Sri Lanka Institute of Information Technology

ECO Smart BIN

Software Requirement Specification

Professional Engineering Practice and Industrial Management - IE2090

Project ID: PEP_18

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1. Introduction

1.1 Purpose

The main aim of this project is to give a solution to the issue of neglecting the task of checking the garbage bins. We aim to alleviate the burden on individuals by providing a convenient and automated solution to waste management by integrating IOT with the dustbins.
With the implementation of an IoT-based smart bin system, we plan to revolutionize existing waste management practices. Live monitoring of bin fill levels and detection of any harmful gases, along with solar powered charging, will be achieved using this system. In addition to that, automatic alerts/notifications will call for immediate appropriate measures to alleviate possible risks, such as full bins, unpleasant smells, and other adverse environmental impacts.
Our aim is not only to provide a short-term solution that addresses the immediate issues in the waste management system, but also to provide long term benefits such as environment sustainability and user convenience.

1.2 Document Conventions

- The Document follows IEEE standards for software requirement standards.
- All the topics are bold.
- The main topic is using the Times New Roman font with the font size 18.
- The subtopics are using the Times New Roman font with the font size 14.
- The paragraphs are using the Times New Roam font with the font size 12.
- All the topics are numbered.

1.3 Intended Audience and Reading Suggestions

This project is a prototype for an efficient waste management system using IOT based smart bins. This will be implemented with the guidance of the local municipal council. The project will be valuable for individuals for domestic usage, to companies, the municipal council workers and the technical staff.

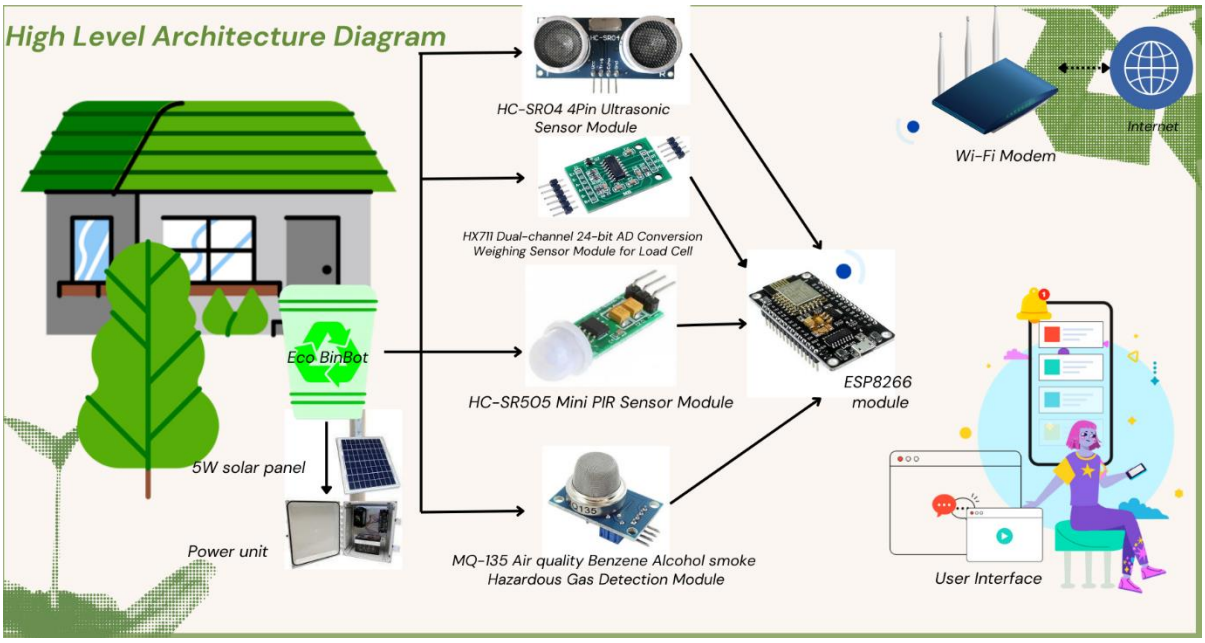
1.4 Product Scope

The Eco Bin Bot's main objective is to keep the environment clean by notifying the municipal council when the garbage bin has reached a level which needs to be collected. The bin is equipped with a set of sensors to monitor variables like the weight, air quality and the fill level of the garbage bin.

This bin can be used by individual homeowners, companies or the municipal council.

Our initial plan is to create a product that can be used in an industrial site, where they can automate the garbage collection system by integrating the bin with the municipal council.

Below diagram represents the high-level architecture diagram of our system



1.5 References

[1] Gov.in. [Online]. Available: https://www.nielit.gov.in/gorakhpur/sites/default/files/Gorakhpur/alevel_iot_13april20_SM.pdf [Accessed: 20-Apr-2024].

[2] e19-3yp-Smart-Waste-Management-System: Smart Waste Management System that aims to make the process of waste collection more efficient. The system utilizes waste bins and manages them through mobile and web applications. With the help of the system, users can easily check the status of the bins and follow a schedule for waste collection based on the bin's status. .

[3] Arduino, "Arduino trash Bin with waste level detection," 12-Feb-2023. [Online]. Available: https://www.youtube.com/watch?v=ZP0wLe3jIXk. [Accessed: 20-Apr-2024].

[4] MYBOTIC, "DIY Smart Contactless IOT Dustbin With Notification using ESP32 and Blynk 2.0," 21-Oct-2021. [Online]. Available: https://www.youtube.com/watch?v=aIUDZkVQ0YE [Accessed: 20-Apr-2024].

[5] Wheelie Bin Solutions, "What is a smart bin and how does it work?," Wheelie Bin Solutions. [Online]. Available: https://wheeliebinsolutions.co.uk/blogs/advice/what-is-a-smart-bin-and-how-does-it-work [Accessed: 20-Apr-2024].

[6] mybotic, "How to build a ESP8266 Web Server," Instructables, 29-Jul-2016. [Online]. Available: https://www.instructables.com/How-to-Build-a-ESP8266-Web-Server/. [Accessed: 20-Apr-2024].

2. Overall Description

2.1 Product Perspective

- The Eco Bin Bot is introduced as a novel solution in the domain of waste management and environmental sustainability. Unlike traditional waste disposal methods, which often rely on manual intervention and lack real-time monitoring capabilities, our smart bin system represents a new, self-contained product poised to revolutionize the way we handle waste.
- This will not be a replacement for the existing waste management system but rather a new addition to the domain of waste management system by introducing an IoT based solution with automation capabilities.
- Our product will communicate with the end users via user-friendly interfaces, giving them access to real-time data and control over how they dispose of their trash. This product can be implemented in both household and metropolitan areas by configuring the Eco bin to run local private networks or using a single control center capable of handling multiple eco bins simultaneously via a vastly distributed WAN. This control center visualizes real-time data from the sensors and implements control methods if an unwanted situation occurs.

2.2 Product Functions

- Check the waste level constantly
- Check for Toxic gases
- Charging the system using solar Pannels (ECO friendly).
- Provide human friendly interface to visualize and control the system.

2.3 User Classes and Characteristics

- For our product we have anticipated multiple user classes with unique requirements for each and their characteristics respectively:

    1. Residential Users
        - Characteristics:
            - Household
            - Local Area Network (LAN)
            - No remote access
            - Data encryption
    2. Commercial Users
        - Characteristics:
            - Intranet (same as LAN, but have more functionalities)
            - No remote access
            - Data encryption
    3. Municipal Council Waste Management Authority (oublic users)
        - Characteristics
            - WAN
            - Remote access capability each individual bins
            - Secured (Prevent from Potential Data breaches)
            - Data encryption

2.4 Operating Environment

- The Eco bin is specifically engineered for outdoor environments. The Eco bin stands equipped with solar panels, diligently replenishing its battery and reserving excess power. Engineered to withstand diverse weather conditions, it boasts a robust design. Leveraging Wi-Fi connectivity, it establishes seamless communication with nearby access points, enabling swift data transmission and responsive control mechanisms.

2.5 Design and Implementation Constraints

- As developers, we need to navigate various constraints that shape our options throughout the development process. These constraints encompass corporate or regulatory policies that set the boundaries for our software development practices. Moreover, hardware limitations, such as timing or memory requirements, can influence our technology choices and tool selection.

- We must also consider interfaces to other applications, which may impose compatibility requirements or necessitate specific integration methods. Similarly, the technologies, tools, and databases we use may be predefined by project specifications or organizational standards.

- Parallel operations add another layer of complexity, requiring careful coordination to ensure smooth execution. Language requirements may steer us towards programming languages or frameworks, while communications protocols set standards for data exchange between components

- Security considerations are paramount in our development efforts, guiding decisions around data protection, access control, and encryption practices. Additionally, adhering to design conventions and programming standards, especially if the customer's organization will maintain the software, shapes our development approach and coding practices.

2.6 Project Documentation

- Introduction:
  - Brief description of the project's purpose and objectives, focusing on creating a small eco-friendly smart bin.
  - Contextual information about the problem domain, emphasizing the need for efficient waste management solutions.
  - Defines the boundaries of the software, including its features and limitations.

- Requirements Documentation:
  - A Software Requirements Specification (SRS) document outlines the functional and non-functional requirements of the software component of this project, detailing what the software should do and how it should behave.
  - It serves as a formal agreement between the client and the development team, providing a clear understanding of the project scope and objectives.
  - The SRS document guides the development process by defining the system's features, interactions, and quality attributes.

- Design and Implementation Documentation:
  - Provides an overview of the system's structure and components, highlighting key design decisions.
  - Specifies the design specifications for each module or component, ensuring clarity in implementation.
  - Presents wireframes or mockups showcasing the user interface design for ease of use.
  - Lists external libraries and third-party libraries used in the project.

2.7 User Documentation

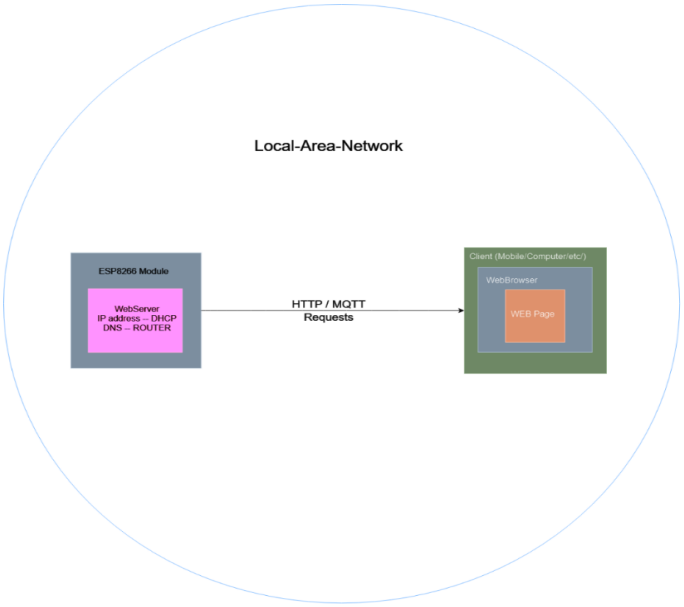
The user documentation is used to help the users and technical staff to gain a better understanding of the product's mechanisms and how to use it efficiently.

- User Manual: The user manual will guide the users on how to use the device properly with step-by-step guide. It also consists of a brief explanation on how the components work.

2.8 Assumptions and Dependencies

- Dependencies on third-party libraries or commercial software components may impact functionality, integration, or licensing considerations.
- Assumptions about the development environment, such as available tools, frameworks, or development platforms, could influence implementation choices and timelines.
- Factors like target operating systems, hardware configurations, or network infrastructure assumptions may affect the software's compatibility and performance.
- Assumptions about regulatory requirements or industry standards may introduce constraints on features or data handling practices.
- Assumptions about the third-party dependencies related code safety and bugs in the tools.

3. External Interface Requirements



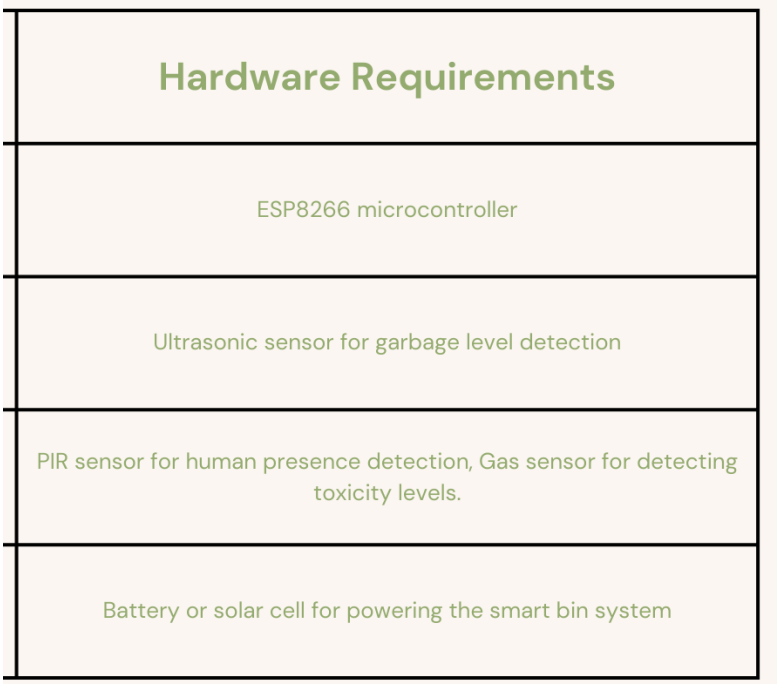
3.1 User Interfaces

- Our Eco Bin Bot smart bin has two real time data monitoring user interfaces. One is the web browser user interface, and the other is the LCD screen built on the lid of the bin.
- The first interface is a web browser-based UI, which allows users to remotely monitor the smart bin's functions from any device with internet access. This could include features such as viewing fill levels, displaying a warning message when the bin needs to be emptied, display a warning message if harmful gas levels are higher than 80%, displaying when the max weight threshold is surpassed, and for waste management optimization
- The second interface is an LCD screen integrated into the lid of the bin itself, providing on-site interaction with immediate feedback. This screen is likely to display real-time information about the bin's status, such as its current fill level, charge level of the battery, identifying the harmful gases in the bin and IP address of the web server using buttons built on to the screen.

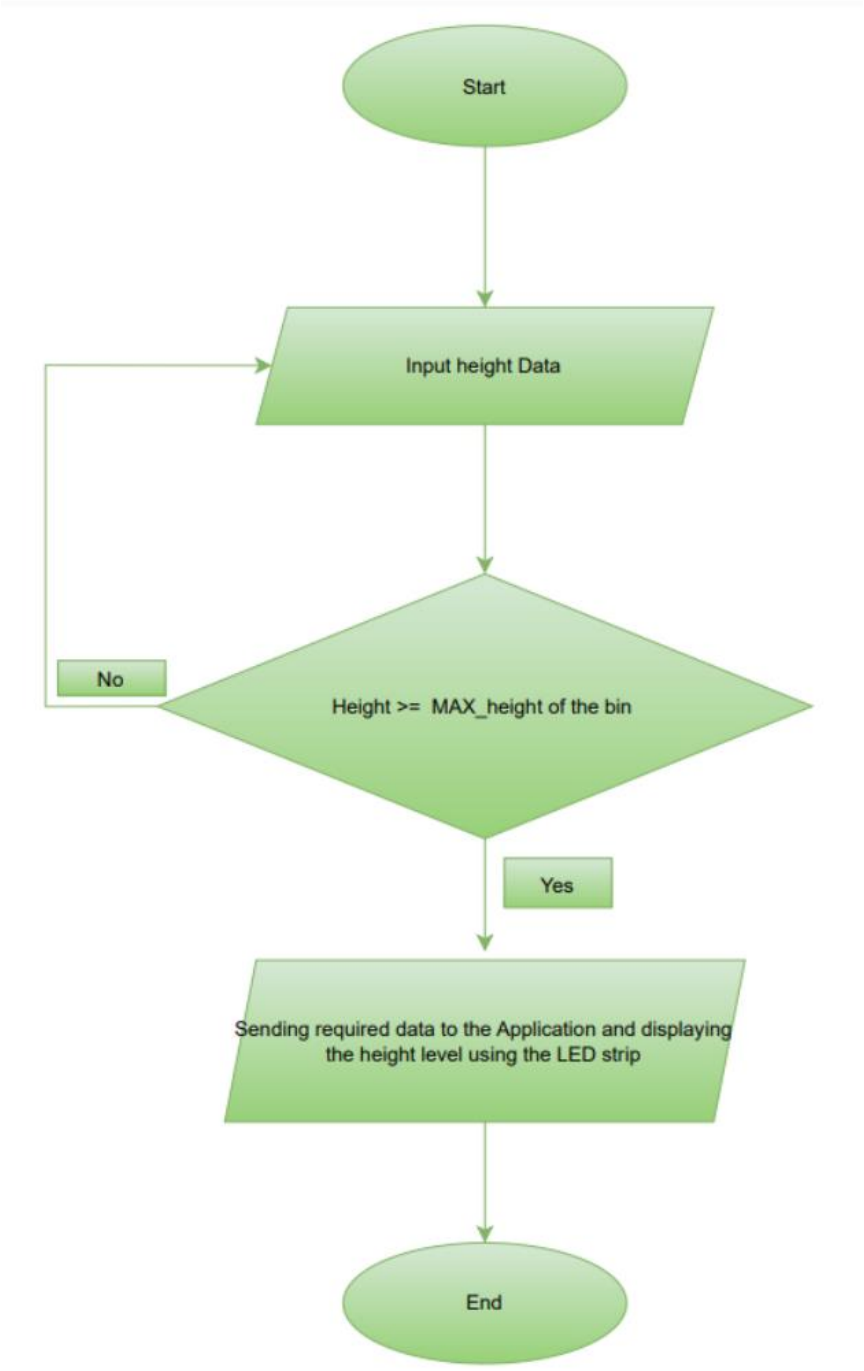
3.2 Hardware Interfaces

- ESP8266 allows the Eco BinBot to interact with its environment through sensors and actuaries, process this information, and communicate wirelessly with the network, all of which are essential for the smart functionalities of the bin.
- It allows Wi-fi connectivity by acting as an access point, microcontroller functions such as read data from the sensors and control actuators, data processing by interpreting sensor readings, remote monitoring from a remote user interface, power efficiency by conserving energy through distributing power among the sensors efficiently, simple integration with MQTT protocol.

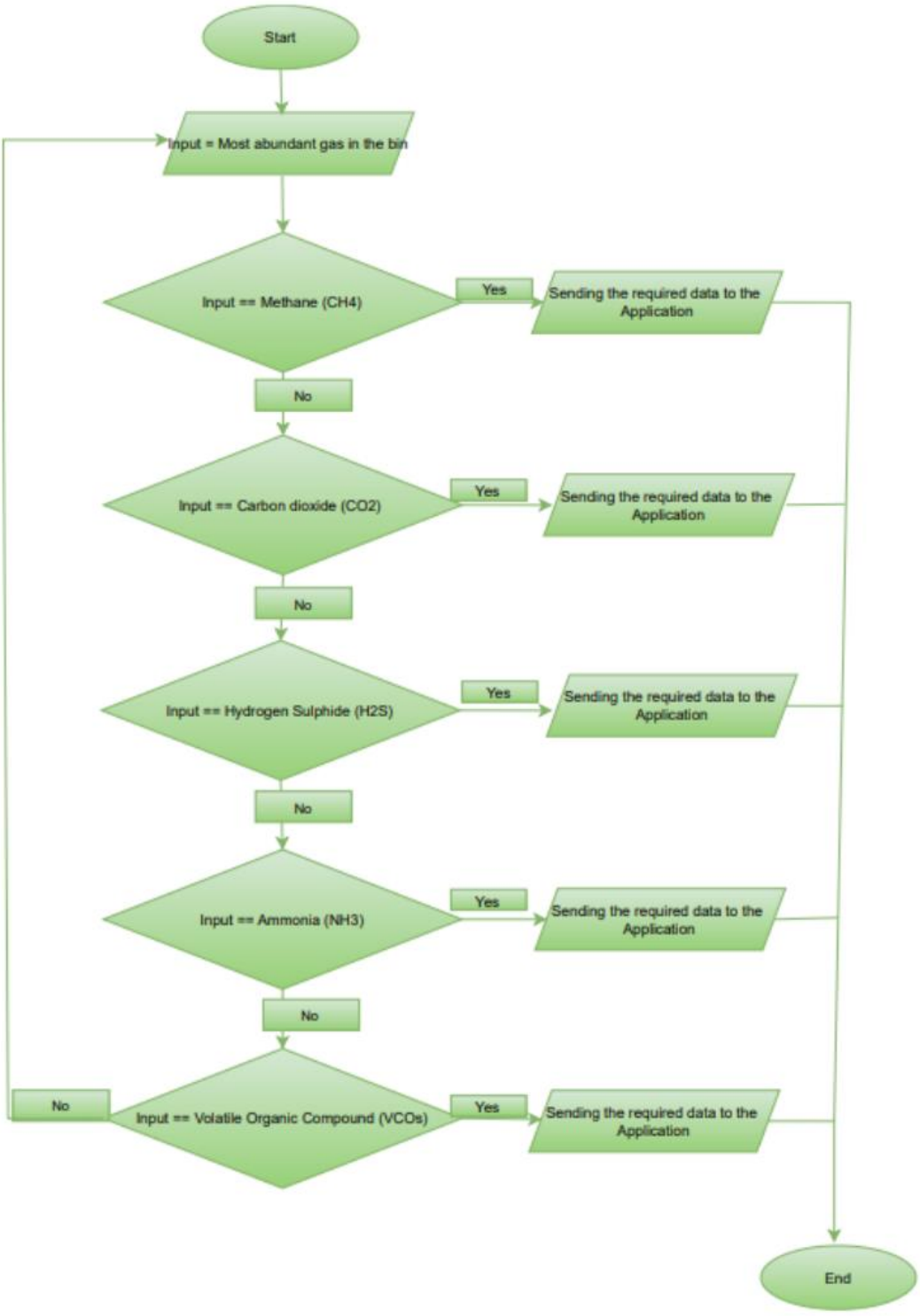
- Below are the flow charts that are used to program the ESP module to process the data gathered via the respective sensors.



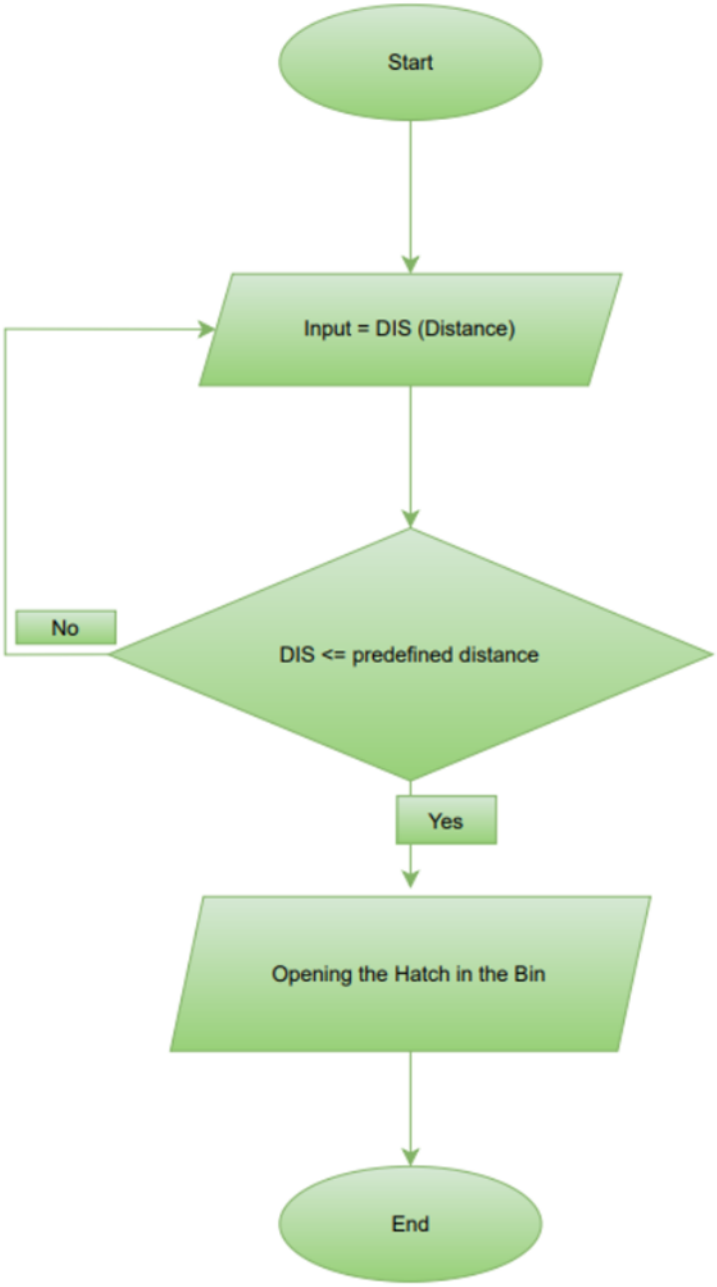
- Sonar sensor



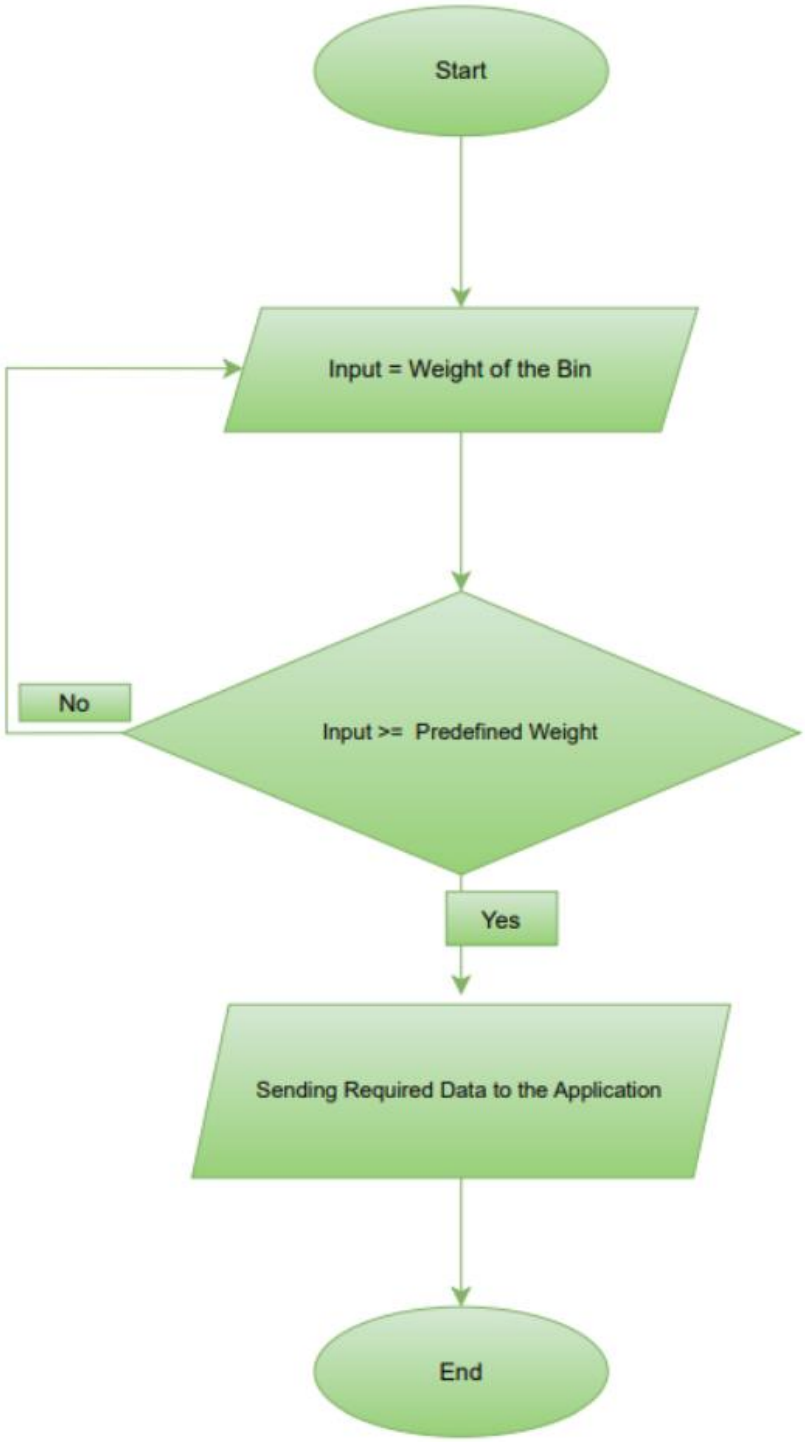
- Gas sensor


Start
Input = Most abundant gas in the bin
Input == Methane (CH4)
Yes
Sending the required data to the Application
No
Input == Carbon dioxide (CO2)
Yes
Sending the required data to the Application
No
Input == Hydrogen Sulphide (H2S)
Yes
Sending the required data to the Application
No
Input == Ammonia (NH3)
Yes
Sending the required data to the Application
No
No
Input == Volatile Organic Compound (VCOs)
Yes
Sending the required data to the Application
End

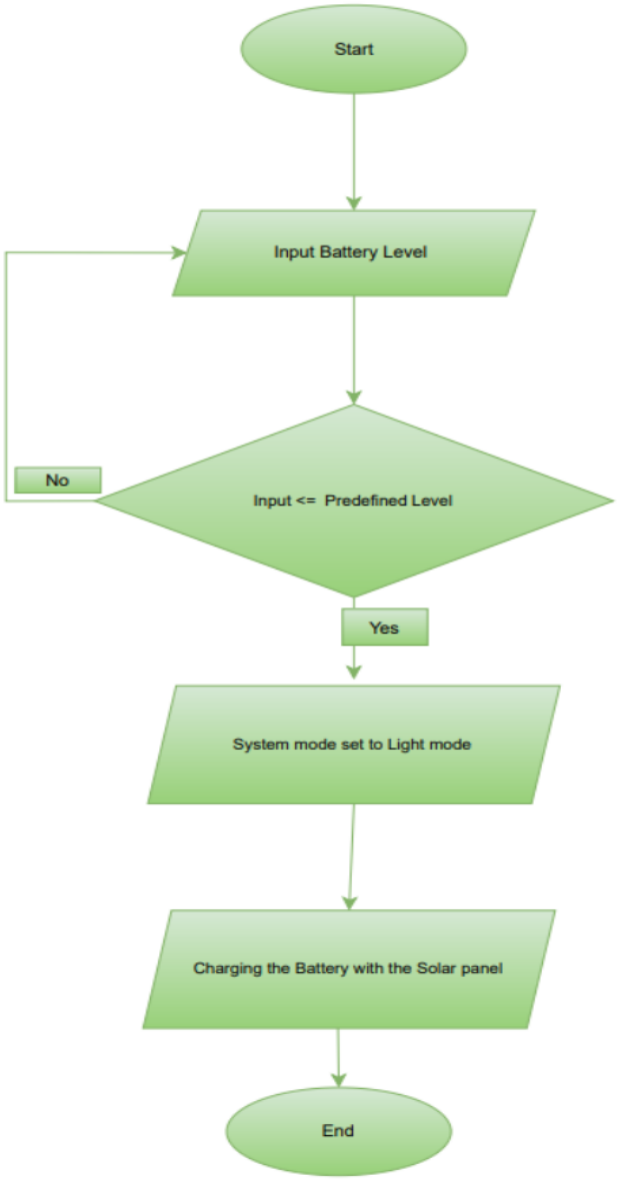
- PIR


Start
Input = DIS (Distance)
No
DIS <= predefined distance
Yes
Opening the Hatch in the Bin
End

- Weight sensor

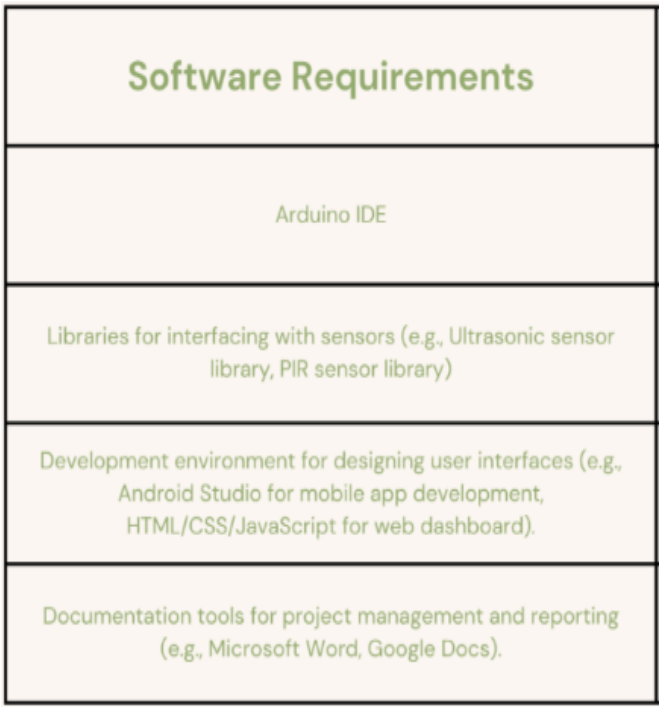


- Charging unit



3.3 Software Interfaces

- Atmel Studio - Version 7.0, programming language is C , to program the ESP8266
- Visual Studio code – Version 17.9, programming language is html, to program the web browser



3.4 Communications Interfaces

- MQTT protocol is used in our system for real time communication between ESP8266 module and the remote device and for data encryption.

4. System Features

4.1 System Feature 1

F1	Automatic bin opening
Input	Positive sensor reading from PIR sensor
Process	If the output signal matches the specific range within the predefined distance, ESP module sends a signal to the actuator.
Output	Opening the bin lid
Definition	PIR - Passive Infrared ESP – Espressif Systems Processor

F2	Continuously monitoring the gas levels of the bin
Input	Sensor readings from the gas sensor
Process	The output signal is processed by the ESP module and transmitted to the web browser through the ESP web server
Output	Display a warning message if harmful gas levels are higher than 80%
Definition	ESP – Espressif Systems Processor

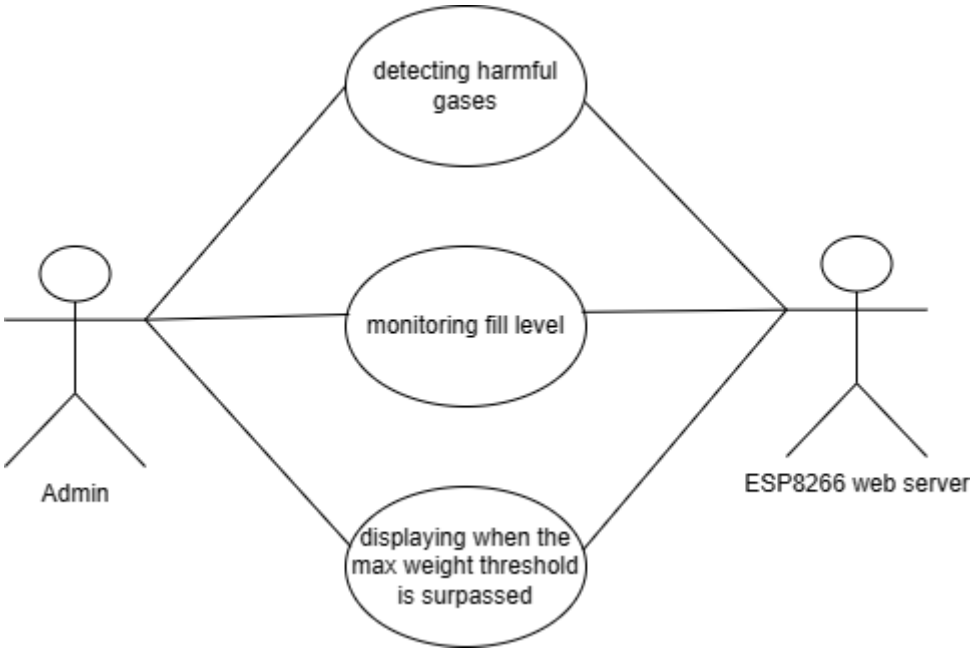
F3	Continuously monitoring the fill levels of the bin
Input	Sensor readings from the SONAR sensor
Process	SONAR sensor emits a pulse of ultrasonic wave, once it encounters an object it reflects the wave, and a receiver picks it up. Using the time interval between the sending and reception of the echo the distance is calculated. If it matches the predefined distances the ESP sends the data to the web browser through the server.
Output	Display whether the bin is empty, halfway full or full through the web browser and LEDs on the bin.
Definition	SONAR – Sound Navigation and Ranging ESP – Espressif Systems Processor

F4	Continuously monitoring the weight levels of the bin
Input	Sensor readings from the weight sensor
Process	Small electrical signal produced by the load cell is converted into a digital output that can be read by the ESP8266 and displayed in the browser.
Output	Displaying when the max weight threshold is surpassed
Definition	ESP – Espressif Systems Processor

F5	Charging unit supply power to the ESP
Input	Solar power
Process	Charging the charging unit using solar power if the battery charge level is lower than the predefined level, if not supply power to the ESP
Output	Power supply to the ESP
Definition	ESP – Espressif Systems Processor

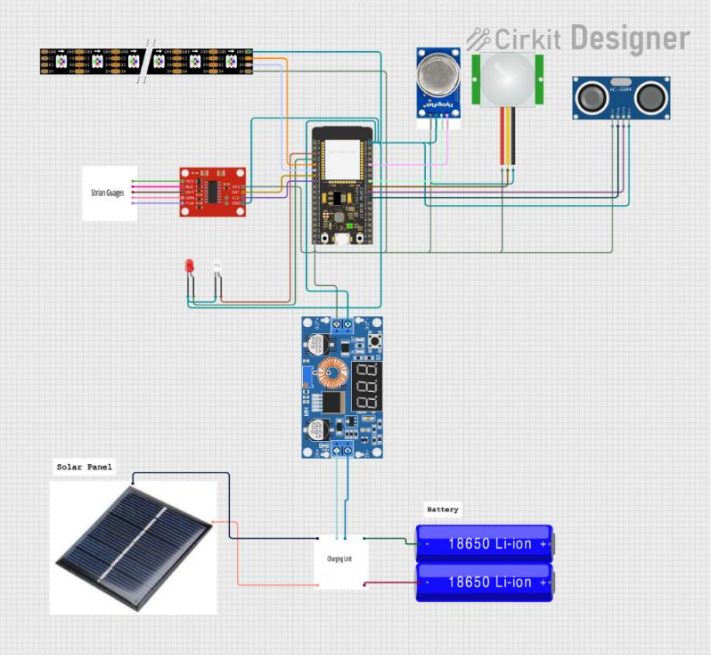
F6	Acting as an intermediary device by transferring data among hardware and software while creating a network.
Input	Data from the sensors
Process	Process output signals of the sensors according to predefined methods.
Output	Displaying the processed data through web browser.
Definition	ESP – Espressif Systems Processor

4.2 System Feature 2



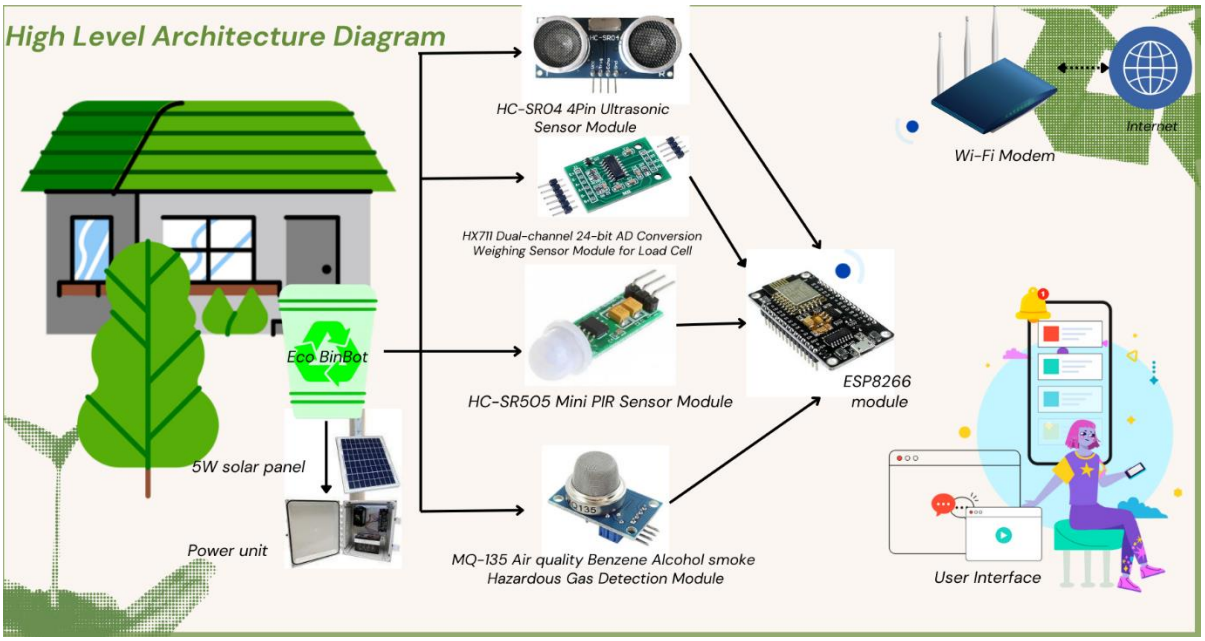
- The above diagram depicts the use case diagram for the web browser user interface of our Eco BinBot smart bin.
- The two actors that directly interacts with our system are administrator (human) and the ESP8266 web server (software).
- Detecting harmful gases, monitoring fill level and displaying when the maximum weight threshold is surpassed are the use cases that describes the functionalities of the web browser user interface provided to the administrator.
- The administrator monitor the real-time sensor data displayed through the web interface.
- The ESP8266 web server retrieves processed sensor data and display it remotely through the web browser user interface.

4.3 System Feature 3



- The above diagram depicts the circuit diagram of our Eco BinBot smart bin project.

4.4 System Feature 4



- The above diagram depicts the high-level architecture diagram of our Eco BinBot smart bin.

5. Other Nonfunctional Requirements

5.1 Performance Requirements

1) Real-time data processing
- Requirement: The user should get the real time data from the sensors and generate alerts with minimum latency when the sensor reaches certain thresholds.
- Rationale: Real time detection can detect and respond to events such as bin overflow or a buildup of a harmful gas, which will ensure the users safety and make the system more effective.

2) Communication Latency
- Requirement: The bin should be able to transfer the data from the bin to the central server within a minimum amount of time through a stable Wi-Fi connection.
- Rationale: Minimizing the communication delay will ensure that the bin works efficiently and alerts the user in a timely manner when the bin should be collected.

3) Power Efficiency
- Requirement: The system must optimize the battery usage and use the solar cells properlly to charge the cells.
- Rationale: One of the main drawbacks of IOT based systems is the need of constant power, with a prolonged battery life the system will ensure minimal maintenance.

4) User Interaction Responsiveness
- Requirements: The display should give real-time data withing 0.5 seconds under normal operational circumstances.
- Rationale: A responsive UI can increase the user experience.

5.2 Safety Requirements

1. Physical Safety
   - The system should be designed in such a way that it does not harm the users or a third party.
   - Implement safety measures such as taper-resistive locks and protective casings.
   - Provide the user with a comprehensive safety manual on the installation and maintenance.

2. Electrical Safety
   - The system should meet the electric safety standards to prevent fire hazards and accidental electric shocks.
   - Make sure all the electronic components are up to standards with relevant safety regulations
   - Make sure only qualified personnels repair the device.

3. Data Security
    - The system should not leak sensitive data.
    - Use data encryption techniques and access control mechanisms.
    - Encourage the users to user strong passwords.

5.3 Security Requirements

1. Data Encryption
    - Requirement: All the data transferred in between the Eco Bin Bot, user interface and the central server must be encrypted to prevent unauthorized access.
    - Rationale: Data encryption ensures that the sensitive data like the sensor readings and location data are safe.

2. Data Minimization
    - Requirement: The system will collect only the minimum required data.
    - Rationale: Reduces the risk of privacy violation.

3. User Identification Authentication
    - Requirement: The system should be able to identify the users individually and verify them.
    - Rationale: To ensure that only the authorized users can access the system.

5.4 Product Quality Attributes

- Eco BinBot can integrate new technologies or adapt to new waste management practices with a turnaround time of no more than 4 weeks for integration.
- BinBot maintains operational availability 24/7 since it is adopted to with the industrial environment.
- The sensors and other components used in our system are accurately calibrated and give an accurate output with all detected errors to be correctable through the calibration.
- Our system allows the user to easily be notified by the user interface by minimizing the need to manually check bins as it will alert the user when it's nearing capacity, preventing overflow situations. And hygiene maintenance is attained since the users do not have to open close the bin manually, which helps the ease of the users.
- The user interface is intuitive enough that any new user can navigate to and understand basic features within 2 minutes, prioritizing ease of use to encourage immediate interaction and long-term engagement.
- Eco Bin Bot fosters sustainability by promoting responsible waste disposal practices. Reduces environmental harm but also cultivates eco-conscious lifestyles and cleaner, healthier living environments.

5.5 Business Rules

- Access to the “Eco bin bot” smart bin’s user interface for monitoring and control, is restricted to authorized personnel at the municipal council.
- The smart bin complies with industrial waste management regulations and standards set by relevant authorities.
- Garbage collectors are promptly dispatched to the location of the smart bin upon receiving any warning messages regarding hazardous gas emissions within the bin, fill level overflow and exceeding weight limits.
- Regular maintenance tasks, such as sensor calibration and battery replacements are scheduled at predefined intervals to ensure optimal performance.

6. Appendix A: Glossary

SRS	*Software Requirement Specification document*
ESP8266	*ESP8266 is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability, developed by Espressif Systems.*
Use case diagram	*Describing the functionality of a system in terms that the client can understand.*
High level architecture diagram	*A visual representation that outlines the overall structure and interconnectedness of a system at a high level of abstraction.*
Real time monitoring	*Real-time monitoring refers to the continuous, immediate observation and analysis of various parameters or processes using technology to promptly detect and respond to any changes.*
MQTT protocol	*Message Queuing Telemetry Transport*

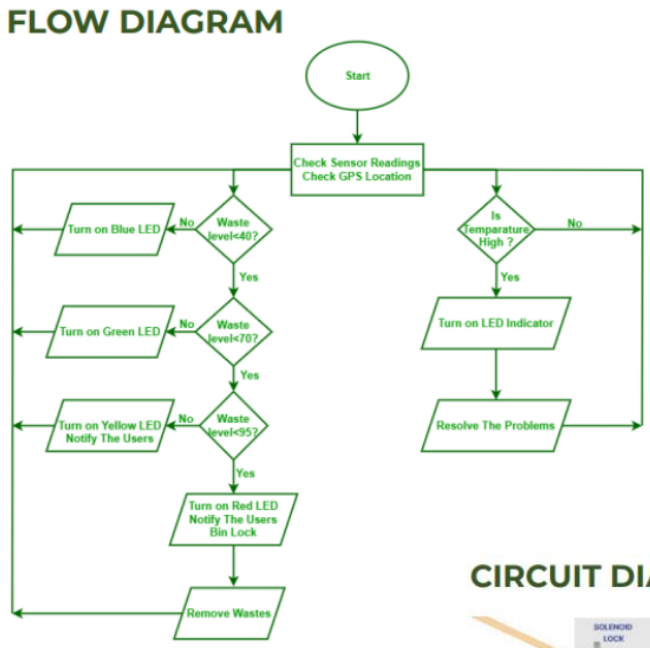
7. Appendix B: Analysis Models

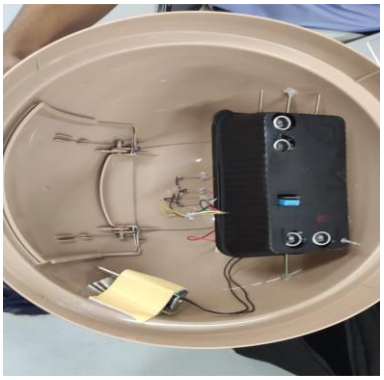
Item	Price(LKR)
HC-SR505 Mini PIR Sensor Module	Rs.350
HX711 Dual-channel 24-bit AD Conversion Weighing Sensor Module for Load Cell	Rs.260
Loadcell 20kg	Rs.400
MQ-135 Air quality Benzene Alcohol smoke Hazardous Gas Detection Module	Rs.420
HC-SR04 4Pin Ultrasonic Sensor Module	Rs.260
5W solar panel	Rs.2500
Arduino UNO (Made in Sri Lanka)	Rs.1180
ESP8266 module	Rs.1100

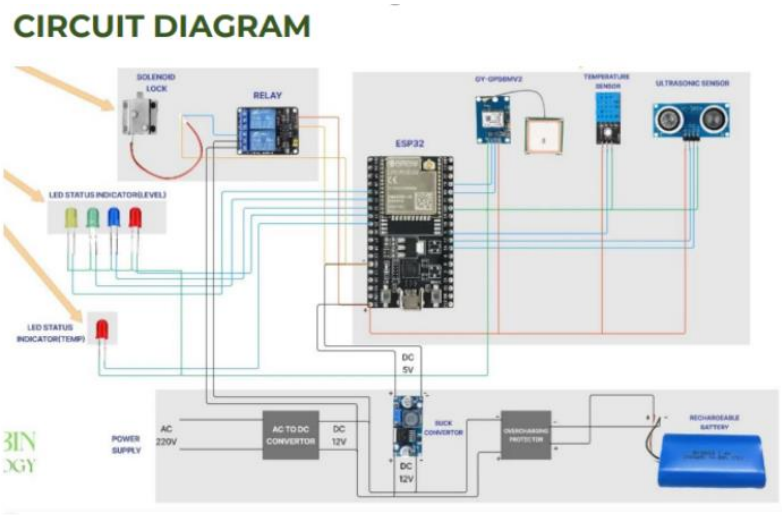
Item	Price(LKR)
Power unit	Rs.2870
Other Utilities	Rs.5000
Transportation	Rs.2000

Total Budget = Rs.16,340.00

- Below diagrams we used as reference.







8. Appendix C: To Be Determined List

Tasks
1. Initiation
1.1. Project Charter Submission
1.2 Project Proposal Submission
2. System Design
2.1. Sensor Configurations
2.2. Arduino uno and ESP8266 configurations
3. Implementation and Testing
3.1. Setting up the App and the ESP communication
3.2. Testing the Sensors
3.3. Testing the communication between the Application and the ESP module
3.4. SRS submission
3.5. Full system integration Test
4. Progress presentations
5. Final presentation