EE/CprE/SE 4920 STATUS REPORT 3

14FEB2025 – 27FEB2025
Group number: sdmay25-04
Project title: Wireless Mesh Network for Pesticide Spray Monitoring and Mapping

Client: Claussen Lab- Iowa State University

Advisor: Nathan Niehart

Team Members/Role:
Software Team

- **Ashley Falcon:** IDEs and Microcontrollers, Group Communicator
- **Drew Scheidler:** Mesh Networking; Note Taker
- **Henry Hingst:** Mesh Networking; Group Leader

Hardware Team

- **Hector Perez Prieto:** Microcontroller; Circuit Design and Testing
- **Yok Quan Ong:** Circuit Design and testing; Microcontroller
- **Wesley Smith:** Circuit Design/Simulation; Microcontrollers; Note Taker

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Period Summary

- Hardware Team Summary:

The hardware team decided on using the voltage divider circuit that uses switches to decide which range is being used by the sensors. Now, we are working on laying out the PCB schematic with our desired components. We have decided on using an external ADC to do our calculations due to the accuracy that we need for our resistance measurements. Additionally, we have decided on using a 9V battery and a voltage regulator to power our system, consisting of a microcontroller and three sensor circuits. We need to figure out if our microcontroller has enough GPIO pins for our three external ADC's, switches, and other components. If we do not we need to figure out a way around this problem. We have also worked on putting together a Bill of Materials (BOM), which includes all the components we will be using.

- Software Team Summary:

The software team's members have each been working separately on three different things. Ashley has been deciding which external ADC to use for reading our sensors, and writing the driver that will be used to counteract with the ADC. Drew and Henry are both working on two different ways to implement the communication between poles for the project. Henry is

still trying to implement the Espressif wifi mesh network. Drew has been testing utilizing LoRa modules to implement direct board-to-board communication.

Past Period Accomplishments

Our hardware and software teams met milestones and accomplishments over the past two weeks. Here are our individual contributions:

- Ashley Falcon:
    - Investigated external ADCs
        - Settled on the AD7171 being used
    - Thorough review of AD7171 documentation
        - Specifically with digital communication
    - Outlined code required to set up drivers
        - Made schematic to better understand the transfer of data between external ADC and microcontroller
    - Wrote initial code to program ADC drivers
        - Drivers allow for the communication between the MC and ADC
        - Essential for transfer of voltage data streaming from the sensor circuitry
        - The initial code was not correct
            - This needs to be changed due to my use of peripherals rather than direct connections.
    - Restarted driver code to better align with project requirements
        - Discussed better approach with our advisor
    - Began identifying troubleshooting techniques

- Drew Scheidler:
    - Researched and ordered LoRa breakout boards to test LoRa communication
    - Put together LoRa boards
        - Soldered pins to board
        - Researched and cut appropriate wire length to act as an antenna for the LoRa boards using 915MHz frequency to communicate
        - Soldered antennas to boards
    - Setup circuit for 2 ESP32 MCs, 2 SD card readers, and the 2 LoRa boards
        - Helped us count and assign pins for the PCB design
    - Downloaded and installed LoRa component code
    - Wrote and tested basic sender and receiver code
        - Served as a simple proof of concept

- Henry Hingst:
    - Successfully transmitted packets full of dummy sensor data over the Espressif wifi mesh network
        - One mesh node was designated as a sender and another as a receiver
        - The sender continuously transmits a dummy sensor reading and the metadata needed to use the reading (time of reading and the sensor it came from)
    - Identified some key flaws in my understanding of how to use the mesh network interface
        - What I thought was an interface used to send packets was actually an example of how to broadcast packets to every node on the network
        - This caused my testing code to fail because the mesh interface was already busy with handling the example's packets
    - Worked with Drew to determine which LoRa module to use
        - We decided on the Adafruit RFM95W due to its widespread use, and because it mounts the LoRa module onto another board which simplifies the interface and allows compatibility with breadboards

- Hector Perez Prieto:
    - Component research for final circuit design, preparing for the PCB design and BOM
    - Collected datasheets of all components being used
    - Looked into power supply (batteries) for the system as a whole

- Yok Quan Ong:
    - Start the PCB schematic for the sensor circuit, ESP32, ADC, and SD card circuit
        - Select footprint for all the component
        - Download components' symbol and footprint
    - Create a BOM for all the components that we are going to use.
    - Look up datasheet for the connection for different components
    - Start initial PCB layout
        - 2 layers board

- Wesley Smith:
    - Part selection for the BOM
    - Simulation work to see if we needed multiple reference voltages (Vin) when using multiple measuring circuits on a PCB
    - Began finalizing a pinout for the ESP32

- Reviewed PCB design
- Looked into voltage regulators

NAME	Individual Contributions	Hours this Period	Cumulative Hours
Ashley Falcon	ADC driver code and documentation review	**12**	**31**
Drew Scheidler	LoRa board implementation and testing	**14**	**42**
Henry Hingst	Wifi mesh packet transfer and LoRa research	**14**	**20**
Hector Perez Prieto	Component Research and Finalization	**12**	**30**
Yok Quan Ong	PCB Schematic and Layout, BOM	**15**	**33**
Wesley Smith	Circuit simulation and BOM Part finalization	**12**	**30**

Plans for the upcoming period

- **Hardware Team**
  - Finalize the PCB schematic and layout
    - Revised by other team members
    - Will be meeting on Sunday or Monday to revise the drawing
  - Change the setting of the layout to wider trace and larger vias
  - Check with JLCPCB for the layout
  - Research a 9V battery and a step down voltage regulator
  - Add the sensor circuits and external ADCs to meet the client requirements
  - Calculate the circuit run time
  - Simulate the worst case of the circuit
  - Double check the Vin (Reference Voltage component) is able to drive 3 sensor circuit
  - Research on the banana plug for the sensor handling
  - Simulate the sensor circuit in parallel to make sure there is enough power
  - Microcontroller pin layout

- **Software Team**
  - Ashley:
    - Rewrite driver code that better aligns with documentation
      - Discard peripheral approach

                - Will utilize SCLK and DOUT/RDY SCLK to transmit and process data successfully
                - The approach discussed with the advisor will be more simplistic and binary
            - Identify techniques to troubleshoot driver code while not having physical ADC available to me.
                - Use scope/power supply method to mimic external ADC
                - Begin troubleshooting
            - Collaborate with the HW team to determine if multiplexers are needed to switch between sensor data and how it will relate to the external ADC and GPIOs
    - Drew:
        - Test range capabilities of LoRa
        - Test having multiple leaf nodes communicating to one central node
        - Write and test code for a simple call and response system between nodes
    - Henry:
        - Create a more complex wifi packet transfer program
            - Try sending packets across a larger network (currently I've only tested in a 2 node network)
        - Verify that the network is using the long range wifi mode
            - I plan on testing this by doing a distance test of how far packets can be reliably sent
            - If the distance exceeds 200 feet then the network must be using the long range mode

<u>Summary of Weekly Advisor Meetings</u>

- Week 4 (Feb 18th)
    - Hardware
        - Use through-hole resistors (0.1 error), surface-mount ESP pins, and a 3.3V source
        - Sensor connection options: banana plugs/alligator clips. PCB can be 2 or 4 layers
    - Switches
        - Use either ADG801 or ADG802, just document choice
        - Microcontroller needs a GPIO pin to trigger from input, with two GPIOs for switches
    - SD Card
        - Can use GPIO 10, 11, 2, 3 or others

- Components
  - Use Neihart's parts, including ADC powered by 3.3V
  - Switches maxed out at range, no attenuation needed
- PCB & BOM
  - Finalize schematic, footprints, and BOM by next week, then start board layout
  - Likely a 2-layer PCB, possibly 4 for ground/power
- ADC & MC
  - Ensure compatibility, no I2C needed
  - Test ADC with PCB, use oscilloscope for clock timing
  - Set GPIOs to start with both switches closed
- To Do by Next Week
  - Finalize schematic, footprints, and BOM
  - Start PCB layout
  - Ensure ADC and MC compatibility

- Week 5 (Feb 25th)
  - Hardware
    - Finalize the PCB schematic and layout
    - Provide feedback to the schematic and layout from advisor
    - Add more sensor circuits and ADC
    - Change the battery from 3.7V to 9V and add a voltage regulator
    - Change to through-hole banana plug
    - Simulate the sensor circuit
    - Increase the trace width and vias diameter
    - Calculate the runtime for the sensor circuit
    - Check the Vin is able to drive all three sensor circuit
  - Software
    - ADC
      - Use 3 GPIO pins (sclk, dout/rdy, pdrst)
      - Ensure reconfigurability and track pin count
      - Supply a clock to ADC when dout/rdy goes low
      - Manually clock by toggling sclk with delays, latching, and reading dout
      - Repeat 16 times per second and average values
      - ADC sends data at 125Hz
    - LoRa
      - Implement call-and-response for data requests

- Test range and capacity