Project: Gotcha!

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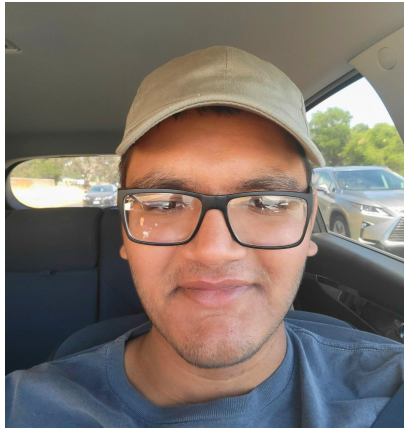
Advisor: Yadi Eslami

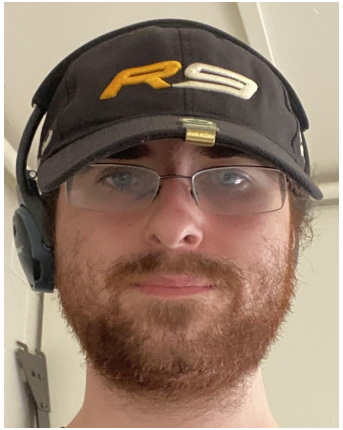
Team 14

Jackson Wallace (EE)



Tirth Patel (EE)

Hakan Saplakoglu (EE)



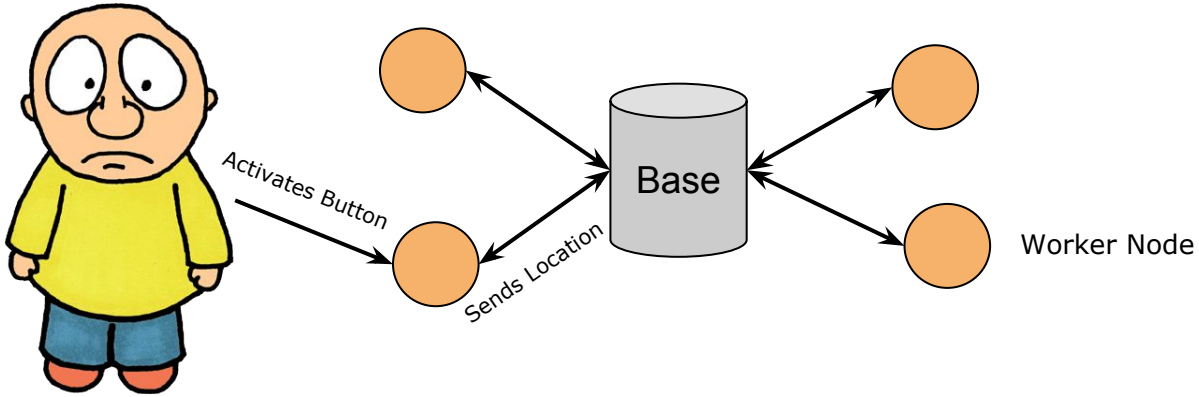
Joseph Mitchell (CompE)

Problem Statement

Natural disasters are frequently occurring throughout the world, and with them comes missing people. Typhoons, flooding, and more recently wildfires are causing people to flee from their homes and try to escape harm. Finding missing people after a disaster (Hurricane Michael 2018) can often take many days of searching and takes a great deal of manpower, with the added possibility of communication networks in the disaster area being offline. What can be done to solve this?

Our Solution

To aid this problem we propose to develop a system consisting of two types of nodes: low-power worker nodes and base nodes connected through a mesh network. Deployable before and/or after a natural disaster, those seeking rescue can use these devices to transmit their location to first responders, who are using the base stations.



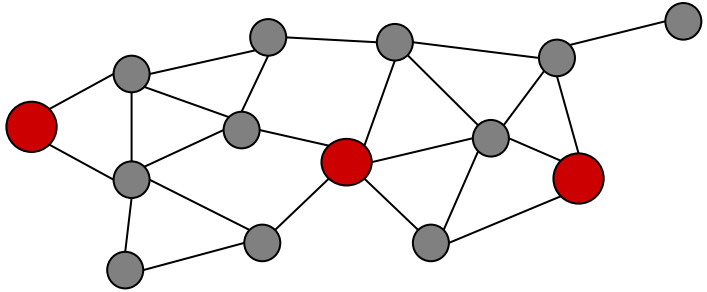
Our Solution

Our system will include:

- One or more base stations and multiple deployable/portable node devices
    - Deployed via plane/drone after, or given to person prior to disaster
- Communication among nodes through a mesh network using low power RF
- Ability to locate portable nodes quickly after being deployed
- A frontend (phone app and/or webserver) for first responders to locate nodes after location is reported
    - Google Maps API with overlays of mesh network nodes

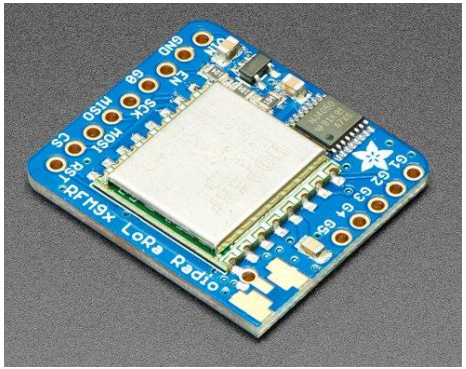
Background - Mesh Network

- Network made of individual nodes in a graph-like structure
- Each node should be able to communicate with at least one other node
- Each node should have a network path to a base station
- Each node keep track of which other nodes are in range and be able to send that information to sibling nodes



Background - LoRa Communication

- Proprietary low-power WAN protocol
- When active, up to 4mA current draw
- 3 KM range in urban area, 10 KM range elsewhere

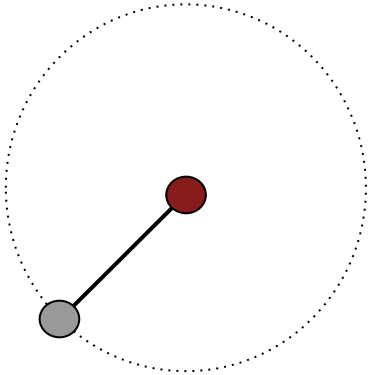


Adafruit

Location?

Network Delays

- Nanosecond precision clock
- Find distance between two nodes using RTT of packet (round-trip time)
- Every node of the mesh network can do this
- Not trivial



GPS

- Use GPS module to find exact location
- Uses a given range to triangulate quicker

Preliminary System Specifications

General Specifications for Each Node

1. Can communicate with any worker node or base node in range
   a. Broadcast custom address to differentiate nodes
   b. At least 2 km range in urban environment
2. Can identify the best neighbor node to propagate signal to (acting as relay host in mesh)

Preliminary System Specifications

Worker Node

1. Pocket size
2. Able to survive a fall at terminal velocity
3. Water resistant and can float on water
4. Sufficient battery capacity and power consumption
    a. >= 1 week runtime (Low Power!)
5. Can determine its own location within 30 secs of activation
6. Speaker and LED for signalling to user and Button used to activate the device

Base Station

7. Portable size (For first responders)
8. Average <= 5W power consumption (For phone port)
9. Always knows its own location
10. Can connect to smartphone via USB or bluetooth to view frontend
11. Rechargeable Battery
12. RJ45 port for connecting to any unsupported device (Laptop)
13. Can display worker node information with no connection to the internet

Survey of existing solutions

- Apple AirTag
  - Battery Life: Greater than 1 year
  - Water resistant
  - Built-in Speaker
  - Can hop over other apple devices (mesh network)
  - Bluetooth, Ultra Wideband
    - Cons:
      - Only compatible with iOS, need Apple ID, low range, need phone with LTE

https://www.apple.com/airtag/

- Tile Tracking Keychain
  - Up to 1 year of battery life
  - Max 400ft of bluetooth range
  - Water resistant
  - Speaker
  - Compatible with windows, android, and ios

https://www.thetileapp.com/en-us/store/tiles/pro

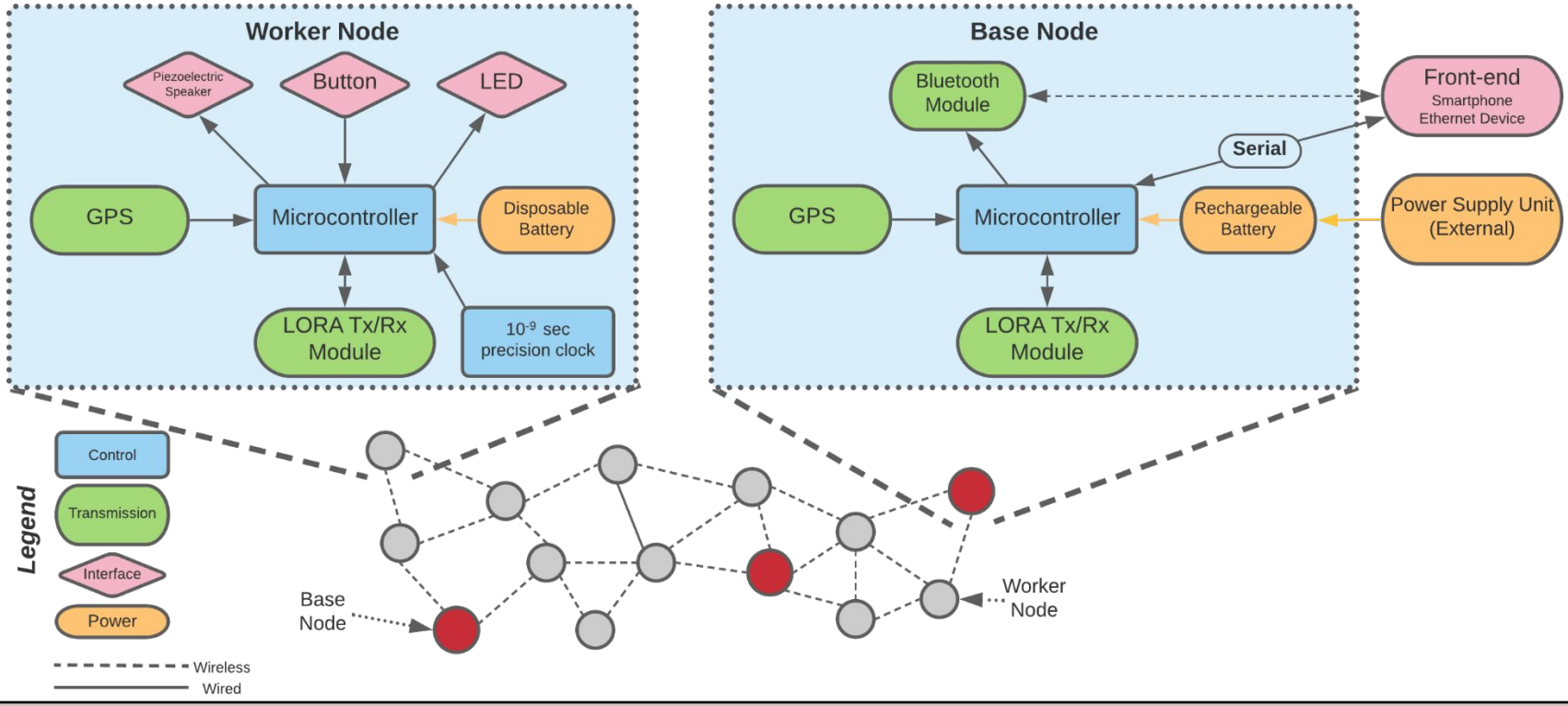
Survey of existing solutions

- Life Robot (BU 2020 ECE Capstone Project)
  - IoT based mini robots and drones to rescue people trapped by disaster
  - Sensors on drones transmit info collected through an established network
  - Meant to detect signs of life, fire hazards, gas leaks, structural stability

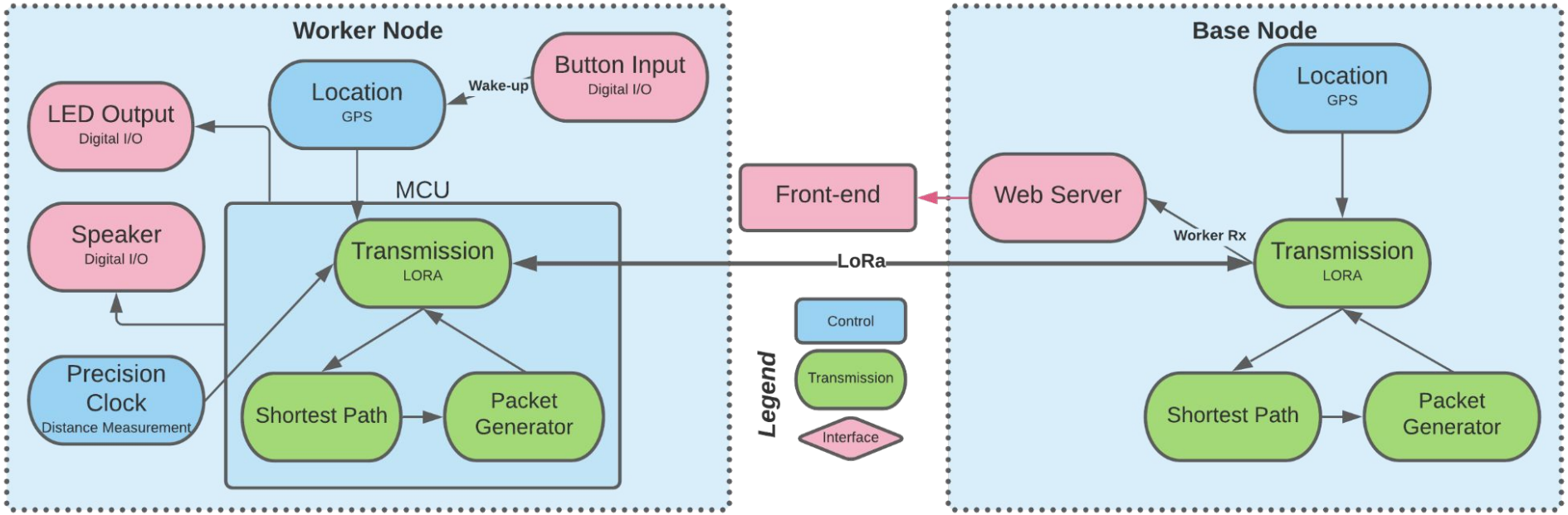
    https://www.bu.edu/eng/files/2020/07/Life-Robot.pdf

- Of these solutions, none were quite like what we intend to make
- Only one of these solutions used a mesh network, and the only one related to rescue is using drones/robots, which have a limited battery life

Hardware Block Diagram



Software Block Diagram



Significant Custom Hardware Design

- Microcontroller for communication with the GPS and the LoRa module to share the worker's location and relay information to the base node.
- Microcontroller for communication to the bluetooth module and displaying user info to a frontend device.
- LoRa Tx/Rx module to effectively communicate with other worker nodes and base station
- Power to all the subsystems

MDR Deliverables

- **Hardware**
  - 1 base station node
  - At least 2x worker nodes
  - Constructed using off-the-shelf modules, prototyping boards
- **Software**
  - Communication of at least 2 worker nodes with 1 base station, with the associated shortest path algorithms
  - Rudimentary front-end which will print coordinates of activated nodes
- **Demonstration**
  - Worker node is activated
  - Front-end receives the signal and prints coordinates of location

Price of Components

Components	Units	Price/Unit
Base Station Microcontroller (Prototype)	1	$0 (already owned)
Worker Node Microcontroller (Prototype)	2+	$15
TX/RX Module	4+	$20
Rechargeable Battery	5+	$5
GPS Module	4+	$18
Timing Modules	3	$10
3D Printed Housing	5	$0 (available in M5)
PCBs (At least 2 Revisions)	5	$250 (total)
Total System	-	**$487**

Member Responsibilities

Hakan Saplakoglu

- Linux Admin, Location Software, Web Software, MCU Programming

Joseph Mitchell

- MCU Programming, App Development, PCB Design, Testing

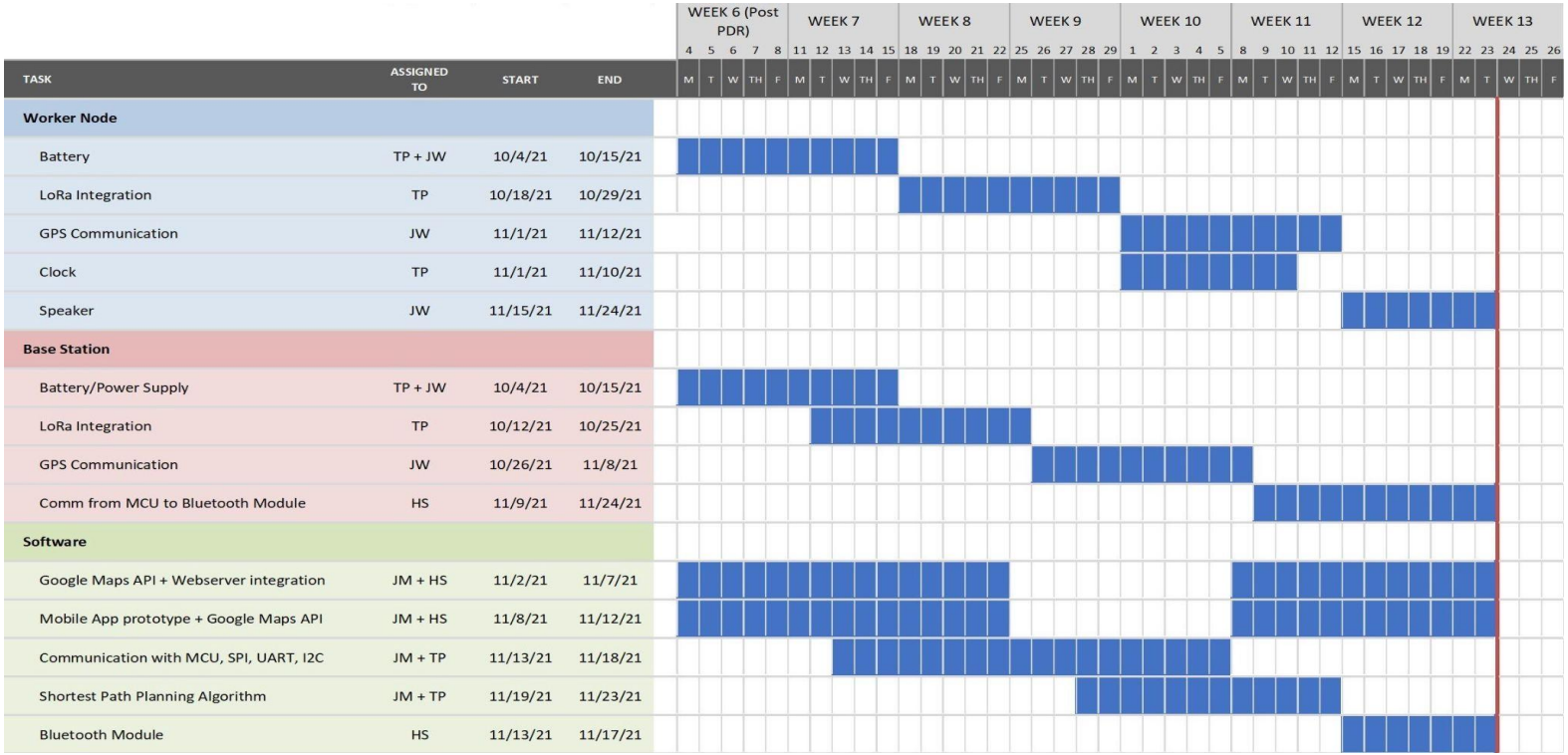
Tirth Patel

- Power/Battery Management, Altium Lead, MCU Programming

Jackson Wallace

- Power/Battery Management, PCB Design, Team Coordinator, 3D Housing Design, Budget Manager

Gantt Chart



TASK	ASSIGNED TO	START	END
Worker Node			
Battery	TP + JW	10/4/21	10/15/21
LoRa Integration	TP	10/18/21	10/29/21
GPS Communication	JW	11/1/21	11/12/21
Clock	TP	11/1/21	11/10/21
Speaker	JW	11/15/21	11/24/21
Base Station			
Battery/Power Supply	TP + JW	10/4/21	10/15/21
LoRa Integration	TP	10/12/21	10/25/21
GPS Communication	JW	10/26/21	11/8/21
Comm from MCU to Bluetooth Module	HS	11/9/21	11/24/21
Software			
Google Maps API + Webserver integration	JM + HS	11/2/21	11/7/21
Mobile App prototype + Google Maps API	JM + HS	11/8/21	11/12/21
Communication with MCU, SPI, UART, I2C	JM + TP	11/13/21	11/18/21
Shortest Path Planning Algorithm	JM + TP	11/19/21	11/23/21
Bluetooth Module	HS	11/13/21	11/17/21

Other Applications (Beyond this Project)

- Forest fire detection using the same framework with different mesh network nodes for fire sensing
- Data transfer for areas where the public internet is heavily restricted
- Hikers that can easily get lost, can be used for search and rescue

Questions? Comments? Concerns?