FOREST FIRE DETECTION SYSTEM

Quad Core Crew

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Detailed Design Document

Version 1.0

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A. Project Overview

The “Wildfire, Forest Fire, and Detection System” or “Wildfire” is a project that will use a combination or existing “on the shelf” technology that will detect fires, forest fires, and wildfires. It will sample the air for both smoke with both ionization and/or photoelectric smoke detector technologies. Also, it will use a temperature sensor in an outdoor enclosure that will be distributed across a grid of forest, woodlands, prairie, and fire prone areas to detect the presence of combusting ions and/or smoke that will signify that a fire is in progress. This project will use telemetry or cellemetry – to a satellite or cellular/wireless network - to notify Command, Control, and Dispatch of a potential fire that could become something even bigger. Fires that are small can be extinguished by a small crew that is dispatched or by water drops by an aircraft – this will prevent the forest from burning. This project will be able to detect and locate the direction and speed of a burn. The idea of this project is to mount it onto a steel pole, tree, or anywhere with altitude so we can get a better reading of where a fire could potentially start. It will be a rechargeable station where it relies on solar energy to generate enough power to run all its components such as: mini camera, cpu and alarm panel, battery charger, heat sensor, telemetry/cellemetry transmitter, and the ionization and photoelectric circuit boards. The ideal plan is to build three stations – triangulation – for a better reading on location, so it could alarm the Command Control.

B. Current Problems and Proposed Solutions

Currently in the world, there are more and larger wildfires that consume thousands of acres of land whether it is at a forest, prairie, or private land. One of the states that has seen the most wildfires is California which caused destruction of natural habitat, wildlife, homes, and human lives. Other countries have also experienced wildfires like Australia. Not only has this damaged the environment but it has cost money due to the loss of livestock, property, firefighting personnel and equipment, disaster aid, and insurance claims. The “Wildfire” project is designed to prevent a fire from growing by sending Command Control a notification that there is a potential fire that is going to spread. This is beneficial to the world because the fire can be contained and extinguished before causing a massive disaster. Usually whenever a forest fire begins, we do not know until its consuming everything in its path and when crews are dispatched, they have difficulty in putting out the fire – so, with the “Wildfire” we plan to detect smoke, smolder, and fire to extinguish it before anything happens to the environment and the people.

C. Requirements

1. Functional Requirements

ID	Functional Requirements	Team Member Responsible	Effort (in %)	Verification
FR1	The “Wildfire” system should be able to detect combustion ions using ionization technology.	Lluviana Vasquez	25%	Demonstration

FR2	The “Wildfire” system should be able to detect combustion ions using photoelectric technology.	Luis Guevara	25%	Demonstration
FR3	The “Wildfire” system should be able to send an alert to the cloud when the outside temperature increases to a maximum of 58 degrees Celsius.	Matthew Wilson	25%	Demonstration
FR4	The “Wildfire” system should allow user to observe and query the sensor readings of each unit stored in the cloud database using a website.	Edwin Hernandez	30%	Demonstration
FR5	The “Wildfire” system should be able to wirelessly transmit the location of the wildfire, which is found using triangulation with the GSM module. The GPS will detect the location if the GSM module is not operating properly	Luis Guevara	25%	Demonstration
FR6	The “Wildfire” system should be able to detect the direction and speed of the wind.	Matthew Wilson	10%	Demonstration
FR7	The "Wildfire" system should be able to query and display the values of all the sensors' readings to the user's computer for in the field debugging.	Luis Guevara	20%	Demonstration
FR8	The “Wildfire” system should be able to display on the website if there is a reading outside a certain threshold indicating an issue with sensors.	Edwin Hernandez	25%	Demonstration
FR9	The “Wildfire” system should have day and night vision mini camera that sends a video	Lluviana Vasquez	25%	Demonstration

	feed to the cloud database when a fire is detected.			
FR10	The "Wildfire" system should send the sensor readings of each unit to a cloud database using cellemetry.	Matthew Wilson	30%	Test
FR11	The "Wildfire" system should be able to send push notifications to cell phones over a cellular network that has their number registered with the website.	Edwin Hernandez	25%	Demonstration
FR12	The enclosure should be able to keep the temperature of the internal components less than 90 degrees Celsius using active cooling.	Matthew Wilson	15%	Demonstration

2. Non-Functional Requirements

ID	Non-Functional Requirements	Team Member Responsible	Effort (in %)	Verification
NFR1	The "Wildfire" system should be in a plastic weather resistant enclosure that meets the IP67 standard.	Lluviana Vasquez	25%	Test
NFR2	The "Wildfire" system should be in an insect proof enclosure.	Lluviana Vasquez	15%	Test
NFR3	The "Wildfire" system should be charged by solar panels and should work for 48 hours when there is no sunlight.	Luis Guevara	15%	Test
NFR4	Enclosure should be 20 cm x 15 cm x 15 cm.	Lluviana Vasquez	10%	Inspection
NFR5	Device should weigh no more than 1 Kg.	Matthew Wilson	10%	Inspection
NFR6	Device enclosure should be green.	Edwin Hernandez	5%	Inspection

NFR7	Should be able to indicate if the device is on/off.	Edwin Hernandez	5%	Demonstration
NFR8	The components for the “Wildfire” system should not cost more than $300.	Matthew Wilson	10%	Analysis
NFR9	A PCB for the “Wildfire” system will be designed so all its sensors and components are on a compact and organized circuit board.	Luis Guevara	15%	Test
NFR10	The website designed for the “Wildfire” system should be able to open in any portable device.	Edwin Hernandez	10%	Demonstration

Note: The team will replicate four (4) “Wildfire” systems for the demonstration.

3. Constraints

a. Completed on 4/30/2023
b. Money constraint on components (should not be more than $300 per box)
c. Sensors need to be compatible with SPI or I2C buses.
d. Power limited by size and cost of the solar panels, usually 0.5 volts per solar cell.

D. Specifications

1. Functional Requirements Specifications

ID	Functional Requirement Specification	Team Member Responsible
FRS1	An ionization type sensor interfaced to the microcontroller will be used to detect combustion ions. The sensor will be placed in an area inside the enclosure where the sensor can detect combustion ions. When there is a combustion, the microcontroller will use the signal from the ionization sensor to then alert Command Control of the presence of combustion ions.	Lluviana Vasquez
FRS2	A photoelectric fire detection sensor interfaced to the microcontroller will be used to detect combustion particles. The sensor will be placed in an area inside the enclosure where the sensor will be exposed to combustion particles. When there is a combustion, the microcontroller will use the signal from the photoelectric sensor to then alert Command Control of the presence of combustion particles.	Luis Guevara
FRS3	The alert threshold is set at 58 degrees Celsius because that temperature is barely higher than most animals can survive. This threshold will allow the	Matthew Wilson

	system to be sensitive enough to irregular temperatures while limiting false positives. This can be accomplished in the software function controlling the temperature sensor by making an if/else statement: if the temperature is above 58 degrees Celsius, alert command control; else, monitor the surroundings.	
FRS4	Command control will need a mobile application to view and receive data analytics that can showcase potential fire cases for each "Wildfire" system unit. Command control will not have access to edit the data, but only view and receive. Command control will be notified if a specific "Wildfire" system unit notices a potential fire.	Edwin Hernandez
FRS5	A GSM module for the microcontroller will allow connectivity to cellular networks, allowing for communication with Command Control. Triangulation using cell towers will allow for the location of the "Wildfire" system unit to be returned. Triangulation of the fire's location will be done by triangulating the coordinates of the "Wildfire" units when they detect combustion. The microcontroller will do the triangulation to then find where the source of the fire was. The GPS module will also triangulate the location of the unit as redundancy.	Luis Guevara
FRS6	Wind vanes measure wind direction and anemometers measure wind speed. These sensors can be bought separately or combined into one sensor. They will need to be placed somewhere on the outside of the enclosure to be affected enough by the wind to give accurate and precise readings. The wind direction and speed will indicate what direction a fire is coming from and where it will spread if one is detected.	Matthew Wilson
FRS7	For the system to monitor the values of all the sensors' readings using serial communication for testing, it will have to loop to transmit and receive information. A loopback test is usually what's used to use both sides of communication for constant checking. Ideally, it will send information to the Arduino software on a computer. The user will receive the readings on the Arduino serial monitor after entering a command to test all sensors.	Luis Guevara
FRS8	This can be accomplished by using error checking programming. If the individual sensors give any reading that doesn't make sense, then there is an issue with that sensor. It will send a notification pop-	Edwin Hernandez

	up on the website alerting that there is an issue with a sensor. This error checking will take place before the sensor readings are sent to the website. If/else statements will be used for this. For example, if the wind vane sensor indicates the wind speed is less than 0 or greater than 500 mph, then there is an issue with the sensor because readings outside those bounds are impossible in our environment. The sensor data will still be sent to the website for users to view. The sensor status will be viewed only by the troubleshooter.	
FRS9	A weatherproof camera will be interfaced to the microcontroller. The microcontroller will then allow for video feed to be sent over to the cloud. The video feed will only be active when the "Wildfire" system detects a fire. The camera module will include IR LEDs that will illuminate the area for nighttime monitoring. The camera will monitor at 30 frames per second.	Lluviana Vasquez
FRS10	Each unit will have a network interface card (NIC) that uses a SIM card to communicate using cellemetry. The NIC will communicate to cell towers using TCP protocol over one or more radio frequencies, the towers will then communicate to satellites, then finally the data is then sent to the server acting as the cloud database. The service we will use for the cloud database will be Amazon Web Services (AWS) and for cell service will be AT&T or T-Mobile.	Matthew Wilson
FRS11	While users have the application installed on their mobile phone, they can enable to receive push notifications. The notifications context will include warnings and potential fires. These notifications will be sent only if a box recognizes a potential fire starting.	Edwin Hernandez
FRS12	90 degrees Celsius is the maximum operating temperature for most processors. The components that generate the most heat are the PSU and processor. The system will use active cooling that will use 1 fan to ventilate the hot air out of the enclosure and colder air in. The fans will activate if the external temperature exceeds 80 degrees Celsius.	Matthew Wilson

2. Non-Functional Requirements Specifications

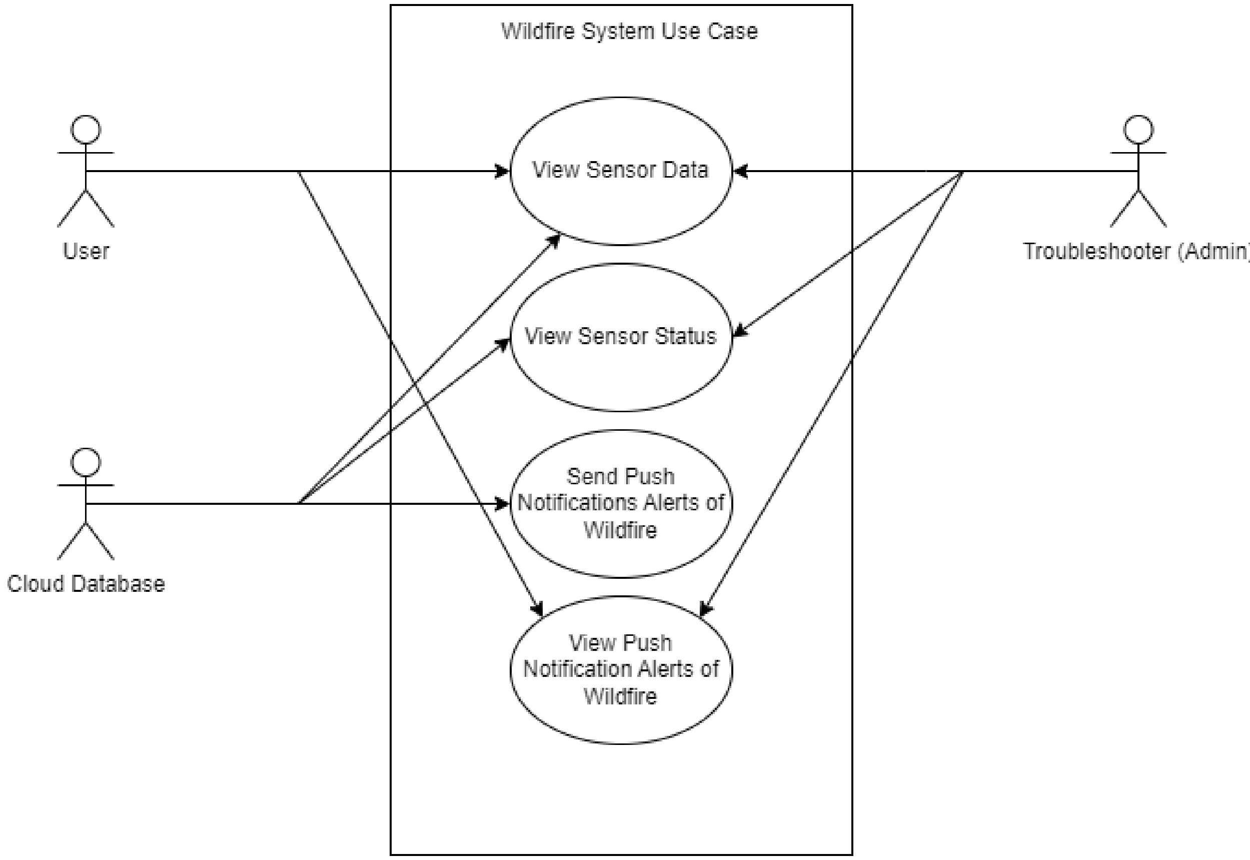
ID	Non-Functional Requirement Specification	Team Member Responsible
NFRS1	The enclosure that the "Wildfire" system would ideally use is a polycarbonate plastic material. The reason is because it's a tough plastic that has	Lluviana Vasquez

	outstanding strength, stiffness, and its impact resistance. Since this box will be outside, the material needs to be resistant to any weather and needs to be able to not retain too much heat. If polycarbonate plastic is hard to get, then we need to use just a plastic material that can withstand the weather. The plastic weather resistant enclosure should meet the standard IP67.	
NFRS2	The open parts of the enclosure will be covered in mesh to prevent insects from going in. The mesh will allow for smoke and air to pass through. The mesh will be fine enough, blocking anything bigger than 400 microns. The mesh will be UV proof and durable. To protect the box from water, we would need to add a slanted edge on top (four sides) to make sure the water slides off without touching the sides of the box.	Lluviana Vasquez
NFRS3	A solar panel will be interfaced to the charge regulator, which will charge a pack of lithium-ion batteries. The batteries will hold enough power to operate the "Wildfire" system at night. The capacity of the battery is 2000 mAH, 3.7 V, and the time to charge is 2.4 hours with a 20% efficiency loss. The solar panel will be a 6 V, 9 W, outputting 6 V at around 1.5 A. The solar energy will be prioritized over battery power to conserve battery. The solar panel will be mounted on the enclosure, in an area that will be the most exposed to the sun. The device will consume about 285 mA every day, so the device can survive for about 1 week on a full battery charge.	Luis Guevara
NFRS4	The "Wildfire" system needs to be in a small enclosure that won't attract too much attention to it, but big enough to handle all its components. It being 20 cm x 15 cm x 15 cm is enough for its components without it being a clutter inside the enclosure. If there is enough space, then that means that all the components will be able to run smoothly in its own section. If we are using any type to plastic, we will need to measure out the size of it and then weld it together for it to be that exact size.	Lluviana Vasquez
NFRS5	Before ordering the components for the "Wildfire" system, I will add together the all the masses given in each component's datasheet to ensure that their combined mass is less than 700 grams. This will leave about 300 grams for the enclosure and PCB. A triple beam balance or digital scale will be used to measure the mass of the entire unit. Material from the enclosure will need to be removed if the unit exceeds 1 kg.	Matthew Wilson

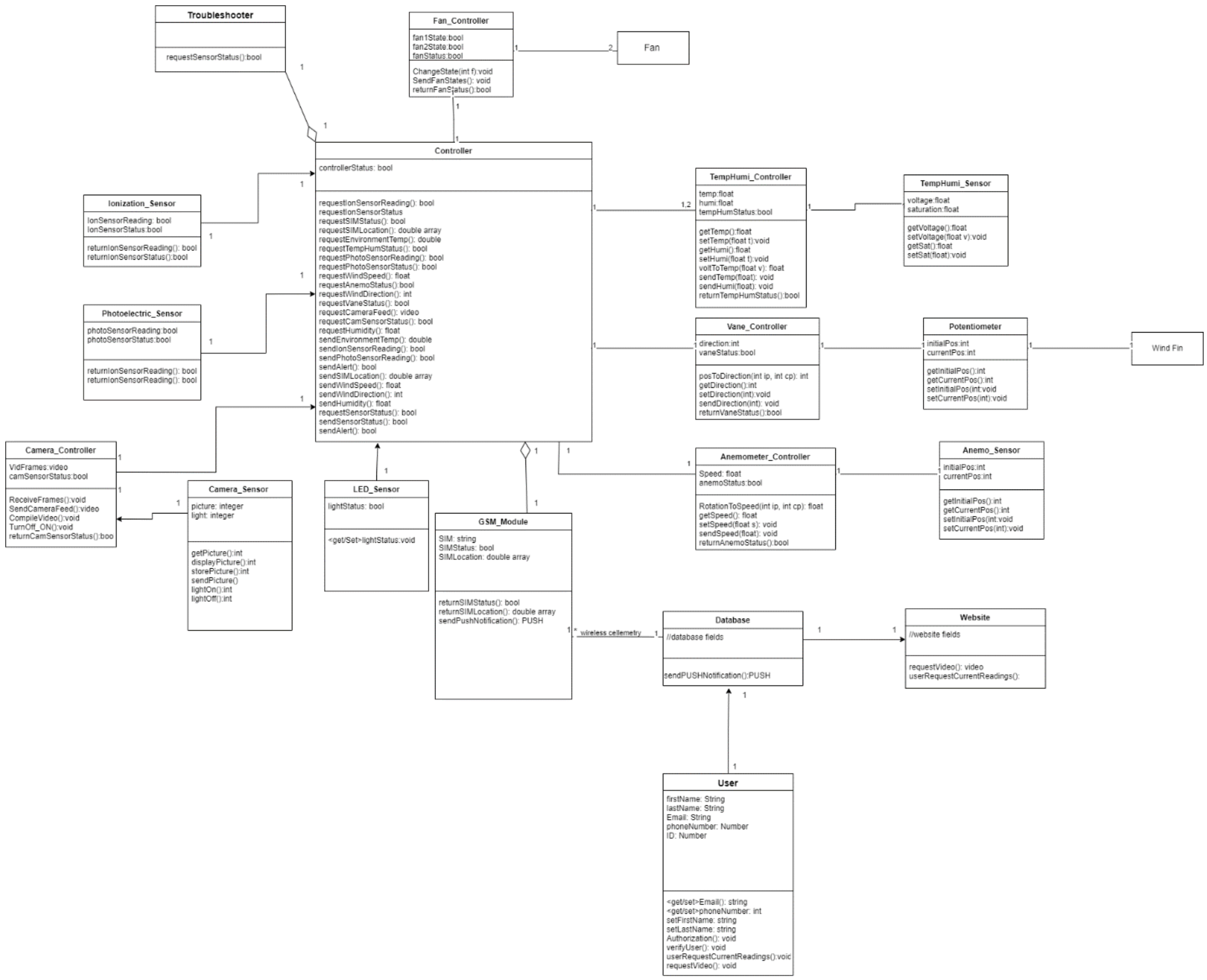
NFRS6	To ensure the device is visible and blends into the forest environment, the device enclosure should be green. This will prevent animals from messing with the device while not disturbing the natural nature look	Edwin Hernandez
NFRS7	The “wildfire” system needs a visible indicator on the system enclosure. An emitting LED will be the indicator for the device. The purpose is to showcase if the device is operating, not working, or turned off.	Edwin Hernandez
NFRS8	The most expensive component of each unit will be the processor. Each member of the Quad Core Crew will select components that will best fulfill their requirements. I will review each component and make certain that the combined price of all the components and the manpower needed to integrate them does not exceed $300.	Matthew Wilson
NFRS9	The components and sensors of the “Wildfire” system will be soldered onto a PCB, so we do not have wires everywhere within the unit. PCB design software will be used to optimize the design of the PCB. This will help reduce the size of the “Wildfire” system unit.	Luis Guevara
NFRS10	There are 3rd party add-ons and software that will allow the website to be properly formatted for any display.	Edwin Hernandez

E. Preliminary Design

1. Use Case Diagrams

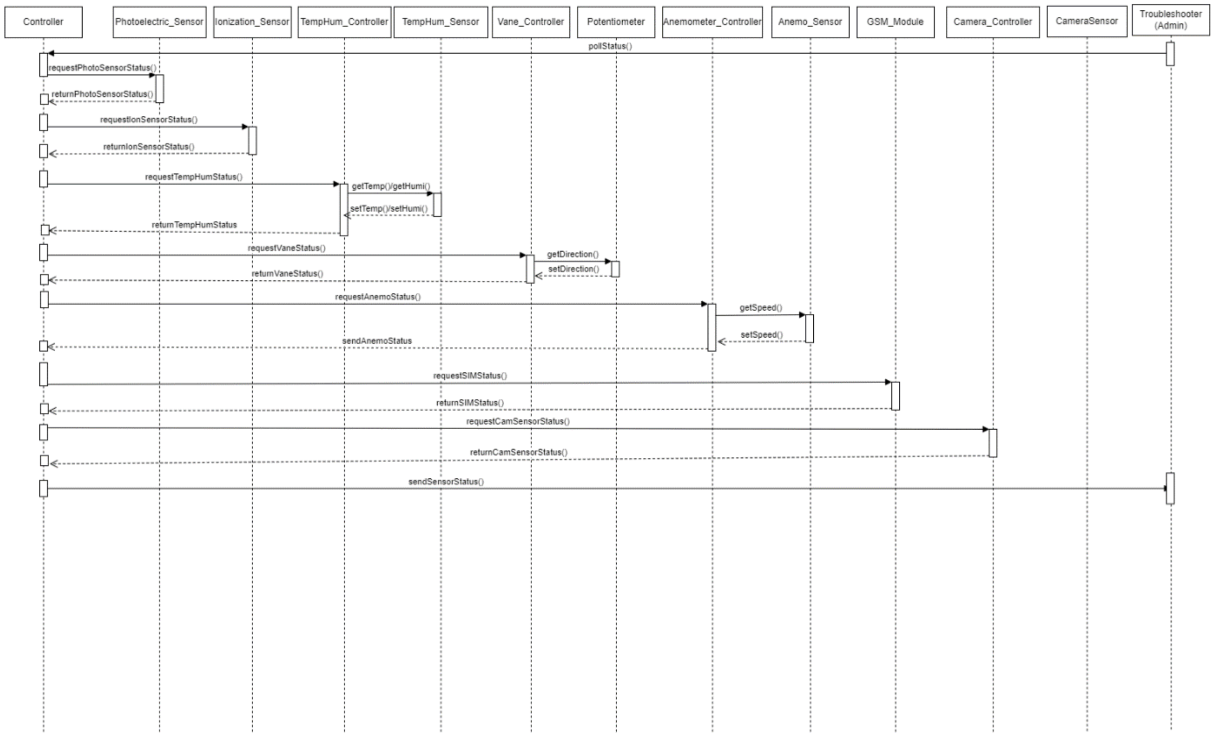


2. Class Diagram

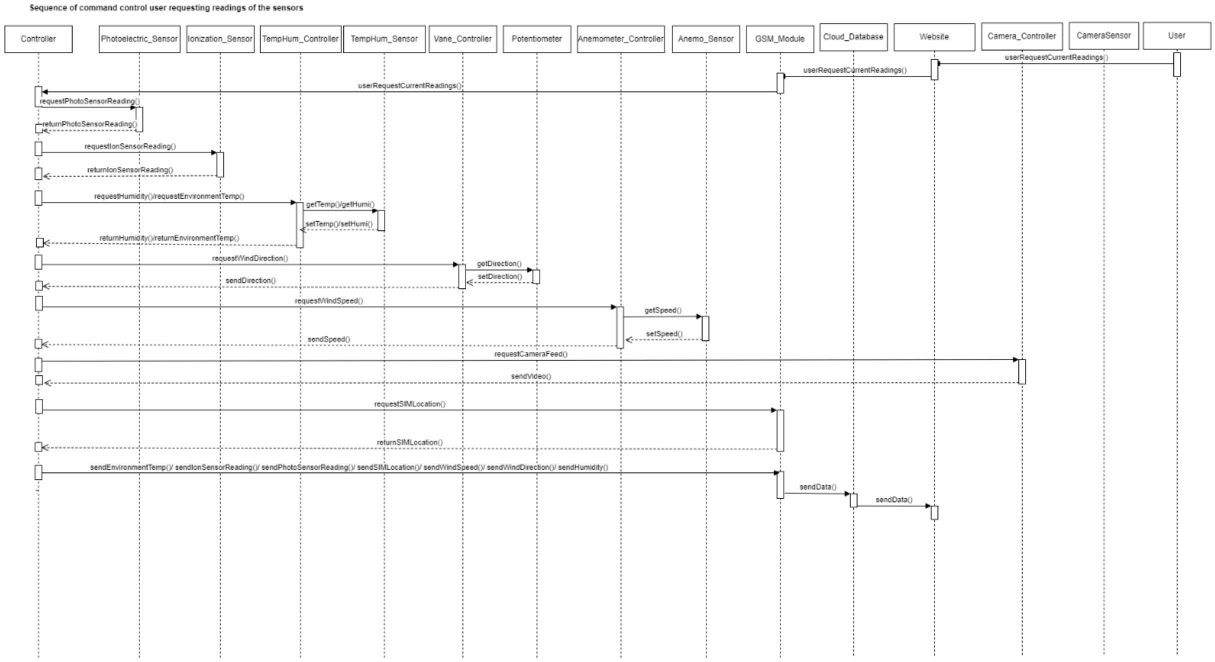


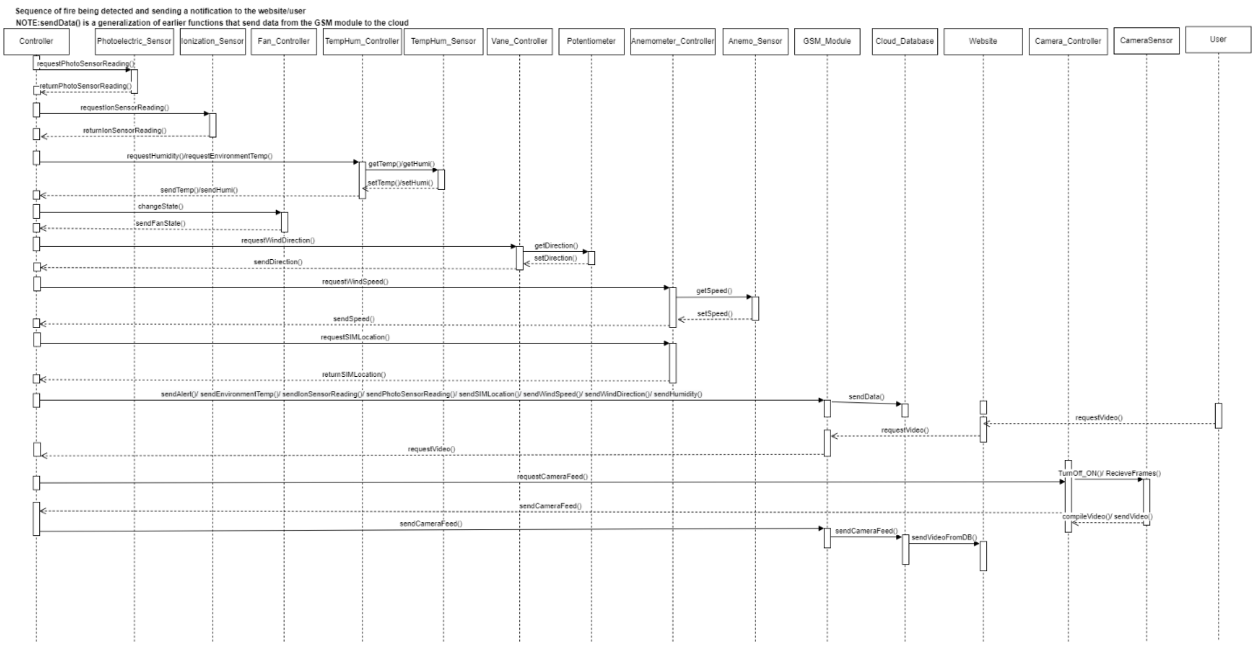
3. Sequence Diagrams

Sequence of troubleshooting the "Wildfire" device by returning the status of the sensors
10 readings of the sensor are done when a request for the status is made



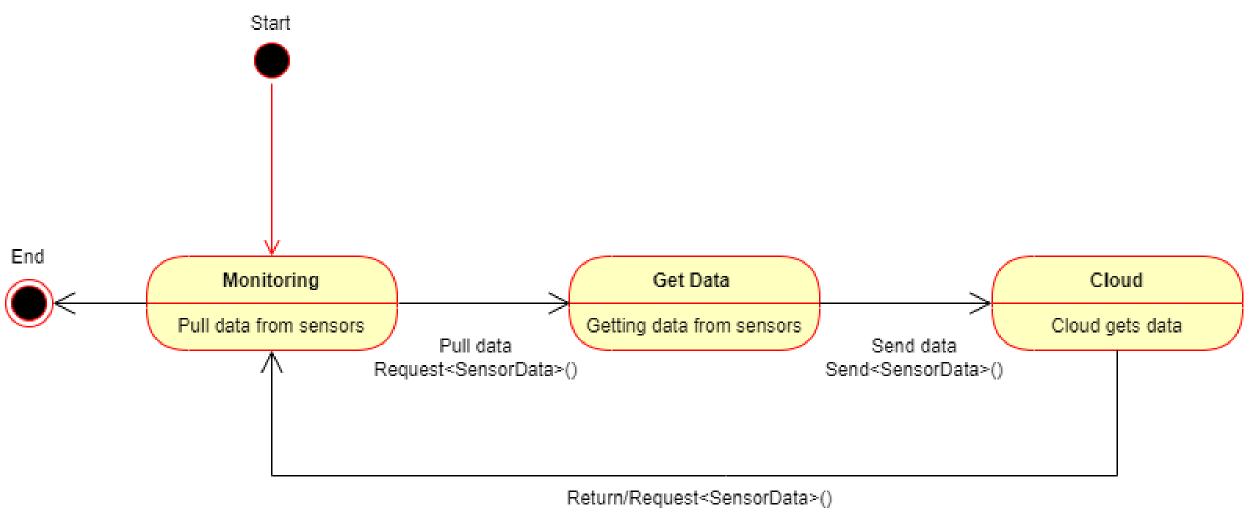
Sequence of command control user requesting readings of the sensors



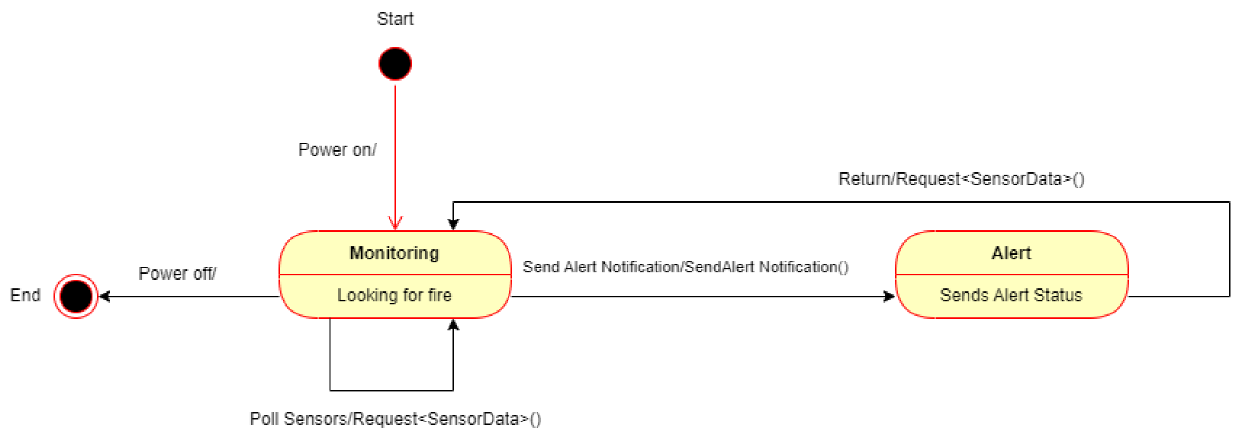


4. State Diagrams

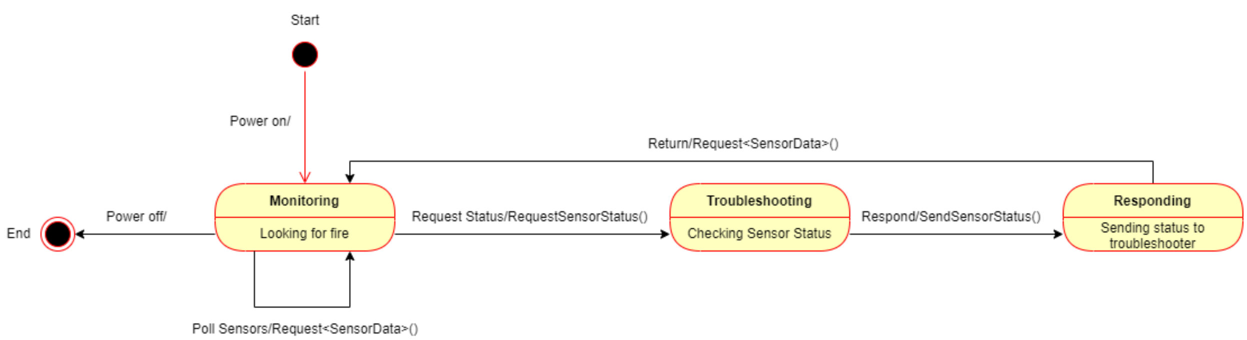
Monitoring Diagram



Wildfire Detected Diagram

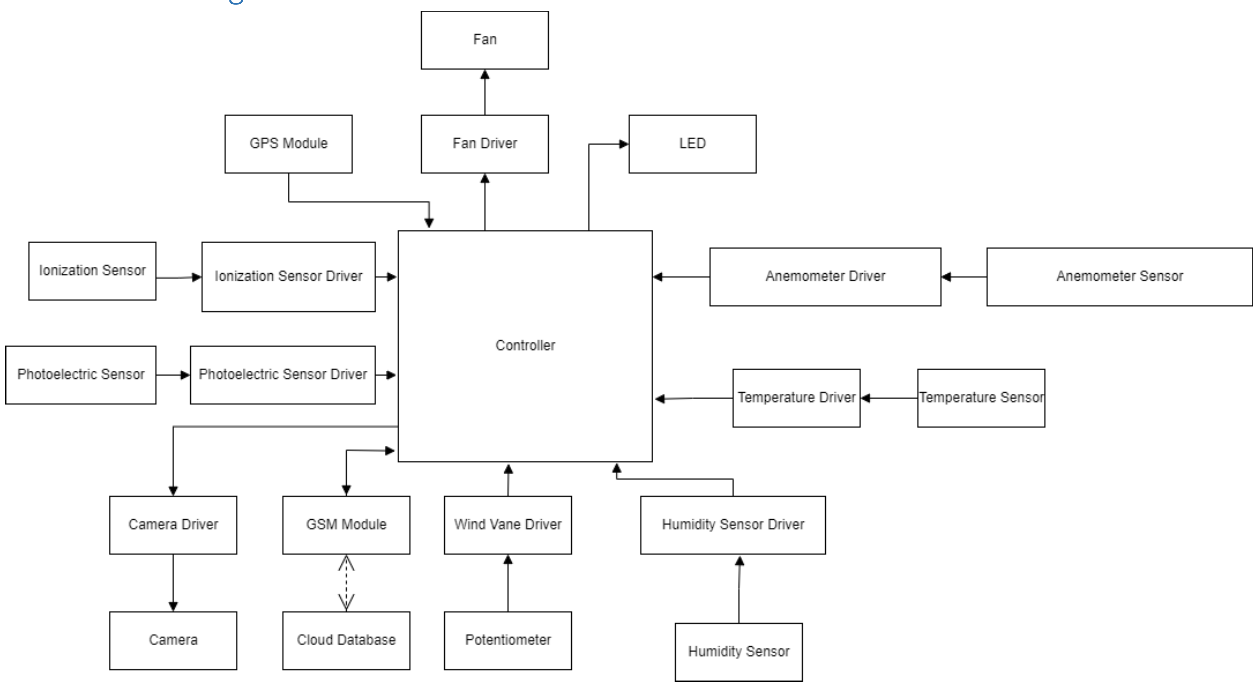


Troubleshooting Diagram



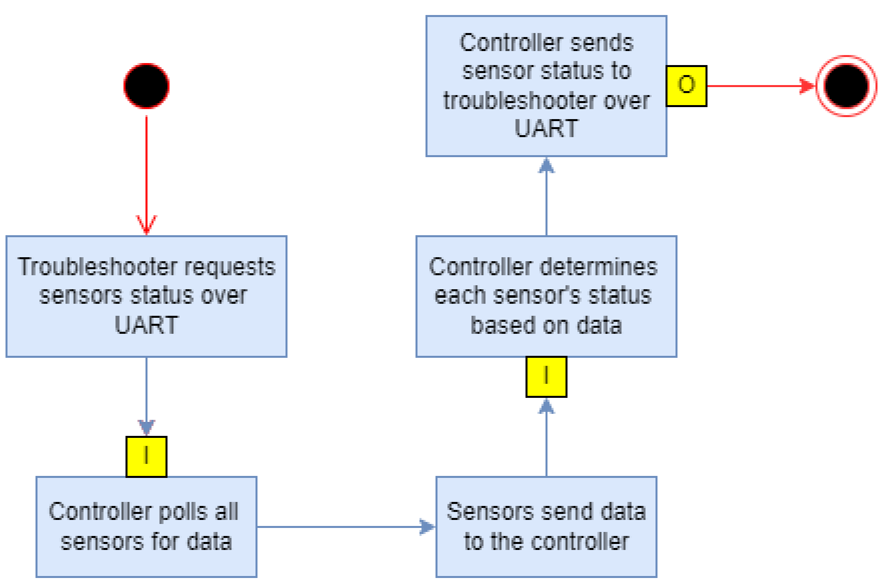
F. Detailed Design

1. Block Diagrams

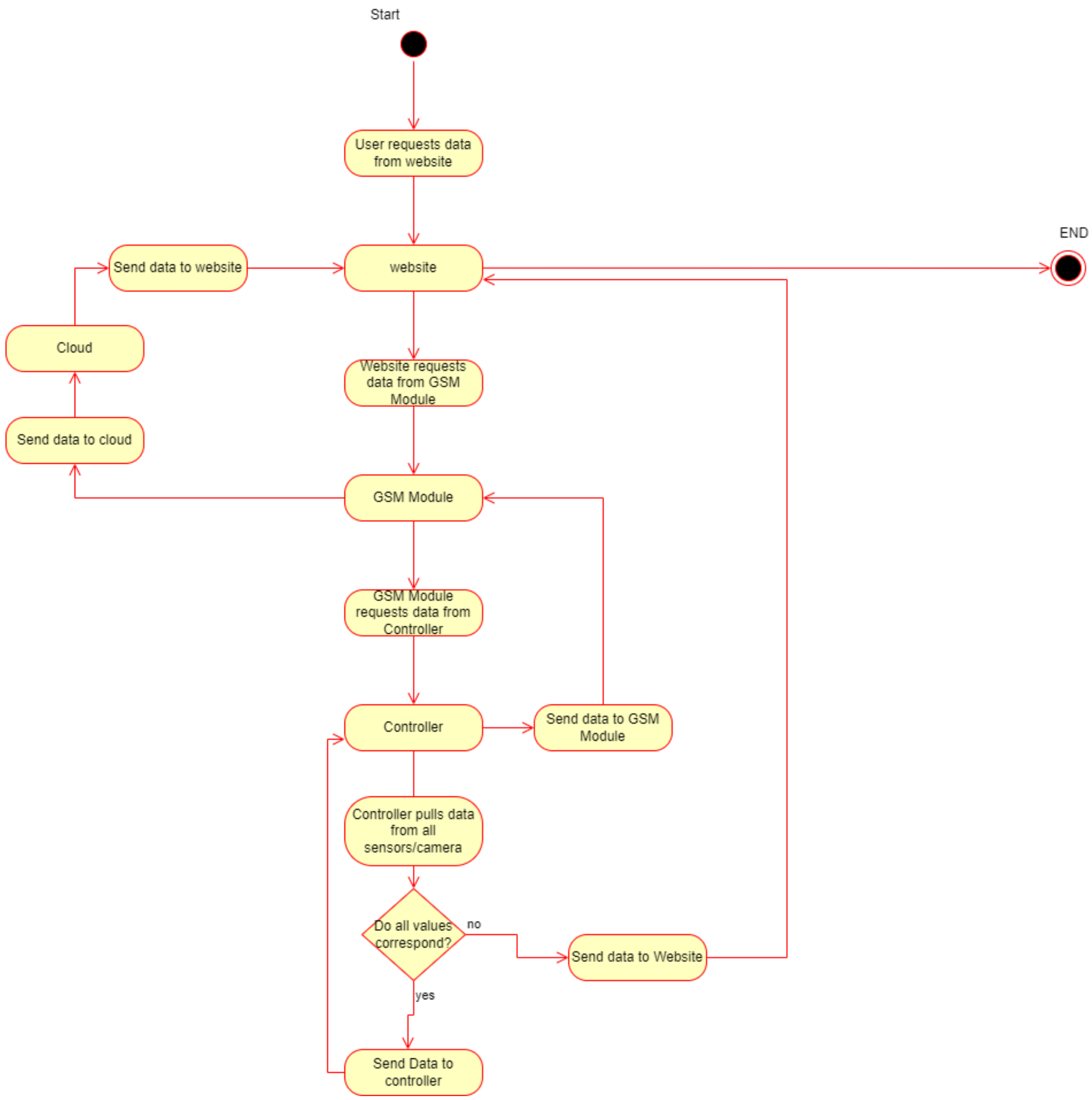


2. Activity Diagrams

Troubleshooting Diagram



Monitoring Diagram



Wildfire Detected Diagram