ALBUKHARY INTERNATIONAL UNIVERSITY

SCHOOL OF COMPUTING AND INFORMATICS

SEMESTER 1 2023/2024

CCC2143

SOFTWARE ENGINEERING

GROUP PROJECT ASSIGNMENT (20%)

PROJECT TITLE	**Carbon footprint calculator to detect greenhouse gas emissions**	
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ITEMS	MARKS
REPORT - 40	
PRESENTATION - 20	
TOTAL (60)	

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A. Introduction

Today, on the heels of an incoming climate change disaster we must use other increasingly sustainable practices and develop more accurate tools to measure individual or group environmental footprint. For example, one of the tools is a Carbon Footprint Calculator that helps to determine and evaluate greenhouse gas emissions due to various activities and operations. It is very essential to choose the right software process model, as it really helps formulate systematic approaches toward a more efficient implementation project.

The primary objective of this report is to identify and recommend what software process model should be used in building a Carbon Footprint Calculator. This tool is intended to empower the informed decisions by the users based on advice related emission origins as a means of avoiding carbon sources thereby instilling an environmental conservation culture.

The Carbon Footprint Calculator has a very vital function in quantifying as well as controlling the GHG emissions. It turns the carbon footprint into quantifiable figures for the users, and thereby inspires informed choices to minimize the environmental damage. For people, firms and even industries monitoring of emissions is extremely important if the goal to achieve sustainable developmental status were realized while at the same time ensuring compliance with all environmental laws.

A Carbon Footprint Calculator is a program that requires many different considerations such as the correct data, complex algorithms for emissions calculations and also the convenience of the interface with regular updates according to factors changing over time. It is required to work with these issues in an adaptive, iterative approaching software development acknowledging the dynamic requirements.

The best suitable software process model to develop your system

As for the nature of environmental data and iterative development, Agile is seen to be an ideal process model when it comes down to developing a Carbon Footprint Calculator. Alternatively, agile approaches such as Scrum and Kanban also emphasize flexibility throughout all development stages.

1. Scrum: Scrum's focus on sprint processes that include frequent releases and the constant stakeholder engagement is perfect for the iterative incorporation of environmental data update as well as user requirements processing.

2. Kanban: Kanban strengths, including the visualization of flow and WIP control may turn out to be very useful for dealing with developing emission factors as well as continuous integration based on user feedback.

B. System Project Objectives

The Carbon Footprint Calculator has been seen as a powerful instrument in the worldwide struggle against climate change with an easy to use, interactive portal for individuals and organizations that will enable them to calculate their carbon footprints. The system is designed according to a particular algorithm which considers various factors such as energy consumption, transportation and waste generation that gives the correct measurement of carbon footprint. A real-time data integration is concerned with timeliness of estimates, and the input categories are varying for a wide variety from different areas of daily activities as well as work operations. It inspires user reflection on how individual and organizational choices impact greenhouse gas levels due to providing multiple options for input personalization. The embedded educational resources on the platform informs users about eco-friendly practices and offers actionable steps that result in emission reduction. Confidentiality and privacy, as well are safe the data of a user that increases trust to the system. As earlier stated, the scalability and API both ensure that people begin to use calculators widely which forms collaboration for a common contribution of fighting against climate change. The user feedback and continuous improvement process make the tool an effective resource to help promote sustainable social behavior that seeks to advance a low carbon society.

C. System Requirement Analysis

C.1 USER REQUIREMENTS

C.1.1 FUNCTIONAL USER REQUIREMENT

User Registration:

Users should have the option to create an account in order to access the calculator. During registration it is necessary to provide information, like name, email address and password .

User Profile:

A profile feature will be available for users to conveniently view and manage their information. They will have the ability to update their profile settings, such as email addresses or passwords.

Carbon Footprint Calculation:

Users will be able to input data related to activities that contribute to greenhouse gas emissions. The calculator will offer options for activity types, including transportation, energy usage and waste management. For each activity users can provide details such as distance traveled, energy consumption or waste generation. Upon processing this data the calculator will estimate the users carbon footprint.

Emission Reduction Suggestions:

Personalized recommendations on reducing emissions should be provided by the system. These suggestions may include tips on conserving energy, exploring alternative transportation methods, adopting recycling techniques or even considering lifestyle changes that're relevant based on activities and preferences.

Progress Tracking:

Users should have access to a feature that allows them to monitor their carbon footprint over a period of time.The system ought to display depictions like graphs or charts illustrating the emission patterns and how users are progressing towards their goals of reducing emissions. It is important for users to receive notifications or reminders to keep their data up to date and effectively monitor their progress.

Database integration:

By integrating the Carbon Footprint Calculator with a database, users can have a centralized and secure storage system for their data, enabling them to retrieve and analyze their carbon footprint information effectively

Multi-Platform Accessibility:

The system should be compatible with the commonly used web browsers and mobile platforms, ensuring that users access and use the calculator seamlessly on their preferred devices

Notification and Alerts:

The system should send automated alerts to users in order for them to stay informed about updates to their carbon footprint data, new emission factors available, or when their data needs to be updated.

User Feedback and Support:

The system should provide feedback options in order for users to report issues, and suggest improvements for the Carbon Footprint Calculator. This can include features like feedback forms or direct contact options.

Multi-Language Support:

The system should provide language preferences or settings in order to cater a diverse user base This ensures that users can understand and navigate the calculator comfortably in their preferred language.

C.1.2 NON FUNCTIONAL USER REQUIREMENTS

Responsiveness:

The system needs to be quick and responsive ensuring interactions, real time tracking and immediate data updates, without any delays.

Security and Privacy:

We must prioritize the security and privacy of user data, transactions and collaborations by implementing encryption measures and access controls.

Usability:

The system should have a user interface that's intuitive to navigate requiring minimal training or technical expertise.

Accuracy and reliability:

Accuracy and reliability are crucial in ensuring that the system delivers calculations based on input data while incorporating the emission factors. This allows users to have confidence in the results and make informed decisions to reduce their carbon footprint.

Compatibility:

Compatibility ensures that the calculator works seamlessly across platforms, devices and web browsers. This allows users to access and utilize the system effortlessly regardless of their technology enhancing convenience and usability.

C.2 SYSTEM REQUIREMENTS

C.2.1 FUNCTIONAL SYSTEM REQUIREMENTS

Technology Stack:

Decide on the programming languages, frameworks and tools needed to develop the calculator. Make sure that the chosen technology stack is compatible and suitable, for both web and mobile application development.

User Interface:

Create an interface that's easy to use and navigate designed with the user in mind.

Ensure that the interface works well on devices and screen sizes.

Calculation Engine:

Build a calculation engine that accurately computes carbon footprints based on user input using industry emission factors.

Include calculations for activities such as transportation, energy usage, waste management, etc.

Sensor Integration (IoT devices):

Integrate high efficiency sensors and IoT devices into the system to gather real time data, on users carbon emissions accurately.

Blockchain Technology:

Incorporate technology to securely track carbon emissions data in a manner and facilitate reward or coin trading.

Data Storage:

Establish a database to store user profiles, activity data and calculation results.

Choose a database management system of handling expected data volume while ensuring data integrity.

Authentication and Authorization:

Implement a robust user authentication system to safeguard user accounts and sensitive information.In order to manage access to features or data in the system it is important to establish user roles and permissions.

Reporting and Visualization:

For understanding and analysis of carbon footprints and emission data visual representations such as charts, graphs or other visualizations can be provided.

Additionally reports can be generated summarizing carbon footprint calculations, progress made in reducing emissions and personalized recommendations.

C.2.2NON FUNCTIONAL-SYSTEM REQUIREMENTS

System Performance

Optimize the systems performance to efficiently handle a number of users and complex calculations ensuring operations.

Conduct thorough performance testing to guarantee response times and minimal delays allowing users to have an experience.

Security Measures

Implement security measures to safeguard user data and prevent access prioritizing the privacy and confidentiality of user information. Employ encryption techniques, secure communication protocols and enforce access controls to enhance the security posture of the system.

Scalability Considerations

Design the system with scalability, in mind allowing it to handle increasing user loads and expanding data volumes gracefully over time.

Ensure that the system can scale both horizontally (by adding servers) or vertically (by upgrading hardware) as needed accommodating growth effectively.

Compatibility Assurance:

Guarantee compatibility across web browsers, operating systems and devices to ensure that users can access the system from any platform seamlessly.

Maintenance and Updates Strategy:

Develop a plan for system maintenance to address any bugs or security vulnerabilities promptly while also optimizing performance continuously.Establish a mechanism for updates and enhancements that can easily incorporate emission factors or calculation methodologies without disrupting user experience.

D.System Model and Architecture

1.System model

1.1.Use case diagram

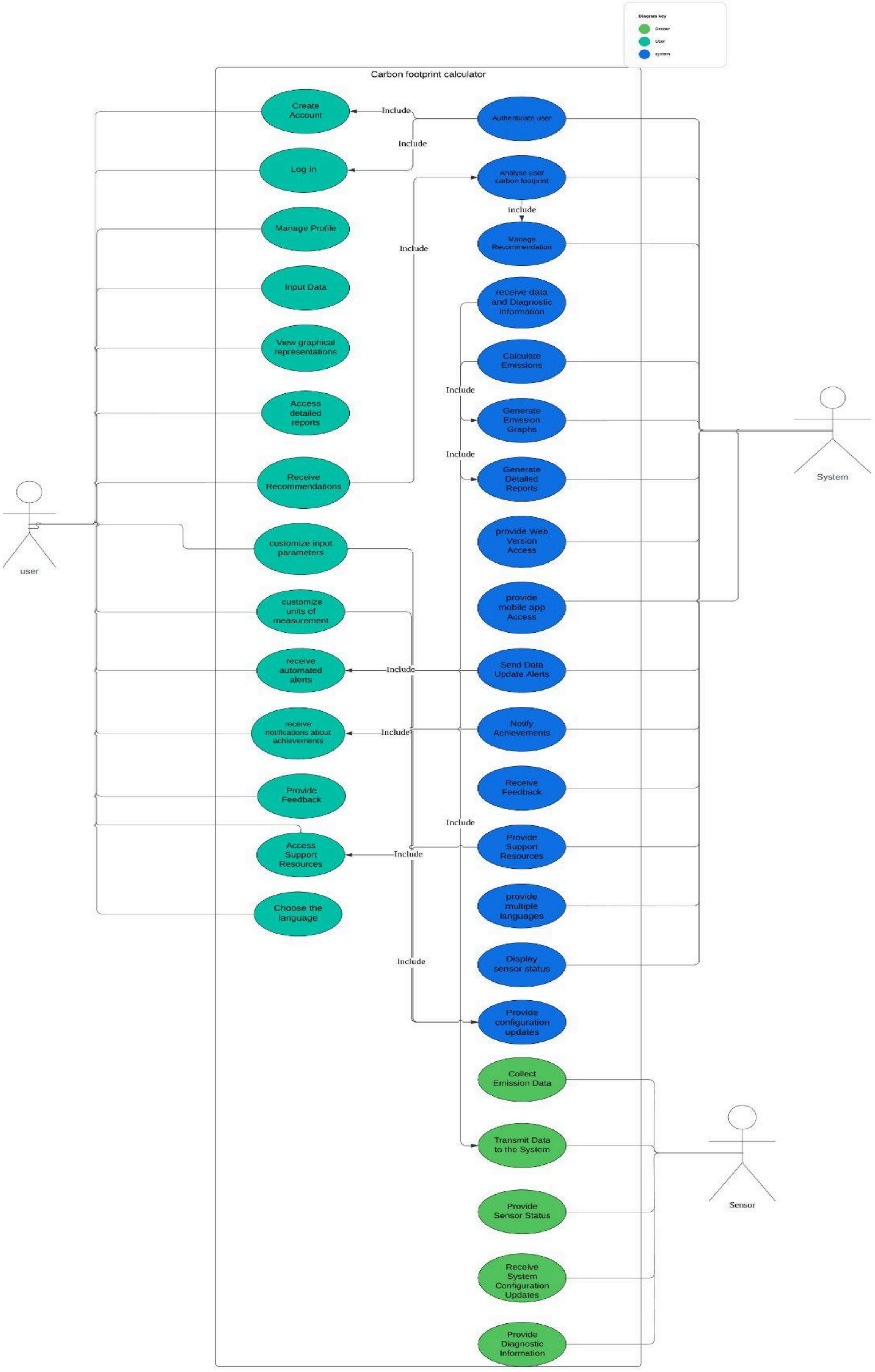
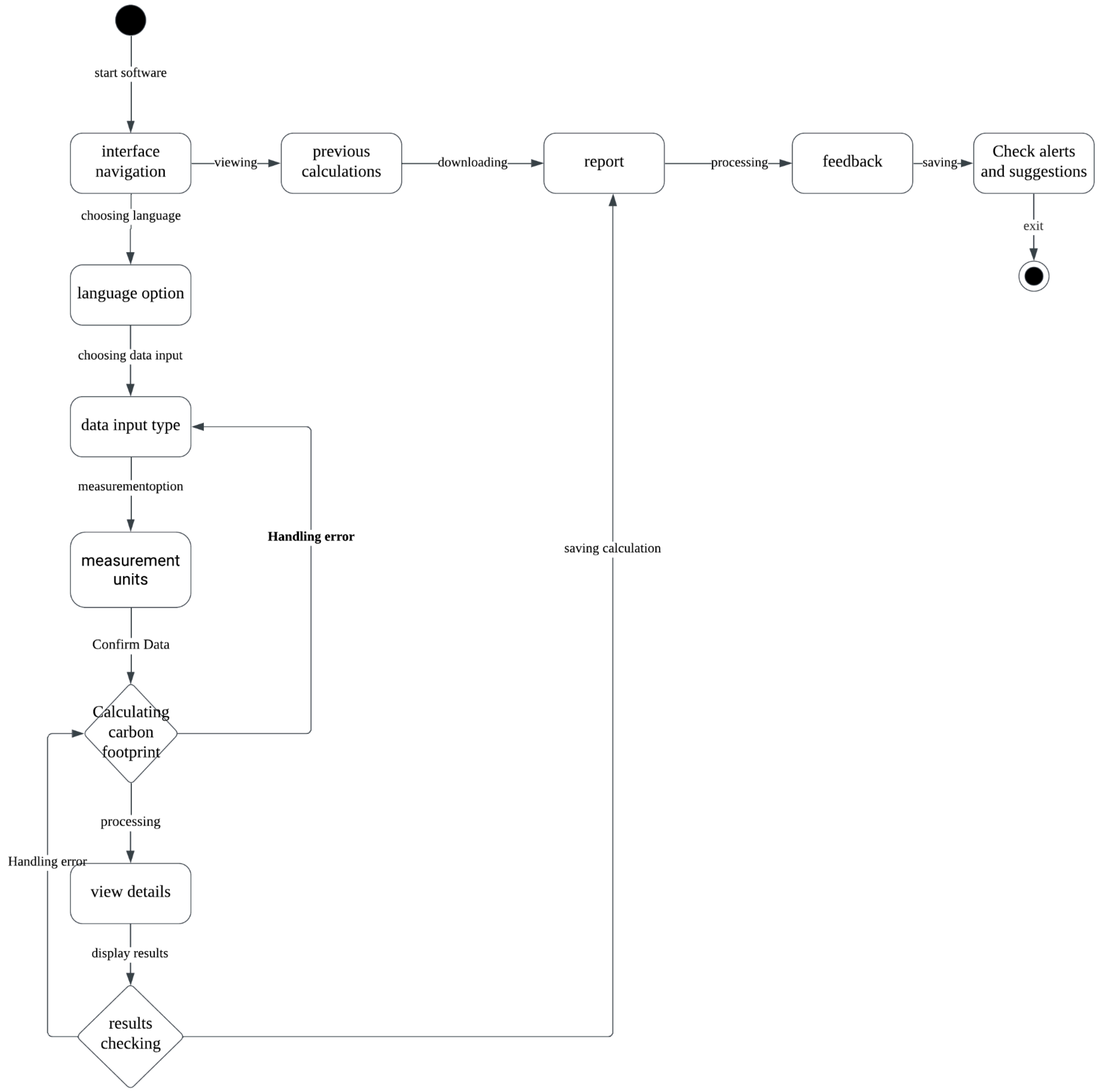
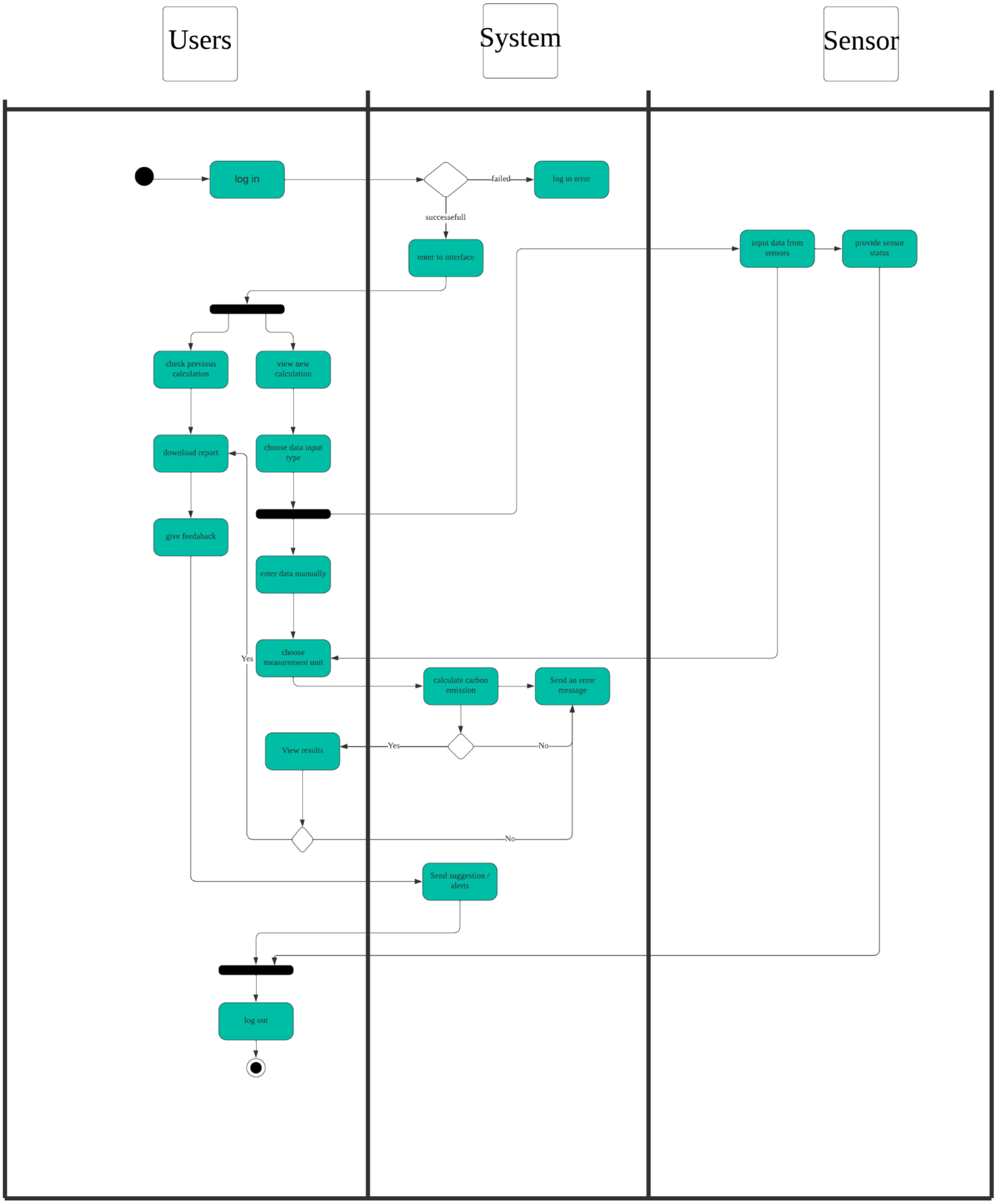


Diagram key
Sensor
User
system
Carbon footprint calculator
Create Account
Log in
Manage Profile
Input Data
View graphical representations
Access detailed reports
Receive Recommendations
customize input parameters
customize units of measurement
receive automated alerts
receive notifications about achievements
Provide Feedback
Access Support Resources
Choose the language
Authenticate user
Analyse user carbon footprint
Manage Recommendation
receive data and Diagnostic Information
Calculate Emissions
Generate Emission Graphs
Generate Detailed Reports
provide Web Version Access
provide mobile app Access
Send Data Update Alerts
Notify Achievements
Receive Feedback
Provide Support Resources
provide multiple languages
Display sensor status
Provide configuration updates
Collect Emission Data
Transmit Data to the System
Provide Sensor Status
Receive System Configuration Updates
Provide Diagnostic Information
Include
Include
include
Include
Include
Include
Include
Include
Include
Include
Include
user
System
Sensor

1.2.State Diagram

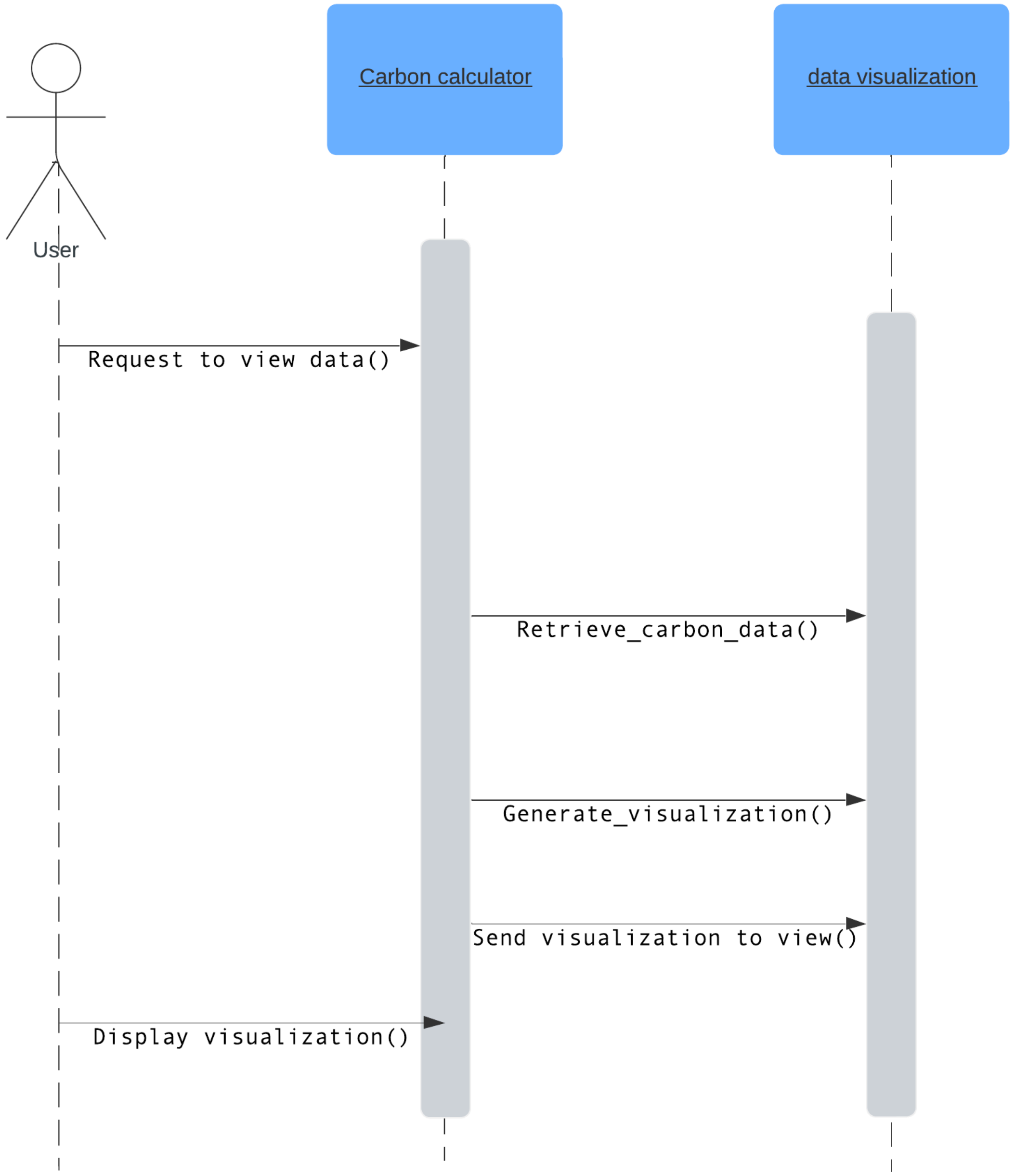


1.3 Activity diagram

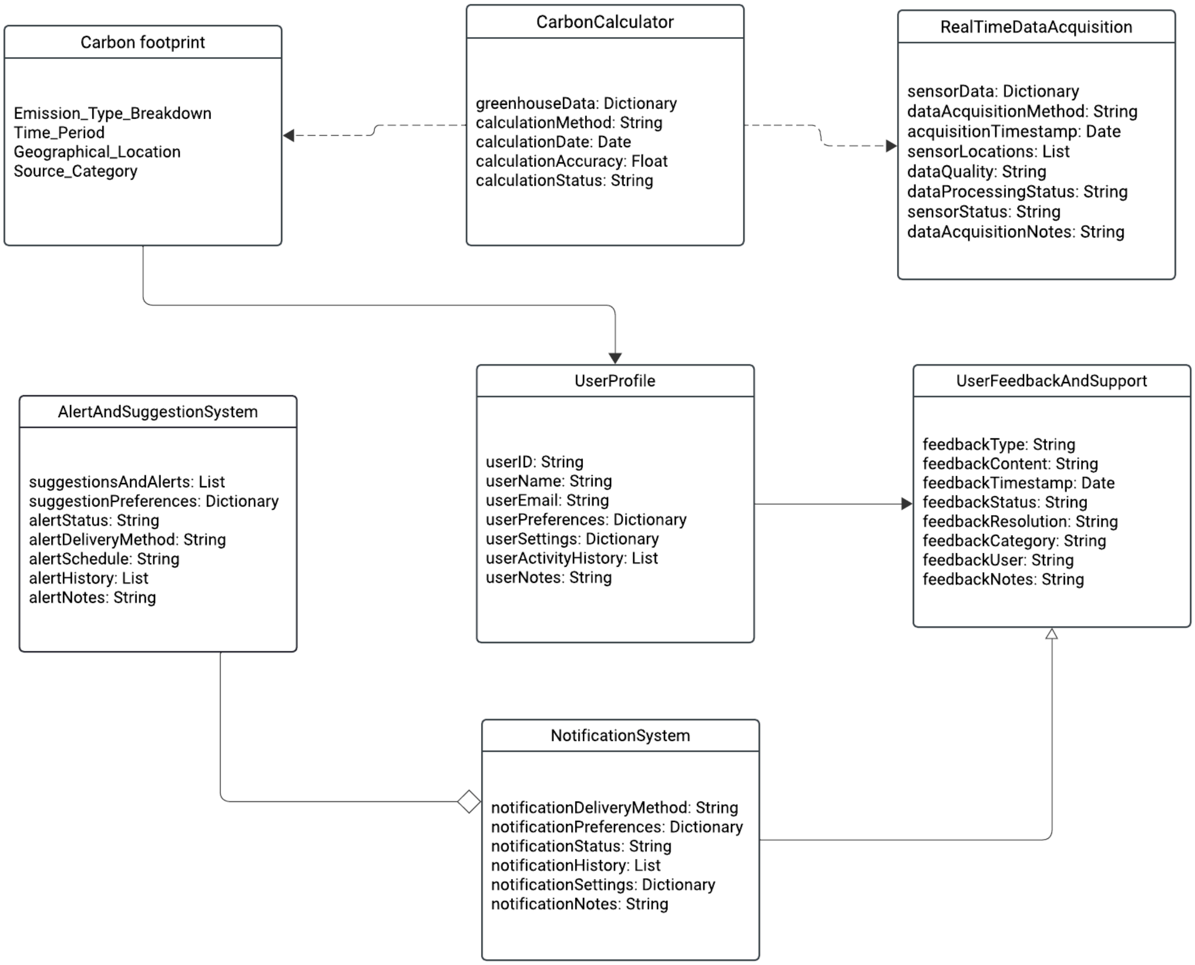


1.4 Sequence diagram :

This diagram focuses on one use case which is graphical representation , the main actors are the user and the system .



1.5 Class diagram



2.System architecture design :

The proposed system architecture is designed as a layered architecture which is ideal for our system as it promotes modularity and separation of concerns, allowing for easier maintenance and scalability. Additionally, the dedicated Security Layer ensures robust security measures are implemented consistently throughout the system, enhancing data protection and compliance.The proposed architecture consists of six layers:

1. Presentation Layer: Handles user interaction and displays information via pages like user registration, dashboard, and profile management.

2. Business Logic Layer: Implements core business rules, user management, data analysis, emission reduction strategies, and progress tracking.

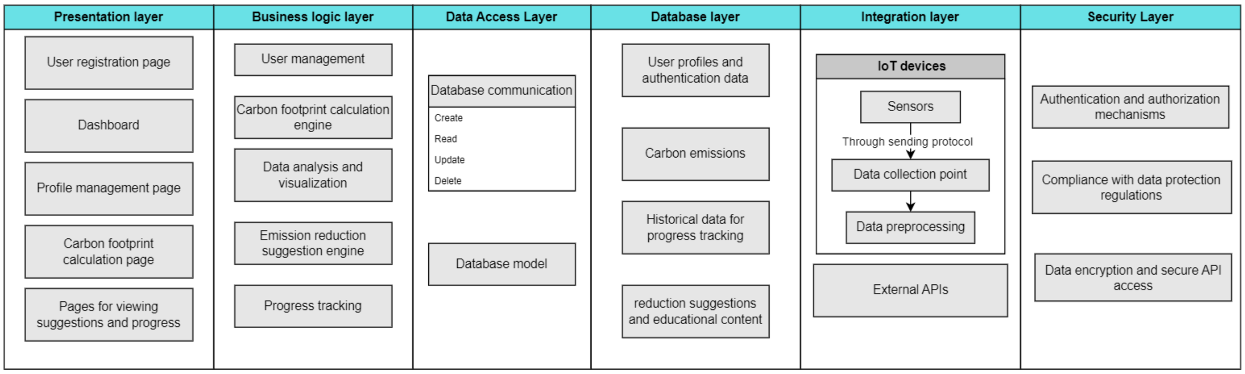
3. Data Access Layer: Communicates with the database and manages data models.

4. Database Layer: Stores user profiles, authentication credentials, carbon emission data, and suggestions/alerts.

5. Integration Layer: Integrates with external services like IoT for sensor data collection and external APIs.

6. Security Layer: Ensures system security through authentication, data protection compliance, encryption, and secure API access.

This layered approach enables clarity, maintainability, and scalability, ensuring effective functionality and security across the system.


Presentation layer
User registration page
Dashboard
Profile management page
Carbon footprint calculation page
Pages for viewing suggestions and progress
Business logic layer
User management
Carbon footprint calculation engine
Data analysis and visualization
Emission reduction suggestion engine
Progress tracking
Data Access Layer
Database communication
Create
Read
Update
Delete
Database model
Database layer
User profiles and authentication data
Carbon emissions
Historical data for progress tracking
reduction suggestions and educational content
Integration layer
IoT devices
Sensors
Through sending protocol
Data collection point
Data preprocessing
External APIs
Security Layer
Authentication and authorization mechanisms
Compliance with data protection regulations
Data encryption and secure API access

E. Component-based model

Building a carbon footprint calculator that detects greenhouse gasses requires the integration of various data sources, algorithms and user interfaces. Below is an overview of the main components we included in our system:

1. User Registration and Profile

Enabling users to create personalized accounts, this component facilitates the customization of settings , the storage of individual data, and adds a user profile management system to allow for easy updates of personal information.

2. Emission Factors Database

A comprehensive database of emission factors would be useful for various functions and resources. The component will represent the emission factors and greenhouse gas emissions per functional unit

3. User Input Interface:

The user input interface component will create an intuitive interface where users can enter their activities or spending habits. This may include fields for travel , energy consumption (electricity consumption and so on) and lifestyle choices (diet).

4. Activity Recognition:

This component will implement algorithms to detect and classify user actions based on input data. For example, distinguish between commuting by car, bicycle or public transport.

5. Data Visualization and Reporting

Presenting emissions data through graphical representations to enhance user understanding. And the component would also generate detailed reports highlighting emission sources and illustrating trends over time.

6.Emission Reduction Suggestions

Offer actionable recommendations to users for reducing their carbon footprint these would be the main functions for this component and clearly communicate the potential impact of suggested changes to encourage sustainable practices.

7. Real-time Data Integration:

The functionality of the component is exclusively   integrating real-time data sources whenever possible. For example, looking up the current carbon intensity of the power grid to get more accurate results on energy-related emissions.

8. Geolocation and Mapping:

By using geolocation information the component can improve the accuracy of calculations, especially when traveling. Map services can provide information about the carbon footprint based on the routes chosen.

9. User Feedback and Recommendations:

Providing users with feedback on their carbon footprint and making practical recommendations to reduce emissions. The component may as well include suggestions for sustainable practices or alternative options that have a lower environmental impact.

10. Graphical User Interface (GUI):

A component that includes an attractive and user-friendly interface to present results. Visualizations such as charts and graphs can help users better understand their carbon footprint and track changes over time.

11. APIs for Third-party Integration:

providing APIs that allow other applications or platforms to integrate with your carbon footprint calculator. This component can facilitate partnerships with other services or organizations.

12. User Accounts and History:

The component would allow user accounts to keep history and track user progress over time. It can also enable personalized recommendations based on individual usage patterns.

13. Educational Content:

Adding educational content to the application can raise awareness of the environmental impact of various activities and the importance of reducing your carbon footprint.

14. Multi-language Support

Adding language options can enable a more diverse user base. Implement localization features to translate content into multiple languages, improving the accessibility of the application.

The privacy and data protection standards should be a priority, especially when dealing with user data. In addition, the emission factor database has to be regularly updated so that the calculator reflects the latest information.

F.System Testing Strategy

Development Testing Stage:

The development testing stage is adopted in this system to ensure the reliability of the system at every level starting from unit testing, then going to Component level testing, and finally testing the whole system in the system testing.

Unit testing:

This type of testing is employed to test individual units like testing individual functions and methods (Sommerville, 2016). For this type of testing several testing frameworks can be used depending on the programming language of the application. For example, a framework like JUnit is used to check java methods, meanwhile we have PyTest for python (Dizdar, 2023). For the Carbon emission system several units need to be tested in this stage. Database operations must undergo the unit testing process to ensure a precise data retrieval from IoT devices. The individual functions are also tested using test cases to ensure their functionality. Other basic blockchain transaction functions shall be well tested to ensure a secure and fluent transaction process.

Component testing:

After ensuring the functionality of the individual units in the unit testing the component testing comes after it to test the functionality of composite components and test these composite components while simulating their interactions with other parts of the system. In the contest of carbon footprint calculator, composite components like the IOT and the database can be tested together to see how these two components are functioning and see how fluent is the process of collecting the data through iot devices then storing it in a database. Checking the proper connection of the user interface and the front end component with the other components is also a crucial process to ensure that the end-user is dealing with a well functioning application.

System testing:

System testing is the final step of the development testing stage. System testing incorporates an end to end checking of all components integrated in the system and their interactions to validate that the system aligns with the system requirements defined previously (Sommerville, 2016). In the system testing the whole system will be tested starting from the initial data capture by IoT sensors, through processing and storage on the blockchain, and culminating in the presentation of this information through the user interface.

Release Testing

This stage involves testing a particular release of the system to ensure that the system is ready to be deployed and released to the intended users.

Requirements-Based Testing:

In this phase of release testing the objective is to confirm that the system meets all the predefined documented requirements and specifications (Sommerville, 2016). In the context of the carbon emission system, the essential functionality of the system has to be validated. Assessing the application ability to accurately track carbon emissions and provide detailed Analysis according to the progress achieved.

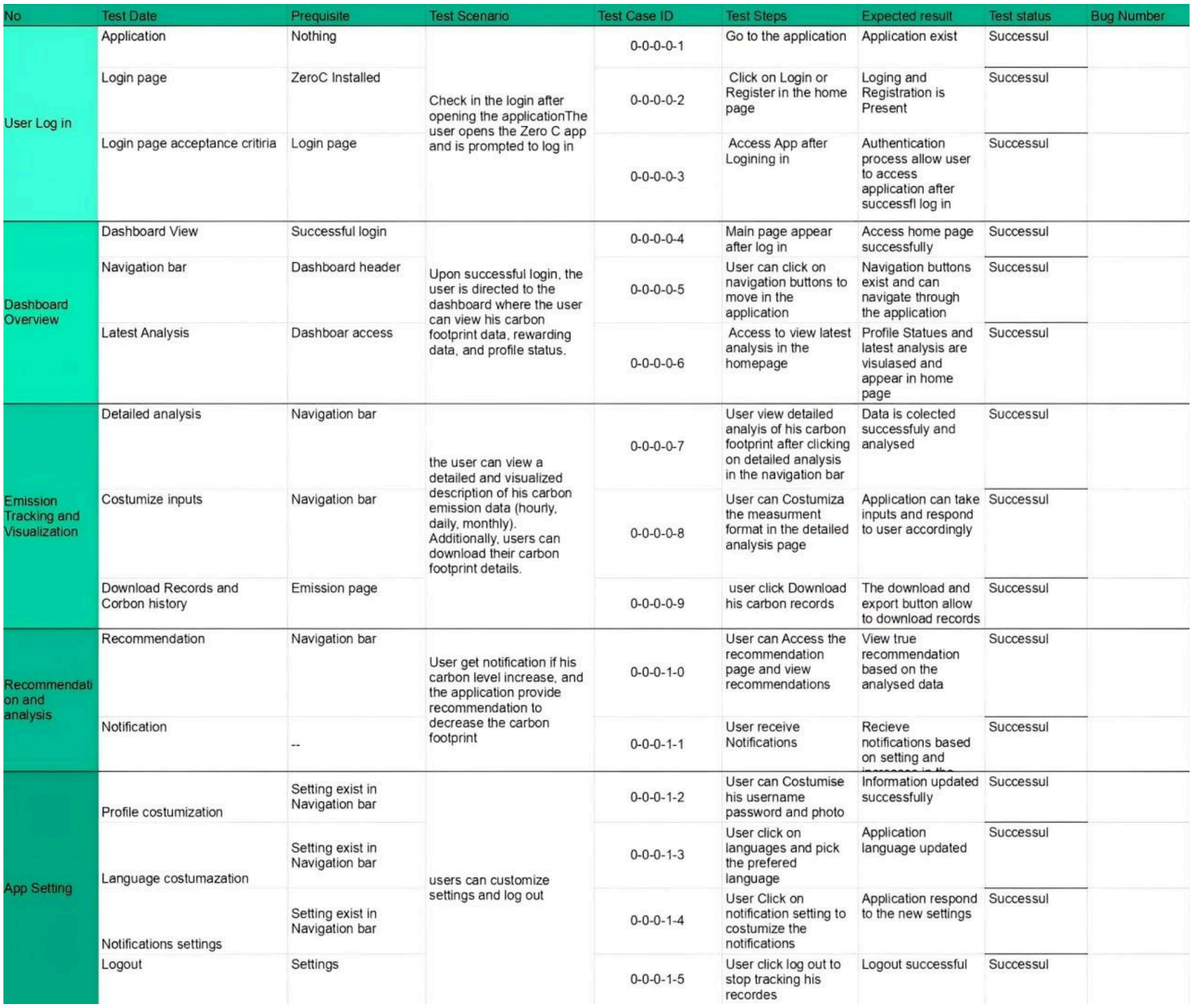
Scenario Testing:

The objective of this testing is to replicate the real-world use by first building a scenario blueprint that we will later on check our application against.

A proposed scenario for a carbon footprint system can be as following:

- User Login: The user opens the Zero C app and is prompted to log in.

- Dashboard Overview: Upon successful login, the user is directed to the dashboard where the user can view his carbon footprint data, rewarding data, and profile status.
- Emission Tracking and Visualization: the user can view a detailed and visualized description of his carbon emission data (hourly, daily, monthly).
- Recommendations and notifications : The user will get notified in case of a sudden footprint increase.
- User Settings: users can customize settings.
- Logout: users can log out of the application.



No	Test Date	Prequisite	Test Scenario	Test Case ID	Test Steps	Expected result	Test status	Bug Number
User Log in	Application	Nothing	Check in the login after opening the applicationThe user opens the Zero C app and is prompted to log in	0-0-0-0-1	Go to the application	Application exist	Successul	
	Login page	ZeroC Installed		0-0-0-0-2	Click on Login or Register in the home page	Loging and Registration is Present	Successul	
	Login page acceptance critiria	Login page		0-0-0-0-3	Access App after Logining in	Authentication process allow user to access application after successfl log in	Successul	
Dashboard Overview	Dashboard View	Successful login	Upon successful login, the user is directed to the dashboard where the user can view his carbon footprint data, rewarding data, and profile status.	0-0-0-0-4	Main page appear after log in	Access home page successfully	Successul	
	Navigation bar	Dashboard header		0-0-0-0-5	User can click on navigation buttons to move in the application	Navigation buttons exist and can navigate through the application	Successul	
	Latest Analysis	Dashboar access		0-0-0-0-6	Access to view latest analysis in the homepage	Profile Statues and latest analysis are visulased and appear in home page	Successul	
Emission Tracking and Visualization	Detailed analysis	Navigation bar	the user can view a detailed and visualized description of his carbon emission data (hourly, daily, monthly). Additionally, users can download their carbon footprint details.	0-0-0-0-7	User view detailed analyis of his carbon footprint after clicking on detailed analysis in the navigation bar	Data is colected successfuly and analysed	Successul	
	Costumize inputs	Navigation bar		0-0-0-0-8	User can Costumiza the measurment format in the detailed analysis page	Application can take inputs and respond to user accordingly	Successul	
	Download Records and Corbon history	Emission page		0-0-0-0-9	user click Download his carbon records	The download and export button allow to download records	Successul	
Recommendation and analysis	Recommendation	Navigation bar	User get notification if his carbon level increase, and the application provide recommendation to decrease the carbon footprint	0-0-0-1-0	User can Access the recommendation page and view recommendations	View true recommendation based on the analysed data	Successul	
	Notification	--		0-0-0-1-1	User receive Notifications	Recieve notifications based on setting and	Successul	
App Setting	Profile costumization	Setting exist in Navigation bar	users can customize settings and log out	0-0-0-1-2	User can Costumise his username password and photo	Information updated successfully	Successul	
	Language costumazation	Setting exist in Navigation bar		0-0-0-1-3	User click on languages and pick the prefered language	Application language updated	Successul	
	Notifications settings	Setting exist in Navigation bar		0-0-0-1-4	User Click on notification setting to costumize the notifications	Application respond to the new settings	Successul	
	Logout	Settings		0-0-0-1-5	User click log out to stop tracking his recordes	Logout successful	Successul	

Performance Testing:

Once the system is completed, performance testing comes to check the performance and reliability of the system ensuring that the application can work well under expected loads. A form of testing called stressed testing is adopted to simulate multiple users by using tools like JMeter to test the application's ability to handle data.

User Testing Stage

This stage involves user input and it is crucial for ensuring the user satisfaction on the application.

Alpha Testing:

The objective of this test is to conduct an internal testing with the user at the developers site to test the application environment whether it resembles the production environment. Selected users from the organization can test the application.

Beta testing:

The objective of this testing is to extend the audience and get feedback from external users to get an extended understanding on its performance and usability.

Acceptance testing:

The objective of this test is to allow the end user to validate the software and decide whether this software is acceptable and is meeting the tracking and trading needs.

G.Roles and responsibilities of project members

Member name	role
Rania kherba	System modeling, architecture
Roua alimam	System testing strategies , architecture
Yusuf Nuru Yesuf	Introduction, conclusion , objective , suitable model
Aminu Ahmad Abdullahi	System requirements
Yousif Esmat Abdalla	component -based system

H.Conclusion

In conclusion, the creation of a Carbon Footprint Calculator is an important milestone in promoting sustainable practices to avoid climate change. It starts by noting the urgency to act on environmental issues as well through mechanisms that are accurate, such as a Carbon Footprint Calculator. The main goal of the system is to enable individuals and organizations to develop policies in accordance with their greenhouse gas emissions, developing a culture of environmental conservation.

The selection of the Agile software process model, namely Scrum and Kanban, is justified by its flexibility in line with dynamic environmental data. The system project objectives are described as a big one with real time integrated data, personalized recommendations and tracked progress to guide users in reducing the carbon footprint. The specific characteristics of the system requirements analysis include grouping user and system needs that stress responsiveness, security.

The sections on system model and architecture design present information about the visual representation with structural elements of Carbon Footprint Calculator involving registration user, emission factors database user input interface alongside live integration. The component-based model is further developed to explicate other important elements such as emission reduction recommendations, data visualization and reporting among others user feedback along with the APIs for third party integration.

The testing strategy is comprehensive encompassing the development stage of testing, release tests and user tests. The fact that unit testing, component testing, system testing and different forms of release-related tests such as requirements based tests, scenario-, performance tests ensure the accuracy and security functionality for Carbon Footprint Calculator.

Finally, such a system is developed in an integrated fashion with competent technological fundamentals and taking user needs into account while documentation of several testing procedures. The significance of privacy, data protection and the continuous updating are emphasized by this report to keep a calculator accurate and effective for promoting sustainability. Finally, the Carbon Footprint Calculator can be considered as a tool that has helped people and organizations to take measures aimed at reducing their environmental footprint.

I.Reference

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J. Appendix

Technical Specifications

1. Hardware Requirements:

- Minimum:
  - Processor: Intel Core i3 or equivalent
  - Memory: 4GB RAM
  - Storage: 100GB HDD/SSD
- Recommended:
  - Processor: Intel Core i5 or equivalent
  - Memory: 8GB RAM
  - Storage: 256GB SSD

2. Software Requirements:

- Operating System: Windows 10 or later, macOS 10.14 or later, Linux (Ubuntu 18.04 LTS or later)
- Web Browser: Latest versions of Google Chrome, Mozilla Firefox, Safari, Microsoft Edge
- Mobile Platform: Android 8.0 or later, iOS 12 or later

3. Programming Languages:

- Backend: Python, JavaScript
- Frontend: HTML5, CSS3, JavaScript (React.js for dynamic interfaces)
- Database: SQL (MySQL, PostgreSQL) for relational databases, NoSQL (MongoDB) for document-oriented databases
- IoT Integration: Python, C/C++, Java

4. Frameworks and Libraries:

- Backend Framework: Django for Python, Express.js for Node.js
- Frontend Framework: React.js, Vue.js
- Database ORM (Object-Relational Mapping): Django ORM, Sequelize for Node.js
- IoT Framework: Raspberry Pi for sensor integration, Arduino for hardware interfacing
- Data Visualization: D3.js, Chart.js, Plotly.js

5. Development Tools:

- Integrated Development Environment (IDE): PyCharm, Visual Studio Code, Atom
- Version Control: Git, GitHub, GitLab
- Project Management: Jira, Trello, Asana
- Collaboration: Slack, Microsoft Teams, Zoom

6. Deployment Environment:

- Web Hosting: AWS (Amazon Web Services), Google Cloud Platform, Microsoft Azure
- Database Hosting: AWS RDS (Relational Database Service), MongoDB Atlas
- Continuous Integration/Continuous Deployment (CI/CD): Jenkins, Travis CI, GitLab CI/CD

7. Security Tools:

- Encryption: SSL/TLS for secure communication, bcrypt for password hashing
- Authentication: JSON Web Tokens (JWT), OAuth 2.0
- Compliance: GDPR (General Data Protection Regulation) compliance measures
- Monitoring: Prometheus, Grafana for system monitoring and logging