Senior Design One: Divide and Conquer Version One

Group 4

Arisa Kitagishi	Computer Engineering BS
Jonathan Kessluk	Computer Engineering BS
Noora Dawood	Electrical Engineering BS
Nicholas Hainline	Electrical Engineering BS

Project Narrative:

Over 100,000 forest fires have occurred worldwide . In the past, forest fires were considered a natural cycle and were ignored [1,3]. However, with increasing awareness emphasizing the preservation of natural resources, as well as recent forest fires, have put forest fires at the forefront of global environmental concerns especially due to the fires Australia in 2001 and 2002 and USA in 2002[2]. Forest fires not only increase the levels of carbon dioxide in the atmosphere, but also burn vegetation and plants that act as nature's CO2 sinks.

The increased carbon dioxide impacts air quality leading to smog and escalates the rate of global warming causing heatwaves [2,4]. In addition, humans and endangered animals' fatalities have been reported due to forest fires. As a result, forest fire detection and monitoring systems have sparked the interests of scientists and researchers worldwide.

The purpose of this project is to design and build a solar powered forest fire detection and monitoring system that will serve as a preventive measure for forest fires. This device would ideally be used in areas where human activity is present such as campsites especially parts of the forest that are highly susceptible to forest fires. This device can also be used to monitor and detect forest fires in general to help researchers and firefighters determine incoming fires or the severity of the existing fires. Thus, the device is aimed for prevention and facilitate extinction of forest fires.

The devices will be portable so that in can be mounted on trees nearby. The method of fire detection will include flame, gas and smoke detection. The sensors used will be infrared sensors, ultraviolet sensor, thermographic camera, combustible gas sensors, metal-oxide-semiconductor sensors, Photoelectric detectors (light scattering) and ionization detectors, and temperature and humidity sensors. A mesh network will be adopted for the monitoring system that .

Current forest fire detection and monitoring systems use video cameras to recognize smoke spectrum, thermal cameras to detect heat glow, IR spectrometers, and LIDAR (detection of light and range) to detect smoke particles using reflected laser. The following forest fire detection and monitoring systems exist in the market:

1. AlarmEYE:
    a. video and infrared system using black and white color frequency.
2. EYEfi SPARC:
    a. Optical sensors that includes camera, light sensors, communication, weather, power system, option for tilt zoom camera.
    b. Does not include smoke detection
3. UraFire:
    a. Smoke detection system focused on “clustering motions and a time input”
4. Forest Fire Finder:
    a. Analyzes how atmosphere absorbs light and differentiates absorption behavior
    b. Can detect smoke in a range of 15km
5. ForestWatch:
    a. Sensor camera mounted on a tower using a using a 360° pan tilt camera that scans the forest in a range of 16-20km for smoke in the daytime and flame at night.
6. FireWatch:
    a. Optical sensor system that scans the forest using a 360° camera with a central office for monitoring and data processing.
7. FireHawk:
    a. Cameras stationed strategically in the forest, the system uses GIS mapping and ForestWatch software to calculate the shortest distance to the fire.

Requirements & Constraints:

ID	Category	Sub-Category	Requirement
1	Electrical	Solar	The system shall be able to draw power from a battery or solar panel
2	Electrical	Solar	The system shall charge a battery with solar panel
3	Electrical	Battery	The system battery shall last 36 hours without charging
4	Electrical	RF	The system shall communicate wirelessly to nearby nodes
5	Software	Mesh	The system shall differentiate other nodes and figure out how to send data to hub
6	Software	Sensors	The system shall read all sensors periodically and store data internally

7	Software	Sensors	The system shall process all sensor data to determine if a fire has started
8	Electrical	Battery	The system shall read voltages of the battery to determine health
9	Software	Battery	The system shall sleep when the battery is dangerously low
10	Software	Health	The system shall report its own status/health to the hub.
11	Electrical	Battery	The system shall draw as little current on average as possible
12	Electrical	Battery	The system shall only have enough stored energy as is required
13	Electrical	Solar	The system shall use solar power when available instead of the battery
14	Software	Health	The system shall store configuration and user defined data in non-volatile memory
15	Mechanical	Enclosure	The system shall withstand fires up to 4 hours
16	Mechanical	Enclosure	The system shall not be bigger than a bird's nest (15 x 15 x 15 cm)
17	Mechanical	Enclosure	The system shall and solar panel will be mounted to a tree
18	Mechanical	Environmental	The system shall be able to withstand normal weather conditions
19	Electrical	Sensors	The system shall detect fire using infrared sensors
20	Electrical	Sensors	The system shall detect smoke using gas sensors

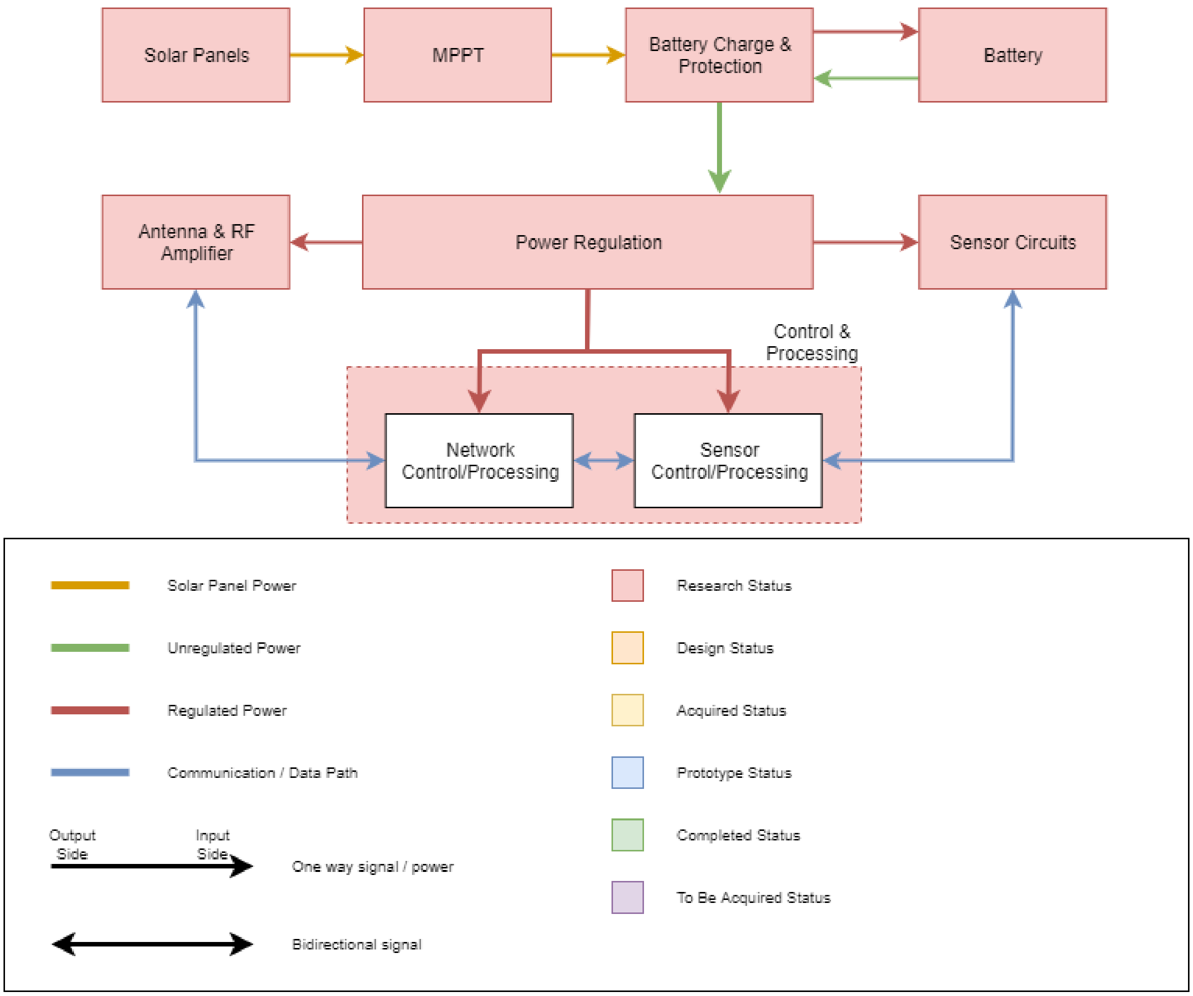
21	Electrical	Sensors	The system shall verify environment with temperature and humidity sensors

Approximate Cost:

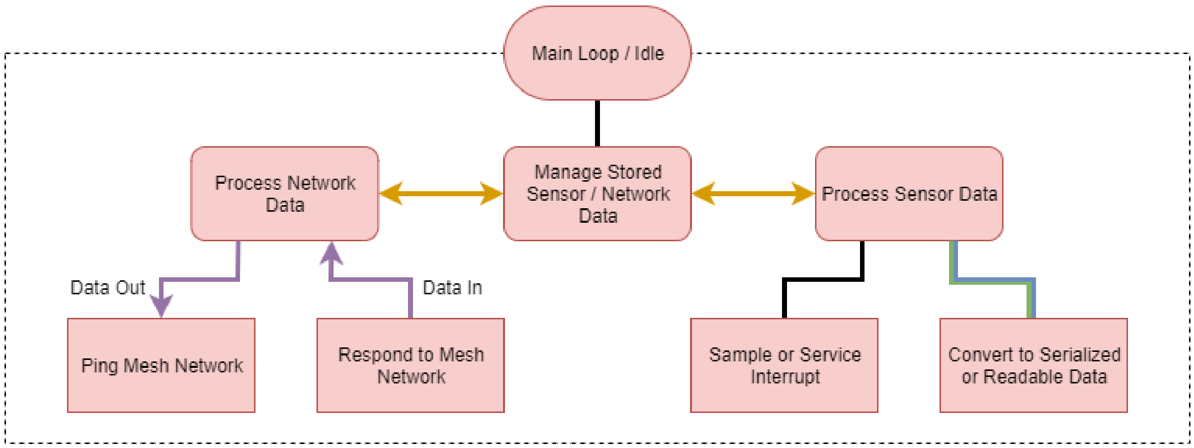
Device	Approximate cost ($)
Solar Panel System	10 - 100
Sensors	
Gas sensor	0.10 - 15
Infrared sensor	10 - 30
Thermal Camera	100 - 4,000
Temperature	0.10 - 1
Humidity	0.10 – 1
Electronics	
Controller	1 – 20
General components (resistor, capacitors, inductors, connectors)	10 – 30
Specialized components (voltage regulation, MPPT, RF)	10 – 30
PCB Manufacturing	20
Prototype (machine shop labor)	80
Development kit (for software)	15 - 30
Miscellaneous (solder, jumper wires, coffee)	20 – 40

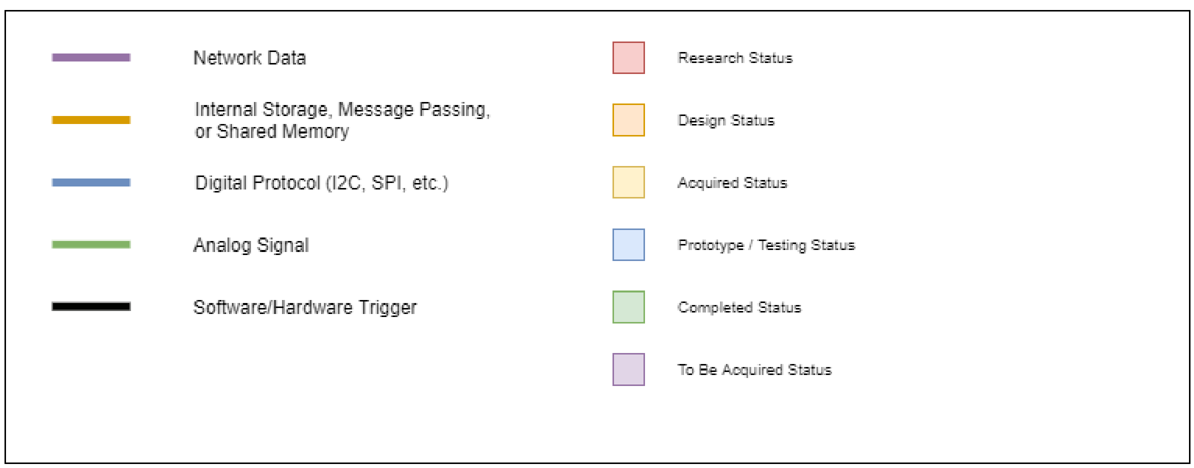
* Shipping not included in cost approximation

Hardware Design Block Diagram



Software Design Block Diagram





Spring 2020

Week	Milestone (Tasks)	Start Date	Deadline
1 to 2	Brainstorm ideas	January 06, 2020	January 17, 2020
3 to 4	Choose a project and discuss basic design and roles	January 20, 2020	January 31, 2020
4	Finish Divide and Conquer V1		January 31, 2020
5	Discuss the details of the project (components, functions, design)	February 03, 2020	February 07,2020
5 to 6	Update Divide and Conquer V2 Finish proposal for sponsor	February 03, 2020	February 14, 2020
6 to 9	Research and finetune design	February 17, 2020	March 06,2020
9	SPRING BREAK		
10	60-page Draft		March 20, 2020
10 to 12	Finalize design Finish technical documentation	March 16, 2020	April 03, 2020
12	100-page Report		April 03, 2020
12 to 15	Organize all documentations Acquire materials and components for prototype	April 06, 2020	April 17, 2020
15	Submit Final Documentation		April 21, 2020

Summer 2020

Week	Milestone (Tasks)	Start Date	Deadline
1 to 2	Assemble/ Build prototype Test components	May 11, 2020	May 22, 2020

3	Acquire components for final product Adjust documentation	May 25, 2020	May 29, 2020
4	Build final product	June 01, 2020	June 05, 2020
5 to 6	Integration Testing (hardware and software)	June 08, 2020	June 19, 2020
6 to 7	Make necessary adjustments	June 22, 2020	July 3, 2020
8	Final testing	July 6, 2020	July 10, 2020
9	Finalize product	July 13, 2020	July 17, 2020
10 to 11	Finalize documentation	July 20, 2020	July 31, 2020
11	Final Product		July 31, 2020

Design Ideas:

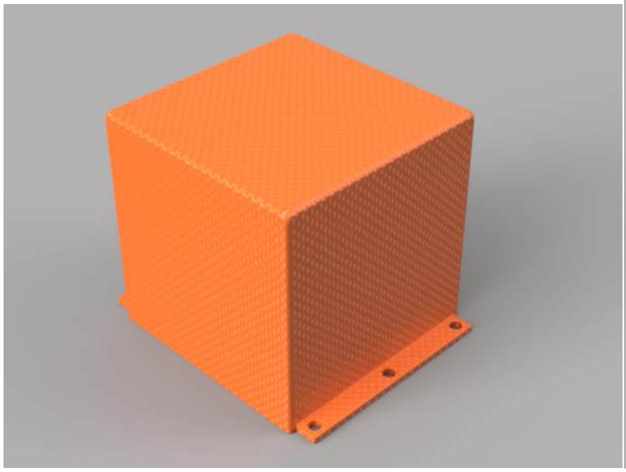


Figure I Nick's design

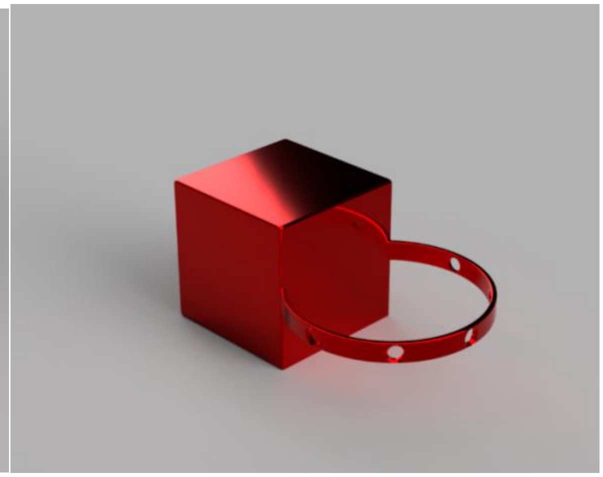


Figure II Noora's design

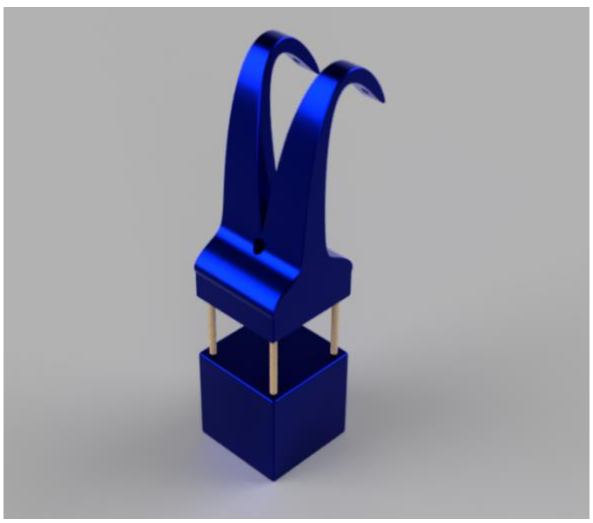


Figure III Arisa's design

Figure IV Jonathan's design

References

[1]S. Ouni, Z. Trabelsi Ayoub and F. Kamoun, "Auto-organization approach with adaptive frame periods for IEEE 802.15.4/zigbee forest fire detection system", Wireless Networks, vol. 25, no. 7, pp. 4059-4076, 2019. Available: 10.1007/s11276-018-01936-x [Accessed 30 January 2020].

[2]M. Jurvélius, "Forest fires and international action", Fao.org, 2003. [Online]. Available: http://www.fao.org/3/XII/0820-B3.htm. [Accessed: 30- Jan- 2020].

[3]A. Alkhatib, "Forest Fire Monitoring", Forest Fire, vol. 3, 2018. Available: 10.5772/intechopen.72059 [Accessed 30 January 2020].

[4]"Governments, smart data and wildfires: where are we at?", UN Environment, 2020. [Online]. Available: https://www.unenvironment.org/news-and-stories/story/governments-smart-data-and-wildfires-where-are-we. [Accessed: 30- Jan- 2020].