REQUIREMENTS SPECIFICATION DOCUMENT

Final Version

Enhancing Energy Production using Artificial Intelligence

HELP THE KELP

Contents

List of Figures

Revision History

Name	Date	Reason for Changes	Version
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Saifa	27-9-2022	1.1-1.5 drafting	0.05
Charlie	3-10-2022	2.1-2.6, 3.1 drafting	0.1
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1 Introduction

1.1 Purpose

This final requirement specification document describes the functionality of the system interface that helps gather, control, and display data for energy harvesting from marine renewable energy systems using AI. This document also describes the physical device to be used to gather additional data to assist the AI in identifying the ideal generation location. The current system the client uses has great potential to be optimized, updated, and gather better-fit data obtained from the new renewable energy systems, which will be the focus of this document.

1.2 Project Scope

The scope of our solution is to help gather and organize incoming data to the system and improve the current analysis system along the Western-Canadian coastlines. This implementation will consist of new hardware fitted with several sensors, a new analysis model running the algorithm to process data, as well as an interface enabling users to view data and interact with the system. The analysis system will make predictions for at least the next ten years, identifying the optimal locations for energy production divided into time blocks of a quarter year. This will allow the employees and managers to easily access the data needed to make adjustments to their energy generation systems. This new system will also allow the client's developers to be able to maintain and update the system. Existing physical infrastructure will not be changed nor tampered with.

1.3 Glossary of Terms

Term	Definition
User Interface (UI)	The software that the user (employee, manager, etc.) interacts with.
AI	Short for Artificial Intelligence, a system that can improve itself based on information given.
AWS	Amazon Web Services
WEC	Wave Energy Converter
TCP	Transmission Control Protocol
IP	Internet Protocol
iOS	iPhone Operating System

User	Anyone who is interacting with the current system or interface.
Admin/Administrator	User who has a high position role (ie. manager) in the company
Employees	General groups of users who work for the company (Researchers, Developers etc.).

1.4 References

[1] C. C. G. Government of Canada, “Government of Canada,” *Canadian Aids to Navigation System*, 13-Dec-2021. [Online]. Available: https://www.ccg-gcc.gc.ca/publications/maritime-security-surete-maritime/aids-aides-navigation/page01-eng.html. [Accessed: 05-Oct-2022].

1.5 Overview

The first section of this requirement document is the overall description of the product which contains product perspective, product features, user classes and characteristics, operating environment, design and implementation constraints, as well as assumptions and dependencies. The second section focuses on each feature of the system's functional requirements, including the AI-assisted generation of accurate energy heatmaps, a UI that allows users to view data and maps, and an all-in-one energy sensor tool. The third section of this document goes into detail about each external interface requirement such as User Interface, Software Interface, Hardware Interface, and Communication Interface. In the fourth section, we will be describing other non-functional requirements such as the usability of the UI, and the durability of the sensors, and the performance of the AI. The fifth section is the other requirement that doesn’t fit into the fourth section. Lastly, the sixth section includes the context flow diagram and level 0 data flow diagram.

2 Overall Description

2.1 Product Perspective

This product is a replacement for an existing system which is ill-suited for collecting and processing renewable energy data from all parts of the expansive Canadian coastline because of the gap in data due to lack of several sensors required to make accurate predictions. However, the three facets of this project have different applications. The data collection device will be deployed alongside and not replace the existing data collection infrastructure but will expand on the data that is being collected with the AI-assisted data processing system and will replace the very few small ocean energy data aggregation systems that are currently in use. The new system will also feature a modern UI to display the information and statistics that the sensors collect

2.2 Product Features

The AI-assisted algorithm will combine all the collected sensor data to create heat maps showing the energy production of Canada's west coastline. This will not only be able to show the history of ocean energy data where the sensors are located but will extrapolate and display projected future energy distribution to find the optimal location for energy generators.

The UI is where the various types of users will interact with this AI-assisted algorithm. It will allow users to view different kinds of heat maps for different methods of ocean energy production as well as an aggregated heat map showing the optimal location. It will also allow users with different roles access to certain features specific to them. For example, a user logged in as a manager would get access to their employee's login and query history, while a developer would be able to control various aspects of the algorithm through a control panel and command line interface.

The physical data collection system will be an easily deployable all-in-one system that incorporates many types of ocean energy surveying tools including the WEC (Wave Energy Converter) that measures wave energy, a barometer to measure tidal frequencies and magnitudes, and an anemometer that measures wind speed and direction. This system will transmit the data it collects wirelessly to an on-land device to be sent to the central database server. The sensors will be durable enough to handle weather events and require minimal maintenance, including being resistant to corrosion, and having a lifespan of approximately 8 years under optimal conditions before needing a replacement.

2.3 User Classes and Characteristics

The primary user of this product would be researchers working for OceanAI who are trying to find the optimal location to install energy generators to maximize energy output. This product can also be used by engineers to tweak their generators in different areas in order to optimize their energy generation. In addition, data will be available for researchers looking for data on the changing of the potential of ocean energy production over time. The most important user class for this product is the researchers who are trying to find the optimal energy potential.

2.4 Operating Environment

Collected data will be kept and processed on many servers across Canada, but the main program and information can be accessed remotely from any computer through a web application. This will work on any operating system and with any browser.

The sensors will operate wirelessly in many locations along the Western-Canadian coastlines. They will have an embedded software element housed in a waterproof floating housing. Data analysis will then be processed on cloud computers hosted through AWS for easy scalability. The UI will be a web application that will be accessible through any modern browser.

2.5 Design and Implementation Constraints

Hardware Constraints

The hardware that makes up the servers dedicated to the AI-assisted algorithm are Linux servers in at least four separate locations. These will be spread out in various cities on Canada's coast for high-speed data retrieval and dissemination.

The hardware required to run the application on the user's machine or the user's employer's machine is a basic desktop or laptop computer with access to the internet and a modern browser. A smartphone can be utilized but it is not recommended as the program will be optimized for a desktop computer.

System Maintenance

The designing team is responsible for updating and maintaining the software elements of the delivered system. A third party or qualified employees of the client are responsible for maintaining the hardware, but the designing team is available for consultation of hardware malfunctions.

2.6 Assumptions and dependencies

2.6.1 Assumptions

Map making

Third party APIs and libraries can be used to create maps and transmit data from sensors to servers

Design and Client Teams Availability

All members from the design team are available during the project period to complete tasks. When issues occur the client team is available to elicitate.

Scheduling

Every feature list below can be completed on time.

2.6.2 Dependencies

Third party services

Third party APIs, libraries and hardware parts will be used frequently in all elements of the solution. This includes software and external cloud storage to help with the storing of data.

Internet connection

All devices running a part of the deployed system will have an internet connection.

3 System Features

This section describes the interconnected network of sensors that will be used to collect data on ocean-focused energy production. Below are diagrams, use cases and descriptions that describe how the sensors will communicate with our servers and databases to provide accurate and digestible information to capture renewable energy from the ocean.

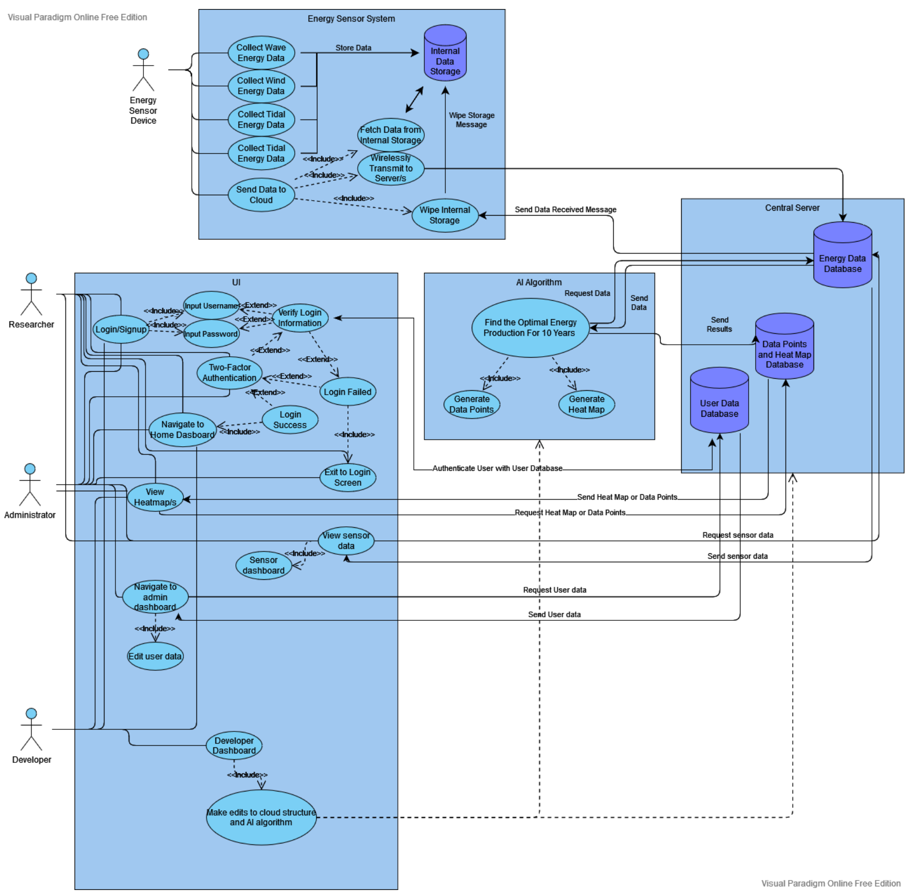

Figure 3.1: Use case diagram of the system

3.1 Ocean Energy Sensors

3.1.1 Description and Priority

The ocean energy sensors will be an all-in-one ocean energy data collection tool. It will contain a WEC (Wave Energy Converter) device that measures the wave energy at that location, the data will be used to calculate the viability for a WEC device. It will also have a barometer that reads the pressure that the tide creates, this data will be used to calculate the viability of a tidal energy turbine or generator. It will also have an anemometer that reads wind speed and direction, this will be used to calculate the viability of offshore wind turbines. This is a high-priority feature.

3.1.2 Functional Requirements

REQ-1-1: WEC device: must collect accurate wave energy data where deployed.

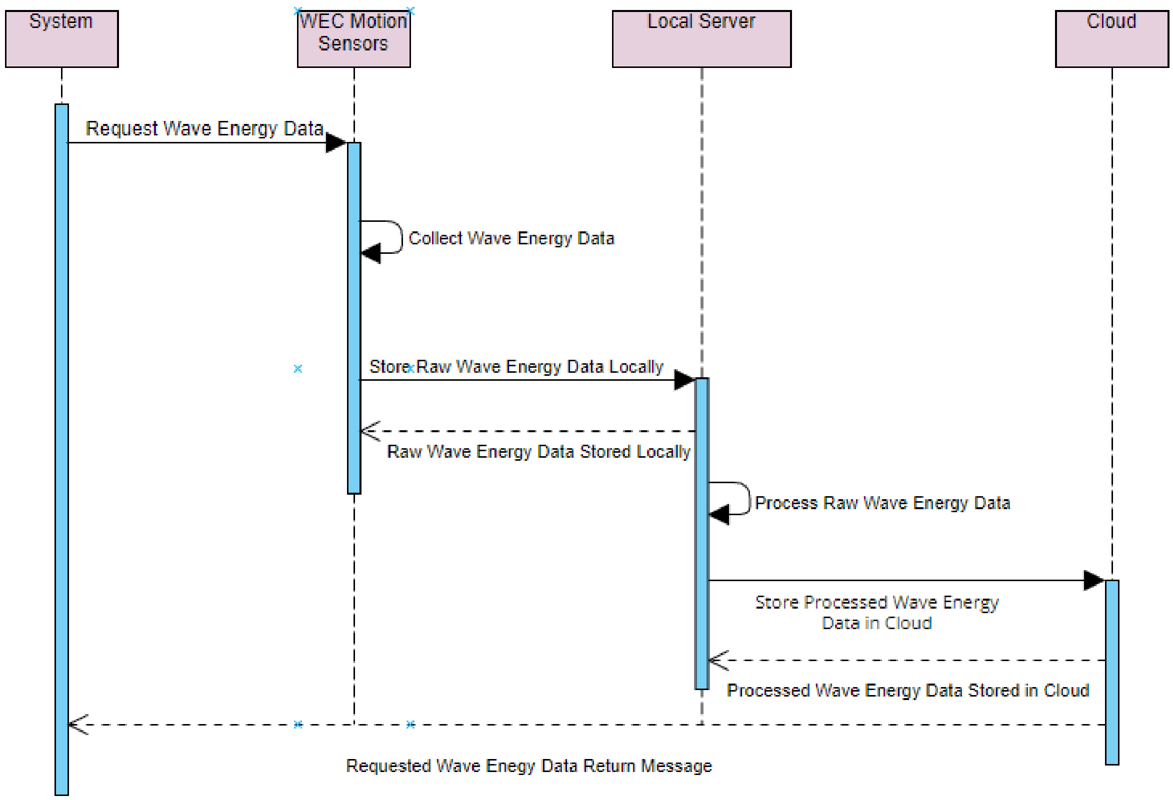

Figure 3.2: Sequence Diagram for REQ-1-1: WEC Device

- The sequence diagram above is a demonstration of how the WEC Device will process the data. Once the device is deployed in the ocean, the motion of waves will cause the sea level to rise and fall above the device so that the WEC Motion Sensors can start collecting the data. Once all the data is collected, then this raw data will be stored locally. On the local server, the raw data will be processed, and the processed data regarding the Wave Energy will be stored in the Cloud.

REQ-1-2: Barometer: must collect accurate tidal pressures where deployed.

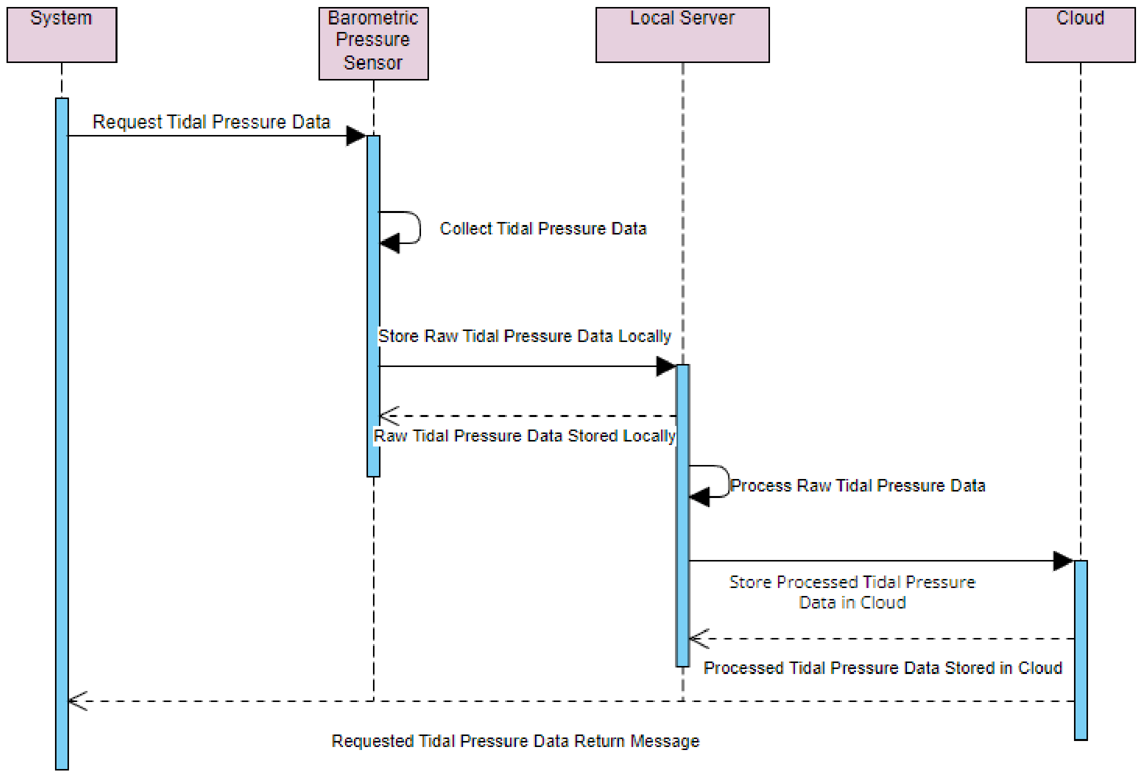

Figure 3.3: Sequence Diagram for REQ-1-2: Barometer

- The sequence diagram above is a demonstration of how the Barometer will process the data, and where the processed data will be stored. Once the hardware device is displayed in the ocean, the barometric pressure sensors will collect the tidal pressure data. Once all tidal pressure data is collected, this raw data will be stored in the local server. On the local server, the raw data will be processed. The processed data regarding the Tidal Pressure will be stored in the Cloud, and then the return message will be sent to the system.

REQ-1-3: Anemometer: must collect accurate wind speed and direction where deployed.

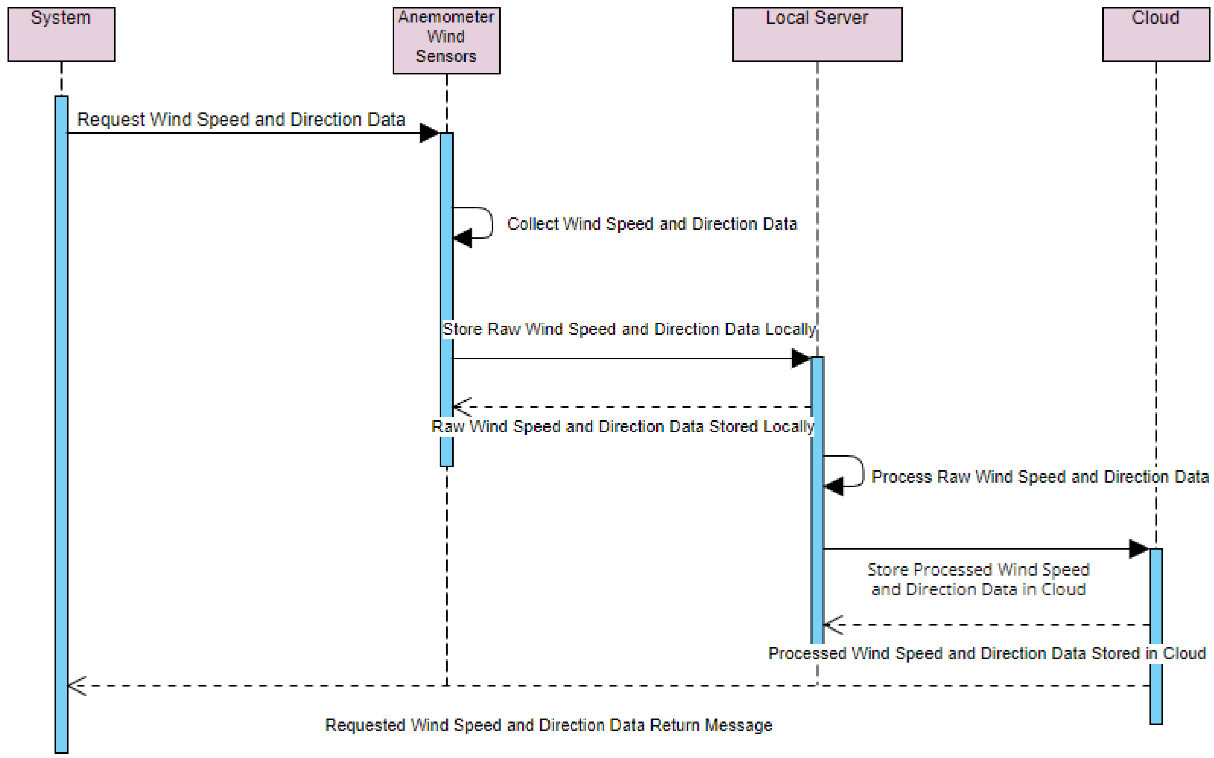

Figure 3.4: Sequence Diagram for REQ-1-3: Anemometer

- The sequence diagram above is a demonstration of how the Barometer will process the data, and where the processed data will be stored. Once the hardware device is displayed in the ocean, the barometric pressure sensors will collect the tidal pressure data. Once all tidal pressure data is collected, this raw data will be stored in the local server. On the local server, the raw data will be processed. The processed data regarding the Tidal Pressure will be stored in the Cloud, and then the return message will be sent to the system.

REQ-1-4: Wireless Transmitter: must transmit sensor data from floatation device to servers wirelessly.

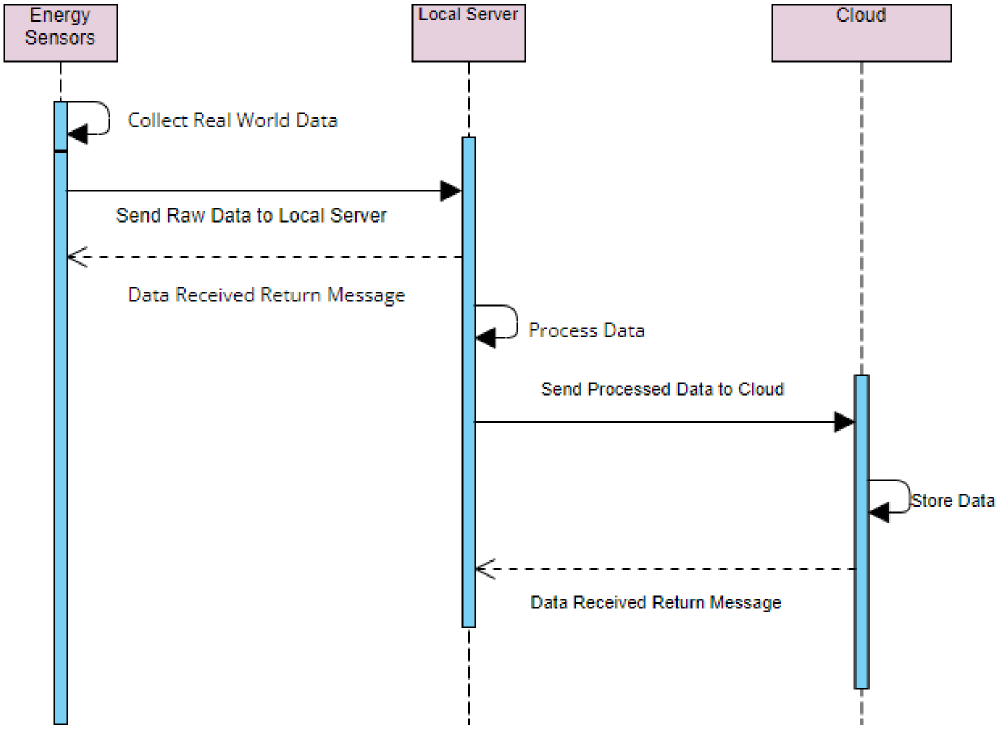

Figure 3.5: Sequence Diagram for REQ-1-4: Wireless Transmitter

- The sequence diagram above is a demonstration of how the transmitter will store the processed data in the cloud. The sensors on the hardware device will collect data and this raw data will be stored in the local server. On the local server, the raw data will be processed data, and sent to the cloud to be stored.

3.1.3 Use Cases

UC-1-1: Sensors detect change in environment

Actors:

- Ocean sensors
- Server

Secondary Use Case

- N/A

Precondition

- Sensors have been set up and calibrated

Postconditions

- Sensors continue to collect data to later send to database

Main Flow

1. Sensor is in the water/air
2. Sensor records change in the environment
3. Change is recorded in sensors memory
4. Sensor continues working

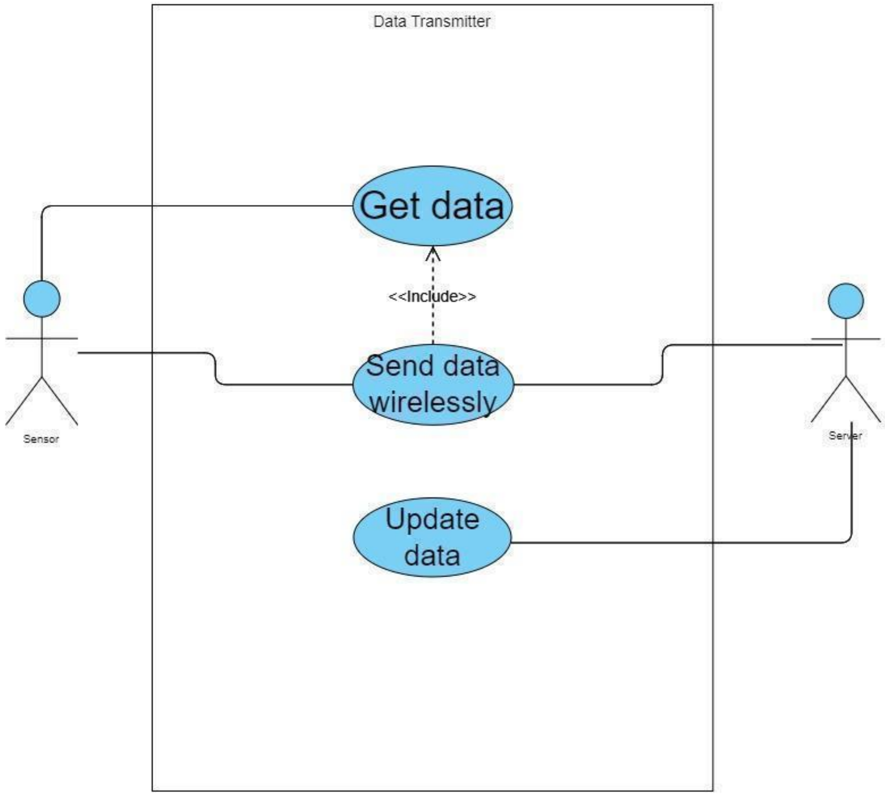

Figure 3.6: use case diagram for UC-1-1: Sensors detect change in environment

3.2 AI Data Algorithm

3.2.1 Description and Priority

The AI algorithm implemented will be the backbone of the project, with the main goal of helping identify the most efficient energy production. This algorithm will collect all data from the ocean energy sensors to run the analysis. The analysis will be a function of variables such as wave energy, temperature, wind, water salinity, and coast geography as input, and output data will show the best geographic location to produce energy efficiently. The algorithm will not only look at present data, but extrapolate years in advance in order to assist with this output. As this is the most important feature of the overall system, this AI is of high priority.

3.2.2 Functional Requirements

REQ-2-1: AI must find the best long-term location for maximum energy production (10+ years).

REQ-2-2: Must compile data from database into heatmap displaying the best locations for energy production through API.

Sequence Diagram 3-2-2: AI Algorithm

The AI will determine and produce heat map for best energy generation spot

Actors

- Ocean Energy Sensors

Secondary Use Case

- N/A

Precondition

- Ocean Energy Sensors have been set up and calibrated

Postconditions

- Users are displayed an energy generation heat map of their chosen locations.

Main Flow

1. The data is collected through the Ocean Energy Sensors.
2. The collected data is analyzed using the AI Algorithm
3. The user requests an energy generation heatmap of Vancouver Island
4. A heatmap is generated and user is displayed an energy generation heatmap of Vancouver Island

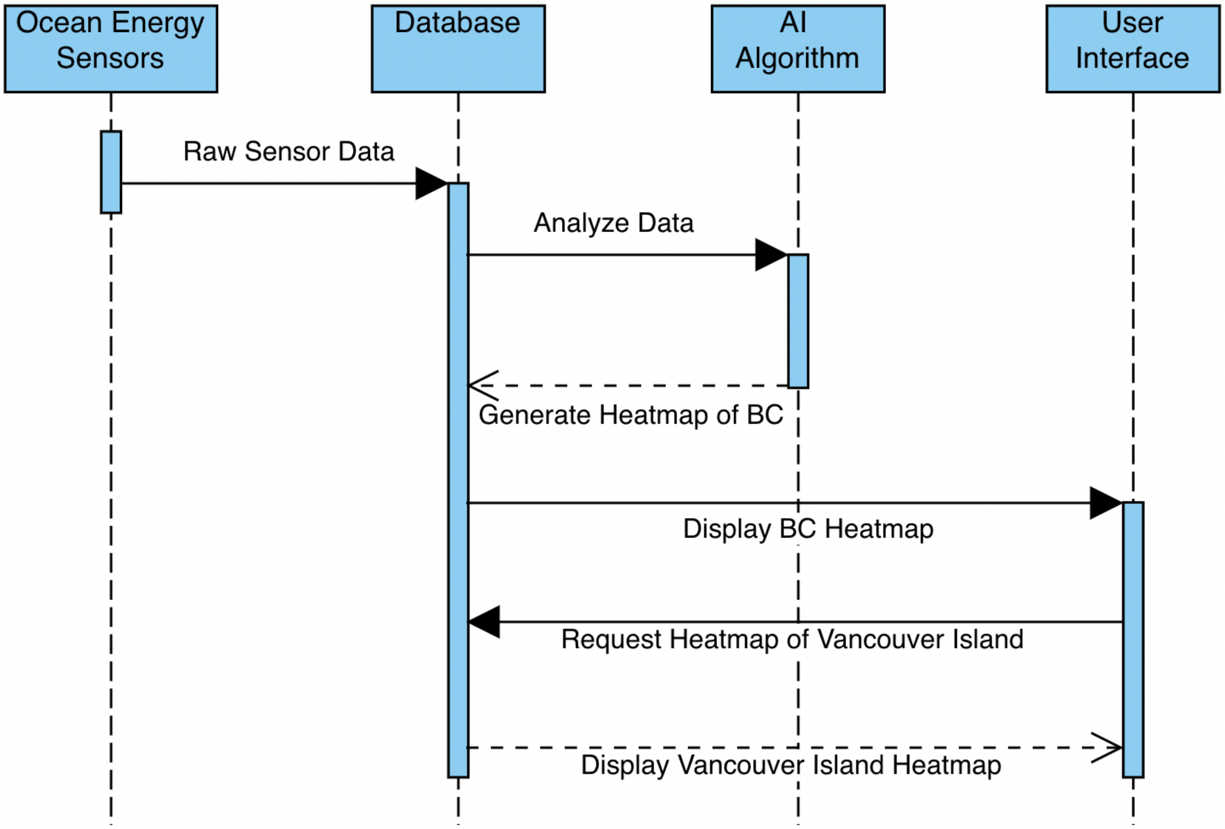

Figure 3.7: Sequence diagram for REQ-2-2: AI algorithm

3.2.3 Use Cases

UC-2-1: AI algorithm

AI determines and produces heat map for best energy generation spot

Actors

- Ocean energy sensors
- User Interface

Secondary Use Case

- UC-1-1

Precondition

- Ocean energy sensors have the data gathered

Postconditions

- User is showed heatmap and data points from user interface

- The resulting heat map of where the best energy generation is stored in the database

Main Flow

1. The data from ocean energy sensors is given to AI as input
2. The AI calculates the best spot for generating energy for 10 years
3. The AI generates an energy generation heat map and data points for best location
4. The AI displays the information to the user and stores the resulting heat map and data points in the database

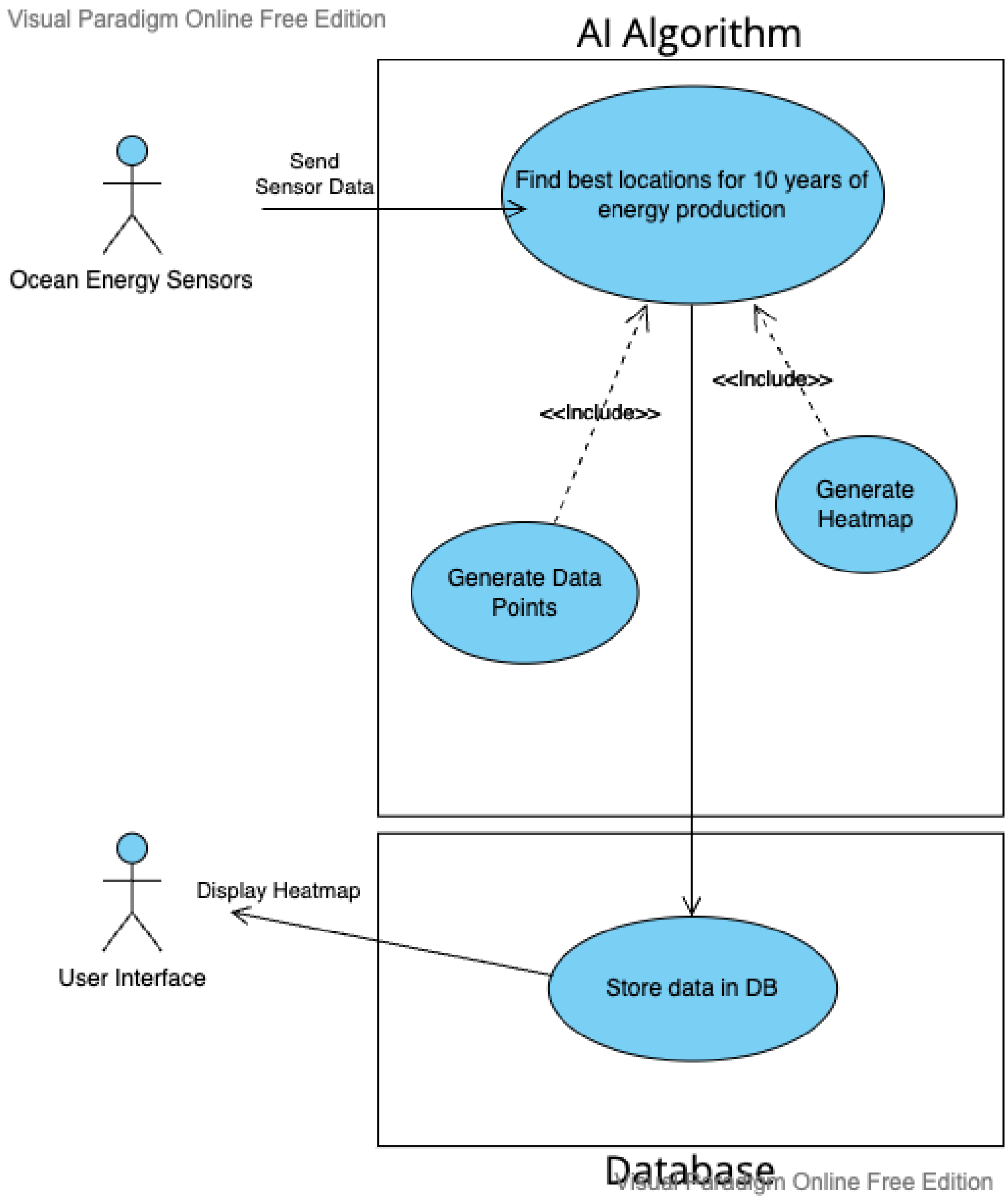

Figure 3.8: use case diagram for UC-2-1: AI algorithm

3.3 Data User Interface

3.3.1 Description and Priority

Managers, employees and developers will interact with this interface to see and control the information from the system and infrastructure that is connected to it. The manager can see more information than the employees like graphs and energy prediction to make the decision on any adjustment. The employees will have control of most infrastructure in the energy plant like generators to control energy generation. The developers will have access to the code of the system and the ability to modify it. Since the interface allows people to interact with the machine to generate energy, it is of a high priority.

3.3.2 Functional Requirements

REQ-3-1: Every user must be able to login to their account given a correct username and password. The user also must verify their identity with 2-factor authentication.

REQ-3-2: The UI must display every sensor's status like power generated, current status etc. For any user regardless of their admin status.

REQ-3-3: Managers must have access to all information and the ability to make changes regarding employees information when they login. They will also be able to request heat maps and interact with the AI.

REQ-3-4: Employees must have access to generator control when they login.

REQ-3-5: Developers must have access to back end code and the ability to incorporate changes to the app when they login.

3.3.3 Use Cases

UC-3-1: Login System

A user can login to the system.

Actor

- User

Precondition

- User has their username, password, and method to verify the two factor authentication

Postcondition

- User is logged in to their home screen

Main flow

1. User click the login button in the dashboard
2. User will then put their username and password in to their respective box then click submit
3. The system will verify the information and give two-factor authentication for the user to do
4. if username, password and two-factor authentication is all correct
    a. the user is login and the system redirect them to user home screen
5. if any one of them is wrong or missing
    a. the system let the user know and the system redirect them back to the login screen

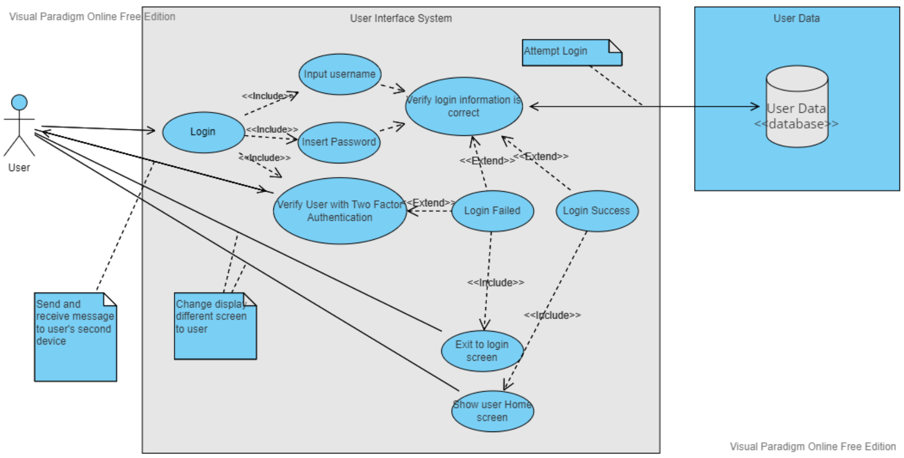

Figure 3.9: Use case diagram for UC-3-1: login system

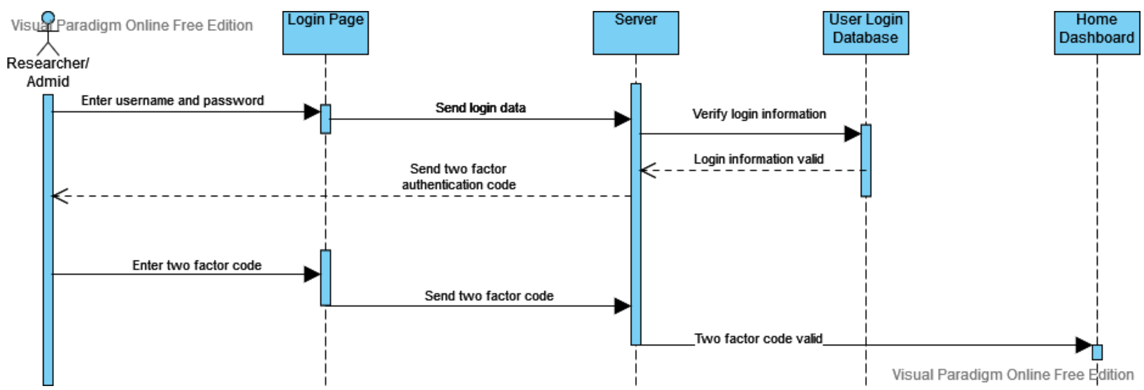

Figure 3.10: Sequence diagram for UC3-1: login system

UC-3-2: Viewing sensor status like power generated, current status etc.

A user can view the status of all sensors regardless of admin or developer status

Actor

- User

Precondition

- User has valid login credentials

Postcondition

- N/A

Main flow

1. User logs in
2. After logging in, the user can navigate to a sensor dashboard from the homepage
3. User can select individual sensors to view more detailed information

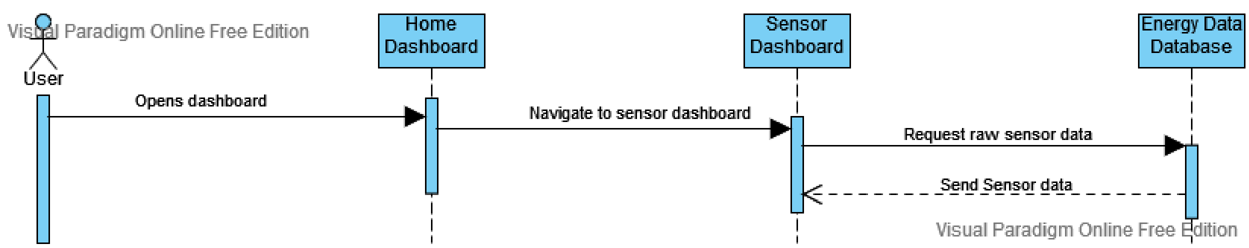

Figure 3.11: Sequence diagram for UC-3-2: Viewing sensor status

UC-3-3: Managers accessing user data

Any managers with an admin account can login and view/edit all user data stored in the system

Actor

- Admin

Precondition

- User has valid login credentials to an admin account

Postcondition

- User data is still usable without interruption

Main flow

1. Admin logs in
2. After logging in, the admin can navigate to a user dashboard from the homepage
3. Admin can create or delete users and change the data stored for current users such as username and password as well as personal information

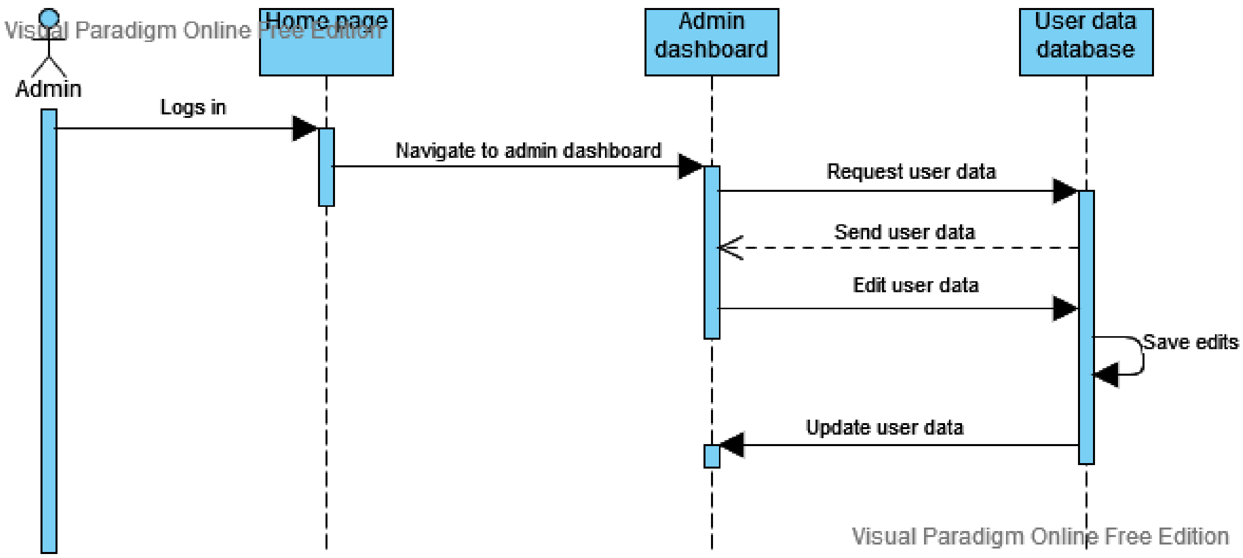

Figure 3.12: Sequence diagram for UC-3-3: Managers accessing user data

UC-3-5: Developer making changes to platform

Any users with development permissions can view and make changes to the structure of the central server and the AI algorithm

Actor

- Developer

Precondition

- User has valid login credentials to an development account

Postcondition

- Server and AI algorithm save changes made

Main flow

1. Developer logs in
2. After logging in, the developer can navigate to a development dashboard from the homepage where changes can be made
3. Developer can make changes to existing server structure and view logs of previous changes made

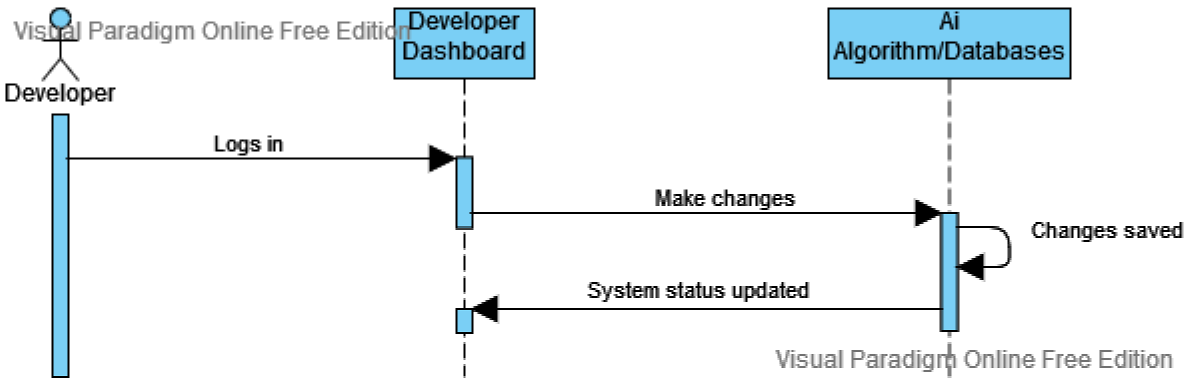

Figure 3.13: Sequence diagram for UC-3-5: Developer making changes to platform

4 External Interface Requirements

- Sensor Map
- Graphs
- Individual sensor readings
- Extrapolations of data over areas between sensors
- Tools to choose locations for wind/tidal generators

4.1 User Interfaces

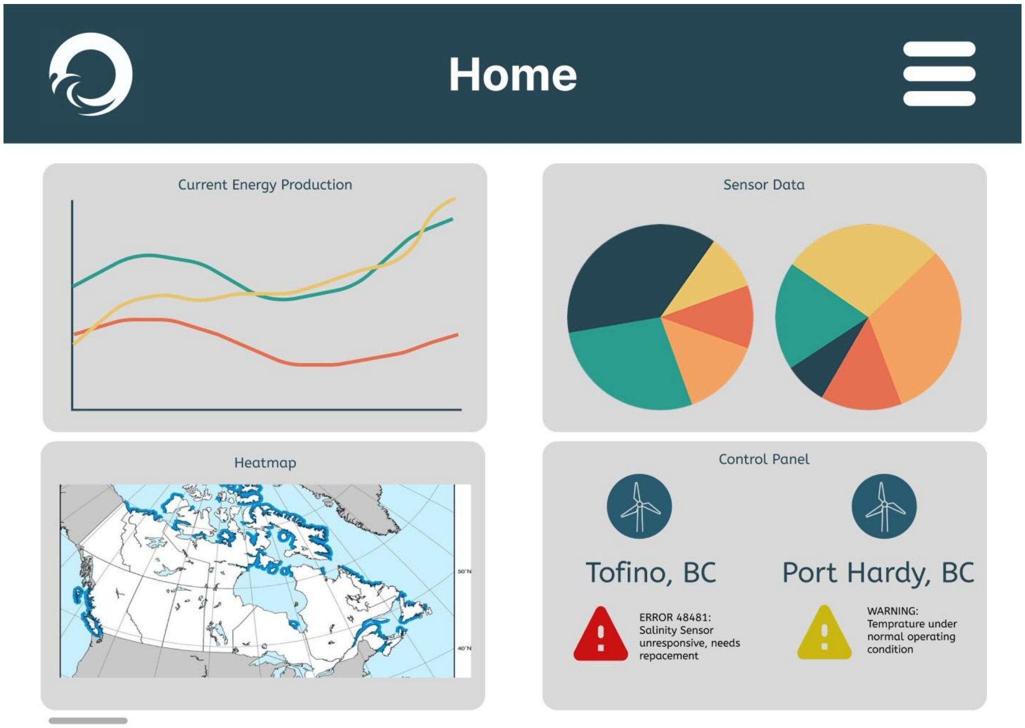

Figure 4.1: A prototype of the OceanAI dashboard, displaying energy production, online systems, total energy produced, as well as sensor data.

As seen in Figure 4.1, the users will interact with the system by visiting a webpage application on their desktop or an online interface. This app will be functional and easy to use. All the data that was gathered from the physical device through sensors will be stored in the server's database and then will be visualized into graphs. Our application will allow users to track current energy production, total energy production, and the sensor data. It will also have a control panel and allow users to locate the hardware device in the field.

4.2 Hardware Interfaces

The webpage application will be functional on any modern browser. The nature of the data that will be collected from the sensors is quantitative, and it will be used to create graphs in our application. The connection between the user's computer and the server will be through the encrypted TCP/IP protocol.

For the sensor, the device will be composed of a camera, wave sensor, temperature sensor, wind sensor, water salinity sensor, radar, and transmitter. All these devices will be wired together into one waterproof device that is able to withstand up to 750 m of water pressure.

4.3 Software Interfaces

In order to run the desktop application, the users are recommended to have the latest version of their desired search browser. The application can still be run on older versions of the desired search browser but will be more unstable to use the older the version is. Any version of search browser that is 6 years or older will be most likely unsupported.

The server will have a database, and all the data that was gathered from the physical device through sensors will be stored in this database. The physical device will consist of multiple tools such as WEC device, a barometer and an anemometer. The WEC device will collect data about the wave energy measurement. The barometer will collect data on tidal frequencies and their magnitudes. The anemometer will collect data on wind speed and its direction.

In order to store all this data in the server's database, the sensors on the physical device will use satellite internet to send packets to the server's database.

4.4 Communications Interfaces

The communication between the server and the webpage application will happen through TCP/IP. The communication between the system and the users will be provided through emails and direct messages. The users will get notified through email if there is a small problem. In case of an emergency situation, the users will receive a direct message to act quick.

5 Other Non-Functional Requirements

5.1 Performance Requirements

REQ-5-1-1: When loading information from the generators, the display must not take more than 5 seconds.

5.2 Safety Requirements

REQ-5-2-1: Ocean energy sensors must be easily identifiable for safety of ocean life, boats, etc using light or be detectable using sensors from the boat.

REQ-5-2-2: Sensors must adhere to the Canadian Aids to Navigation System[1] standards.

REQ-5-2-3: Sensors must not interfere with wildlife or the ecosystem by keeping the noise level below 20dB.

5.3 Security Requirements

REQ-5-3-1: After 3 failed login attempts from a device, the system must lock out that device from future login attempts for 15 minutes and notify the manager via email immediately.

5.4 Software Quality Attributes

REQ-5-4-1: AI must use input data from sensors giving location, wave energy, tidal pressure, wind speed and direction.

REQ-5-4-2: Must generate heatmap in under a week given current OceanAI hardware systems.

REQ-5-4-3: Must handle missing input in case of broken/malfunctioning sensor(s) with notification on the UI side.

REQ-5-4-4: Must be able to redirect focus of output if necessary (i.e. narrowing focus of heatmap, changing bias of certain inputs, etc.)

5.5 Usability Requirements

REQ-5-5-1: The UI must be easy to use. For first time users there will be a video tutorial that is no longer than 10 minutes demonstrating all the functionalities of the UI.

6 Other Requirements

REQ-6-1-1: A prototype for the Ocean Energy Sensor(OES) must be presented to the client at the end of 5 months after the start of prototype design.

7 Data Flow Diagrams

This section showcases the data flow in and out of the system in reference to the additional systems, users, and actors it interacts with.

7.1 Context Diagram

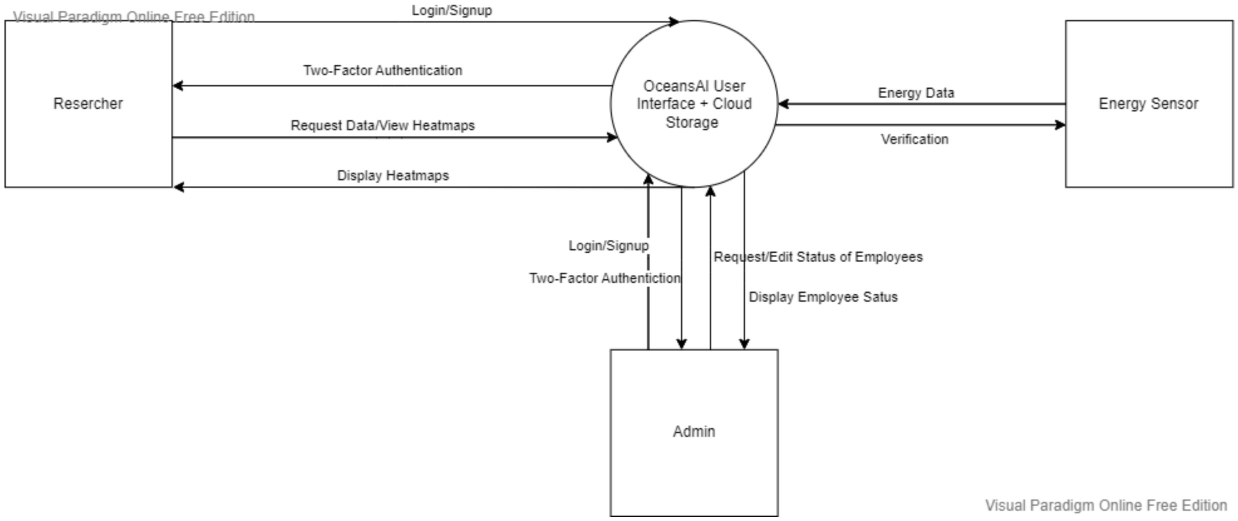

Figure 7.1 - This context diagram shows the main data flow between the energy sensors, researchers, admins, and the central AI, user interface, and cloud storage system.

7.2 Data Flow Diagram

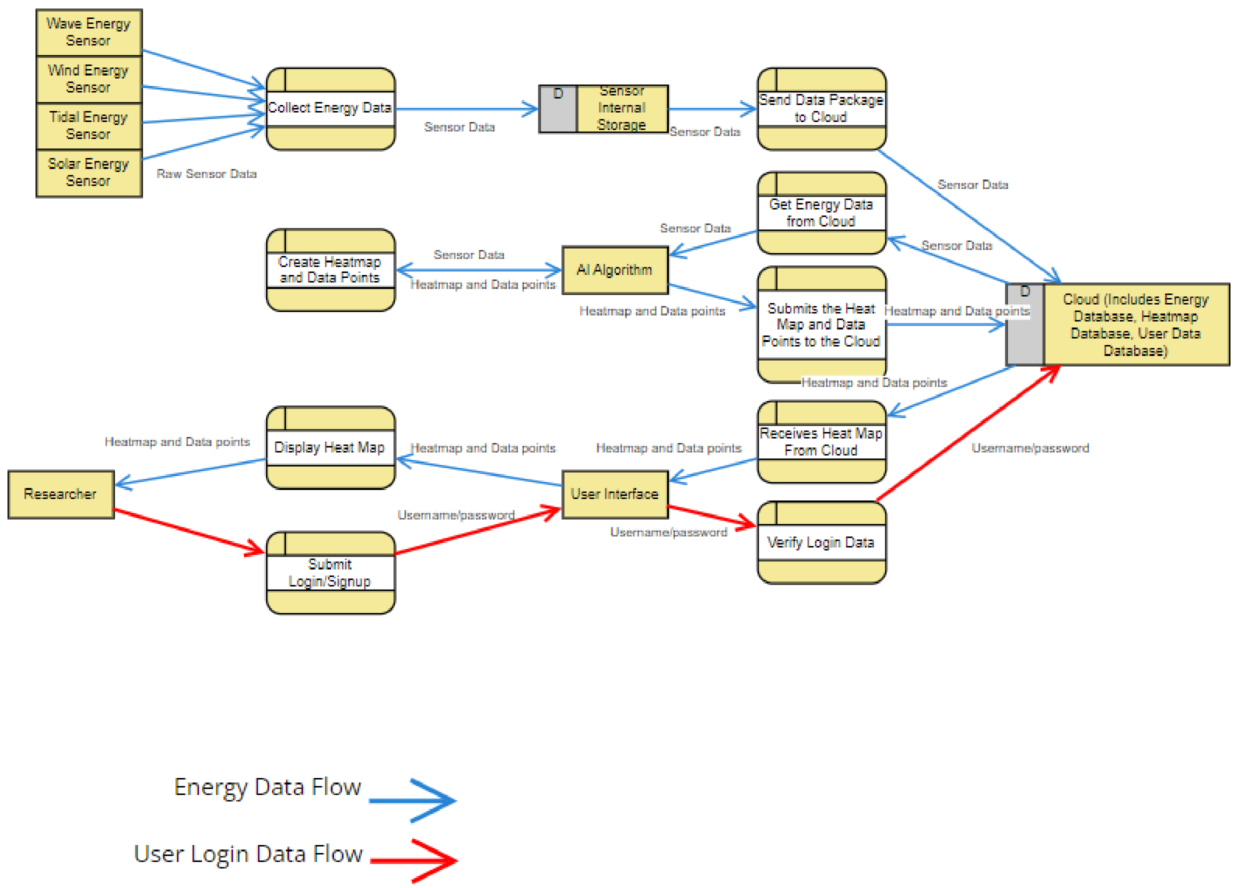

Figure 7.2 - This level 0 data flow diagram presents a deeper view into how each part of the overall system interacts and communicates together.