Software Requirements Specification

for

AI assisted Carbon Footprint Monitoring System
Collaborating with Sysco LABS

Prepared by Infinity
Group-14

Faculty of Information Technology
University of Moratuwa

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1. Introduction

1.1. Purpose

This document outlines the software specifications for the AI-assisted Carbon Footprint Monitoring System (iCFMS). Created to analyze, visualize, and predict CO2 emissions, iCFMS uses advanced Machine Learning technology to turn raw data into user-friendly visualizations. Specifically designed for a leading food distribution company, the system not only offers clear graphics but also acts as a predictive model, foreseeing CO2 emissions for future periods. Essentially, iCFMS reflects the company's commitment to being environmentally responsible and sustainable through the use of cutting-edge technology.

1.2. Document Conventions

IEEE 830-1998 standard for writing SRS documents was used in writing this SRS document.

1.3. Intended Audience and Reading Suggestions

This document is specifically designed for a diverse audience ranging from stakeholders in the foodservice industry, sustainability enthusiasts, to researchers interested in the intersection of technology and carbon footprint monitoring. The primary audience includes executives and decision-makers within foodservice distribution companies, particularly those supplying food and related products to restaurants, healthcare facilities, educational institutions, and hospitality establishments.

Additionally, environmental policymakers aiming to encourage eco-friendly initiatives within the foodservice sector and researchers investigating the practical applications of technology in mitigating carbon footprints will benefit from the analysis presented in this report. The content provides an understanding of the system's implementation and effectiveness, making it a valuable resource for those actively engaged in sustainable business practices and those seeking to enhance the environmental performance of foodservice distribution operations.

1.4. Project Scope

The proposed software is a comprehensive Carbon Footprint Monitoring System designed for a food service distribution company specializing in the supply of food and related products to diverse sectors, including restaurants, healthcare facilities, educational institutions, and hospitality establishments. The primary objective of this software is to enable the efficient calculation, and representation of carbon emissions associated with each food product throughout its production to point of sale processes.

1.4.1. Purpose

The purpose of the software is to empower the food service distribution company to measure and manage their products' environmental impact, specifically in terms of carbon emissions.

By providing detailed insights into production emissions, transportation emissions, and warehouse/factory emissions for each food product, the system aims to facilitate informed decision-making and strategic planning to minimize the carbon footprint associated with the company's products from production through distribution to point of sale.

1.4.2. Benefits

- Environmental Sustainability: The software empowers the company to actively contribute to environmental sustainability by identifying areas for improvement and implementing targeted measures to reduce carbon emissions associated with its products lifecycle.
- Regulatory Compliance: Makes it easier to follow environmental norms and laws by providing accurate and auditable data on Scope 1, Scope 2, and Scope 3 emissions.
- Operational Efficiency: Enables the company to optimize its supply chain, transportation, and procurement processes, leading to potential cost savings and resource efficiency.

1.4.3. Objectives

- Accurate Emission Calculation: Develop AI-algorithms to accurately calculate carbon emissions associated with food production, transportation (inbound & outbound), and warehouse activities for each food product.
- Comprehensive Reporting: Easy to make comprehensive reports detailing production emissions, transportation emissions, and supplier-wise emissions, categorized into Scope 1, Scope 2, and Scope 3 emissions.
- User-Friendly Interface: Design a user interface that allows stakeholders to easily navigate through the system, visualize data, and derive actionable insights.

1.4.4. Goals

- Develop a reliable and scalable system that can handle the diverse and dynamic data associated with the food service distribution industry.
- Enable data-driven decision-making to reduce carbon emissions while maintaining a steady supply of food goods for the diverse range of customers served by the organization.

The development and implementation of the Carbon Footprint Monitoring System align with the company's overall commitment to corporate social responsibility and sustainable business practices. By proactively addressing environmental concerns and measuring the carbon impact of each products' lifecycle, the company aims to reinforce its position as a socially and environmentally responsible player in the food service distribution sector.

1.5. References

1. CarbonCloud: The Climate Intelligent Platform; url: https://carboncloud.com/

2. Overall Description

2.1 Product Perspective

The carbon footprint monitoring system described in this Software Requirements Specification (SRS) is a standalone software solution closely linked to the existing databases of the food distribution company. It is designed to provide comprehensive tracking and analysis of carbon emissions associated with each company's food product, from its production to point of sales processes. The system stands independently, functioning as a crucial component within the organizational framework, aimed at monitoring and mitigating the environmental impact of the company's activities. It does not replace any existing systems but rather augments the company's commitment to sustainability by introducing a dedicated tool for real-time monitoring and reporting of carbon emissions. The system interfaces seamlessly with the company's databases, ensuring a robust flow of data to facilitate accurate calculations and reporting.

2.2. Product Features

1. All users shall be able to login.
2. Users can view CO2e emission associated with each food product (kg co2e/kg).
3. Users can also view emission information related to food production, transportation, and energy use in warehouses and factories associated with each food product.
4. Users can insert Food production, Transportation (inbound & outbound), and Warehouse/Factory energy consumption related data.
5. Users can obtain statistical data related to the distribution company's CO2e emissions for Scope 1, Scope 2, and Scope 3.

2.3. User Classes and Characteristics

The carbon footprint monitoring system for the food service distribution company is designed to accommodate two distinct user classes: Users and Admins. Each user class possesses specific characteristics, responsibilities, and privileges specifically designed to their role within the system.

2.3.1. Users

Characteristics:

1. Frequency of Use: Users interact with the system regularly to input diverse data related to food production, transportation, warehouse/factory energy consumption and supplier details. Their engagement is primarily focused on data entry and retrieval.

2. Technical Expertise: Users possess a varied technical background, ranging from basic data entry skills to a moderate understanding of environmental impact metrics. The system is designed to be user-friendly to cater to a diverse user base.
3. Security and Privilege Levels: Users have restricted access to certain administrative functionalities. Their privileges are aligned with data input, retrieval, and viewing statistics related to each product's carbon dioxide equivalent (CO2e) emissions.
4. Educational Level and Experience: The educational background and experience of users may vary. The system accommodates users with different levels of expertise, ensuring accessibility and usability for a broad user spectrum.

Functions:

1. Viewing CO2e emission associated with each food product (kg co2e/kg).
2. Accessing detailed statistics for each food product in terms of transportation, warehouse/factory energy consumption, food production, and supplier-wise emissions.
3. Inserting data related to transportation (inbound & outbound), warehouse/factory energy consumption, and food production, including supplier details.
4. Exploring insights into distribution company's distinct emission scopes, including Scope1, Scope2, and Scope3.

2.3.2. Administrators

Administrators hold elevated privileges compared to users and have access to additional functionalities to oversee and manage the system comprehensively.

Characteristics:

1. Frequency of Use: Administrators interact with the system regularly, overseeing data inputs, ensuring data integrity, and managing user access levels. Their engagement extends beyond data entry to encompass system administration tasks.
2. Technical Expertise: Administrators possess a higher level of technical expertise, including an understanding of environmental impact metrics and system administration. Their role involves ensuring the accuracy and reliability of the data entered into the system.
3. Security and Privilege Levels: Administrators have elevated privileges, enabling them to manage user access, monitor system performance, and ensure the overall integrity of the carbon footprint monitoring system.
4. Educational Level and Experience: Administrators typically possess a more advanced educational background and extensive experience in environmental management or related fields.

Functions:

In addition to the functionalities available to users, administrators are responsible for:

1. Managing user roles and access levels.
2. Add new food products or remove an existing one from the system.

3. Overseeing the overall performance and security of the system.
4. Generating comprehensive reports for stakeholders.

Distinguishing the user classes is essential for tailoring the system's functionalities to the specific needs and competencies of each group, thereby enhancing the overall user experience and system effectiveness.

2.4. Operating Environment

The software operates as a web application built using React for the front-end and Spring Boot for the back-end. The application relies on a MySQL database for data storage. It is designed to run in a web environment, compatible with modern web browsers. The hardware platform should support web hosting requirements, and the recommended operating system versions include those compatible with React, Spring Boot, and MySQL. The software must peacefully coexist with common web server technologies for hosting React and Spring Boot applications. Additionally, compatibility with standard web development tools and frameworks is assumed for seamless integration and optimal performance.

2.5. Design and Implementation Constraints

- Data Volume: The system works best with a good amount of data. If only the system trains using less data the system will provide less accurate insights and predictions.
- Internet Connection: Being a cloud-based ML model, a stable internet connection is needed for it to work smoothly.
- Company policies: The food distributing company strictly considers their data security so they don’t provide their own data sets.Therefore we have to find open source data sets.

2.6. User documentation

A user manual is provided with this software to the Users.
We also include online help in the application.

2.7 Assumptions and Dependencies

Assumptions:

1. The availability and reliability of the internet are assumed for the successful operation of the AI-assisted Carbon Footprint Monitoring System (iCFMS).
2. It is assumed that users will have access to standard web browsers for interacting with the system.
3. The accuracy of CO2 emission predictions is contingent upon the quality and completeness of historical data provided to the system.

Dependencies:

1. The project depends on the utilization of a compatible web hosting environment to deploy the iCFMS, including server infrastructure and related configurations.
2. The successful implementation of the system relies on third-party Machine Learning libraries and frameworks, which are subject to their respective update and support schedules.

3. System Features

System features represent the functional requirements of a product, organizing key capabilities and services. They provide clarity for development, aiding in design, implementation, and testing to meet user expectations effectively.

3.1. User account creation

3.1.1. Description and Priority

All the users should have an user account to login to the system. Therefore this feature allows users to create an user account by providing required information. During this process the system will verify the given information by the user. This is a high priority feature because this is an essential requirement to use the system for new users.

Priority Ratings:

- Benefit:5
- Penalty:5
- Cost:3
- Risk:3

3.1.2. Stimulus/Response Sequences

- Stimulus:
    1. User inputs required details for creating an account.
    2. System process and verify the given details.
    3. System creates an account for the user.
- Responses:
    1. System sends an email to verify the email address.
    2. The system updates the database and relevant statistics automatically.
    3. The system encrypts the users' personal information.

3.1.3. Functional Requirements

REQ-1: System should load the UI.

REQ-2: Users are able to create user accounts.

REQ-3: Users are able to login to the system.

REQ-4: Users can reset the password.

3.2. Predicting CO2e Emission

3.2.1. Description and Priority

The feature involves predicting carbon dioxide equivalent (CO2e) emissions associated with each food product, specifically focusing on transportation (inbound & outbound), food production, and warehouse energy consumption emissions. This feature is of high priority due to its critical role in providing comprehensive insights into the company's environmental impact.

Priority Ratings:

- Benefit: 8
- Penalty: 2
- Cost: 6
- Risk: 4

3.2.2. Stimulus/Response Sequences

- Stimulus:
    1. User inputs data related to transportation (inbound & outbound), food production, and warehouse energy consumption.
    2. System processes the input data.
    3. Automatic trigger when new or updated data is received.
- Response:
    1. System provides a prediction of CO2e emissions for each product based on the input data (Transportation, Food production, Warehouse energy consumption).
    2. The system updates the database and relevant statistics automatically.

3.2.3. Functional Requirements

REQ-1: The system must employ predictive algorithms to calculate CO2e emissions associated with each food product's specified sectors.

REQ-2: The system must update the database with the newly predicted CO2e emission data for each food product.

REQ-3: The system must automatically trigger emission calculations when new or updated data is received.

REQ-4: The system must update emission statistics for each food product automatically following each prediction.

REQ-5: The system should handle and provide appropriate feedback for invalid or erroneous data.

3.3. Distributing Warehouse and Transportation Emissions Among Products

3.3.1. Description and Priority

This high-priority feature involves the distribution of warehouse and transportation emissions among products and food items based on the types of equipment and processes and the vehicles used for transportation. The objective is to allocate emissions to specific products, allowing for a more granular understanding of the carbon footprint associated with each item. Priority ratings for this feature are as follows:

Priority Ratings:

- Benefit: 9
- Penalty: 3
- Cost: 6
- Risk: 5

3.3.2. Stimulus/Response Sequences

- Stimulus:
    1. Emission prediction for warehouse energy consumption is completed.
    2. Warehouse emission distribution trigger.
    3. Emission prediction for transportation (inbound & outbound) is completed.
    4. Transportation emission distribution trigger.
- Response:
    1. The system allocates emissions among food products based on equipment and processes.
    2. System allocates transportation (inbound & outbound) emissions to food products based on the vehicles used for transportation.
    3. Updated emission distribution data is stored for each food product.

3.3.3. Functional Requirements

REQ-1: The system must receive and process emission prediction data for warehouse energy consumption and Transportation.

REQ-2: The system must identify and categorize products based on the types of equipment and processes encountered in the warehouse and the vehicle which the product is being carried from.

REQ-3: The system must allocate warehouse emissions as well as Transportation emission proportionally among the identified product categories based on the quantities (Normalized quantity).

REQ-4: The system must update the database with the distributed emission data for each product.

REQ-5: The emission distribution process should be triggered automatically as soon as the emission is predicted for warehouse energy consumption and Transportation.

REQ-6: The system should provide a mechanism for manual adjustment or intervention in the allocation process if needed.

3.4. Transportation Data Input and Statistical Analysis

3.4.1. Description and Priority

This high-priority feature allows users to input transportation-related data into the system, encompassing details of transportation from suppliers to the warehouse (inbound) as well as from warehouse to customers (outbound). Users can then view statistical analysis of transportation emissions associated with each food product. The feature facilitates a detailed examination of the environmental impact associated with the transportation sector. Priority ratings for this feature are as follows:

Priority Ratings:

- Benefit: 6
- Penalty: 4
- Cost: 5
- Risk: 3

3.4.2. Stimulus/Response Sequences

- Stimulus:
    1. User inputs transportation-related data.
- Response:
    1. System predicts CO2e emissions for the specific transportation.
    2. The system processes and stores the transportation-related data along with the predicted CO2e emission.
    3. Update the transportation emission details for each product related to that particular transportation.

3.4.3. Functional Requirements

REQ-1: The system must provide a user interface to input transportation-related data, including details of transportation from suppliers to the warehouse (inbound) and from the warehouse to customers (outbound).

REQ-2: The system must employ predictive algorithms to calculate CO2e emissions for each specific transportation event.

REQ-3: The system must process and store transportation-related data along with the predicted CO2e emission for each transportation event.

REQ-4: The system must update the transportation emission details for each food product associated with the specific transportation event.

REQ-5: The system should provide users with statistical analysis of transportation emissions associated with each food product.

REQ-6: The system should handle and provide appropriate feedback for invalid or erroneous transportation-related input data.

3.5. Warehouse Energy Data Input and Statistical Analysis

3.5.1. Description and Priority

This high-priority feature allows users to input warehouse energy-related data into the system. This includes details such as the duration of equipment usage (e.g., forklifts, pallet jacks, picking & packing systems, refrigeration units) and the products associated with each equipment during that period. Users can view statistical analysis of warehouse energy emissions associated with each food product, gaining insights into the environmental impact of energy consumption within the warehouse. Priority ratings for this feature are as follows:

Priority Ratings:

- Benefit: 7
- Penalty: 3
- Cost: 6
- Risk: 4

3.5.2. Stimulus/Response Sequences

- Stimulus:
    1. User inputs warehouse/factory energy-related data.
- Response:
    1. The system processes and stores the energy-related data.
    2. The system predicts CO2e emissions at the warehouse/factory level using energy-related data from the warehouse/factory.
    3. Allocate and update the predicted CO2e emission for each product based on the equipment and procedures utilized within the warehouse/factory by each product.

3.5.3. Functional Requirements

REQ-1: The system must provide a user interface to input warehouse/factory energy-related data, including details such as the duration of equipment usage (e.g., forklifts, pallet jacks, picking & packing systems, refrigeration units) and the products associated with each equipment during that period.

REQ-2: The system must process and store the warehouse/factory energy-related data.

REQ-3: The system must employ predictive algorithms to calculate CO2e emissions at the warehouse/factory level using the energy-related data from the warehouse/factory.

REQ-4: The system must allocate and update the predicted CO2e emission for each food product based on the equipment and procedures utilized within the warehouse/factory for each product.

REQ-5: The system should provide users with statistical analysis of warehouse energy emissions associated with each food product.

REQ-6: The system should handle and provide appropriate feedback for invalid or erroneous warehouse energy-related input data.

3.6. Vendor Supply Data Input and Statistical Analysis

3.6.1. Description and Priority

This high-priority feature enables users to input supply-related data received from vendors into the system. The data includes details of food products, quantities supplied, and information about the supplier. Users can then view statistical analyses of food production emissions associated with each food product. This feature is crucial for tracking the environmental impact associated with the procurement of goods from vendors. Priority ratings for this feature are as follows:

Priority Ratings:

- Benefit: 7
- Penalty: 3
- Cost: 6
- Risk: 4

3.6.2. Stimulus/Response Sequences

- Stimulus:
    1. User inputs supply-related data, including details of food products, quantities, and supplier information.
- Response:
    1. The food production emissions related to the food products that are specified in the supply data are predicted by the system.
    2. The system processes and stores the supply-related data along with the predicted food production emissions for each food product mentioned in the supply data.

3.6.3. Functional Requirements

REQ-1: The system must allow users to input supply-related data, including details of food products, quantities, and supplier information.

REQ-2: The system must employ predictive algorithms to calculate food production emissions associated with each food product specified in the supply data.

REQ-3: The system must process and store the supply-related data along with the predicted food production emissions for each food product mentioned in the supply data.

REQ-4: The system should provide users with statistical analysis of food production emissions associated with each food product.

REQ-5: The system should update the predicted food production emissions for each food product mentioned in the supply data.

REQ-6: The system must handle and provide appropriate feedback for invalid or erroneous supply-related data input by the users.

3.7. Viewing CO2e Emission Associated with Each Food Product

3.7.1. Description and Priority

This feature entails allowing users to view the carbon dioxide equivalent (CO2e) emissions associated with each food product. It is a high-level priority, enabling users to access information regarding the emissions in kilograms of CO2e per kilogram of product (kg_CO2e/kg). The emissions are calculated based on data related to food production, transportation, and warehouse energy consumption activities associated with each product. Additionally, users should have the capability to discern the proportion of total emissions attributable to food production, transportation, and warehouse activities for each food product.

Priority Ratings:

- Benefit: 10
- Penalty: 2
- Cost: 6
- Risk: 3

3.7.2. Stimulus/Response Sequences

- Stimulus:
    1. User selects a food product to view its associated CO2e emissions.
- Responses:
    1. System provides the CO2e emissions associated with the selected food product in kg CO2e/kg.
    2. The system displays the breakdown of the total emissions (kg CO2e/kg) of the selected food product, indicating the portion attributable to food production, transportation, and warehouse activities.

3.7.3. Functional Requirements

REQ-1: The system must retrieve and utilize data related to food production, transportation, and warehouse energy consumption to calculate CO2e emissions for each food product.

REQ-2: The system must display the CO2e emissions associated with each food product in kg CO2e/kg.

REQ-3: The system must present the breakdown of the total emissions (kg CO2e/kg) of the selected food product, showing the contribution of food production, transportation, and warehouse activities.

REQ-4: The system should provide intuitive user interfaces for users to easily access and interpret CO2e emissions information for each food product.

REQ-5: The system must ensure data accuracy and reliability when presenting CO2e emissions information to users.

3.8. View Statistical Analysis of Scope 1 Carbon Emission

3.8.1. Description and Priority

This medium-priority feature enables users to view statistical analyses of Scope 1 carbon emissions. Scope 1 emissions are direct greenhouse gas emissions resulting from sources owned or controlled by the entity, reflecting the environmental impact of an organization's own activities, facilities, or equipment. Examples include emissions from company-owned vehicles, on-site power generation, and industrial processes. The feature provides insights into the immediate impact an organization has on the environment through its operational activities. Priority ratings for this feature are as follows:

Priority Ratings:

- Benefit: 6
- Penalty: 4
- Cost: 5
- Risk: 3

3.8.2. Stimulus/Response Sequences

- Stimulus:
    1. User requests statistical analysis of Scope 1 carbon emissions.
- Response:
    1. The system processes and analyzes Scope 1 emission data.
    2. The system generates and displays statistical analyses of Scope 1 carbon emissions.

3.8.3. Functional Requirements

REQ-1: The system must provide a user interface for users to request statistical analysis of Scope 1 carbon emissions.

REQ-2: The system must retrieve and process Scope 1 emission data.

REQ-3: The system must generate statistical analyses based on the stored Scope 1 emission data.

REQ-4: The statistical analysis of Scope 1 carbon emissions should be accessible through the user interface.

REQ-5: The feature is triggered upon user request for statistical analysis.

REQ-6: The system should handle and provide appropriate feedback for invalid or erroneous requests.

3.9. View Statistical Analysis of Scope 2 Carbon Emission

3.9.1. Description and Priority

This medium-priority feature allows users to view statistical analyses of Scope 2 carbon emissions. Scope 2 emissions are indirect greenhouse gas emissions associated with the production of electricity, heat, or steam that an organization consumes. Unlike direct emissions (Scope 1), these emissions are generated off-site but are linked to the organization's activities, primarily from the electricity purchased from external sources. Priority ratings for this feature are as follows:

Priority Ratings:

- Benefit: 6
- Penalty: 4
- Cost: 5
- Risk: 3

3.9.2. Stimulus/Response Sequences

- Stimulus:
    1. User requests statistical analysis of Scope 2 carbon emissions.
- Response:
    1. The system processes and analyzes Scope 2 emission data.
    2. The system generates and displays statistical analyses of Scope 2 carbon emissions.

3.9.3. Functional Requirements

REQ-1: The system must provide a user interface for users to request statistical analysis of Scope 2 carbon emissions.

REQ-2: The system must retrieve and process Scope 2 emission data.

REQ-3: The system must generate statistical analyses based on the stored Scope 2 emission data.

REQ-4: The statistical analysis of Scope 2 carbon emissions should be accessible through the user interface.

REQ-5: The feature is triggered upon user request for statistical analysis.

REQ-6: The system should handle and provide appropriate feedback for invalid or erroneous requests.

3.10. View Statistical Analysis of Scope 3 Carbon Emission

3.10.1. Description and Priority

This medium-priority feature allows users to view statistical analyses of Scope 3 carbon emissions. Scope 3 emissions are indirect greenhouse gas emissions that result from activities associated with an organization but occur outside its direct control or ownership. Unlike Scope 1 and Scope 2 emissions, which involve a company's own operations and energy consumption, Scope 3 emissions encompass a broader range of sources, including the entire supply chain, business travel, employee commuting, and product use. These emissions often make up a significant portion of a company's total carbon footprint and can be challenging to measure and manage due to their complex and interconnected nature. Priority ratings for this feature are as follows:

Priority Ratings:

- Benefit: 6
- Penalty: 4
- Cost: 5
- Risk: 3

3.10.2. Stimulus/Response Sequences

- Stimulus:
    1. User requests statistical analysis of Scope 3 carbon emissions.
- Response:
    1. The system processes and analyzes Scope 3 emission data.
    2. The system generates and displays statistical analyses of Scope 3 carbon emissions.

3.10.3. Functional Requirements

REQ-1: The system must provide a user interface for users to request statistical analysis of Scope 3 carbon emissions.

REQ-2: The system must retrieve and process Scope 3 emission data.

REQ-3: The system must generate statistical analyses based on the stored Scope 3 emission data.

REQ-4: The statistical analysis of Scope 3 carbon emissions should be accessible through the user interface.

REQ-5: The feature is triggered upon user request for statistical analysis.

REQ-6: The system should handle and provide appropriate feedback for invalid or erroneous requests.

3.11.View the Statistical Analysis of Supplier-wise Emission

3.11.1. Description and Priority

This feature facilitates the user to view the statistical analysis of supplier-wise emission. System represents the Statistical analysis of each supplier. This feature is crucial for taking an idea about CO2 emission from each supplier. Priority ratings for this feature are as follows:

Priority Ratings:

- Benefit: 7
- Penalty: 3
- Cost: 6
- Risk: 4

3.11.2. Stimulus/Response Sequences

- Stimulus:
    1. User requests statistical analysis of Supplier-wise carbon emissions.
- Responses:
    1. The system processes and analyzes Supplier-wise emission data.
    2. The system generates and displays statistical analyses of Supplier-wise carbon emissions.

3.11.3. Functional Requirements

REQ-1: The system must provide a user interface for users to request statistical analysis of Supplier-wise carbon emissions.

REQ-2: The system must retrieve and process Supplier-wise emission data.

REQ-3: The system must generate statistical analyses based on the stored Supplier-wise emission data.

REQ-4: The statistical analysis of Supplier-wise carbon emissions should be accessible through the user interface.

REQ-5: The feature is triggered upon user request for statistical analysis.

REQ-6: The system should handle and provide appropriate feedback for invalid or erroneous requests.

4. External Interface Requirements

4.1. User Interfaces

The User Interface (UI) for the Carbon Footprint Monitoring System presents a sleek and intuitive design, ensuring user-friendly navigation. With a clean layout and interactive elements, users can effortlessly access real-time carbon emission data, analyze trends, and make informed decisions. The UI prioritizes clarity, making it an efficient tool for sustainable decision-making.

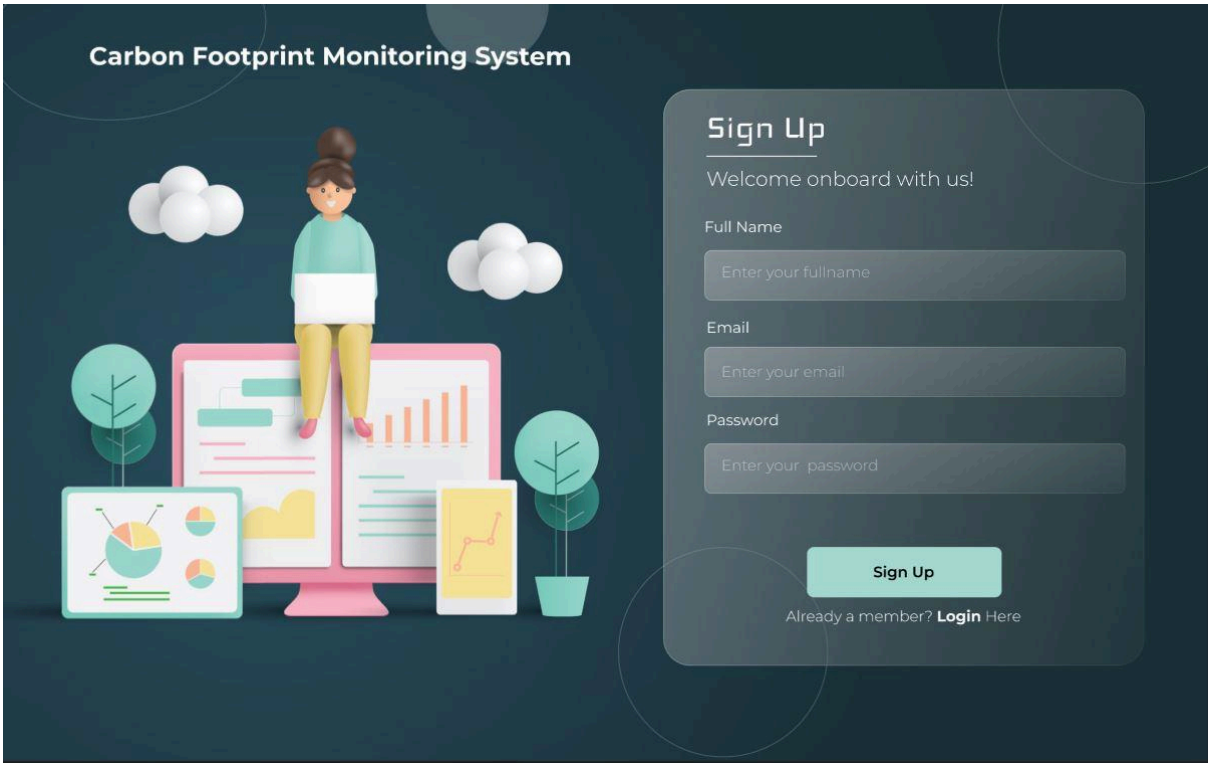

Figure 1: SignUp

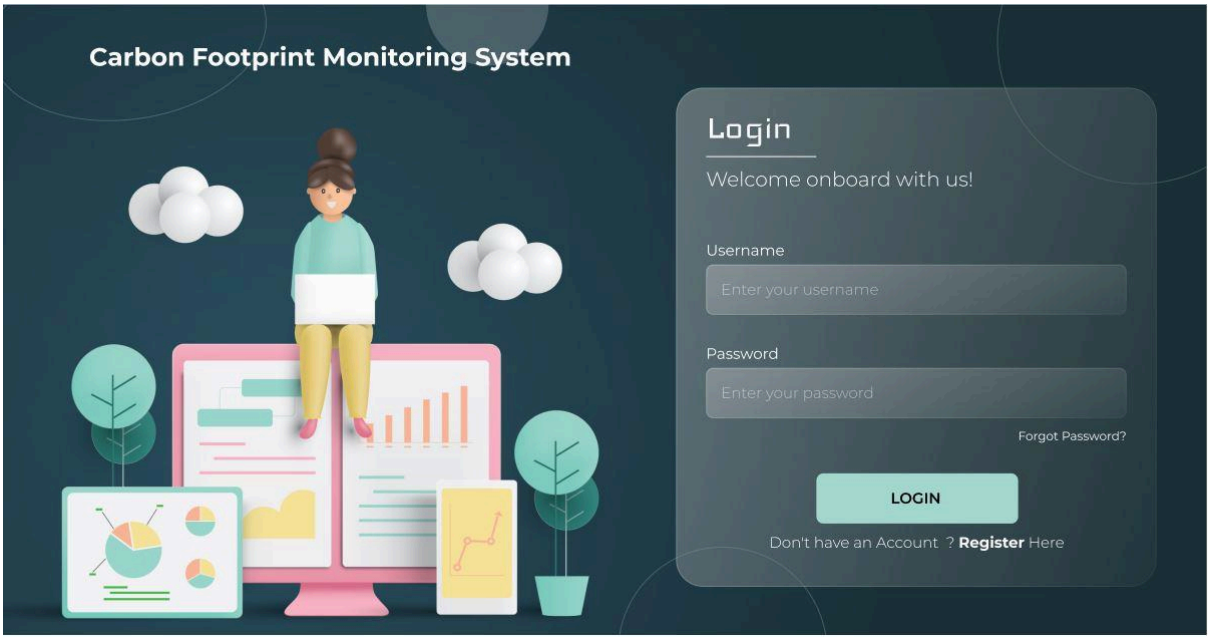

Figure 2: LogIn

Figure 3: Dashboard

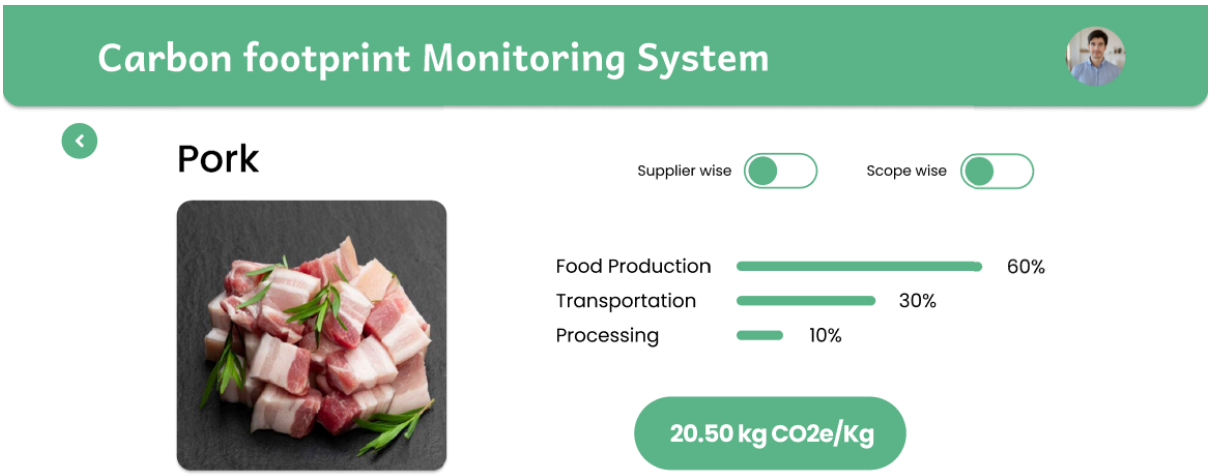

Figure 4: Product Details

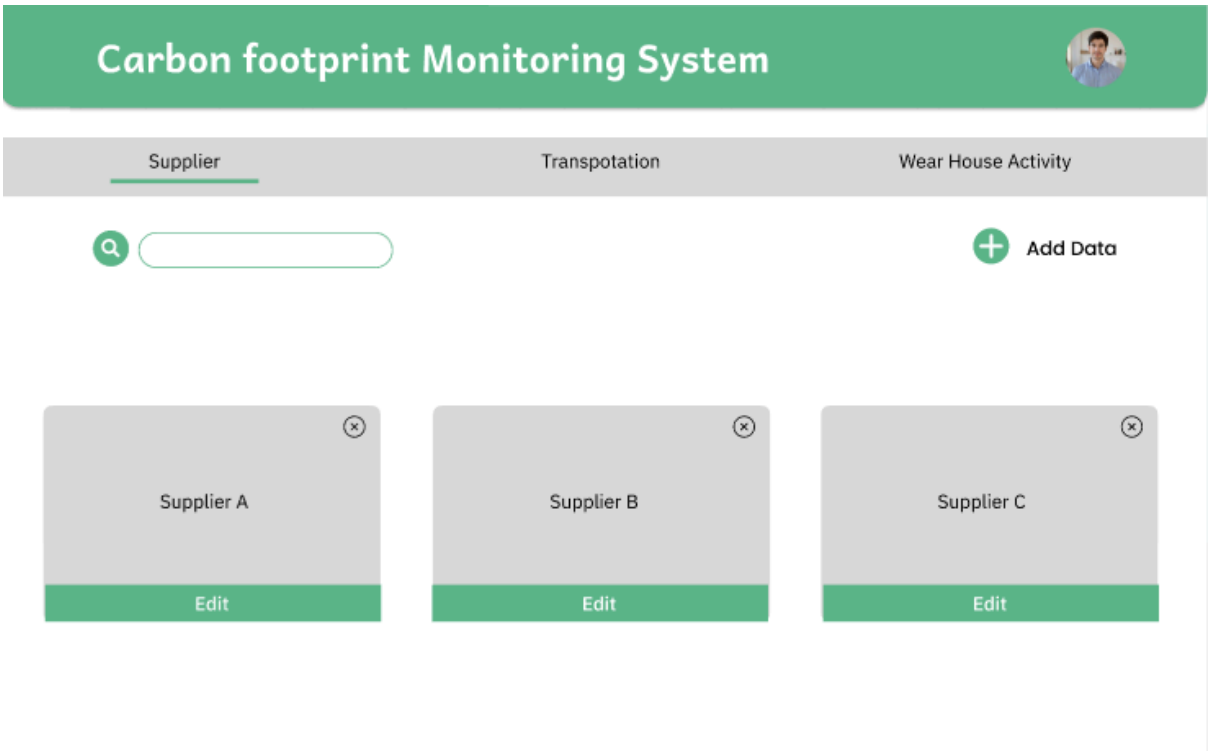

Figure 5: Supplier Data

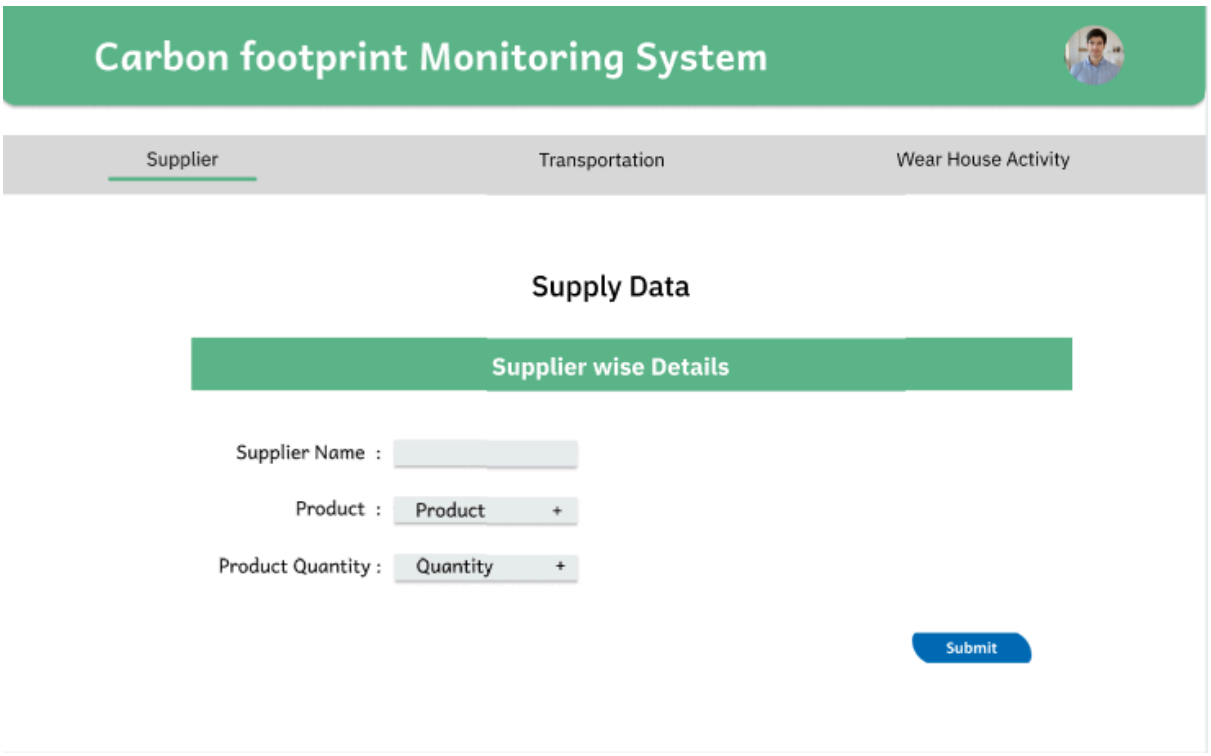

Figure 6: Supply Data Input Form

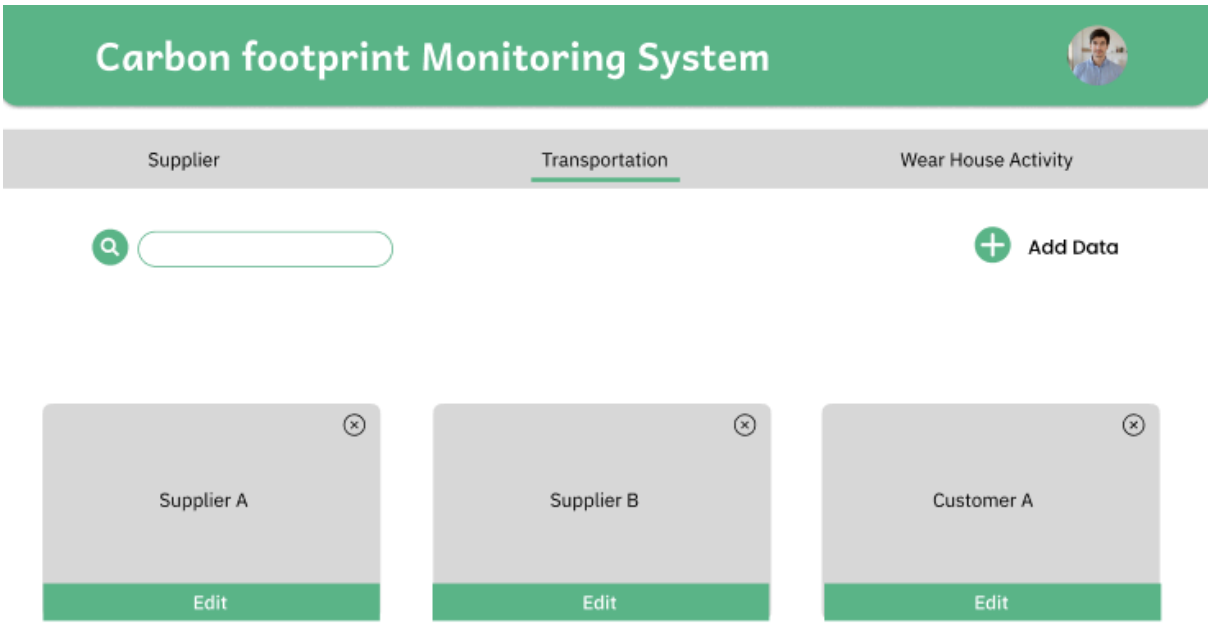

Figure 7: Transportation Data

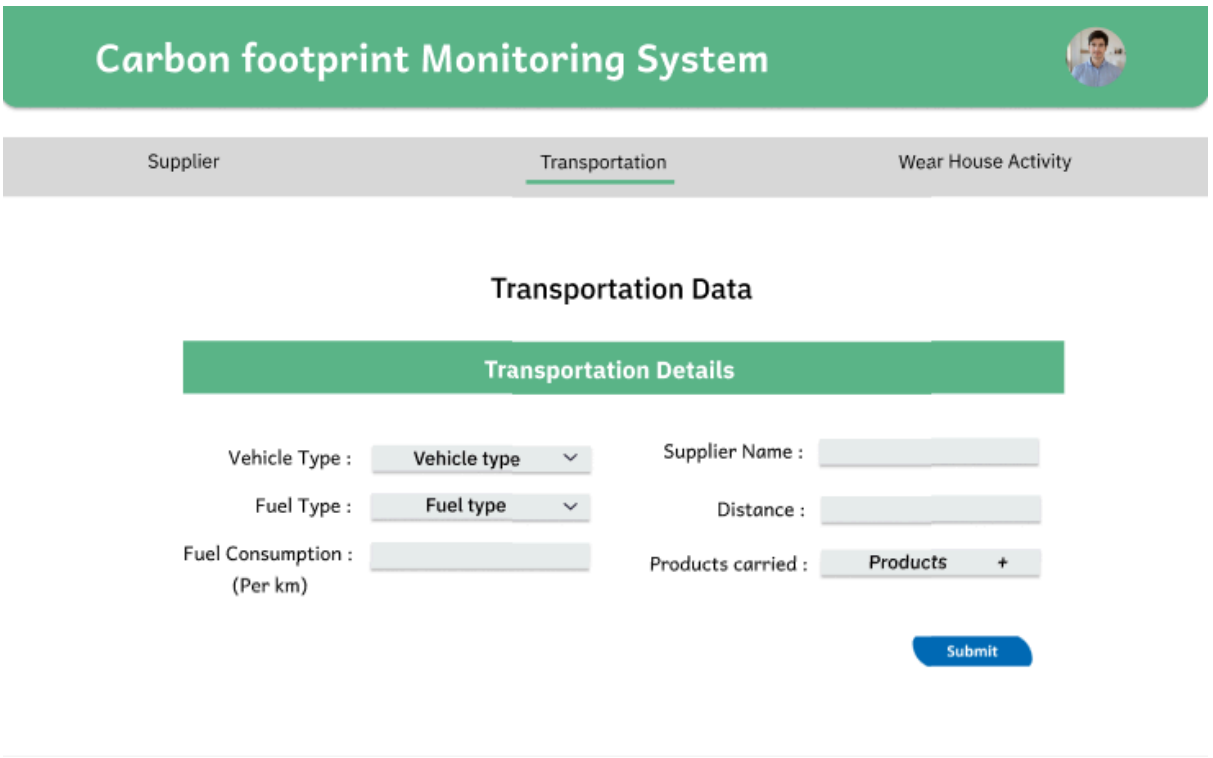

Figure 8: Transportation Data Input Form

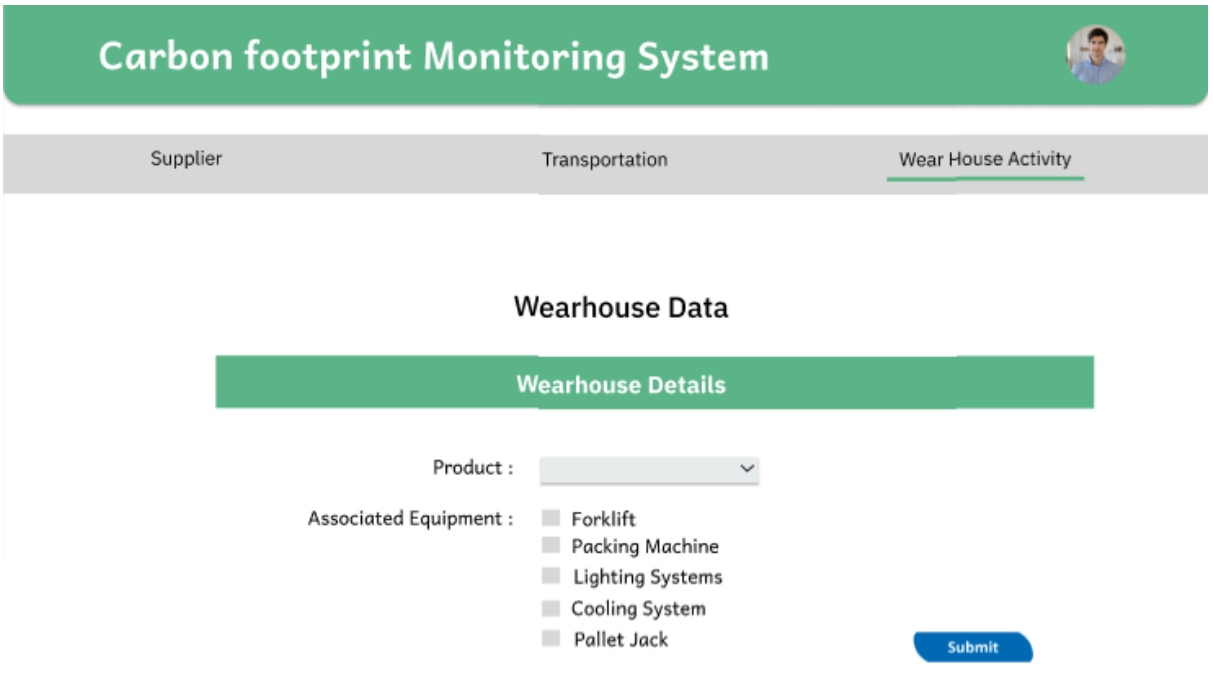

Figure 9: Warehouse Data Input Form

4.2. Hardware Interfaces

This system is designed as a web-based application, ensuring compatibility with various devices and web browsers. It offers uninterrupted access and doesn't demand a specific internet connection or additional CPU/GPU processing power. The system operates efficiently with standard data processing, and the minimum hardware requirement aligns with typical specifications for regular web surfing on a device.

4.3. Software Interfaces

The carbon footprint monitoring system operates through an advanced network of software interfaces, seamlessly connecting its diverse components. At the forefront, the React-based frontend ensures an interactive and user-friendly experience, while the Spring backend manages the complicated processes of data calculation and system logic. The MySQL database serves as the repository for essential emissions data, encouraging data consistency and providing the foundation for comprehensive reporting.

Incorporating artificial intelligence capabilities, the system leverages Python, integrating renowned frameworks such as TensorFlow, Numpy, and Pandas. This AI integration empowers the system to conduct advanced analytics, enabling predictive modeling and generating actionable insights into the carbon emissions associated with food service distribution. Figma plays a pivotal role as the UI framework, facilitating collaborative design efforts and contributing to the creation of an aesthetically pleasing and intuitive user interface.

The communication between these software components is facilitated by well-defined APIs, ensuring interoperability and system reliability. The intricacies of these interfaces enhance the system's scalability and maintainability. This comprehensive software interface strategy underlines the system's commitment to efficiency, accuracy, and adaptability in monitoring and mitigating carbon footprints.

4.4. Communication Interfaces

The communications interfaces for the carbon footprint monitoring system will involve the implementation of an external API to facilitate seamless communication between the application and its backend. All communication channels, including those between the application and backend, will be conducted through HTTPS web requests, ensuring a secure and encrypted data transfer environment. The system places a strong emphasis on security, particularly when handling sensitive information such as passwords, which will be encrypted using industry-standard methods to enhance data protection. This approach adheres to best practices in secure communication and data handling, ensuring the confidentiality and integrity of the information exchanged within the system.

5. Other Nonfunctional Requirements

5.1. Performance Requirements

This is an AI-assisted Carbon Footprint Monitoring System.This system performs functions like login,check CO2 emission of food products,show statistical details of Scope1 and Scope2 Emission,visualize CO2 emission of selected products using graphs,predict CO2 emission for upcoming terms.

- User interfaces should be user friendly
- System should have quick response times.
- Scalability : System can scale to handle increasing amount of users and data
- Reliability : System should provide high accurate predictions
- Availability : 24 hour accessibility

5.2. Safety Requirements

To enhance user safety and data integrity, the system will prioritize prediction reliability, providing confidence intervals for all emissions forecasts. Security measures, including data encryption and strict user authentication, will be implemented to safeguard sensitive information. The system will comply with relevant environmental and privacy regulations, featuring clear user warnings on prediction limitations. In case of anomalies, the system will integrate with emergency response protocols, triggering timely alerts. Continuous monitoring, accessibility design, and fail-safe mechanisms will be in place to ensure a secure and inclusive user experience.

5.3. Security Requirements

The proposed carbon footprint monitoring system for the food service distribution company is designed to prioritize the confidentiality, integrity, and availability of sensitive data associated with carbon emissions. The system will implement robust user identity authentication mechanisms to ensure that only authorized personnel have access to critical information pertaining to food emissions, transportation emissions, supplier-wise emissions, and various scopes of emissions.

Authentication processes will adhere to industry best practices, requiring users to undergo secure login procedures. Furthermore, the system will enforce strict access controls, defining roles and permissions based on user responsibilities to prevent unauthorized access or modifications to the data.

In addition, data transmission and storage will be encrypted to prevent unauthorized interception or tampering, especially user passwords.

5.4. Software Quality Attributes

The carbon footprint monitoring system prioritizes adaptability, ensuring seamless integration with evolving industry standards and data sources. Availability is paramount, minimizing downtime for real-time access to carbon footprint data. Correctness is fundamental, emphasizing accurate emission calculations and data representation. The system is designed to be flexible, interoperable, and maintainable, facilitating easy updates and modifications. Portability allows smooth transitions across different operating systems, and reliability ensures consistent operation under various conditions. Reusability is encouraged for efficient development, and robustness minimizes vulnerabilities, ensuring continuous operation. Testability is emphasized for thorough and efficient testing, while usability is a key focus, promoting an intuitive interface for users of varying experience levels in carbon footprint monitoring. These software quality attributes collectively contribute to a reliable, adaptable, and user-friendly system for the food service distribution company.

Appendix: Analysis Models

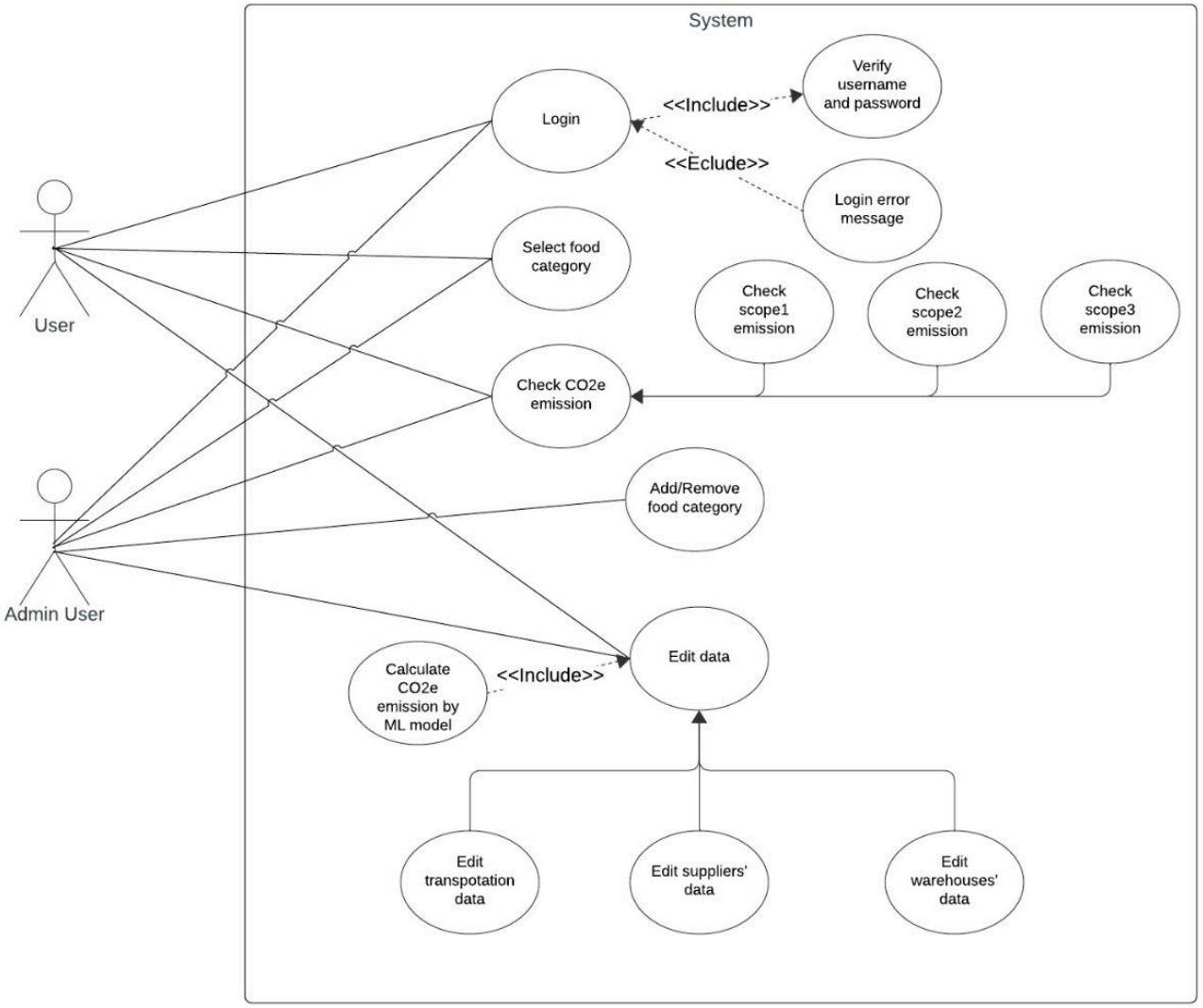

Figure 10: Use Case Diagram

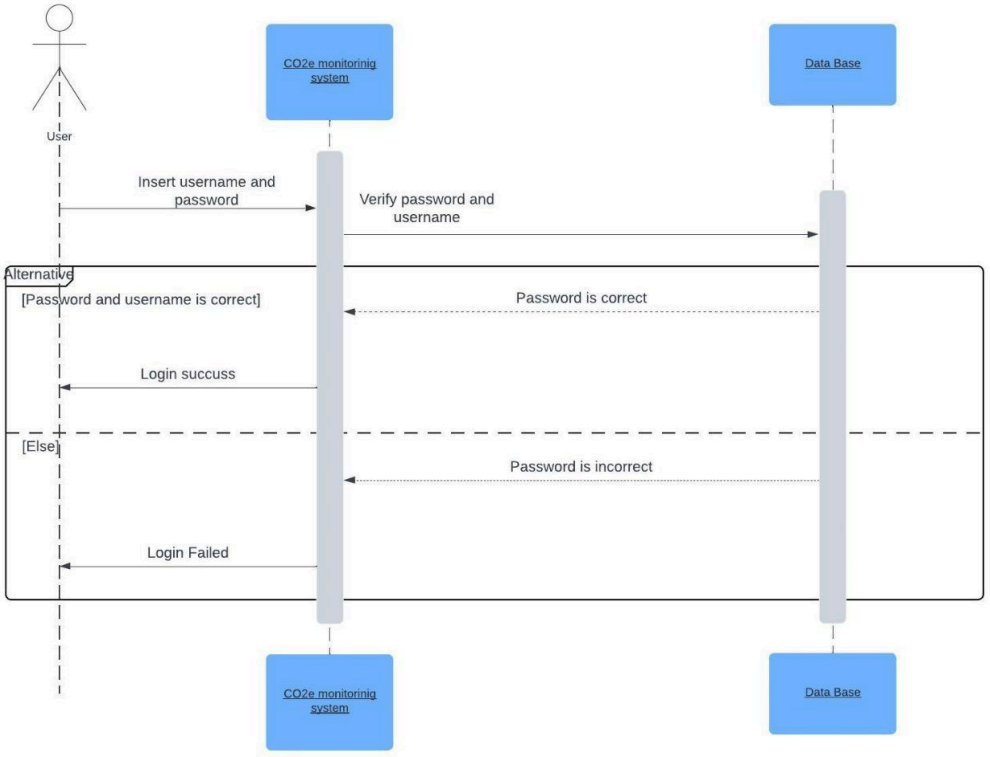

Figure 11: Login Sequence Diagram

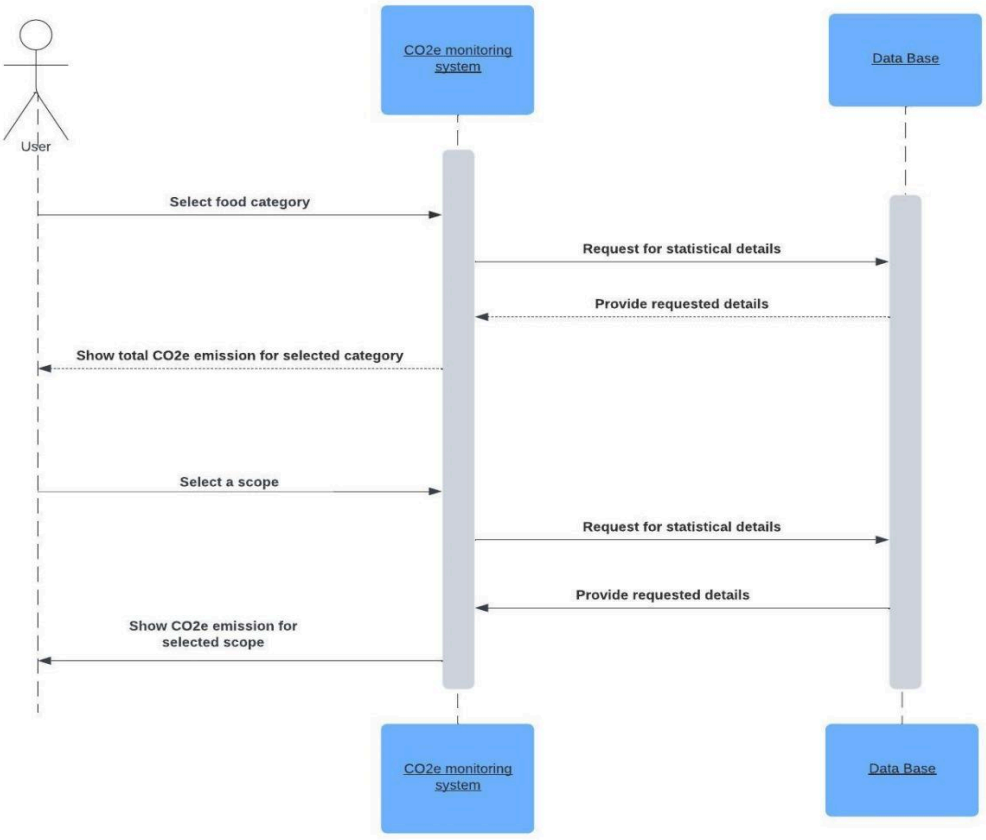

Figure 12: Food Product Selection Sequence Diagram

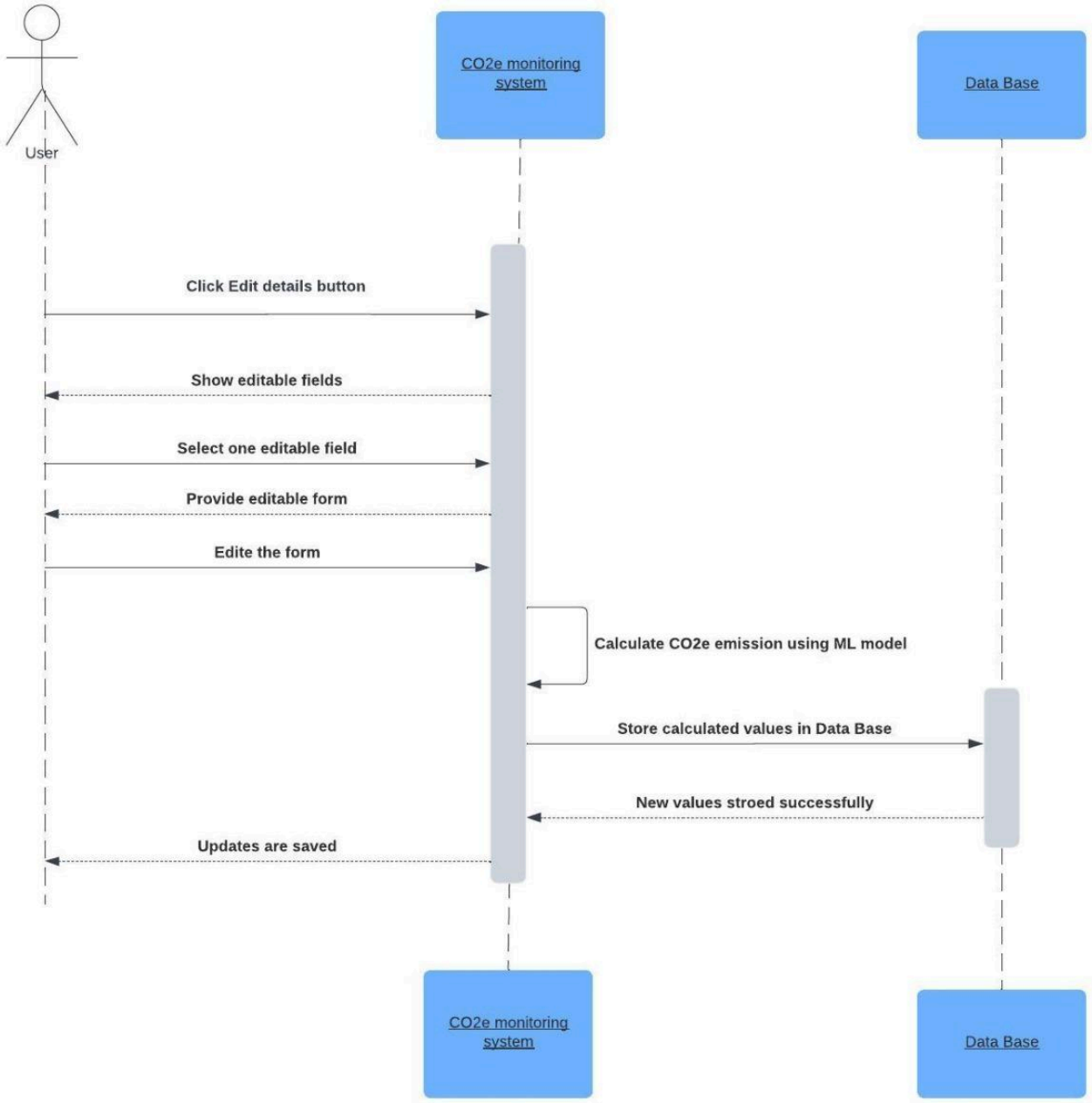

Figure 13: Data Input Sequence Diagram

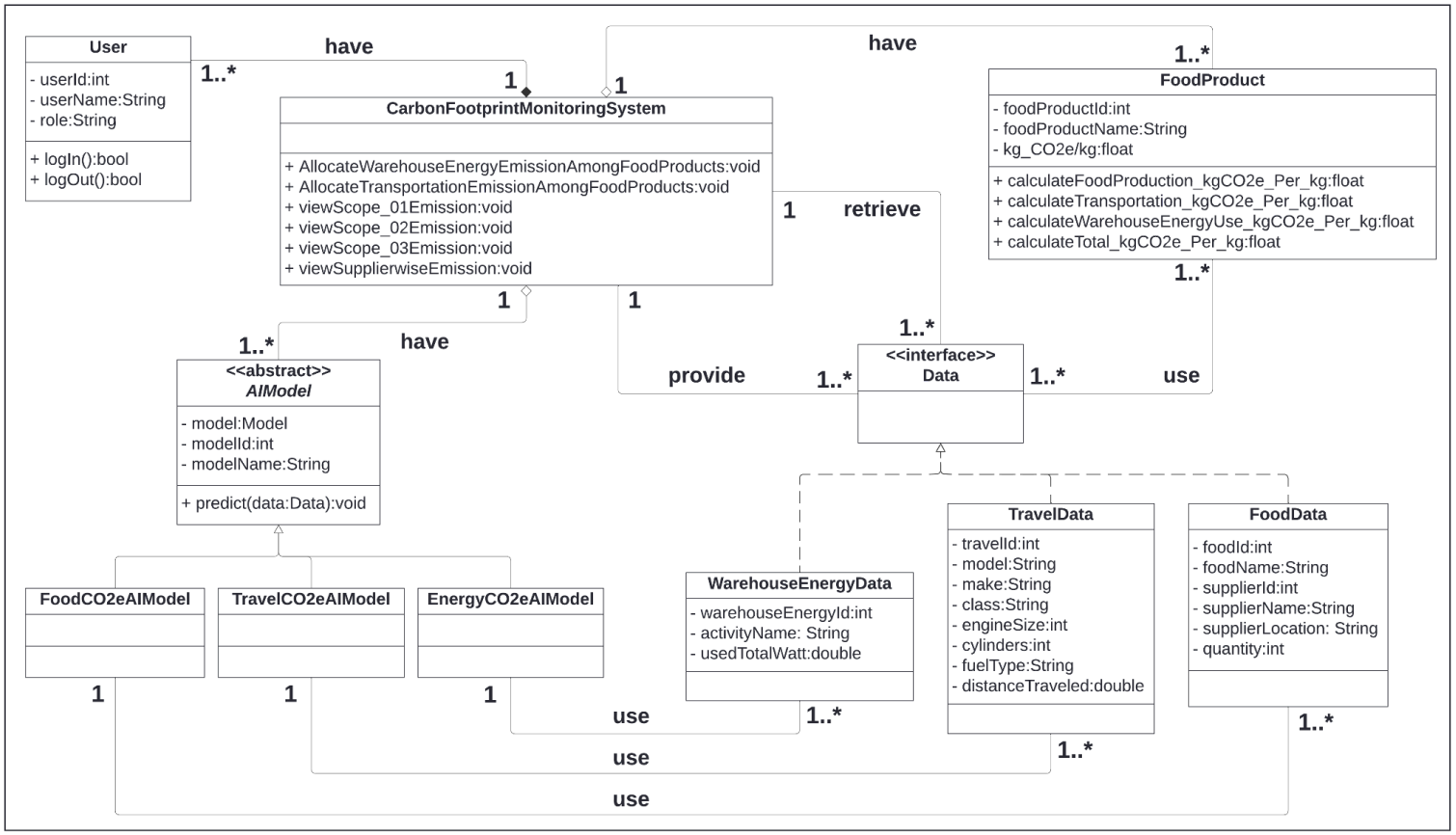

Figure 14: Class Diagram