IoT Environmental Monitor

Group: May19-45

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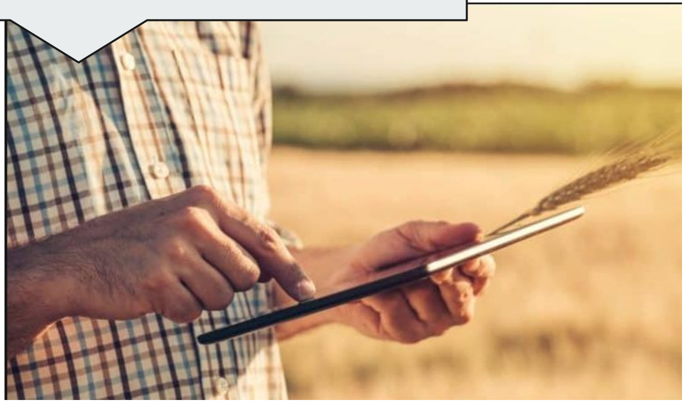
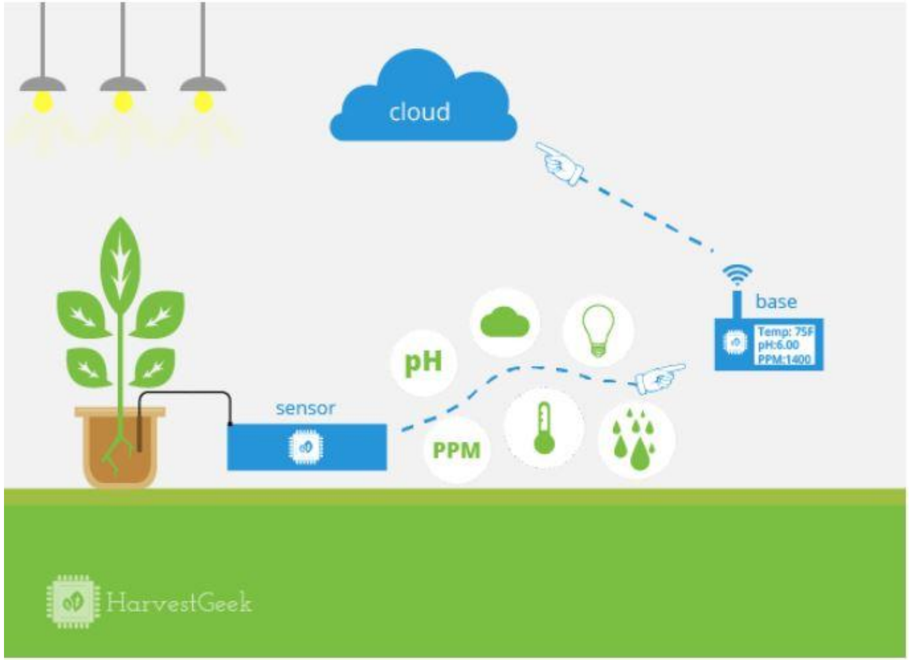
Overview

- **Executive Summary**
- **Requirements**
  - Functional requirements (tied to the problem statement)
  - May include high-level requirements & Use-cases
  - Non-functional requirements
- System Design & **Development**
  - Design plan
  - Design Objectives, System Constraints, Design Trade-offs
- **Implementation**
  - Sensor Nodes
  - Internet Gateway
  - Web Server
- **Testing & Evaluation**
  - Test Plan
  - Completed Testing
- **Project and Risk Management**
  - Contribution and Roles
  - Risks and Mitigation
  - Project Schedule
- **Conclusion**
  - Lessons Learned
  - Future Work
  - Closing Remarks
  - Questions

Executive Summary

……Let me take a look, it's time to plant, harvest and irrigate my fields to result in higher yields.





Requirements specification

Sensor Nodes

- Record data every 30 minutes
- Transmit data at least twice each day.
- Gypsum sensors measure soil moisture level between 10-30%
- Can transmit radio signals at a distance of 1 km.
- Must construct Wireless Sensor Network(WSN) automatically on initialization.
- Soil moisture sensors to stabilize should be under two minutes.
- Messages must take shortest path through WSN.

Internet Gateway

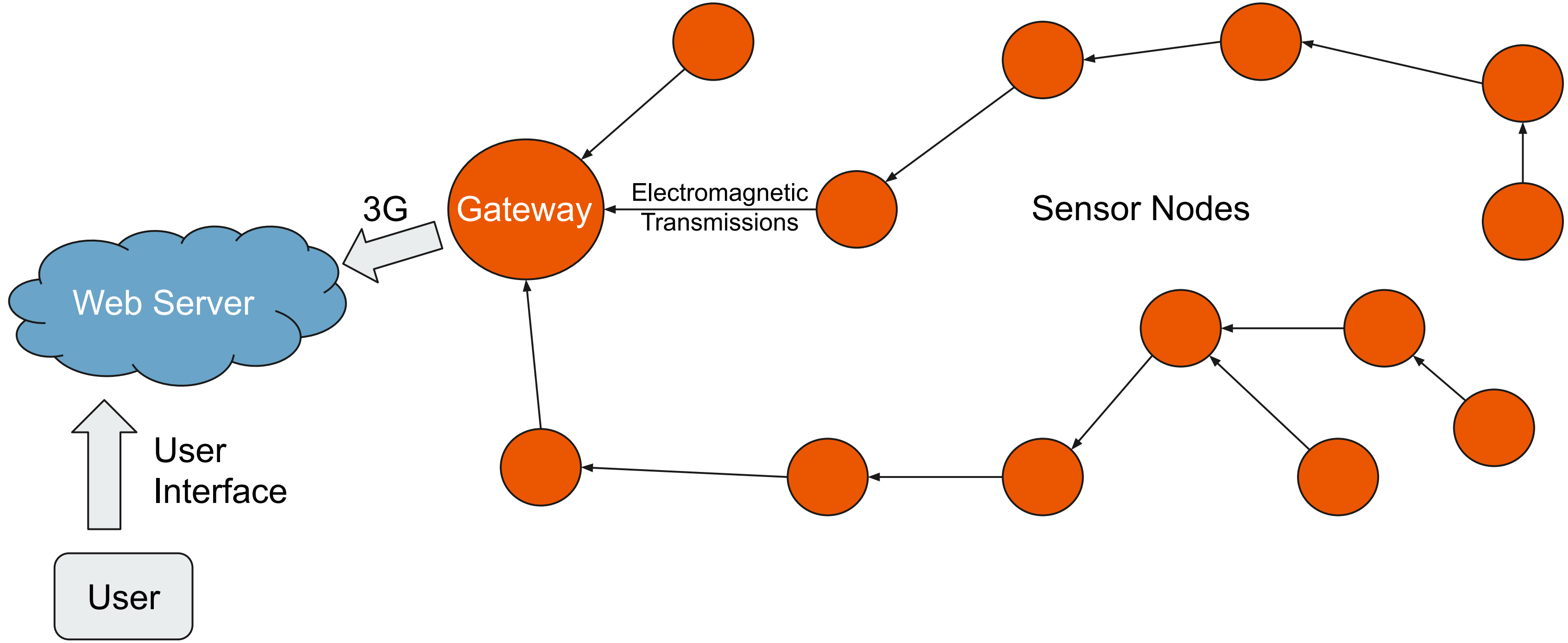
- Has access to the internet.
- Can upload sensor data to the web server.
- Can receive data from sensor nodes.
- Runs required programs on startup.

Web Application

- Hosts and displays data in intuitive fashion
- Allows user to view sensor nodes on a map.
- Allows user to select data from particular node.
- Redundantly stores sensor readings.

System Design & Development

System Design & Development - Design Plan



System Design & Development - Design Plan

- Insulated substrate
- Interdigital electrodes (Cu)
- Gypsum (RH sensing material)
- Protective layer (Polystyrene) *(proposal)*

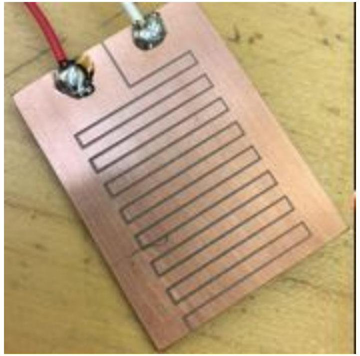
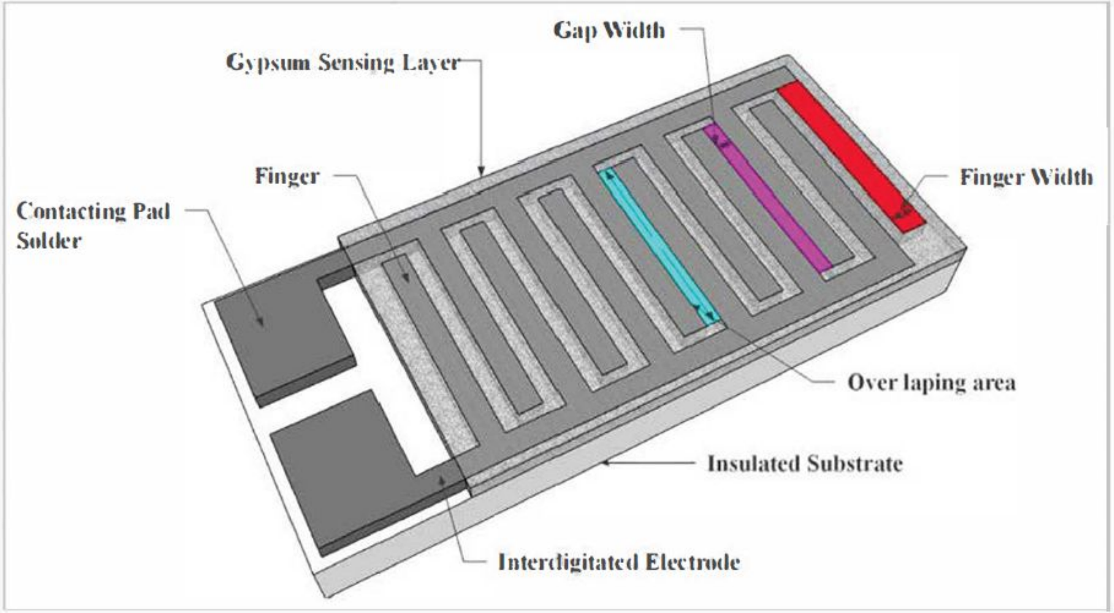


Figure 2. Sketch of a humidity sensor based on the interdigitated structure with the gypsum sensing layer.



Implementation

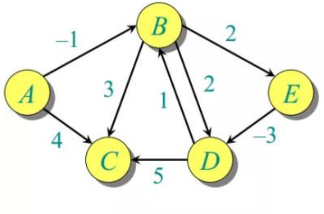
Implementation - Sensor Nodes

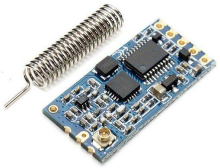
Software

- C++ application that periodically records sensor data, generates packets, and forwards packets.
- Bellman-Ford algorithm to discover route paths.
- Custom message protocol used for messages between nodes.

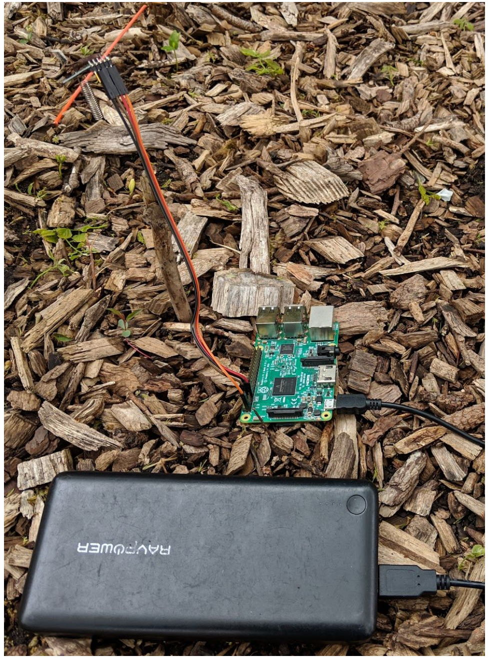
Hardware

- Custom PCB with Atmega328p for microcontroller.
- HC-12 433 MHz radio transceiver for communication.
- Gypsum based soil moisture sensor.
- Lithium Ion Batteries.





Implementation - Internet Gateway

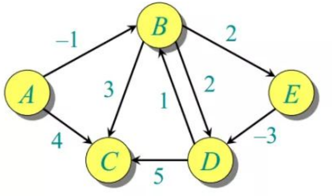


Software

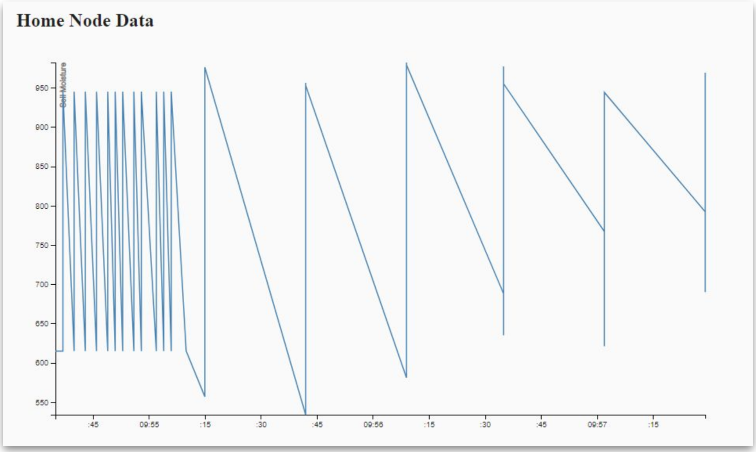
- Python application that receives, acknowledges, and uploads to web-server packets from sensor nodes.
- Bellman-Ford algorithm to discover route paths.
- Custom message protocol used for messages between nodes.

Hardware

- Raspberry Pi 3 B
- HC-12 433 MHz radio transceiver for communication.
- T-Mobile USB broadband modem.



Implementation - Web Server



Screenshot of front-end

Back-end

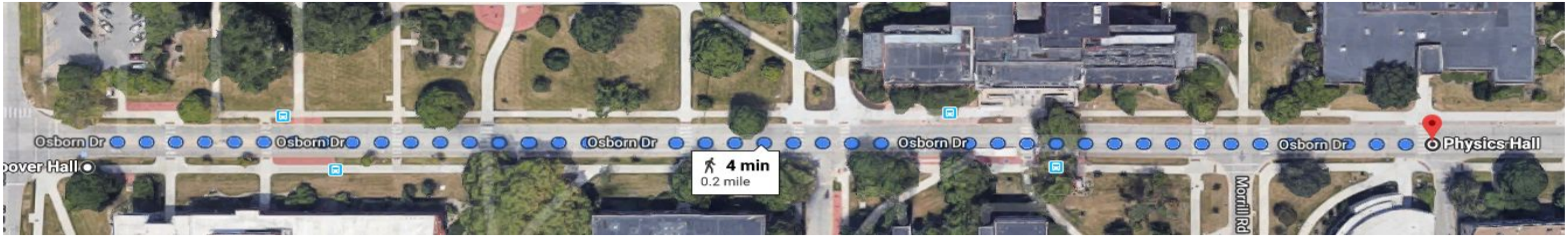
- Java Spring API that queries the database and returns results in JSON.
- Hibernate to convert database values into objects.
- MySQL database.

Front-end

- Simple Angular 2 application that calls API and graphs the data.
- Needs an extensive amount of additional development.

Implementation Tradeoff - Power Supply Influences

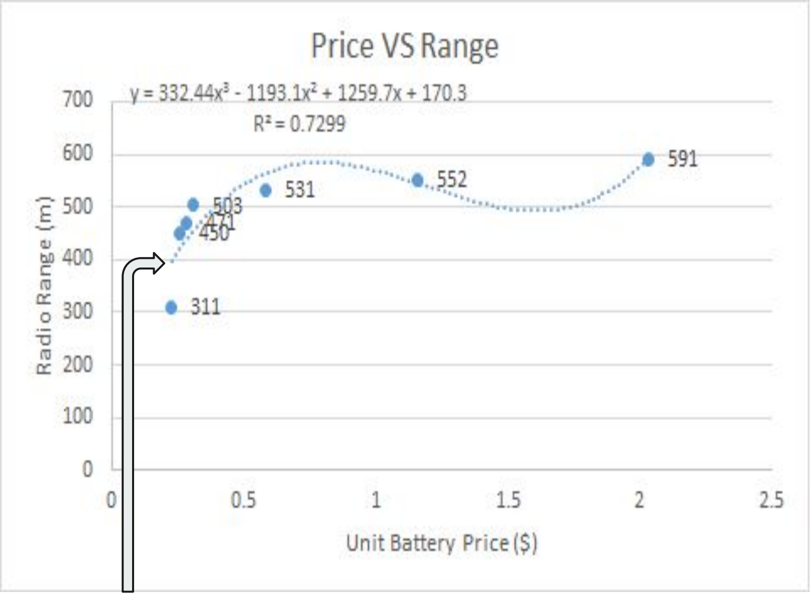
Distance : 0.39 mile (627.65 m) ~~~~~ 0.401 Mile (645.35 m)
Power Supply : 5 v & 2.4 A



Distance : 0.27 mile (434.52 m) ~~~~~ 0.28 Mile (450.61 m)
Power Supply : 4.5 v & 1.1 A

Cost Evaluation

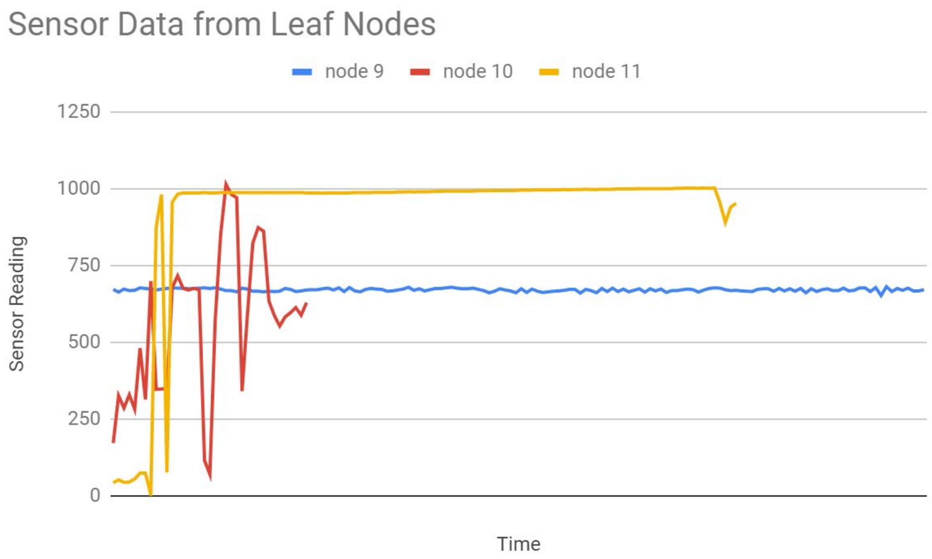
Package	unit price	Quantity	package price	
Parts per node				
Male connector	0.226	2	0.452	https://www.digikey.
Female connector	0.427	2	0.854	https://www.digikey.
Switch	0.58	1	0.58	https://www.digikey.
Atmega 328p	1.895	1	1.895	https://www.digikey.
16MHz Clk	0.6	1	0.6	https://www.digikey.cor
22pF Cap	0.34	2	0.68	https://www.digikey.cor
10M Resistor	0.01	1	0.01	ETG
ICSP program pins	0.31	1	0.31	https://www.digikey.
AAA batteries	0.255	1	0.255	https://www.digikey.
433MHZ HC-12 module	4	1	4	https://www.ebay.com/i
AAA battery holder	0.305	3	0.915	https://www.digikey.
PCB	0.392	1	0.392	OSH Park, PCB Way
Crystal	0.847	1	0.847	https://www.mouser.coi
TOTAL:	11.79			



The batteries here are variable according to its performances of output currents and unit prices from $0.21 to $5.7, the one we used here has the most efficient value.

Test Results

- Field tests for radio range.
    - Able to transmit at ranges of 600m in an open field.
- Integration Tests on entire system.
    - Were able to transmit data from sensor nodes to web server.
- Small Scale field test of system (3 sensor nodes).
    - All nodes were able to successfully get their data to the web server.
- Sensor Calibration Results



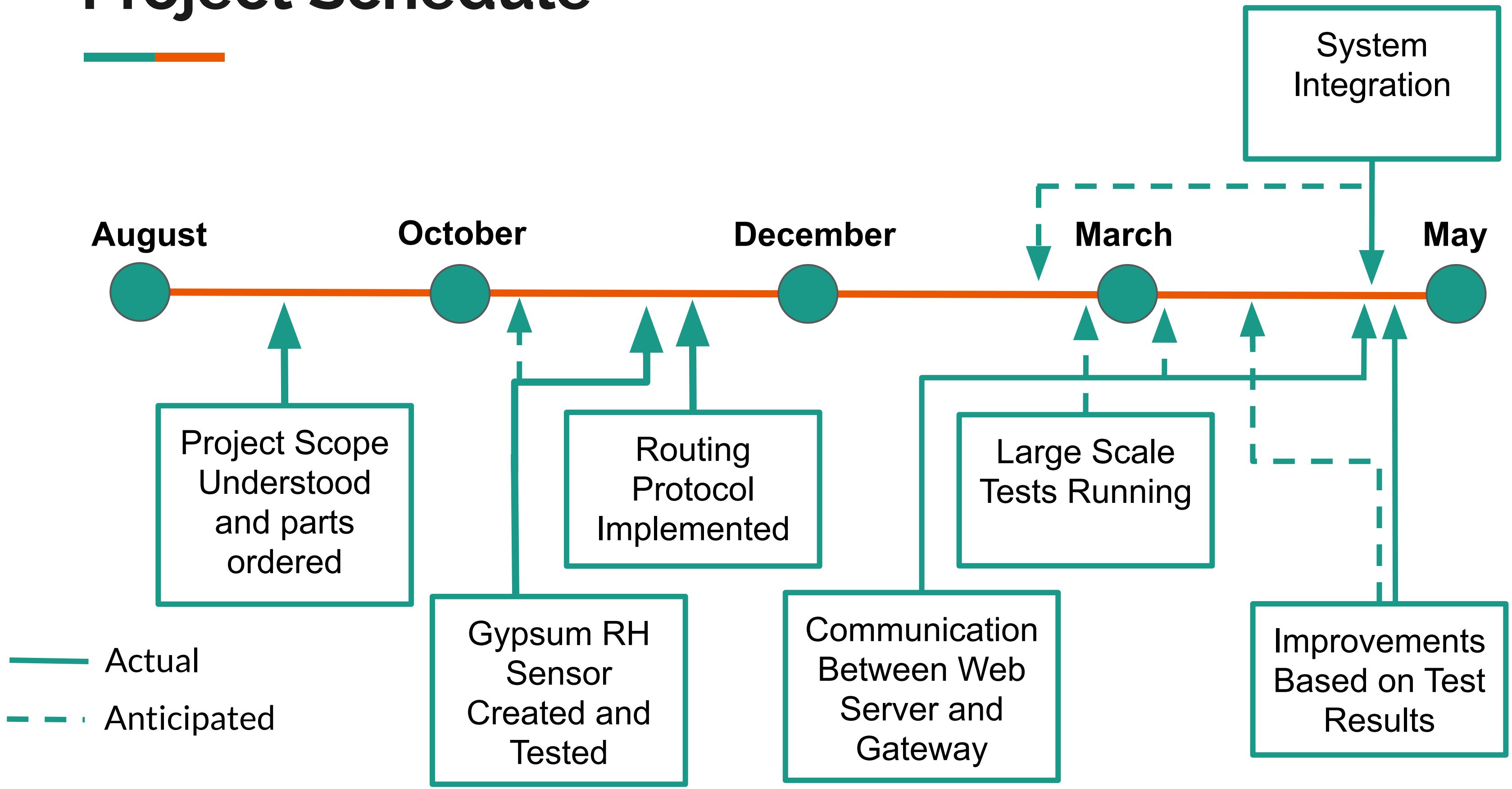
Contributions & Roles:

- Tyler Fritz - Sensor nodes, and webserver
- Ahmed Abuhjar - Gateway and Sensor nodes
- Dong Xing -Gateway and Web server
- Haoyue Ma-Gateway, Sensor nodes and Web server
- Yuanzhe Wang-Gateway and Sensor Nodes

Risks and Mitigation

- **Anticipated Risk 1:** Radio interference could occur with all nodes transmitting on the same frequency.
  - **Mitigation:** Add error checking scheme to message protocol, and introduce random delays to reduce chance that nodes transmit at the same time.
- **Anticipated Risk 2:** Ground could be frozen when we need to start testing.
  - **Mitigation:** Delay start of testing to later in the spring when snow has melted.
- **Unanticipated Risk 1:** Internet gateway chip breaks right before we start testing.
  - **Mitigation:** Switch over to use a raspberry pi.
- **Unanticipated Risk 2:** Web server front-end did not work with web server back-end.
  - **Mitigation:** Keep back-end but rewrite simple front-end.
- **Unanticipated Risk 3:** Limited resources constrain our ability to get accurate results when making sensor.
  - **Mitigation**: Try to control environment the best that we can.

Project Schedule



Lessons Learned

- Buy good hardware.
- Good communication and teamwork is required for success
- Be forward thinking and order parts early in case of delays.
- Plan thoroughly and anticipate setbacks.
-

Future work (potential directions)

- Automated deployment system
- Significant extensions to front-end
- Long term tests of system
- Power optimization strategies
- Custom Casing for leaf nodes

Closing Remarks

- There is potential for this to be a powerful, effective, and affordable system if a little more work is done.
- It would be relatively easy to modify our work to allow the network to record other types of data, for different applications.
- We have set up a good framework for future development on this project.

Question?