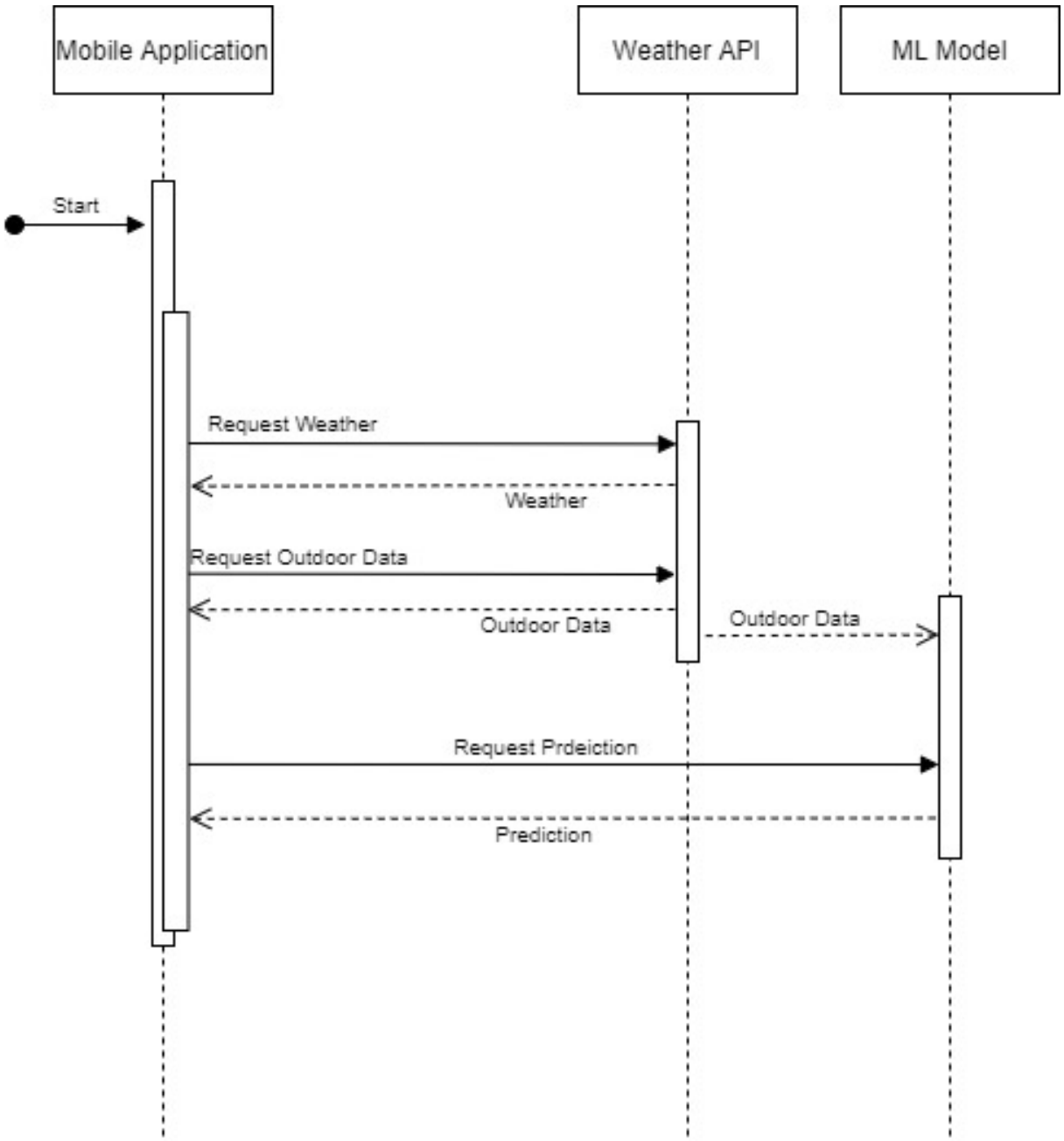


(Figure # 3.2: Class Diagram)

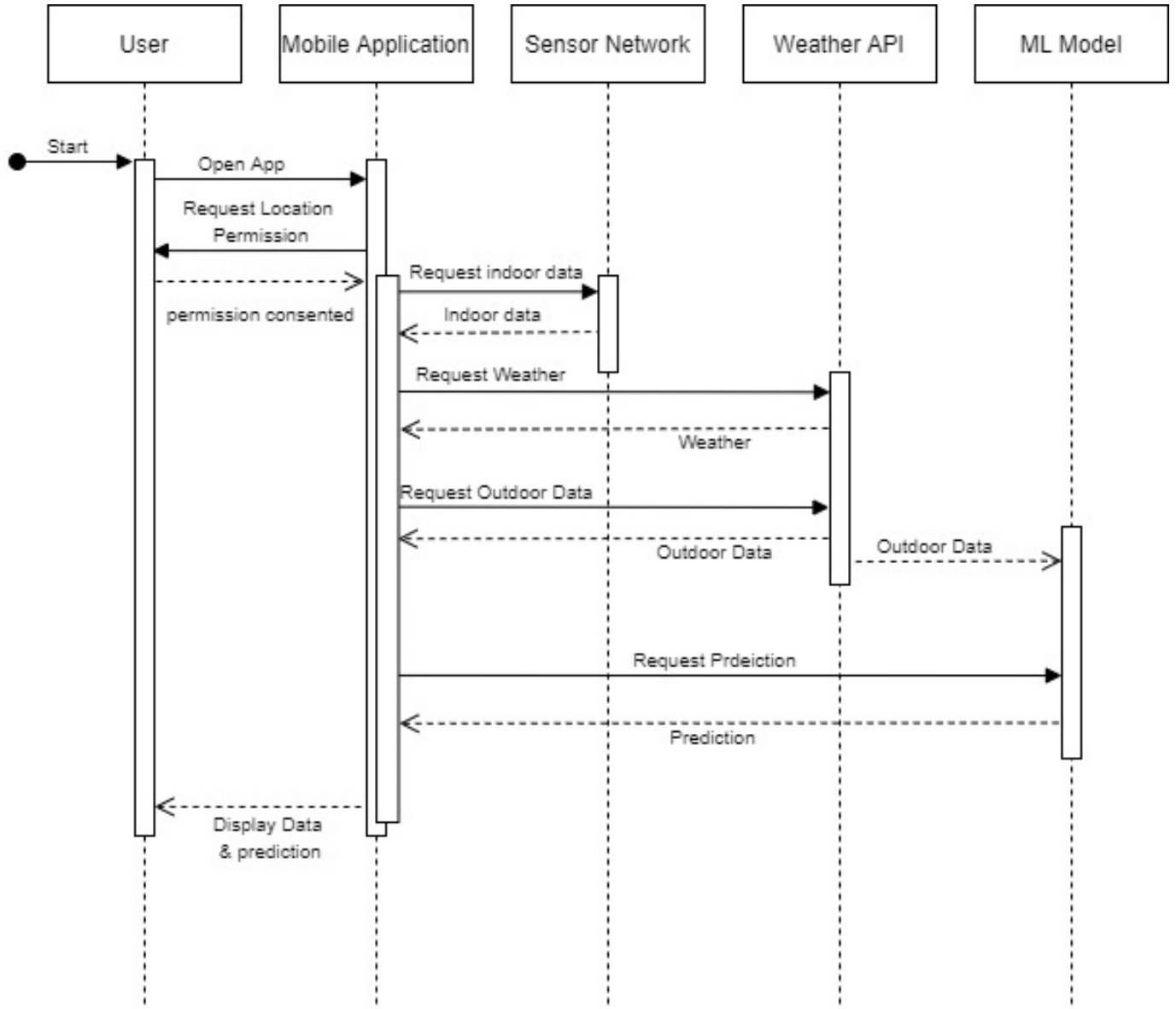
3.4. Sequence Diagram



(Figure # 3.3.1: Sequence Diagram of sensors)

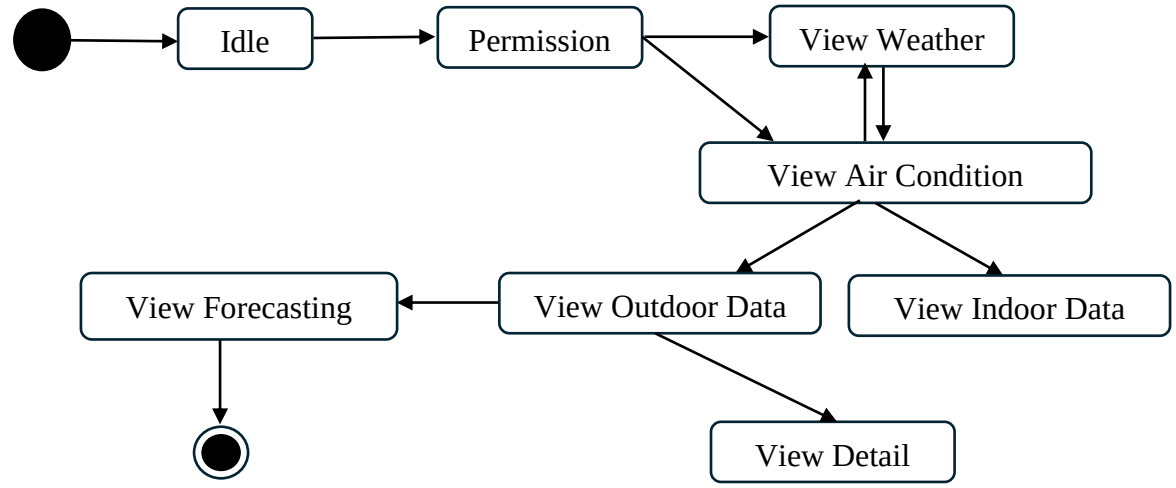


(Figure # 3.3.2: Sequence Diagram of ML Model)



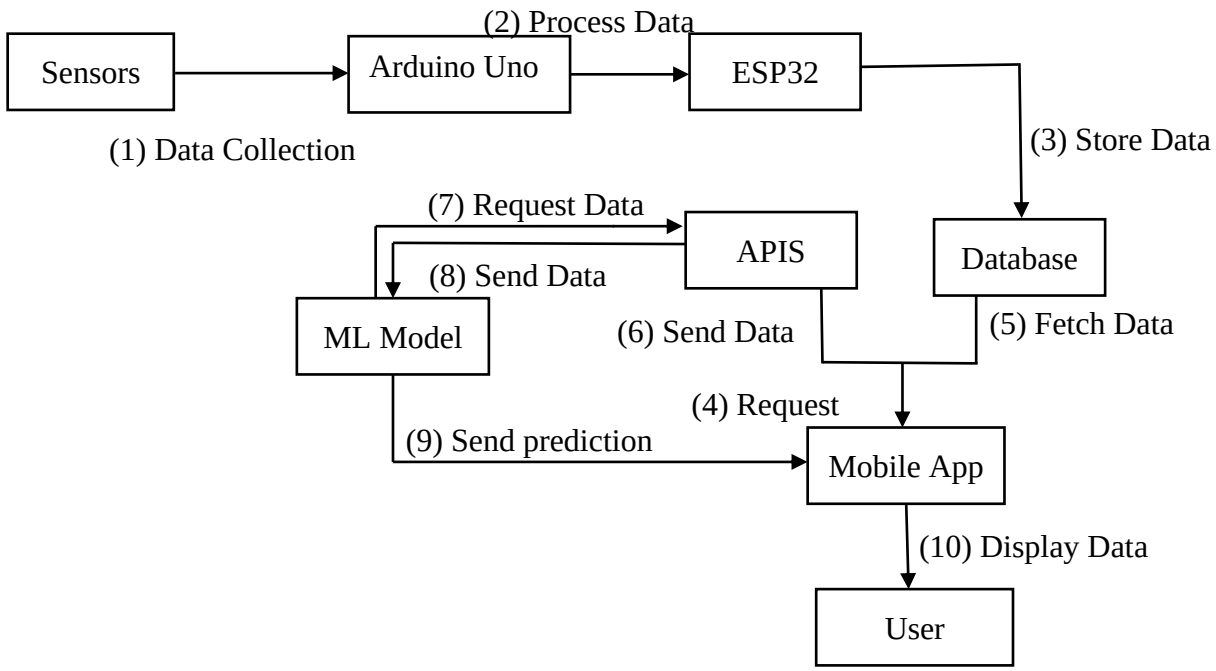
(Figure # 3.3: Sequence Diagram)

3.5. State chart diagram



(Figure # 3.4, State Chart Diagram)

3.6. Collaboration Diagram



(Figure # 3.5 Collaboration Diagram)

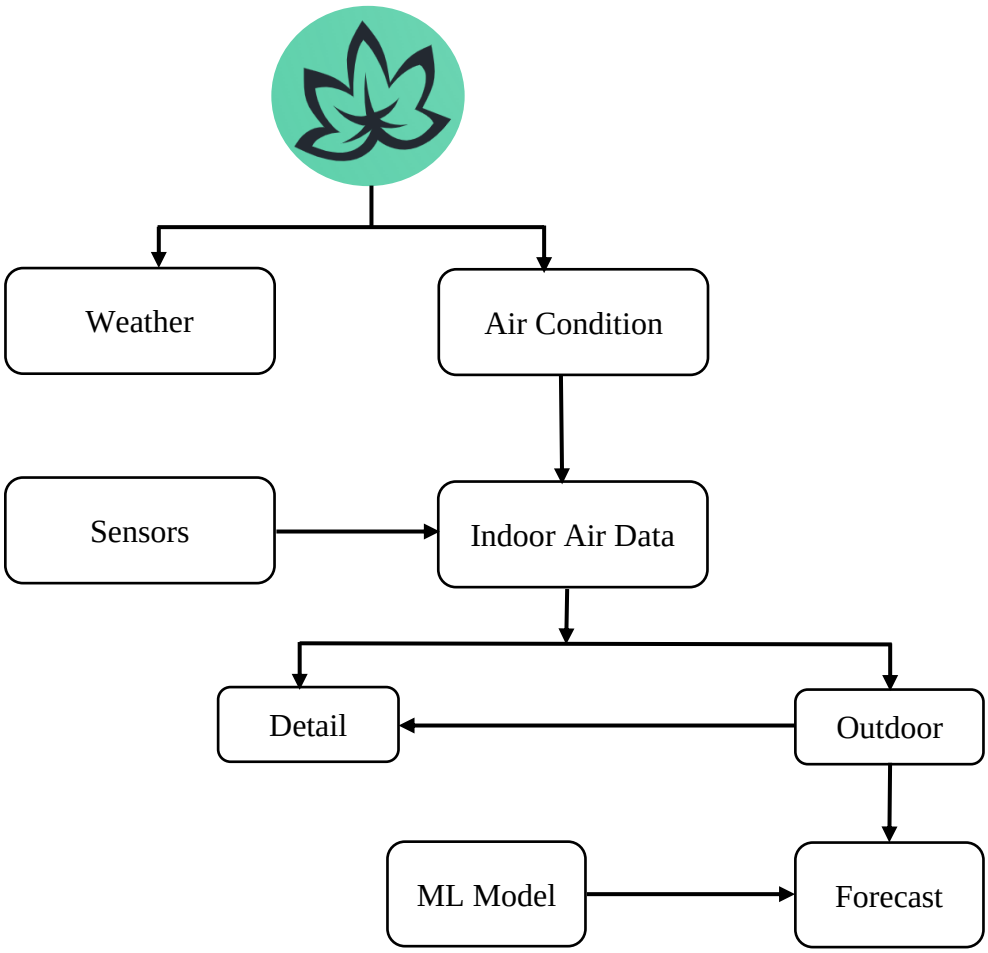
Chapter 4: User Interface Design

4.1. Introduction

A user interface design consists of three main parts:
Page elements should be visualized on paper before building them in the computer. Just as you draw a site map to plan the site, use cartoons and storyboards to begin blocking out the site's appearance and navigational scheme.

1. Site maps
2. Storyboards
3. Navigational maps

4.2. Site Maps



(Figure # 4.1: Site Maps)

4.3. Story boards

Scene 1 (Landing Page): The customer opens the EnviroCast application on their phone. They are greeted with a splash screen with a message that says, **"Take control of your air, breath clean with envirocast."**

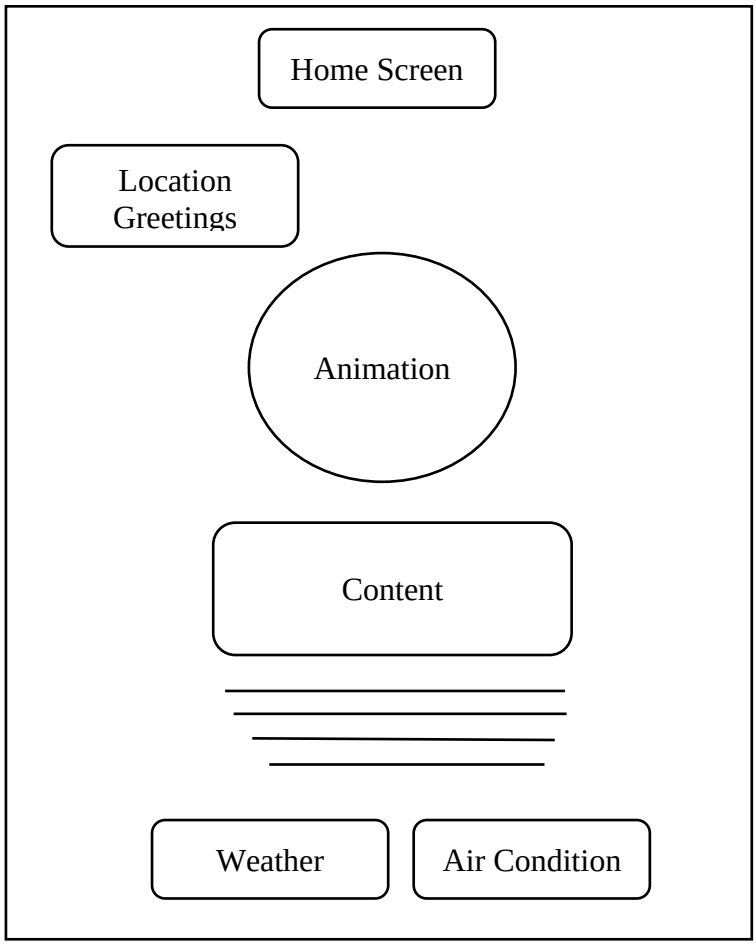
Scene 2: Home Screen: The home screen displays comprehensive weather information, including sunrise and sunset times, as well as the maximum and minimum temperatures for the specified location.

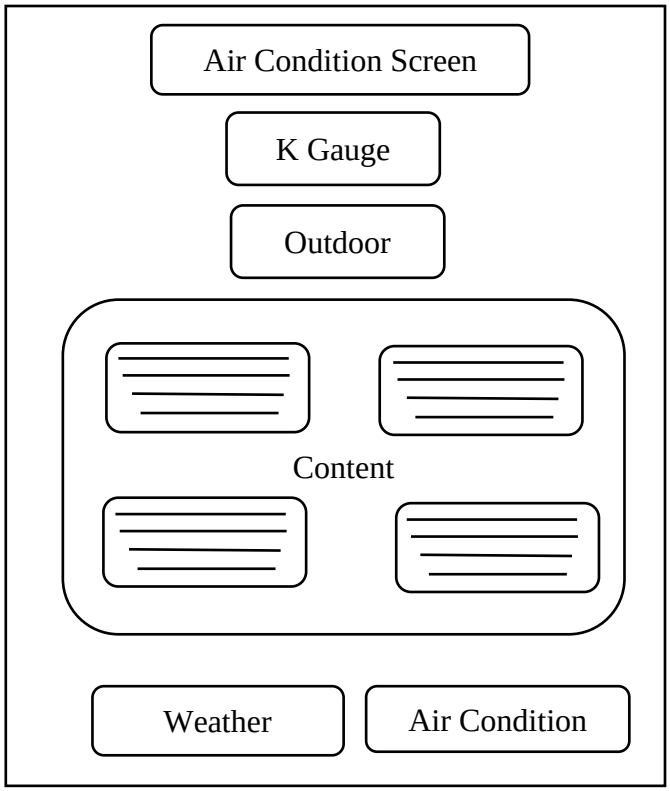
Scene 3: Air Condition Screen: The air condition screen presents data based on indoor parameters, including natural gas (LPG), dust, NH2, smoke, CO2, and AQI levels, displayed through a K-gauge meter.

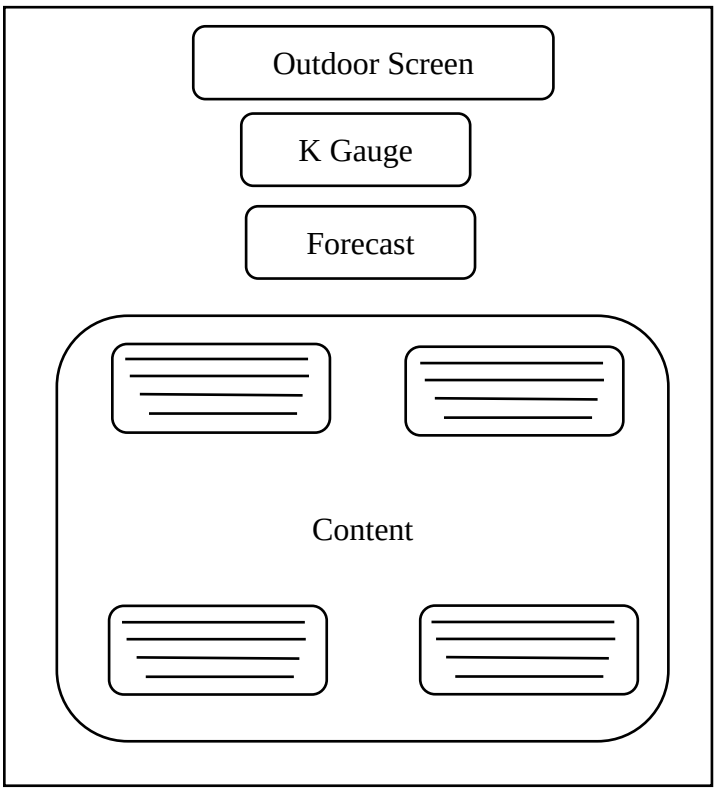
Scene 4: Outdoor Screen: The outdoor screen displays the current values of outdoor parameters, including temperature, AQI, CO, NO2, O3, SO2, PM2.5, and PM10, along with a one-hour forecast for these parameters.

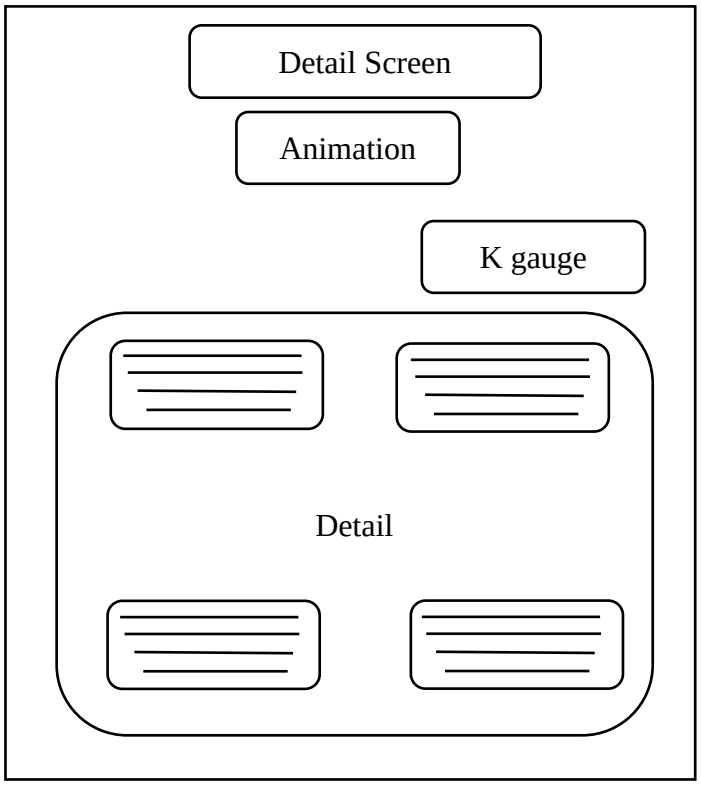
Scene 5: Detail Screen: The detail screen provides comprehensive information on both indoor and outdoor parameters, categorizing them according to their ranges as good, moderate, unhealthy, or poor, along with other relevant details.

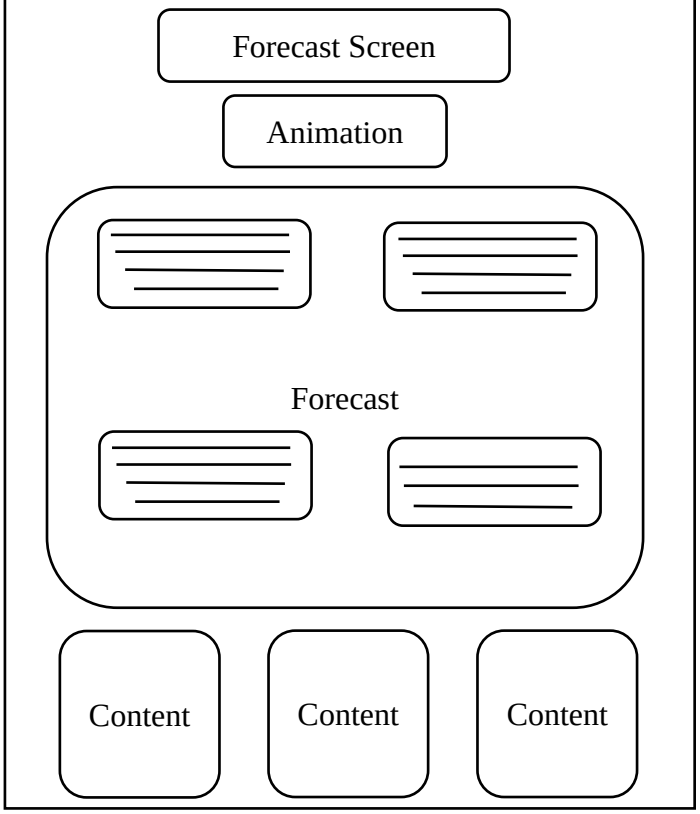
Scene 6: Forecasting Screen: The forecasting screen presents a 7-day forecast for outdoor parameters, along with a 7-day weather forecast.



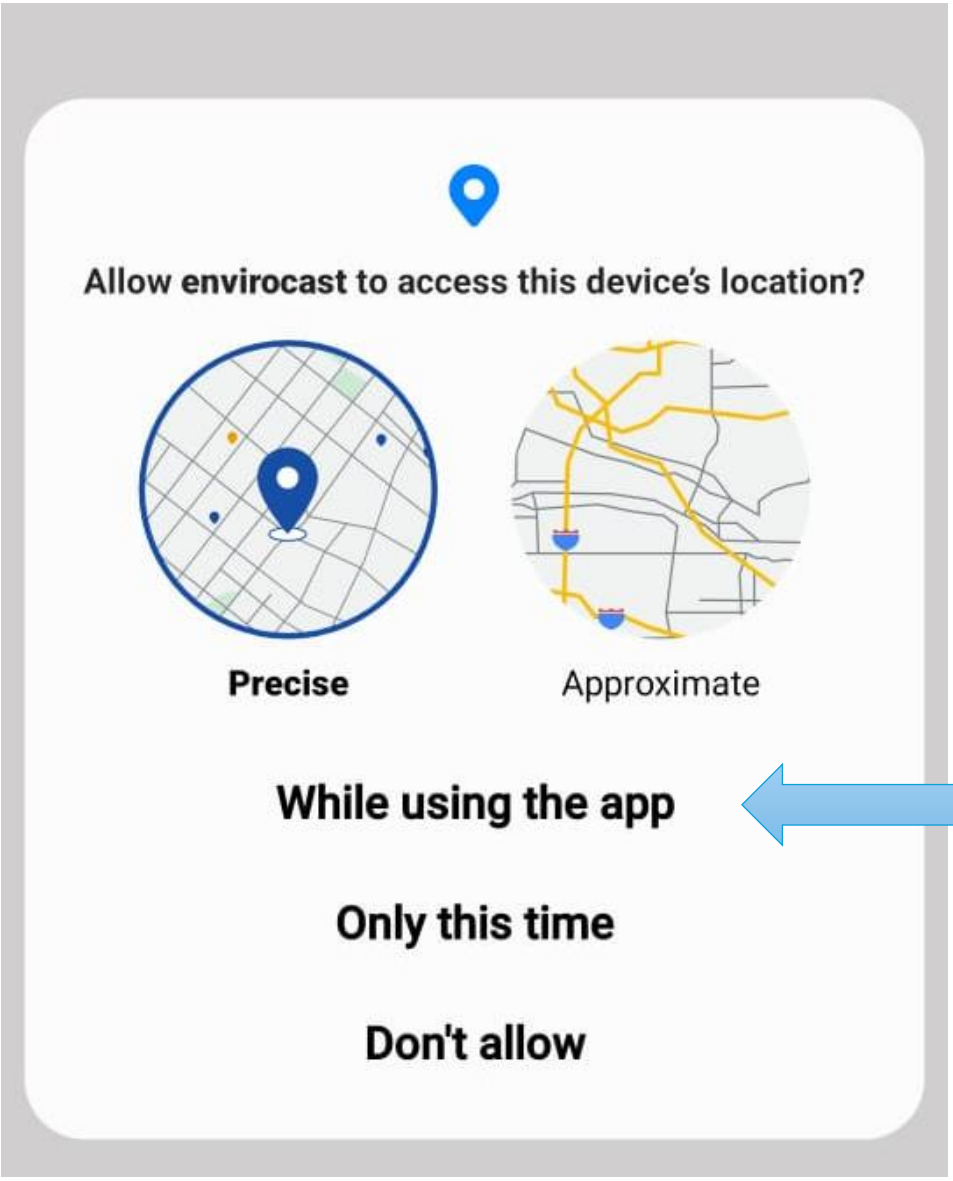




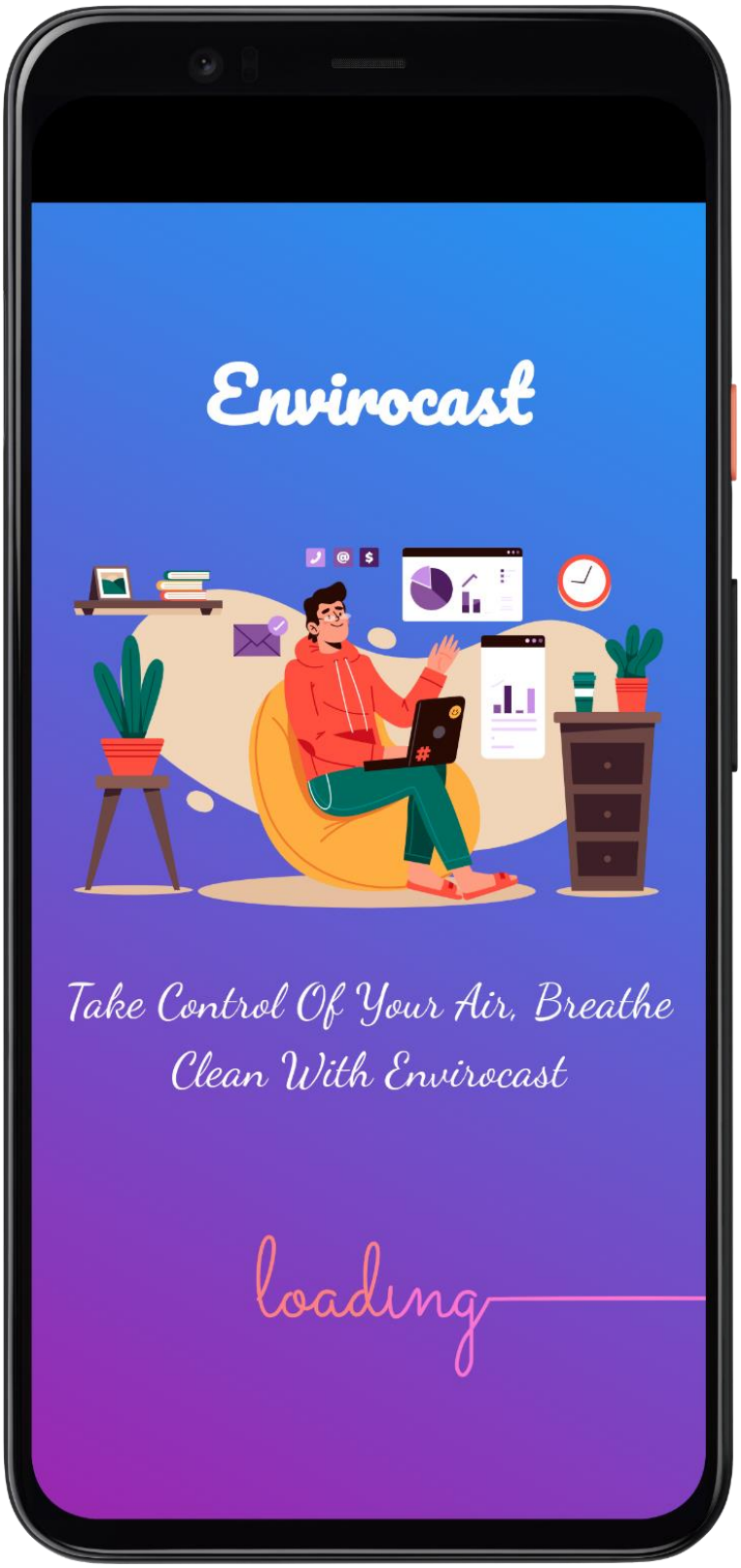




4.4. Navigational maps:

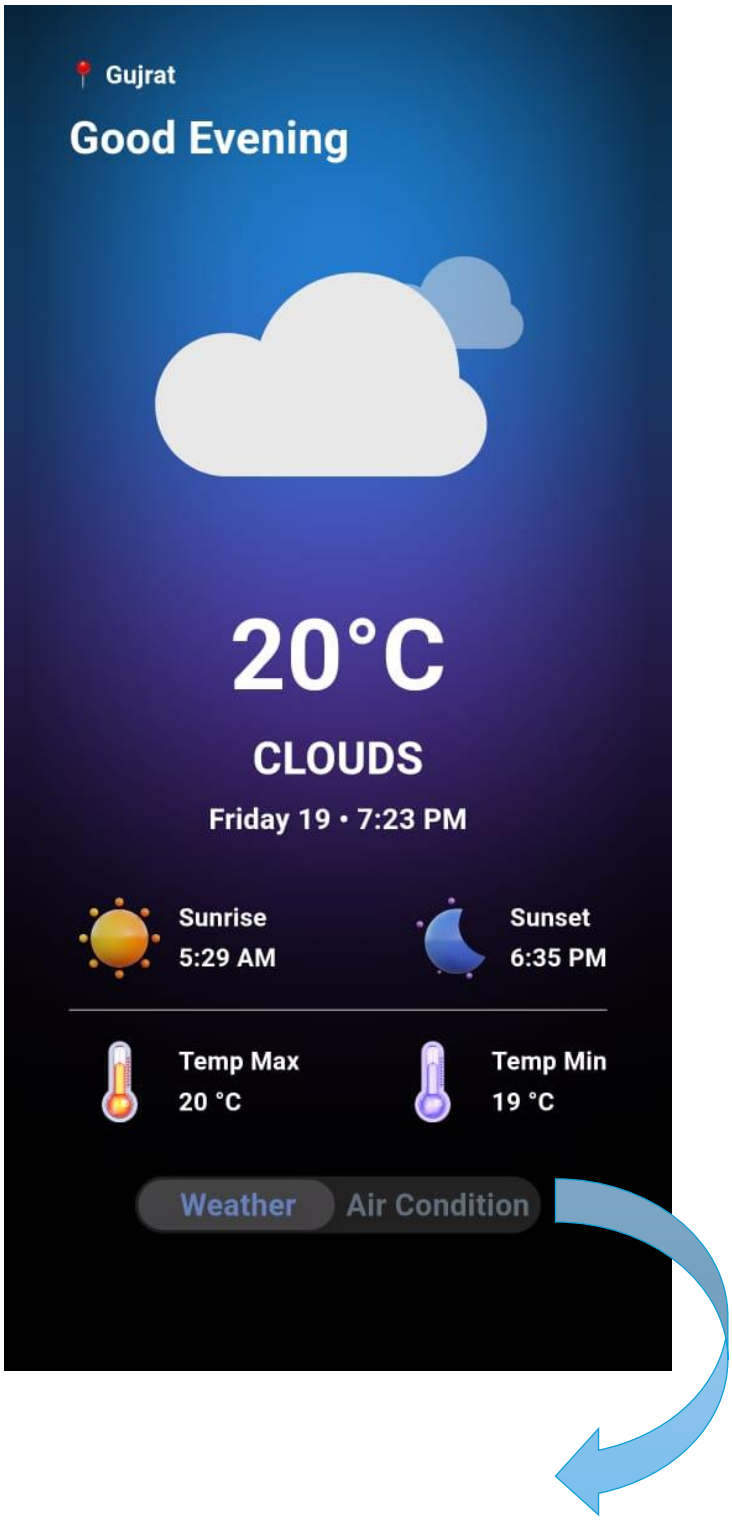


After opening the app for the first time user will be asked to provide location permission to proceed


Envirocast
Take Control Of Your Air, Breathe Clean With Envirocast
loading

Home Screen

After loading user will be directed to the home screen from where user can select Air condition data to switch to the Indoor data screen.



Indoor Screen

Navigate to outdoor Screen.

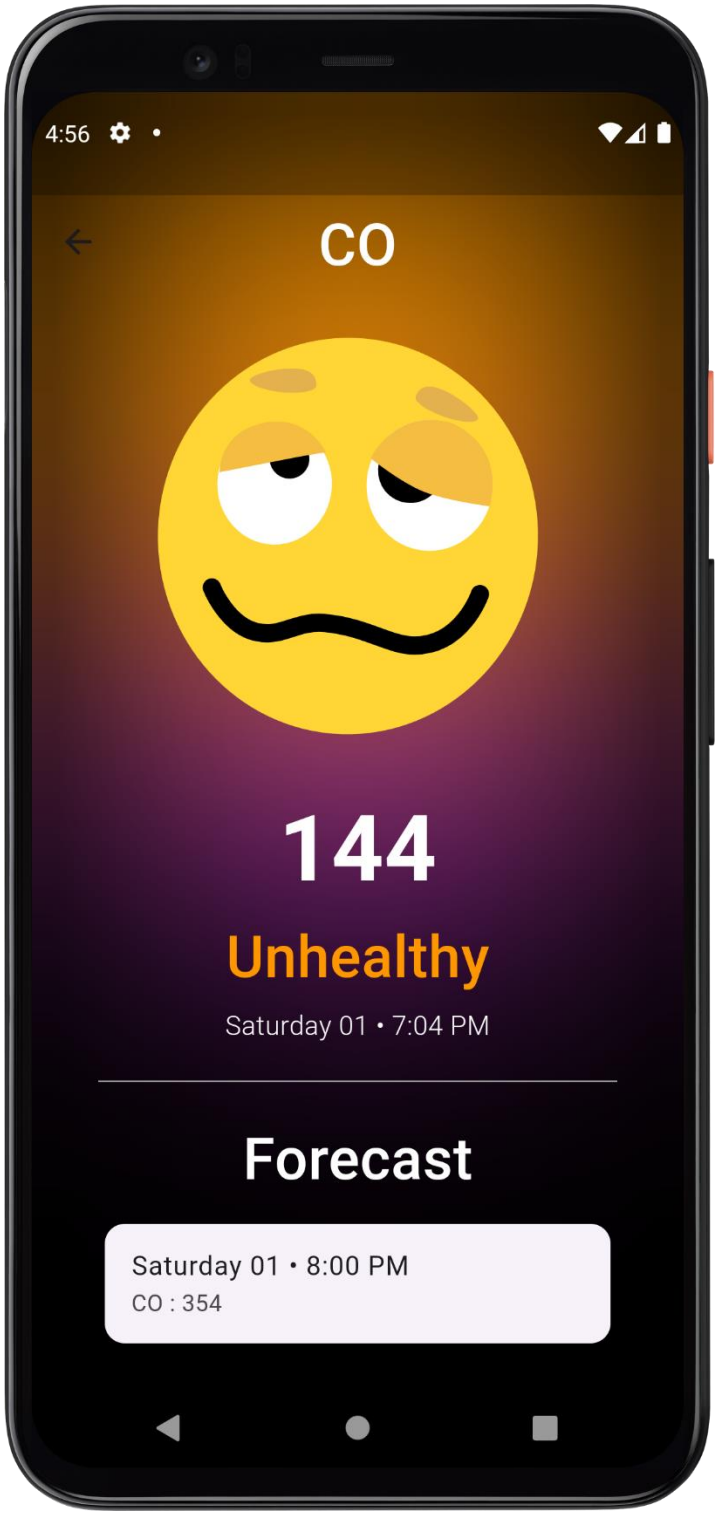
Click on outdoor button to navigate to Outdoor Screen.

Outdoor screen

Navigate to detail Screen.

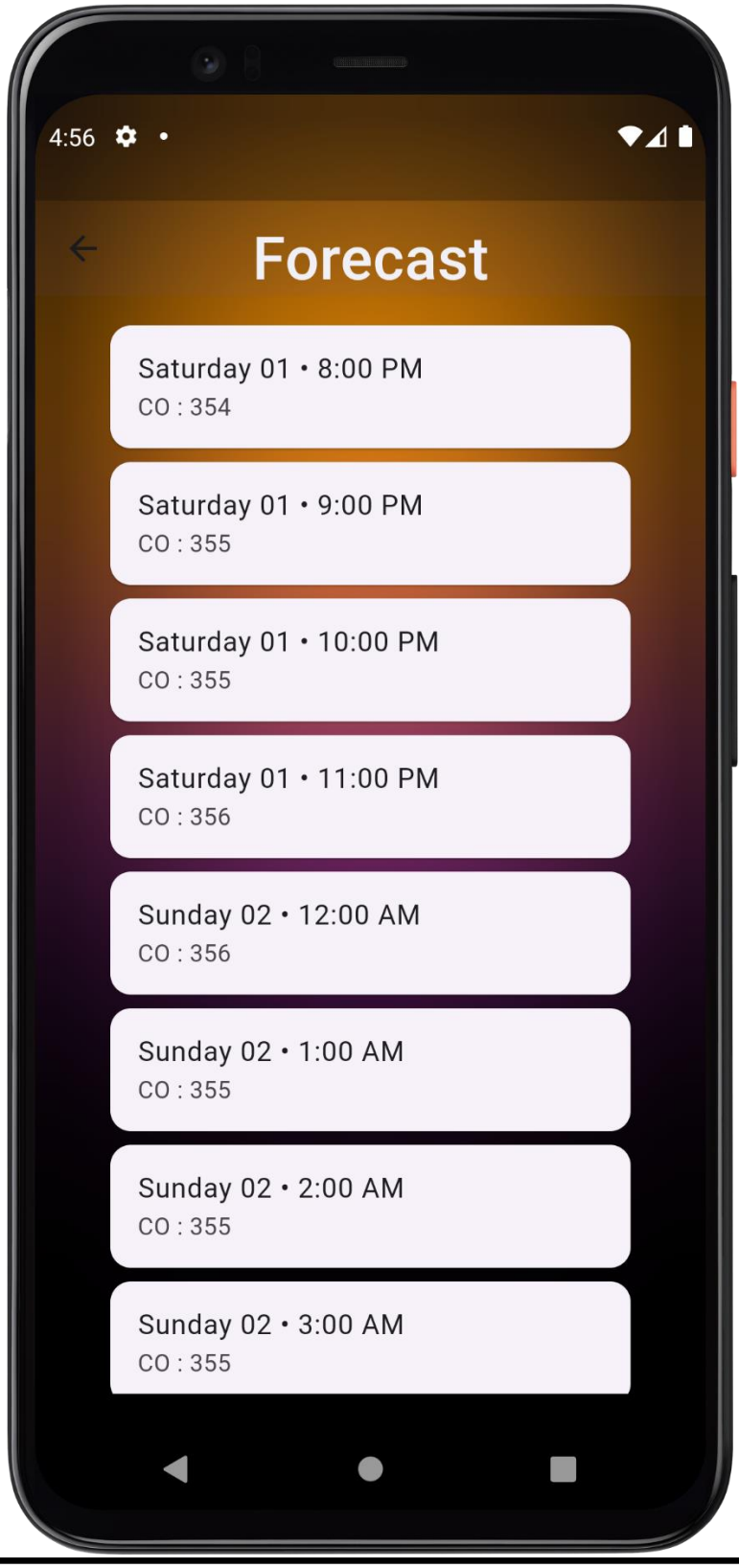
Click on outdoor button to navigate to Outdoor Screen or click on parameters to see the detail of specific parameter.

Detail Screen



Detail Screen presents the detail about the parameters.

Forecast Screen



Chapter 5: Software Testing

5.1 Introduction:

This deliverable is based on the IEEE standard of software testing i.e. IEEE SOFTWARE TEST DOCUMENTATION Std 829-1998. This standard describes a set of basic test documents that are associated with the dynamic aspects of software testing (i.e., the execution of procedures and code). The standard defines the purpose, outline, and content of each basic document. While the documents described in the standard focus on dynamic testing, several of them may be applicable to other testing activities (e.g., the test plan and test incident report may be used for design and code reviews). This standard may be applied to commercial, scientific, or military software that runs on any digital computer. Applicability is not restricted by the size, complexity, or criticality of the software. However, the standard does not specify any class of software to which it must be applied. The standard addresses the documentation of both initial development testing and the testing of subsequent software releases. For a particular software release, it may be applied to all phases of testing from module testing through user acceptance. However, since all of the basic test documents may not be useful in each test phase, the particular documents to be used in a phase are not specified. Each organization using the standard will need to specify the classes of software to which it applies and the specific documents required for a particular test phase.

The standard does not call for specific testing methodologies, approaches, techniques, facilities, or tools, and does not specify the documentation of their use. Additional test documentation may be required (e.g., code inspection checklists and reports). The standard also does not imply or impose specific methodologies for documentation control, configuration management, or quality assurance. Additional documentation (e.g., a quality assurance plan) may be needed depending on the particular methodologies used.

Following are standard artifacts, which must be included in this deliverable:

1. Test Plan
2. Test Design Specification
3. Test Case Specification
4. Test Procedure Specification
5. Test Item Transmittal Report
6. Test Log
7. Test Incident Report
8. Test Summary Report

5.2. Test plan

5.2.1. Purpose

To prescribe the scope, approach, resources, and schedule of the testing activities. To identify the items being tested, the features to be tested, the testing tasks to be performed, the personnel responsible for each task, and the risks associated with this plan.

5.2.2. Outline

A test plan shall have the following structure:

a. Test plan identifier
b. Introduction
c. Test items
d. Features to be tested
e. Features not to be tested
f. Approach
g. Item pass/fail criteria
h. Suspension criteria and resumption requirements
i. Test deliverables
j. Testing tasks
k. Environmental needs
l. Responsibilities
m. Staffing and training needs
n. Schedule
o. Risks and contingencies
p. Approvals

The sections shall be ordered in the specified sequence. Additional sections may be included immediately prior to Approvals. If some or all of the content of a section is in another document, then a reference to that material may be listed in place of the corresponding content. The referenced material must be attached to the test plan or available to users of the plan.
Details on the content of each section are contained in the following sub-clauses.

5.2.2.1. Test plan identifier
A test plan identifier for our project EnviroCast Smart Environment Monitoring System, its mobile application, and the associated database might look like:
Identifier: ESEMS-TP-2024-1001
This identifier, ESEMS-TP-2024-1001, is a unique code assigned to this specific test plan for EnviroCast. The format suggests:
• ESEMS: Denotes that this test plan is specifically for the EnviroCast Smart Environment Monitoring System.
• TP: Stands for "Test Plan".
• 2024: Represents the year the test plan is created or intended for.
• 1001: A sequential number, indicating that this is the first test plan for that year.
This number will increment with each subsequent test plan created within the same year

5.2.2.2. Introduction
The following document outlines the software items and features to be tested for the EnviroCast: Smart Environment Monitoring System (ESEMS). The ESEMS aims to monitor and forecast indoor and outdoor environmental parameters, providing real-time data and predictive analytics. This system integrates sensor technology, data processing, and machine learning to deliver actionable insights through a user-friendly mobile application.

a. Indoor Environment Monitoring
    - Temperature and humidity sensors
    - Air Quality Index (AQI) monitoring
    - Detection of dust particles, smoke, and gases (LPG, CO, NH3, CO2, Smoke, Temperature, Humidity, Dust(PM2.5))
b. Outdoor Environment Monitoring:
    - AQI and specific pollutants (CO, NO2, O3, SO2, PM2.5, PM10)
    - Weather data including temperature, sunrise, sunset, max/min temperature.
c. Data Processing and Machine Learning:
    - Real-time data collection and processing
    - Predictive analytics for indoor and outdoor air quality
    - 7-day forecast for outdoor parameters and weather
d. Mobile Application:
    - User interface displaying real-time data.
    - Forecasting screen for 7-day environmental and weather forecast.
    - Detailed screen showing parameter ranges and classifications.

5.2.2.3. Test items

The test items for the EnviroCast: Smart Environment Monitoring System (ESEMS) are listed below along with their version/revision levels and any necessary pre-testing transformations. Each test item is accompanied by references to relevant documentation to ensure comprehensive coverage and traceability.

a. Indoor Environment Monitoring Module
b. Outdoor Environment Monitoring Module
c. Data Processing and Machine Learning Module
d. Mobile Application

5.2.2.4. Features to be tested

The following are the software features and combinations of features to be tested for the EnviroCast: Smart Environment Monitoring System (ESEMS).

1. Indoor Environment Monitoring

a. Features:

- Room temperature monitoring
- Humidity monitoring
- LPG, CO, NH3, CO2 monitoring
- Smoke monitoring
- Dust particle detection.

2. Outdoor Environment Monitoring

a. Features:

- Outdoor temperature monitoring via API.
- AQI monitoring for the outdoor environment via API.

- Pollutant detection (CO, NO2, O3, SO2, PM2.5, PM10) via API.

3. Data Processing and Machine Learning

a. Features:

- data processing
- Predictive analytics for outdoor environment
- Forecasting for outdoor environment

4. Mobile Application

a. Features:

- User interface for data visualization
- Notification and alert system
- Forecasting data access

5. API Data Transmission

a. Features:

- Secure data transmission
- Data synchronization between model and application
- API endpoint functionality

6. Integration Features

a. Combinations of Features:

- Indoor and outdoor data integration
- Mobile app integration with data processing module
- Real-time alerts and notifications based on combined data

By identifying and testing these features and their combinations, we ensure that the EnviroCast system operates reliably and meets the specified requirements, providing accurate and timely environmental monitoring and forecasting.

5.2.2.5. Features not to be tested

The following features and significant combinations of features of the EnviroCast: Smart Environment Monitoring System (ESEMS) have been identified as not within the scope of current testing efforts. The reasons for their exclusion are provided.

1. Advanced Predictive Analytics for Unusual Weather Patterns

Reason: The current focus is on standard predictive analytics and real-time data processing. Advanced analytics for unusual weather patterns require extensive historical data and specialized algorithms, which will be considered in future development phases.

2. Integration with Third-Party Home Automation Systems

Reason: While integration with home automation systems (like smart thermostats or lighting systems) is a future goal, it is not part of the initial development and testing phase. This integration requires additional compatibility checks and development effort.

3. Historical Data Analysis for Long-Term Trends

Reason: While the system supports historical data access for a limited period, in-depth analysis for long-term trends and patterns is deferred to future updates when more extensive data has been collected and the necessary analytical tools have been developed.

4. Advanced Security Features
Reason: Basic security features such as secure data transmission are included in the current scope. However, advanced security features like multi-factor authentication and advanced encryption protocols are planned for future development.
By explicitly identifying these features as not being tested, we can focus our current resources and efforts on ensuring the core functionalities of the EnviroCast system are robust and reliable. These features will be revisited and included in the test plans of future development cycles as the project evolves.

5.2.2.6. Approach
We use the Iterative testing approach for EnviroCast which ensures that testing activities are integrated seamlessly into the iterative development process. This approach facilitates continuous improvement and enhances the overall quality of the system with each iteration.

5.2.2.7. Item pass/fail criteria
The test cases executed on "EnviroCast" will pass if they meet the specific requirement mentioned of the project. A test case it said to fail if the desired functionality is not satisfied by the system. All core functionality of the system should function as expected and outlined in the individual test cases. There must be no critical defects found and an end user must be able to use the application successfully. 95% of all test cases should pass and no failed cases should be crucial to the end-user's ability to use the application.

5.2.2.8. Suspension criteria and resumption requirements
Suspension criteria and resumption requirements are essential aspects of testing. These criteria help ensure that testing is conducted under controlled conditions and that any potential risks or issues are managed effectively. Here's an example of suspension criteria and resumption requirements for the EnviroCast are as follow:

Suspension Criteria:
Critical Defects: If critical defects are identified that significantly impact the system's functionality, such as data loss, security vulnerabilities, or system crashes.
Regulatory Non-Compliance: Discovery of non-compliance with relevant regulations or standards governing indoor environment monitoring systems.
Resource Constraints: Unforeseen resource constraints, such as budgetary limitations, staffing shortages, or unavailability of essential tools or technology.

Resumption Requirements:
Defect Resolution: Critical defects must be addressed promptly, and appropriate measures taken to ensure the stability, security, and functionality of the system before resuming the project.

Compliance Remediation: If regulatory non-compliance is identified, corrective actions must be implemented to bring the project into alignment with relevant regulations and standards.
Resource Reallocation: Assess resource constraints and take necessary steps to secure additional resources or reallocate existing resources to overcome constraints and resume project activities.
Quality Assurance: Conduct thorough quality assurance checks to verify the effectiveness of defect resolution, regulatory compliance remediation, and resource reallocation efforts before resuming project activities.
By establishing clear suspension criteria and resumption requirements, EnviroCast project management can effectively address unforeseen challenges while ensuring the project's successful completion and delivery of a high-quality indoor environment monitoring system.

5.2.2.9. Testing tasks

- Verify accurate monitoring and forecasting of indoor and outdoor parameters.
- Test the system's ability to provide real-time insights and predictive analytics based on collected data.
- Validate the functionality of alerts and notifications for abnormal indoor environment conditions.
- Assess the accuracy of pollutant detection sensors.
- Verify the reliability of data transmission from sensors to the monitoring system.
- Test the system's responsiveness in updating environmental parameters based on changes.
- Evaluate the user interface for ease of use and clarity in presenting environmental data.
- Validate the system's ability to handle different indoor environments and variations in environmental conditions.
- Assess the system's performance under different loads and usage scenarios.
- Verify compatibility with various devices for accessing monitoring data.

5.2.2.10. Environmental needs

Certainly, EnviroCast, its mobile application, and the associated database have specific environmental needs in terms of hardware and software. Here's an overview of these requirements:

Hardware Needs:

- Mq5
- Mq7
- Mq135
- Dust sensor
- Dht11 (temp)
- Arduino uno
- Esp32
- Bread board

- Jumper wires
- 16x2 lcd
- Adapter
- Circuit base

Environmental Needs:
- Arduino IDE
- Android flutter

It's important to ensure that both hardware and software components are compatible and work seamlessly together to achieve the desired functionality of EnviroCast Smart Environment Monitoring System.

5.2.2.11. Responsibilities
Each member is responsible for designing, deploying, executive and documenting the system properly. The test manager is responsible for testing, managing, resolving, and removing all kind of failures that are most likely to cause the whole system. It's the duty of the testing manager to provide an error-free system which fulfills the purpose for which it was designed.

5.2.2.12. Staffing and training needs
No specific skills are required however, the tester must know how to use the system from start to end and how to carry out the designed tests.

5.2.2.13. Schedule

Activities	Members	Immediate Predecessor
Test planning & specification	Meerab, Hassan, Sheraz	3
Perform Testing	Meerab, Hassan, Sheraz	5
Test Report	Meerab, Hassan, Sheraz	4
Test Delivery	Meerab, Hassan, Sheraz	3
Defect Verification and Regression Testing	Meerab, Hassan, Sheraz	4

(TABLE # 5.2.13: Schedule Table)

5.2.2.14. Risks and contingencies

Identifying risks and establishing contingencies is essential for mitigating potential issues during the development and implementation of the EnviroCast project. Here are some potential risks along with suggested contingencies:

Hardware or Sensor Failures:

Risk: Malfunctioning hardware components or sensor inaccuracies leading to unreliable data.

Contingency: Maintain a backup inventory of essential hardware components and sensors. Implement automated monitoring systems to detect hardware failures early. Regularly calibrate sensors to ensure accuracy.

Integration Issues:

Risk: Challenges in integrating various software and hardware components, leading to compatibility issues.

Contingency: Conduct thorough compatibility testing during the development phase. Implement standardized communication protocols to facilitate seamless integration.

User Acceptance:

Risk: Low user adoption due to usability issues or lack of engagement with the EnviroCast system.

Contingency: Continuously iterate on the user interface and user experience based on user feedback. Provide comprehensive training and support resources to users to maximize adoption rates.

Project Scope Creep

Risk: Continuous requests for additional features might expand the project scope beyond the initial plan.

Contingency: Clearly define and document the project scope before starting development. Establish a change management process to evaluate and approve scope changes.

5.2.2.15. Approvals

Name: Dr. Abdur Rehman
Title: Project Supervisor

Signature: _____

5.3. Test design specification

5.3.1. Purpose

To prescribe the scope, approach, resources, and schedule of the testing activities. To identify the items being tested, the features to be tested, the testing tasks to be performed, the personnel responsible for each task, and the risks associated with this plan.

5.3.2. Outline

A test plan shall have the following structure:

a. Test plan identifier;
b. Introduction;
c. Test items;
d. Features to be tested;
e. Features not to be tested;
f. Approach;
g. Item pass/fail criteria;
h. Suspension criteria and resumption requirements;
i. Test deliverables;
j. Testing tasks;
k. Environmental needs;
l. Responsibilities;
m. Staffing and training needs;
n. Schedule;
o. Risks and contingencies;
p. Approvals.

The sections shall be ordered in the specified sequence. Additional sections may be included immediately prior to Approvals. If some or all of the content of a section is in another document, then a reference to that material may be listed in place of the corresponding content. The referenced material must be attached to the test plan or available to users of the plan.
Details on the content of each section are contained in the following sub-clauses.

5.3.2.1 Test plan identifier

Identifier: ESEMS-TP-2024-1001
This identifier, ESEMS-TP-2024-1001, is a unique code assigned to this specific test plan for EnviroCast. The format suggests:
• ESEMS: Denotes that this test plan is specifically for the EnviroCast Smart Environment Monitoring System.
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• 1001: A sequential number, indicating that this is the first test plan for that year.
This number will increment with each subsequent test plan created within the same year.

5.3.2.2. Introduction

A Test Design Specification (TDS) is a detailed document that outlines how testing will be carried out for a specific system or application. Here's an example of what a TDS might contain for the EnviroCast Smart Environment Monitoring System.

a. Indoor Environment Monitoring
    - Temperature and humidity sensors
    - Air Quality Index (AQI) monitoring
    - Detection of dust particles, smoke, and gases (LPG, CO, NH3, CO2, Smoke, Temperature, Humidity, Dust(PM2.5))

b. Outdoor Environment Monitoring:
    - AQI and specific pollutants (CO, NO2, O3, SO2, PM2.5, PM10)
    - Weather data including temperature, sunrise, sunset, max/min temperature.

c. Data Processing and Machine Learning:
    - Real-time data collection and processing
    - Predictive analytics for indoor and outdoor air quality
    - 7-day forecast for outdoor parameters and weather

d. Mobile Application:
    - User interface displaying real-time data.
    - Forecasting screen for 7-day environmental and weather forecast.
    - Detailed screen showing parameter ranges and classifications.

5.3.2.3. Test items

Test items for a Test Design Specification (TDS) outline what specific components, features, or functionalities will be tested. Here are some potential test items for the EnviroCast Smart Environment Monitoring System, and its mobile application:

a. Indoor Environment Monitoring Module
b. Outdoor Environment Monitoring Module
c. Data Processing and Machine Learning Module
d. Mobile Application

5.3.2.4. Features to be tested

The following are the key features that should be tested as part of the Test Design Specification for EnviroCast: Smart Environment Monitoring System (ESEMS).

1. Indoor Environment Monitoring

b. Features:
- Room temperature monitoring
- Humidity monitoring
- LPG, CO, NH3, CO2 monitoring
- Smoke monitoring
- Dust particle detection.

c. Test Design Specifications:

- TDS-001: Validate sensor accuracy and data transmission for temperature.
- TDS-002: Validate sensor accuracy and data transmission for humidity.
- TDS-003: Validate LPG, CO, NH3, CO2 sensor data accuracy.
- TDS-004: Validate sensor accuracy and data transmission for Smoke.
- TDS-005: Validate dust sensor accuracy and data reporting.

2. Outdoor Environment Monitoring

b. Features:

- Outdoor temperature monitoring via API.
- AQI monitoring for the outdoor environment via API.
- Pollutant detection (CO, NO2, O3, SO2, PM2.5, PM10) via API.

c. Test Design Specifications:

- TDS-005: Validate the accuracy of outdoor temperature data retrieved from the API and ensure correct data transmission.
- TDS-006: Validate the calculation of outdoor AQI using data retrieved from the API and ensure the accuracy of the data.
- TDS-007: Validate the accuracy of pollutant detection data retrieved from the API and ensure correct data reporting.

3. Data Processing and Machine Learning

b. Features:

- data processing
- Predictive analytics for outdoor environment
- Forecasting for outdoor environment

c. Test Design Specifications:

- TDS-008: Validate data processing algorithms.
- TDS-009: Validate machine learning models for predictive analytics.
- TDS-010: Validate forecasting accuracy for outdoor environmental conditions.

4. Mobile Application

b. Features:

- User interface for data visualization
- Notification and alert system
- Forecasting data access

c. Test Design Specifications:

- TDS-011: Validate UI/UX design and responsiveness.
- TDS-012: Validate accuracy and timeliness of notifications and alerts.
- TDS-013: Validate access and display of Forecasting data.

5. API Data Transmission

b. Features:

- Secure data transmission
- Data synchronization between model and application

- API endpoint functionality

c. Test Design Specifications:

- TDS-015: Validate security protocols for data transmission.
- TDS-016: Validate data synchronization processes.
- TDS-017: Validate all API endpoints for correct data handling.

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5.3.2.5. Features not to be tested

The following features and significant combinations of features of the EnviroCast: Smart Environment Monitoring System (ESEMS) have been identified as not within the scope of current testing efforts. The reasons for their exclusion are provided.

1. Advanced Predictive Analytics for Unusual Weather Patterns

Reason: The current focus is on standard predictive analytics and real-time data processing. Advanced analytics for unusual weather patterns require extensive historical data and specialized algorithms, which will be considered in future development phases.

2. Integration with Third-Party Home Automation Systems

Reason: While integration with home automation systems (like smart thermostats or lighting systems) is a future goal, it is not part of the initial development and testing phase. This integration requires additional compatibility checks and development effort.

3. Historical Data Analysis for Long-Term Trends

Reason: While the system supports historical data access for a limited period, in-depth analysis for long-term trends and patterns is deferred to future updates when more extensive data has been collected and the necessary analytical tools have been developed.

4. Advanced Security Features

Reason: Basic security features such as secure data transmission are included in the current scope. However, advanced security features like multi-factor authentication and advanced encryption protocols are planned for future development.

By explicitly identifying these features as not being tested, we can focus our current resources and efforts on ensuring the core functionalities of the EnviroCast system are robust and reliable. These features will be revisited and included in the test plans of future development cycles as the project evolves.

5.3.2.6. Approach

We use the Iterative testing approach for EnviroCast which ensures that testing activities are integrated seamlessly into the iterative development process. This approach facilitates continuous improvement and enhances the overall quality of the system with each iteration.

5.3.2.7. Item pass/fail criteria

The test cases executed on "EnviroCast" will pass if they meet the specific requirement mentioned of the project. A test case it said to fail if the desired functionality is not satisfied by the system. All core functionality of the system should function as expected and outlined

in the individual test cases. There must be no critical defects found and an end user must be able to use the application successfully. 95% of all test cases should pass and no failed cases should be crucial to the end-user's ability to use the application.

5.3.2.8. Suspension criteria and resumption requirements

Suspension criteria and resumption requirements are essential aspects of testing. These criteria help ensure that testing is conducted under controlled conditions and that any potential risks or issues are managed effectively. Here's an example of suspension criteria and resumption requirements for the EnviroCast are as follow:

Suspension Criteria:

Critical Defects: If critical defects are identified that significantly impact the system's functionality, such as data loss, security vulnerabilities, or system crashes.

Regulatory Non-Compliance: Discovery of non-compliance with relevant regulations or standards governing indoor environment monitoring systems.

Resource Constraints: Unforeseen resource constraints, such as budgetary limitations, staffing shortages, or unavailability of essential tools or technology.

Resumption Requirements:

Defect Resolution: Critical defects must be addressed promptly, and appropriate measures taken to ensure the stability, security, and functionality of the system before resuming the project.

Compliance Remediation: If regulatory non-compliance is identified, corrective actions must be implemented to bring the project into alignment with relevant regulations and standards.

Resource Reallocation: Assess resource constraints and take necessary steps to secure additional resources or reallocate existing resources to overcome constraints and resume project activities.

Quality Assurance: Conduct thorough quality assurance checks to verify the effectiveness of defect resolution, regulatory compliance remediation, and resource reallocation efforts before resuming project activities.

By establishing clear suspension criteria and resumption requirements, EnviroCast project management can effectively address unforeseen challenges while ensuring the project's successful completion and delivery of a high-quality indoor environment monitoring system.

5.3.2.9. Test deliverables

After completion, the test result will be saved and test manager should circulate the complete test report to the whole team and customer care the complete

5.3.2.10. Testing tasks

- Verify accurate monitoring and forecasting of indoor and outdoor parameters.
- Test the system's ability to provide real-time insights and predictive analytics based on collected data.

- Validate the functionality of alerts and notifications for abnormal indoor environment conditions.
- Assess the accuracy of pollutant detection sensors.
- Verify the reliability of data transmission from sensors to the monitoring system.
- Test the system's responsiveness in updating environmental parameters based on changes.
- Evaluate the user interface for ease of use and clarity in presenting environmental data.
- Validate the system's ability to handle different indoor environments and variations in environmental conditions.
- Assess the system's performance under different loads and usage scenarios.
- Verify compatibility with various devices for accessing monitoring data.

5.3.2.11. Environmental needs

Certainly, EnviroCast, its mobile application have specific environmental needs in terms of hardware and software. Here's an overview of these requirements:

Hardware Needs:

- Mq5
- Mq7
- Mq135
- Dust sensor
- Dht11 (temp)
- Arduino uno
- Esp32
- Bread board
- Jumper wires

Environmental Needs:

- Arduino IDE
- Android flutter

It's important to ensure that both hardware and software components are compatible and work seamlessly together to achieve the desired functionality of EnviroCast Smart Environment Monitoring System.

5.3.2.12. Responsibilities

Each member is responsible for designing, deploying, executive and documenting the system properly. The test manager is responsible for testing, managing, resolving, and removing all kind of failures that are most likely to cause the whole system. It's the duty of the testing manager to provide an error-free system which fulfills the purpose for which it was designed.

5.3.2.13. Staffing and training needs

No specific skills are required however, the tester must know how to use the system from start to end and how to carry out the designed tests.

5.3.2.14. Schedule

Activities	Members	Immediate Predecessor
Test planning & specification	Meerab, Hassan, Sheraz	3
Perform Testing	Meerab, Hassan, Sheraz	5
Test Report	Meerab, Hassan, Sheraz	4
Test Delivery	Meerab, Hassan, Sheraz	3
Defect Verification and Regression Testing	Meerab, Hassan, Sheraz	4

(TABLE # 5.3.2.14: Schedule Table)

5.3.2.15. Risks and contingencies

Identifying risks and establishing contingencies is essential for mitigating potential issues during the development and implementation of the EnviroCast project. Here are some potential risks along with suggested contingencies:

Hardware or Sensor Failures:

Risk: Malfunctioning hardware components or sensor inaccuracies leading to unreliable data.

Contingency: Maintain a backup inventory of essential hardware components and sensors. Implement automated monitoring systems to detect hardware failures early. Regularly calibrate sensors to ensure accuracy.

Integration Issues:

Risk: Challenges in integrating various software and hardware components, leading to compatibility issues.

Contingency: Conduct thorough compatibility testing during the development phase. Implement standardized communication protocols to facilitate seamless integration.

User Acceptance:

Risk: Low user adoption due to usability issues or lack of engagement with the EnviroCast system.

Contingency: Continuously iterate on the user interface and user experience based on user feedback. Provide comprehensive training and support resources to users to maximize adoption rates.

Project Scope Creep
Risk: Continuous requests for additional features might expand the project scope beyond the initial plan.
Contingency: Clearly define and document the project scope before starting development. Establish a change management process to evaluate and approve scope changes.

5.3.2.16. Approvals

Name: Dr. Abdur Rehman
Title: Project Supervisor

Signature: _____

5.4. Test Case Specification

5.4.1. Purpose
To define a test case identified by a test design specification.

5.4.2. Outline
A test case specification shall have the following structure:

a. Test case specification identifier
b. Test items
c. Input specifications
d. Output specifications
e. Environmental needs
f. Special procedural requirements
g. Inter case dependencies

The sections shall be ordered in the specified sequence. Additional sections may be included at the end. If some or all of the content of a section is in another document, then a reference to that material may be listed in place of the corresponding content. The referenced material must be attached to the test case specification or available to users of the case specification. Since a test case may be referenced by several test design specifications used by different groups over a long time period, enough specific information must be included in the test case specification to permit reuse.
Details on the content of each section are contained in the following sub-clauses.

5.4.2.1. Test case specification identifier
Specify the unique identifier assigned to this test case specification

Test Case for Monitoring Indoor Temperature	
Test Engineer	Sheraz
Test Case ID	TC-01
Input Specifications	Indoor temperature DHT-11 sensor readings
Expected Output	Accurate indoor temperature displayed
Actual Output	Accurate indoor temperature displayed
Requirements	DHT-11 sensor, Display module, Wires
Status	Pass

(TABLE # 5.4.1: Temperature)

Test Case for Monitoring Indoor Humidity	
Test Engineer	Sheraz
Test Case ID	TC-02
Input Specifications	Indoor humidity sensor readings
Expected Output	Accurate indoor humidity displayed
Actual Output	Accurate indoor humidity displayed
Requirements	DHT-11 sensor, Display module, Wires
Status	Pass

(TABLE # 5.4.2: Humidity)

Test Case for Monitoring Indoor Dust	
Test Engineer	Sheraz
Test Case ID	TC-03
Input Specifications	Indoor Dust sensor readings
Expected Output	Accurate indoor dust displayed
Actual Output	Accurate indoor dust displayed
Requirements	Dust sensor, Display module, Wires
Status	Pass

(TABLE # 5.4.3: Dust)

Test Case for Monitoring Indoor Smoke, NH3 & CO2	
Test Engineer	Sheraz
Test Case ID	TC-04
Input Specifications	Indoor MQ-135 sensor readings
Expected Output	Accurate indoor reading displayed
Actual Output	Accurate indoor reading displayed
Requirements	MQ-135 sensor, Display module, Wires
Status	Pass

(TABLE # 5.4.4: Smoke, NH3 & CO2)

Test Case for Monitoring Indoor CO	
Test Engineer	Sheraz
Test Case ID	TC-05
Input Specifications	Indoor MQ-7 sensor readings
Expected Output	Accurate indoor CO displayed
Actual Output	Accurate indoor CO displayed
Requirements	MQ-7 sensor, Display module, Wires
Status	Pass

(TABLE # 5.4.5: CO)

Test Case for Monitoring Indoor LPG	
Test Engineer	Sheraz
Test Case ID	TC-06
Input Specifications	Indoor MQ-5 sensor readings
Expected Output	Accurate indoor LPG displayed
Actual Output	Accurate indoor LPG displayed
Requirements	MQ-5 sensor, Display module, Wires
Status	Pass

(TABLE # 5.4.6: LPG)

Test Case for Fetching Outdoor Pollutant Levels Via API	
Test Engineer	Hassan
Test Case ID	TC-07
Input Specifications	API endpoints for CO, NO2, O3, SO2, PM2.5, PM10
Expected Output	Correct pollutant levels fetched and displayed
Actual Output	Correct pollutant levels fetched and displayed
Requirements	API access, Display module, Network connectivity
Status	Pass

(TABLE # 5.4.7: Outdoor Pollutants)

Test Case for Machine Learning Model Accuracy	
Test Engineer	Hassan
Test Case ID	TC-08
Input Specifications	Historical outdoor environment data
Expected Output	Accurate predictions for outdoor environment conditions
Actual Output	Better predictions for outdoor environment conditions
Requirements	Historical data, Machine learning model, Processing unit
Status	Pass

(TABLE # 5.4.8: Machine Learning Model)

Test Case for Outdoor Data Forecasting	
Test Engineer	Hassan
Test Case ID	TC-09
Input Specifications	API endpoints providing outdoor environment data
Expected Output	Accurate 7-day forecasts for outdoor parameters
Actual Output	Better forecasting results for outdoor environment conditions
Requirements	API access, Network connectivity, Display module
Status	Pass

(TABLE # 5.4.9: Outdoor Data Forecasting)

Test Case for Displaying Indoor Parameters	
Test Engineer	Meerab
Test Case ID	TC-10
Input Specifications	Sensor data for indoor parameters
Expected Output	Accurate display of all indoor parameters
Actual Output	Accurate display of all indoor parameters
Requirements	Sensors, Display module, Wires
Status	Pass

(TABLE # 5.4.10: Indoor Parameters)

Test Case for Displaying Outdoor Parameters	
Test Engineer	Meerab
Test Case ID	TC-11
Input Specifications	API data for outdoor parameters
Expected Output	Accurate display of all outdoor parameters
Actual Output	Accurate display of all outdoor parameters
Requirements	API access, Display module, Network connectivity
Status	Pass

(TABLE # 5.4.11: Outdoor Parameters)

Test Case for Detailed View Display	
Test Engineer	Meerab
Test Case ID	TC-12
Input Specifications	Sensor and API data for detailed view
Expected Output	Detailed and accurate parameter ranges displayed
Actual Output	Detailed and accurate parameter ranges displayed
Requirements	Sensors, API access, Display module
Status	Pass

(TABLE # 5.4.12: View Display)

Test Case for 7-Day Forecast Display	
Test Engineer	Meerab
Test Case ID	TC-13
Input Specifications	Accurate predictions from ML model
Expected Output	Accurate 7-day forecast displayed
Actual Output	Accurate 7-day forecast displayed
Requirements	API access, Display module, Network connectivity, ML model prediction
Status	Pass

(TABLE # 5.4.13: Forecast Display)

Test Case for Alerts	
Test Engineer	Meerab
Test Case ID	TC-14
Input Specifications	data exceeding thresholds
Expected Output	Timely and accurate system alerts
Actual Output	Timely and accurate system alerts
Requirements	Alert mechanism, Notification system, User interface, Display module
Status	Pass

(TABLE # 5.4.14: Alerts)

5.5. Test procedure specification

5.5.1. Purpose
To specify the steps for executing a set of test cases or, more generally, the steps used to analyze a software item in order to evaluate a set of features.

5.5.2 Outline
A test procedure specification shall have the following structure:

a. Test procedure specification identifier
b. Purpose
c. Special requirements
d. Procedure steps

The sections shall be ordered in the specified sequence. Additional sections, if required, may be included at the end. If some or all of the content of a section is in another document, then a reference to that material may be listed in place of the corresponding content. The referenced material must be attached to the test procedure specification or available to users of the procedure specification.
Details on the content of each section are contained in the following sub clauses.

5.5.2.1. Test procedure specification identifier
Unique identifier for test procedure specification is TPS-001

5.5.2.2. Purpose
The purpose of the Test Procedure Specification (TPS) for the EnviroCast project is to provide detailed guidance on how to execute the test cases outlined in the project. This module outlines the step-by-step process for conducting each test case effectively, ensuring that testers understand their roles and responsibilities in executing the tests. The TPS serves as a comprehensive reference document for testers, guiding them through the entire testing process from test setup to result verification. By following the instructions provided in this module, testers can accurately and systematically execute the designated test cases (TC-01 to TC-14) and validate the functionality, performance, and reliability of the EnviroCast system.

5.5.2.3. Special requirements
Special Requirements for EnviroCast Test Procedure Specification:

- Verify accurate monitoring and forecasting of indoor and outdoor parameters.
- Test the system's ability to provide real-time insights and predictive analytics based on collected data.
- Validate the functionality of alerts and notifications for abnormal indoor environment conditions.
- Assess the accuracy of pollutant detection sensors.
- Verify the reliability of data transmission from sensors to the monitoring system.

- Test the system's responsiveness in updating environmental parameters based on changes.
- Evaluate the user interface for ease of use and clarity in presenting environmental data.
- Validate the system's ability to handle different indoor environments and variations in environmental conditions.
- Assess the system's performance under different loads and usage scenarios.
- Verify compatibility with various devices for accessing monitoring data.
- There must be present and accurate every physical module to follow this all procedure.
- There must be necessary to test the project as unit and integrating level, we have tested in both.
- Specialized skills of all group members and our teacher help to make the project effective manners.

5.5.2.4. Procedure steps

Include the steps in 8.5.2.4.1. through 8.5.2.4.10 as applicable.

5.5.2.4.1. Set up

System Initialization: Ensure all hardware components (sensors, servers, network devices) are powered on and functioning.
Software Deployment: Deploy the latest version of EnviroCast software on the testing environment.
Configuration: Configure the system to match the test environment specifications, including network settings and API endpoints.

5.5.2.4.2. Start

Start this Procedure by installing EnviroCast Application in Android. Execute initial test scripts to verify system readiness. Confirm that the test environment is correctly set up and that initial conditions are as expected.

5.5.2.4.3. Proceed

Test Execution: Follow the predefined test cases sequentially, executing each step as outlined in the test plan.

Real-Time Monitoring: Monitor system performance and functionality in real-time, noting any deviations from expected outcomes.

Incident Logging: Record any incidents or anomalies encountered during the test execution in the log.

5.5.2.4.4. Measure

Measurement is mostly based on the human observations. Human can judge the application are working in properly and measure key metrics such as response times, data accuracy, and system stability. We will Collect data at predefined intervals and after specific actions to ensure comprehensive measurement and Record performance metrics such as API response times, data transmission rates, and system throughput.

5.5.2.4.5. Shut down

Suspension Criteria: If an unscheduled event occurs (e.g., a critical system error), we must suspend testing by halting all ongoing test scripts.
Documentation: We will document the reason for suspension, the steps taken before suspension, and any relevant system state information.

5.5.2.4.6. Restart

Restart Points: Identify logical points in the test procedure where testing can be restarted without significant loss of progress.
Procedure for Restart: Follow the documented steps to restore the system to a known good state and resume testing from the identified restart point.
Verification: Verify that the system is stable and ready to continue testing after a restart.

5.5.2.4.7. Stop

We follow the planned steps to bring the test execution to an orderly halt. This includes completing any in-progress test cases and recording final system states. all results and incidents from the current test session will be logged.

5.5.2.4.8. Wrap up

Restoring the test environment to its original state, including resetting any configurations or data that were altered during testing. We will release any resources (hardware, software, network) that were allocated for testing and should check that all test log is written.

5.5.2.4.9. Contingencies

Anomalous Events: Document procedures for handling anomalous events such as unexpected system crashes, data corruption, or network failures.
Fallback Plans: Establish fallback plans to ensure that testing can continue or be rescheduled in the event of significant disruptions.

5.6. Test item transmittal report

5.6.1. Purpose

The purpose of this report is to identify the test items being transmitted for testing within the EnviroCast project. It includes the person responsible for each item, its physical

location, and its status. Any variations from the current item requirements and designs are noted in this report.

5.6.2. Outline

A test item transmittal report shall have the following structure:

a. Transmittal report identifier
b. Transmitted items
c. Location
d. Status
e. Approvals

The sections shall be ordered in the specified sequence. Additional sections may be included just prior to Approvals. If some or all of the content of a section is in another document, then a reference to that material may be listed in place of the corresponding content. The referenced material must be attached to the test item transmittal report or available to users of the transmittal report.
Details on the content of each section are contained in the following sub clauses.

5.6.2.1. Transmittal report identifier

The unique identifier assigned to this test item transmittal report is TRI- ESEMS-001.

5.6.2.2. Transmitted items

The EnviroCast application is transmitted to the targeted person for usage and testing purpose because testing is most important part of successful Project. All team Members are responsible for its transmittal and use.

5.6.2.3. Location

Arfa Kareem Department of University of Gujrat is used for test item of EnviroCast: Smart Environment Monitoring System and Student of university of Gujrat and other linked fellow have installed and used our application. This can be used by any sort of user either for home, offices or at workplaces etc. and can help to maintain a healthy environment.

5.6.2.4. Status

- The status of all compulsory items being transmitted is pass.
- All others test items are completely in working state and perform their task efficiently.
- The actual results are achieved and same with the desire results.
- All the requirements are achieved.

5.6.2.5. Approvals

Name: Dr. Abdur Rehman
Title: Project Supervisor

Signature: _____

5.7. Test log

5.7.1. Purpose

The purpose of this test log is to provide a chronological record of relevant details about the execution of tests for the EnviroCast project. This log will help track the progress of testing activities, capture any incidents or anomalies observed during testing, and document the results and status of each test case.

5.7.2. Outline

A test log shall have the following structure:

a. Test log identifier;
b. Description;
c. Activity and event entries.

The sections shall be ordered in the specified sequence. Additional sections may be included at the end. If some or all of the content of a section is in another document, then a reference to that material may be listed in place of the corresponding content. The referenced material must be attached to the test log or available to users of the log. Details on the content of each section are contained in the following sub clauses.

5.7.2.1. Test log identifier

The unique identifier assigned to this test log is TLI- ESEMS-001.

5.7.2.2. Description

The test log for the EnviroCast project documents the execution of tests for monitoring indoor and outdoor environmental parameters. Items tested include the software system, sensors, APIs, and machine learning models. Each item is identified by its version/revision level, with references to corresponding transmittal reports.

5.7.2.3. Activity and event entries

Test Case	Test ID	Status	Event Entries	
			Start Date	End Date
Monitoring Indoor Temperature	TC-01	PASS	24-04-2024	25-04-2024
Monitoring Indoor Humidity	TC-02	PASS	26-04-2024	27-04-2024
Monitoring Indoor Dust	TC-03	PASS	28-04-2024	29-04-2024
Monitoring Indoor Smoke, NH3 & CO2	TC-04	PASS	30-04-2024	2-05-2024
Monitoring Indoor CO	TC-05	PASS	3-05-2024	4-05-2024
Monitoring Indoor LPG	TC-06	PASS	4-05-2024	5-05-2024

Fetching Outdoor Pollutant Levels Via API	TC-07	PASS	6-05-2024	9-05-2024
Machine Learning Model Accuracy	TC-08	PASS	10-05-2024	15-05-2024
Outdoor Data Forecasting	TC-09	PASS	15-05-2024	20-05-2024
Displaying Indoor Parameters	TC-10	PASS	20-05-2024	23-05-2024
Displaying Outdoor Parameters	TC-11	PASS	24-05-2024	27-05-2024
Detailed View Display	TC-12	PASS	28-05-2024	05-06-2024
7-Day Forecast Display	TC-13	PASS	05-06-2024	15-06-2024
Alerts	TC-14	PASS	15-06-2024	20-06-2024

(TABLE # 5.7.1: Activity and event entries)

5.7.2.3.1. Execution description

The group members are listed above perform all the test. There are also listed status and Test-ID and date duration. This testing can be done within 3-4 weeks Dr. Abdur Rehman is the Supervisor of our EnviroCast: Smart Environment Monitoring system. He supervised the whole testing process of the Project.

5.7.2.3.2. Anomalous events

Before the unexpected event, the system requested an outdoor data update from the API, which usually takes 2 seconds. However, the response took an unusually long 15 seconds. Repeating the request resulted in a delay. There were some errors and wrong prediction related to forecasting. But these were solve by some modification.

5.8. Test incident report

5.8.1. Purpose

To document any event that occurs during the testing process that requires investigation.

5.8.2. Outline

A test incident report shall have the following structure:

a. Test incident report identifier
b. Summary
c. Incident description
d. Impact

The sections shall be ordered in the specified sequence. Additional sections may be included at the end. If some or all the content of a section is in another document, then a

reference to that material may be listed in place of the corresponding content. The referenced material must be attached to the test incident report or available to users of the incident report.
Details on the content of each section are contained in the following sub clauses.

5.8.2.1. Test incident report identifier
The unique identifier assigned to this test incident report TI- ESEMS-001.

5.8.2.2. Summary
Several incidents were recorded during the testing of the EnviroCast system. The primary issues involved delays in API response times and network communication failures. Specifically, the system experienced prolonged response times (15 seconds instead of the usual 2 seconds) when updating outdoor data from the API. Additionally, a network issue prevented API communication during the initiation of a test procedure, and a power failure disrupted a sensor calibration test.

5.8.2.3. Incident description

Inputs	API request to retrieve outdoor air quality data.
Expected results	Response from the API with updated outdoor air quality data within 2 seconds.
Actual results	Response from the API was delayed, taking 15 seconds to retrieve data.
Anomalies	Unusually long response time from the API.
Date and time	6-05-2024
Environment	Testing environment included a stable internet connection and the latest version of the EnviroCast system
Attempts to repeat	Issue was repeated three times, with the same prolonged response time observed.
Testers	1
Observers	3

(TABLE # 5.8.1: Incident description)

5.8.2.4. Impact
Potential delays and dissatisfaction due to inability to display data timely and correctly.

5.9. Test summary report

5.9.1. Purpose
To summarize the results of the designated testing activities and to provide evaluations based on these results.

5.9.2. Outline
A test summary report shall have the following structure:

a. Test summary report identifier
b. Summary
c. Variances
d. Comprehensive assessment
e. Summary of results
f. Evaluation
g. Summary of activities
h. Approvals

The sections shall be ordered in the specified sequence. Additional sections may be included just prior to Approvals. If some or all of the content of a section is in another document, then a reference to that material may be listed in place of the corresponding content. The referenced material must be attached to the test summary report or available to users of the summary report.
Details on the content of each section are contained in the following sub clauses.

5.9.2.1. Test summary report identifier
The unique identifier assigned to this test summary report is TSR- ESEMS-001.

5.9.2.2. Summary of results
fourteen test cases were designed to be carried out during testing. All of them carried out successfully and the actual result received matched with the expected result, therefore, all of them declared as pass.

5.9.2.3. Evaluation
The process to carry out the testing was simple, and we received the results as we expected them to be like. The thing we have concluded from testing our system is that if the user follows the user manual provided, then they can work through the system without having to deal with issues.

5.9.2.4. Summary of activities
The items listed under 5.2.2.3 Test Items tested against the features listed under 5.2.2.4. Features to be tested. The duration spent on the testing activities is given below.

Activities	Members	Immediate Predecessor
Test planning & specification	Meerab, Hassan, Sheraz	3

Perform Testing	Meerab, Hassan, Sheraz	5
Test Report	Meerab, Hassan, Sheraz	4
Test Delivery	Meerab, Hassan, Sheraz	3
Defect Verification and Regression Testing	Meerab, Hassan, Sheraz	4

(TABLE # 5.9.1: Schedule Table)

5.9.2.5. Approvals

Name: Dr. Abdur Rehman
Title: Project Supervisor

Signature: _____

Chapter 7: Results

The implementation of the EnviroCast project has yielded significant results in the monitoring and forecasting of indoor and outdoor environmental conditions. Key outcomes include:

Accurate Real-Time Monitoring
EnviroCast successfully monitors real-time indoor parameters such as temperature, humidity, AQI, and dust particles using advanced sensors. The system provides continuous and accurate data, allowing users to maintain optimal indoor air quality and comfort.

Reliable Predictive Analytics
Leveraging machine learning algorithms, EnviroCast offers reliable predictive analytics for outdoor environments. Users receive forecasts for the next 7 days, enabling proactive management of air quality and environmental conditions.

Comprehensive Data Visualization
The EnviroCast mobile application, developed using the Flutter framework, presents data in an intuitive and user-friendly manner. Users can easily access detailed information on current conditions, historical trends, and future forecasts.

Improved User Awareness and Health
By providing actionable insights into air quality, EnviroCast empowers users to take necessary measures to improve indoor air quality. This leads to enhanced health and well-being, particularly for individuals with respiratory issues or sensitivities to pollutants.

Enhanced Environmental Control
Facility managers, homeowners, and public space administrators can utilize EnviroCast to ensure optimal environmental conditions, leading to increased comfort, productivity, and compliance with health regulations.

Cost-Effective Solution
EnviroCast demonstrates economic feasibility by providing a cost-effective solution for air quality monitoring and forecasting. The system's initial investment is justified by the tangible and intangible benefits, including health improvements, regulatory compliance, and potential energy savings.

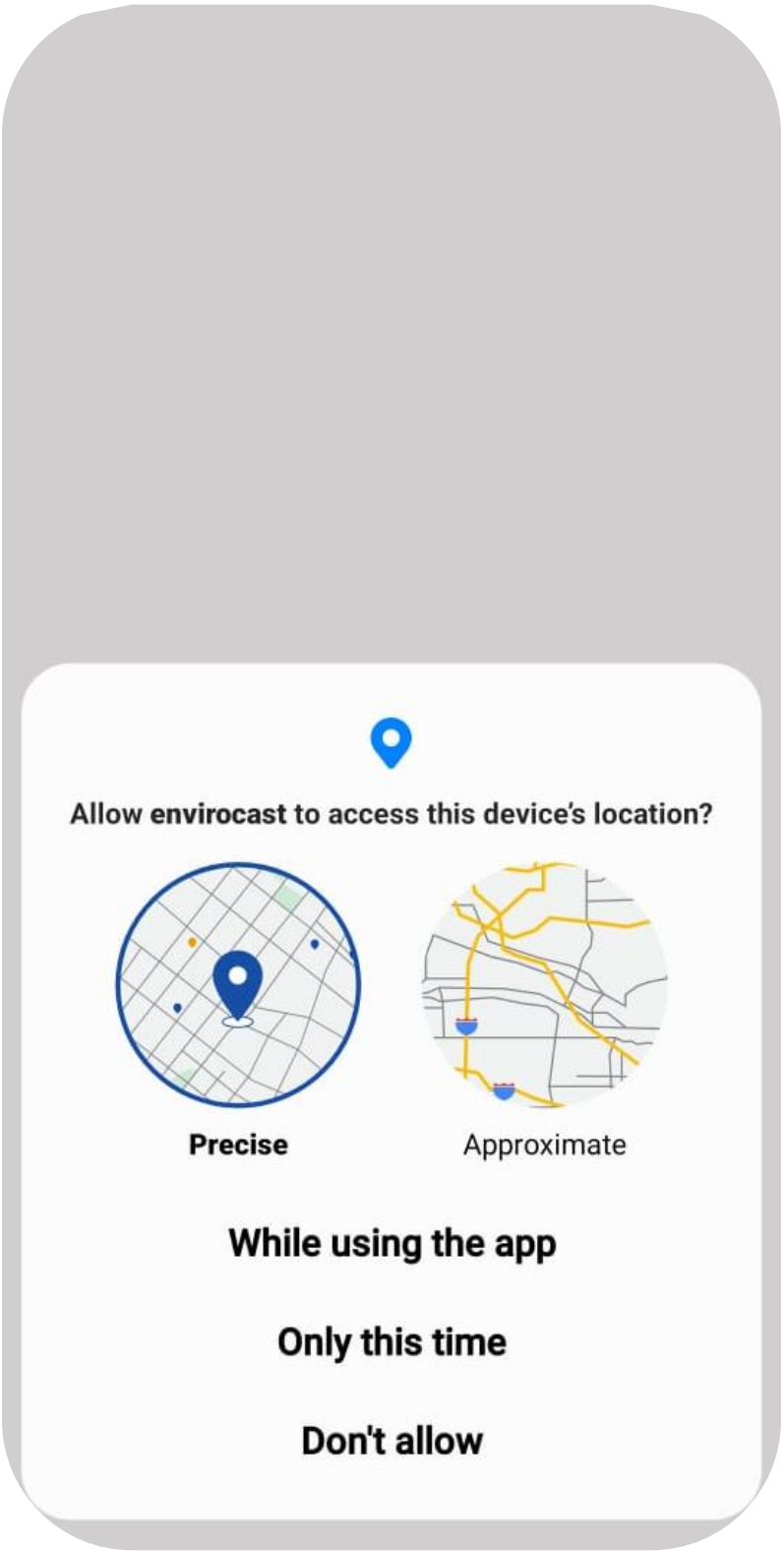
User Satisfaction: High user satisfaction based on feedback and user surveys, indicating that the system meets or exceeds user expectations.

Documentation & Testing Results: Comprehensive documentation, including user manuals, technical documentation, and test reports. Detailed test reports that outline test cases, test execution results, and any identified defects or issues.

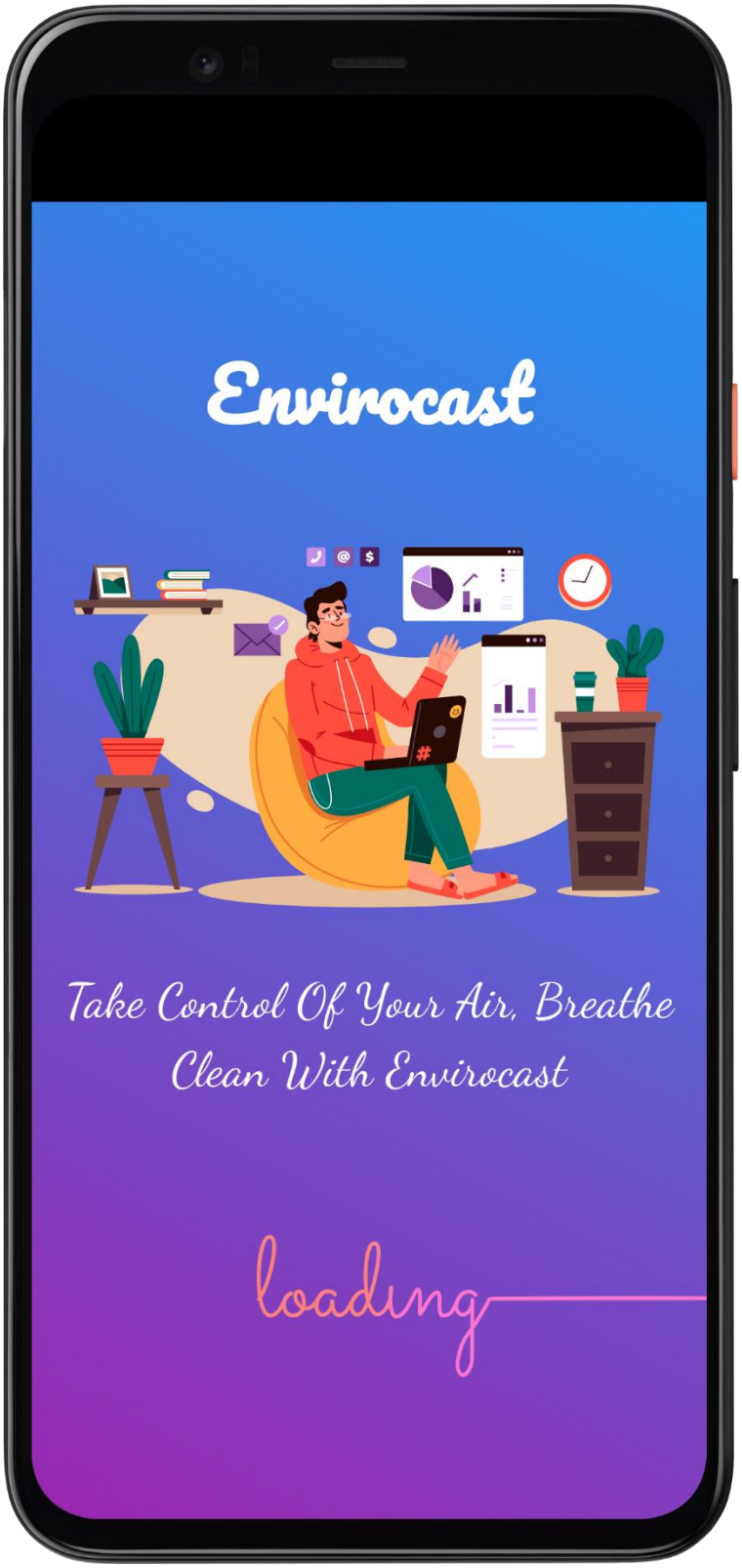
Overall, the EnviroCast project has proven to be a valuable tool in managing indoor and outdoor air quality, contributing to healthier living, and working environments.

Chapter 8: User Manual

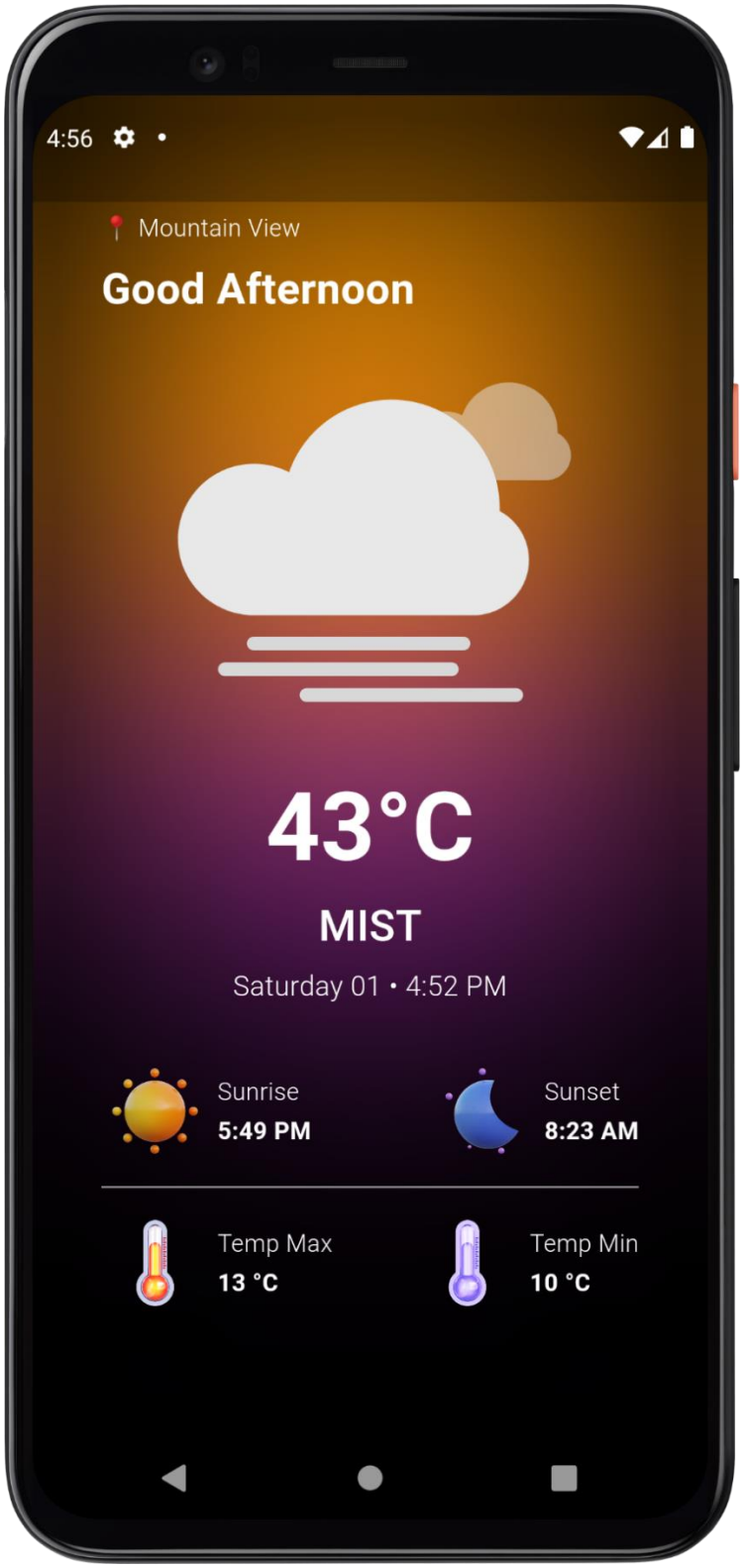
After installing the app provide location permission to proceed



Wait until the app is loaded completely.

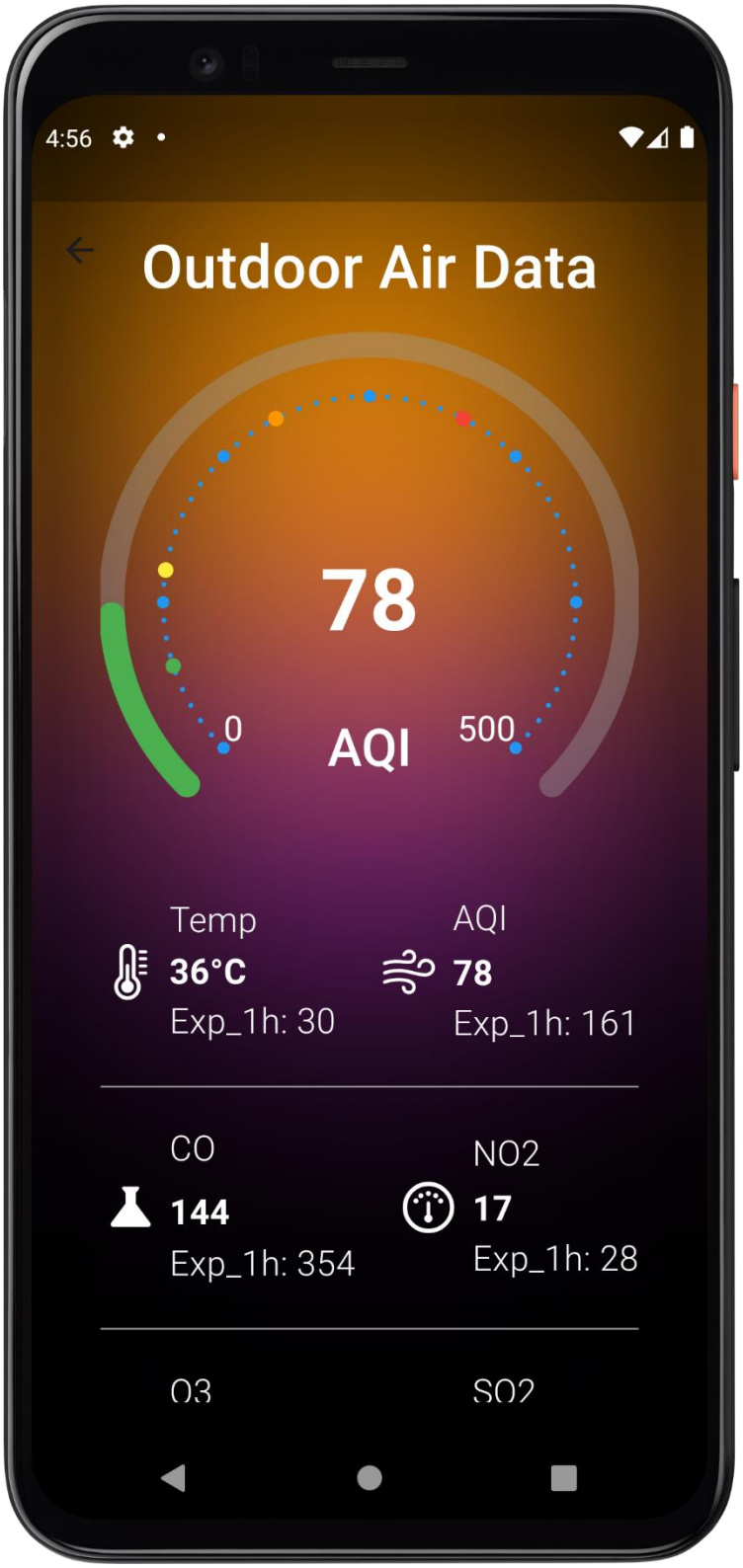


Home Screen it contains the information about weather.

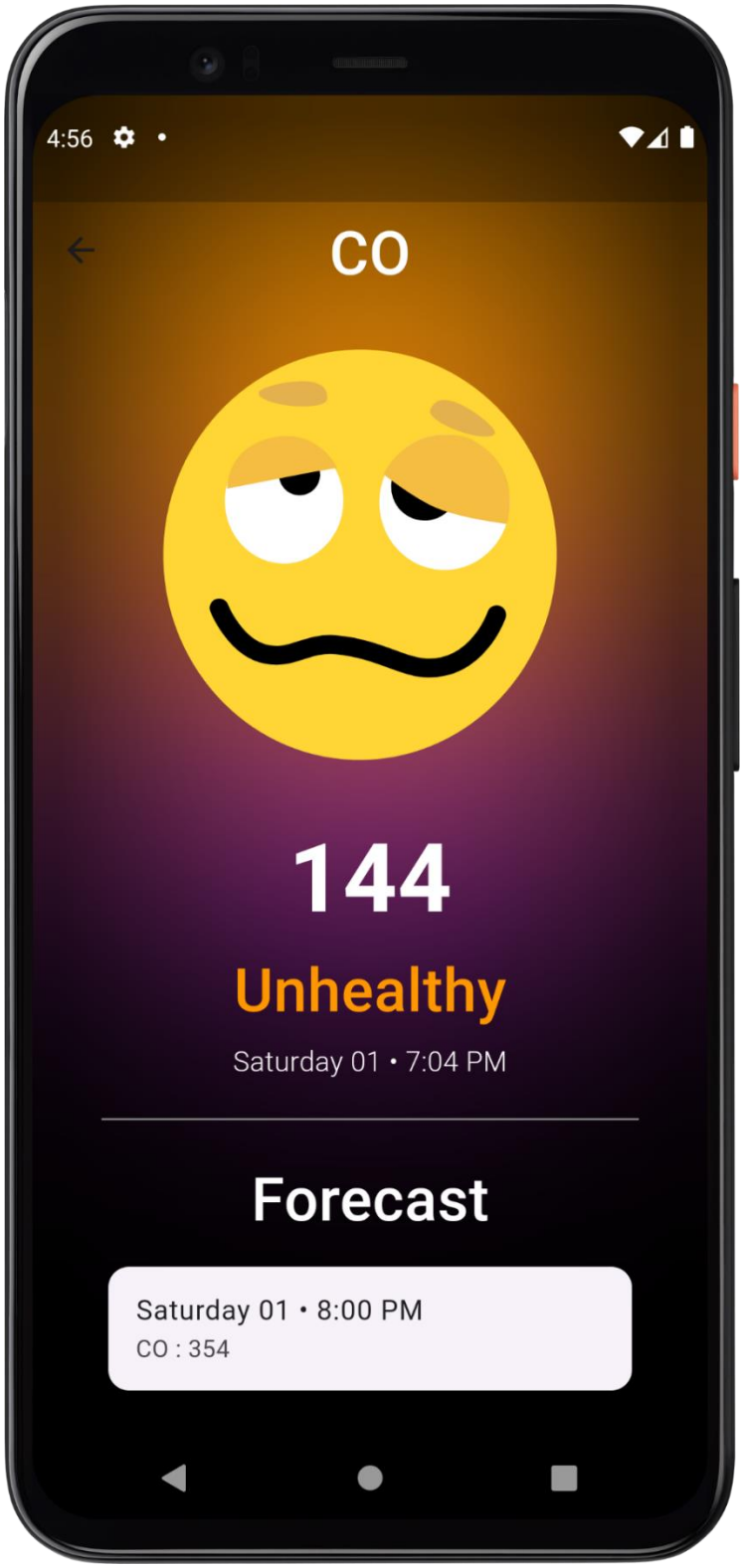


Indoor screen represents the data that is collected from sensors i-e indoor data

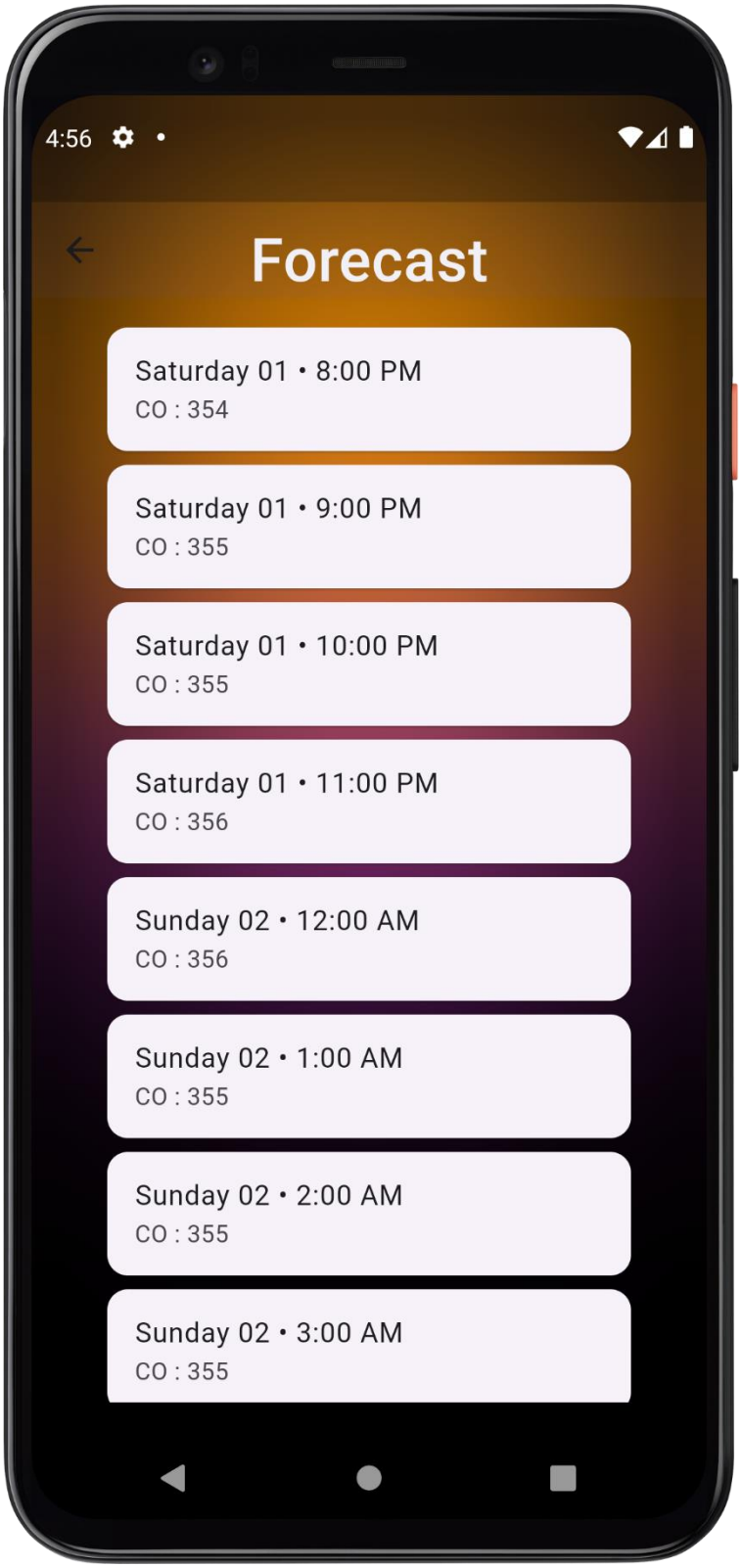
Outdoor screen represents the outdoor data.



Detail screen represents the detail about indoor and outdoor parameters



Forecast screen represents the forecast data



Chapter 9: Conclusion and Future Work

Conclusion

The EnviroCast project has successfully developed a comprehensive system for monitoring and forecasting indoor and outdoor environmental conditions. By integrating cutting-edge sensor technology, machine learning, and a user-friendly mobile application, EnviroCast provides accurate real-time data and predictive analytics for key parameters such as temperature, humidity, AQI, and various pollutants.

The system has demonstrated its ability to significantly improve indoor air quality management, enhancing health and well-being for users. It has proven to be both technically and economically feasible, offering a cost-effective solution with tangible and intangible benefits. The seamless integration with existing infrastructure and high user satisfaction underscores its practical applicability and value.

Overall, EnviroCast represents a robust, innovative approach to environmental monitoring, empowering users to make informed decisions for healthier and more comfortable living and working spaces. The project sets a strong foundation for future enhancements and broader applications, positioning itself as a critical tool in the ongoing effort to address air quality challenges.

Future Work

While the EnviroCast system has demonstrated significant success, several avenues for future work could enhance its functionality and broaden its applications:

Advanced Machine Learning Models

Future iterations of EnviroCast can integrate more sophisticated machine learning models to improve predictive accuracy for both indoor and outdoor parameters. This includes utilizing deep learning techniques and incorporating more extensive datasets for better forecasting capabilities.

Expanded Sensor Integration

Incorporating additional sensors to monitor more environmental parameters, such as volatile organic compounds (VOCs), radon, and noise pollution, could provide a more comprehensive overview of indoor air quality. Enhanced sensor technology can also improve data accuracy and reliability.

Real-Time Response Systems

Developing automated response systems that can adjust HVAC settings, activate air purifiers, or alert users to take specific actions based on real-time data can further enhance the system's utility. Integration with smart home devices and IoT ecosystems can provide seamless environmental control.

User Customization and Alerts

Enhancing the user interface to allow for greater customization, such as setting personalized thresholds for different parameters and receiving tailored alerts, can improve user engagement and satisfaction. Adding features for health risk assessments based on individual health profiles can offer more personalized insights.

Geographic Expansion
Expanding the geographic scope of EnviroCast to include more diverse outdoor environments and weather conditions can make the system applicable to a broader range of users. Collaborations with local environmental agencies can help in adapting the system to specific regional needs.

Longitudinal Health Studies
Conducting long-term studies to assess the impact of improved air quality on health outcomes can provide valuable data to support the benefits of using EnviroCast. Partnerships with health institutions and research organizations can facilitate these studies.

Enhanced Data Security
Implementing advanced data encryption and security measures to protect user data is crucial as the system collects and processes sensitive information. Ensuring compliance with data protection regulations can enhance user trust and adoption.

Community and Educational Outreach
Developing educational programs and resources to raise awareness about the importance of air quality can drive broader adoption of EnviroCast. Community outreach initiatives can involve schools, workplaces, and public spaces to promote healthier environments.

By focusing on these future work areas, EnviroCast can continue to evolve and provide even greater value to its users, contributing to healthier and more sustainable living environments.