UMassAmherst

Preliminary Design Review

Mappa Signa
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Department of Electrical and Computer Engineering

Introduction

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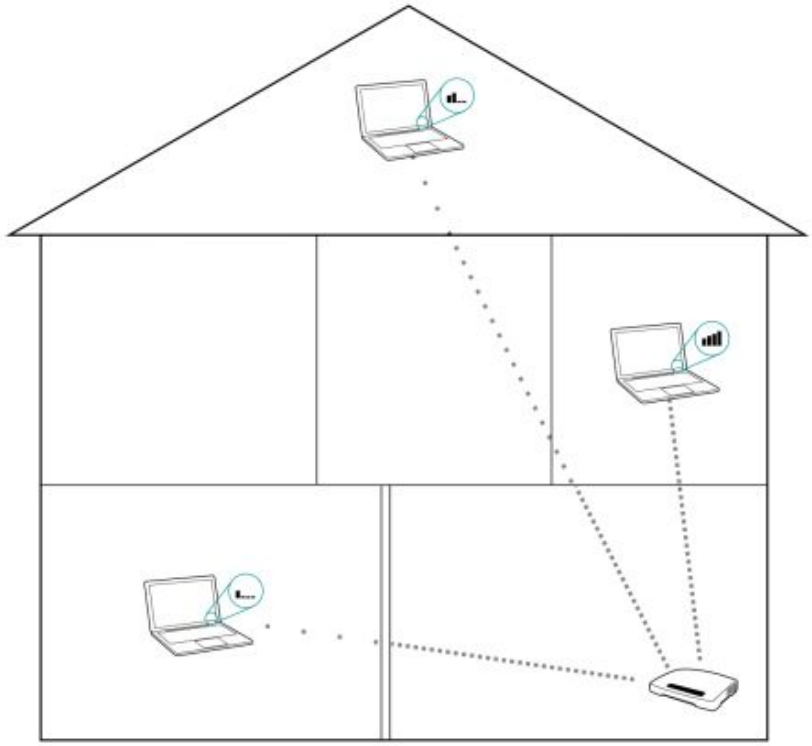
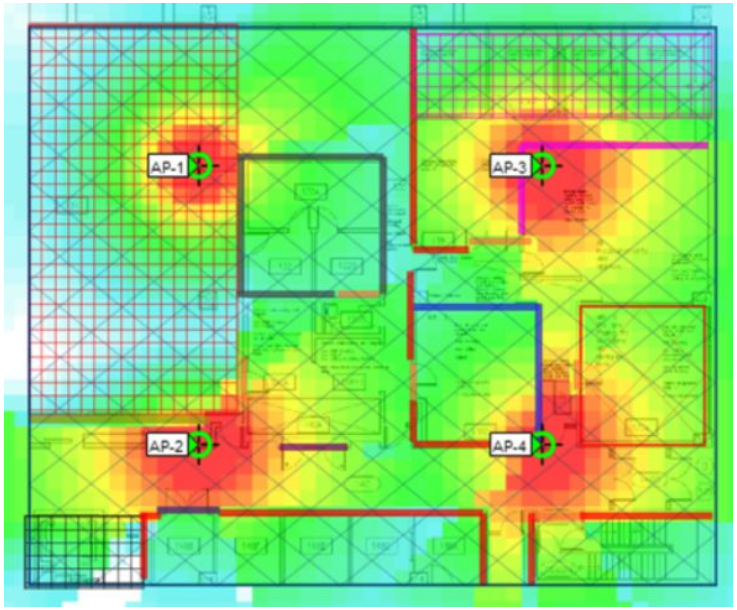
Problem Statement

- WiFi signal is inconsistent throughout homes and offices
- Most homes have a single access point
- Houses are filled with walls and furniture that block WiFi signals
- Current solutions require copious manual input of data



Solution

- Creates WiFi signal strength heat map
- Suggests optimal location for signal booster
- Enables the easy, accurate, and visible optimization of WiFi-Strength throughout buildings



System Specifications

1. **Last long enough to map the entire building and transfer data to host device**
2. Automatically create 2D map and localize user in area without user input of preexisting map/blueprint.
3. Accurately suggest locations for additional access points, or relocation of single access point
4. Turn on and go functionality, no user intervention until data analysis
5. Interface with computer application

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Typical Design Alternative:

Pros:

- Only requires laptop

Cons:

- User must upload blueprint or hand drawn map
- Plotting location depends entirely on user input

Ex: NetSpot, VisiWave

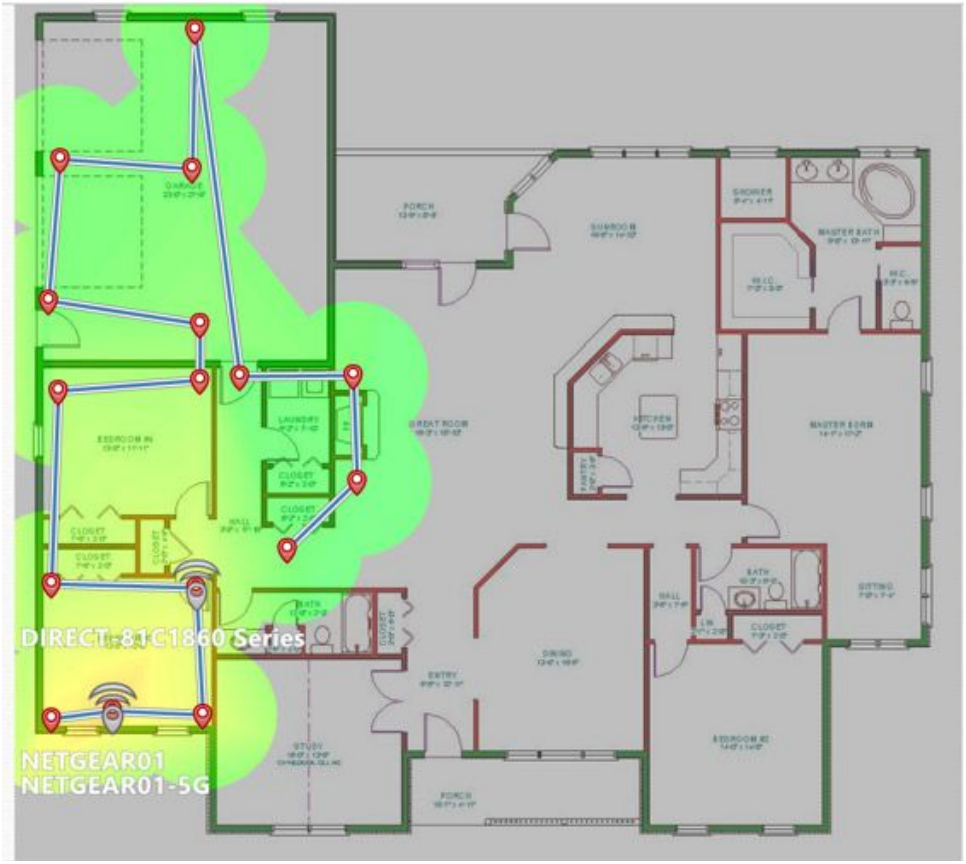
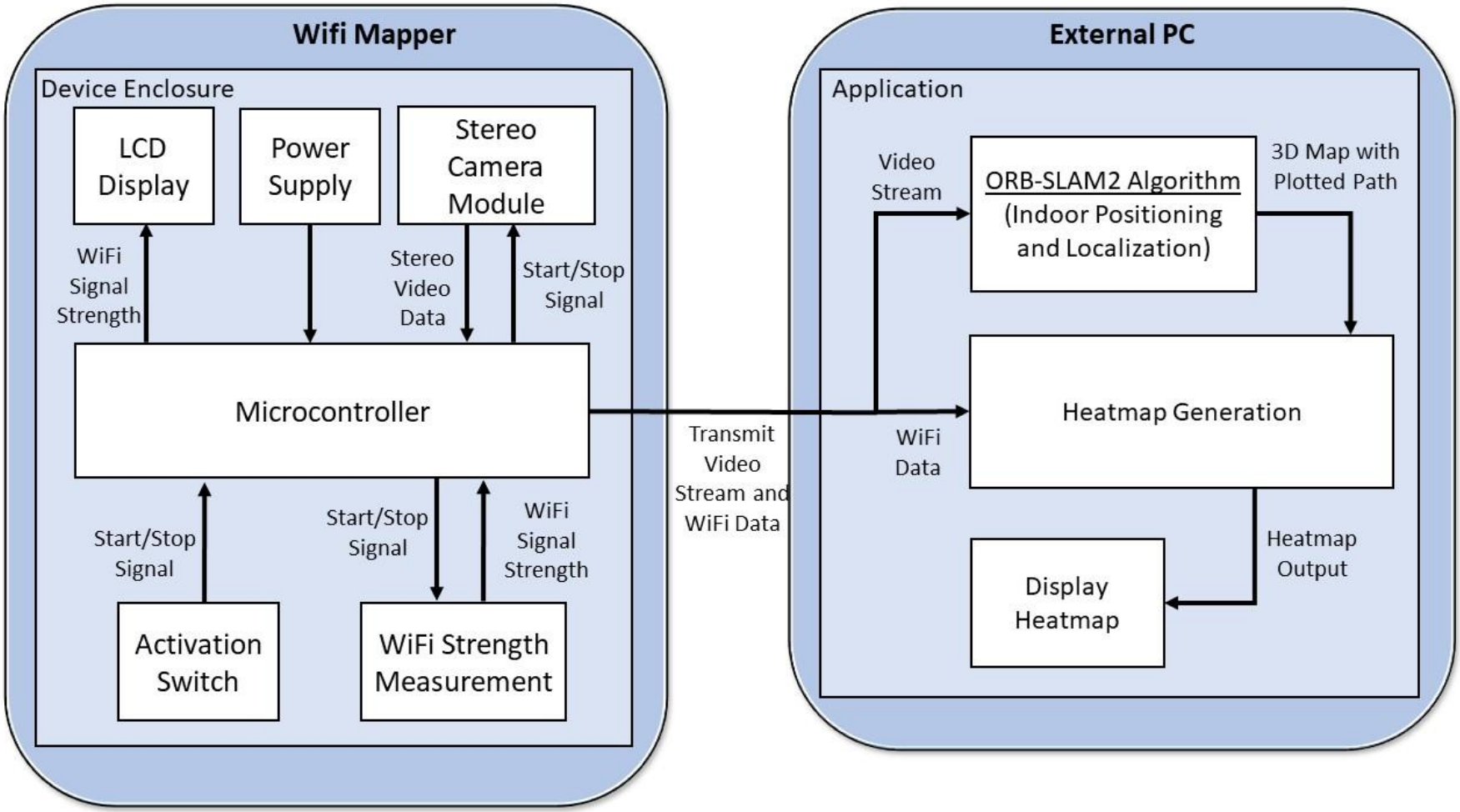


Fig. 1: Sample NetSpot heatmap

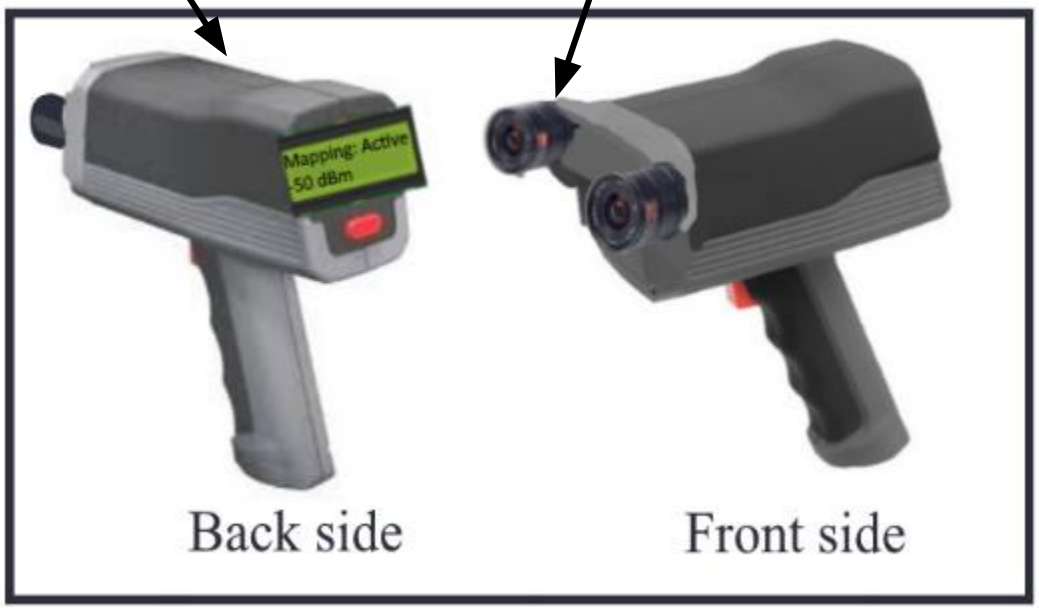
Solution: Block Diagram



Our Current Design Concept

Measure WiFi Strength

Stereo Cameras record video



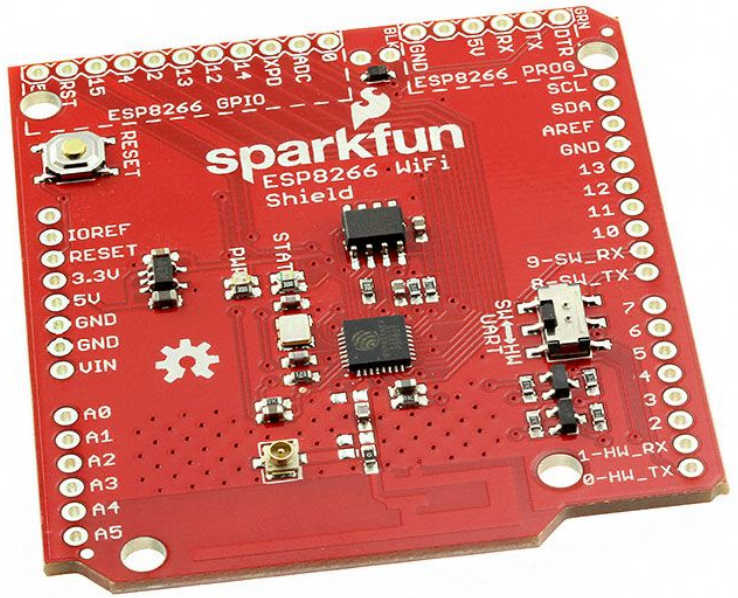
Handheld Device

stereo video and wifi signal strength data

External PC which generates Heatmap

Measuring WiFi Signal Strength

- Measure signal strength
- Gives data in easily readable format

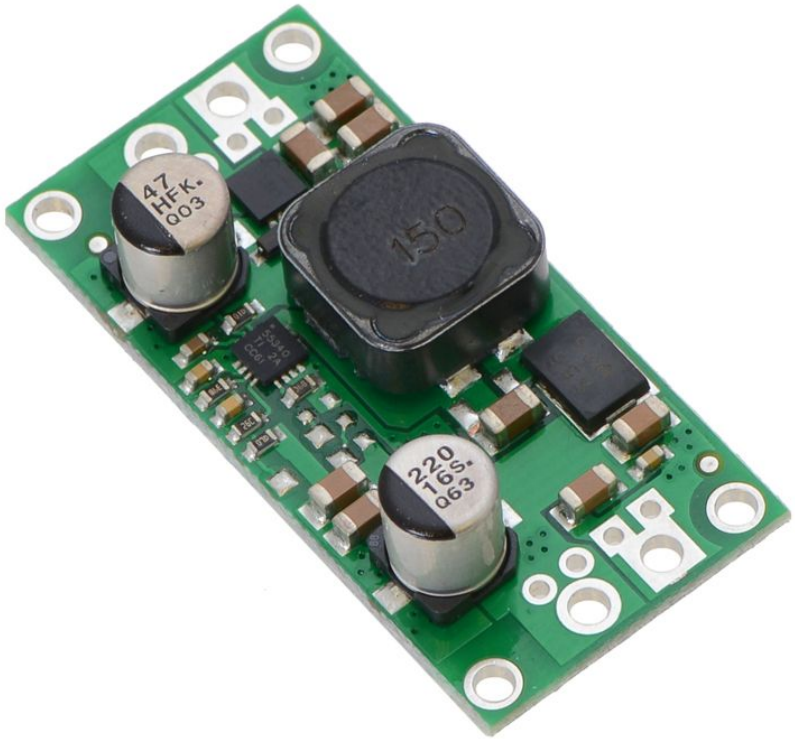


Measuring WiFi Signal Strength

Device	Pro	Con
The Argon	• Small form factor • Flexible antenna	• More expensive • Not very customizable
SparkFun WRL-13287	• Able to be reflashed to fully custom firmware • Easily bypass onboard microcontroller • Cheaper	• Large form factor • PCB antenna

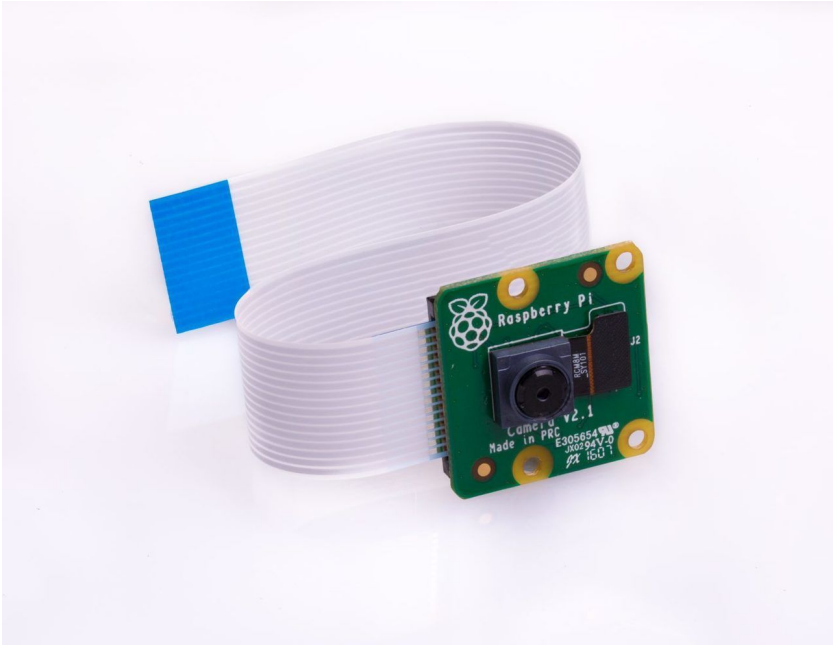
Significant Hardware Component

- Data transfer from WiFi device to Microcontroller
- Regulate power for each component
- Display current signal strength
- Bridge all components



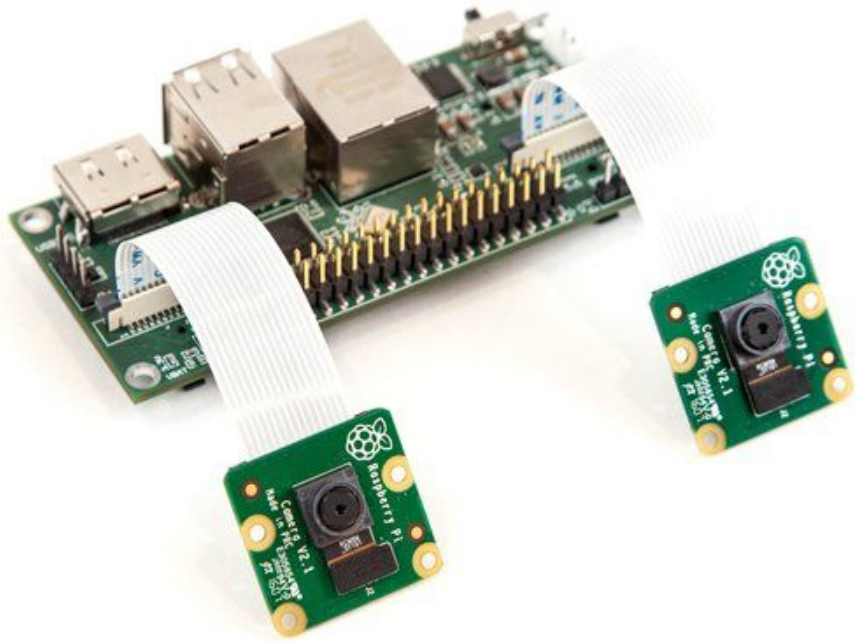
Stereo Camera: Sony IMX219 Image Sensors

- Requirements:
  - Decent video quality for post-image processing
- Solution:
  - Sony IMX219 image sensors
  - 8MP camera with 1080p + 30fps capabilities



Microcontroller: StereoPi

- Requirements:
  - Stereo video data
  - Wireless data streaming
- Solution:
  - StereoPi + Raspberry Pi Compute Module 3
  - Capture, save, livestream, and process stereoscopic video and images



External PC

- Requirements:
  - Wirelessly receive stereo video and WiFi strength data
  - Perform SLAM algorithm
  - Create WiFi signal strength heatmap by plotting signal measurements over trajectory calculated by SLAM

Simultaneous Localization and Mapping (SLAM)

- ORB-SLAM2:
  - Open-source SLAM system for monocular, stereo, and RGB-D camera
- Purpose:
  - Localize positions of WiFi data points

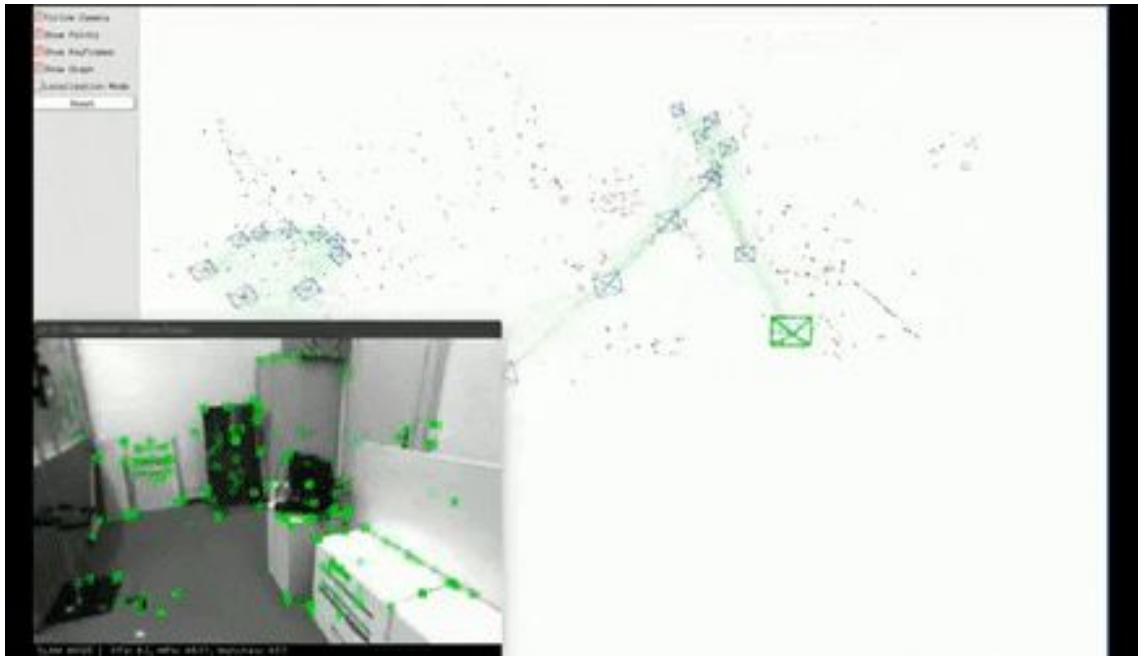


Fig. 4: ORB-SLAM2 path and environment mapping

Indoor Positioning Alternative: LiDAR SLAM

- Pros:
  - Computationally simpler
  - Ex: Google Cartographer
- Cons:
  - LiDAR sensors expensive
  - Requires IMU accuracy
  - Higher likelihood of drift w/o IMU

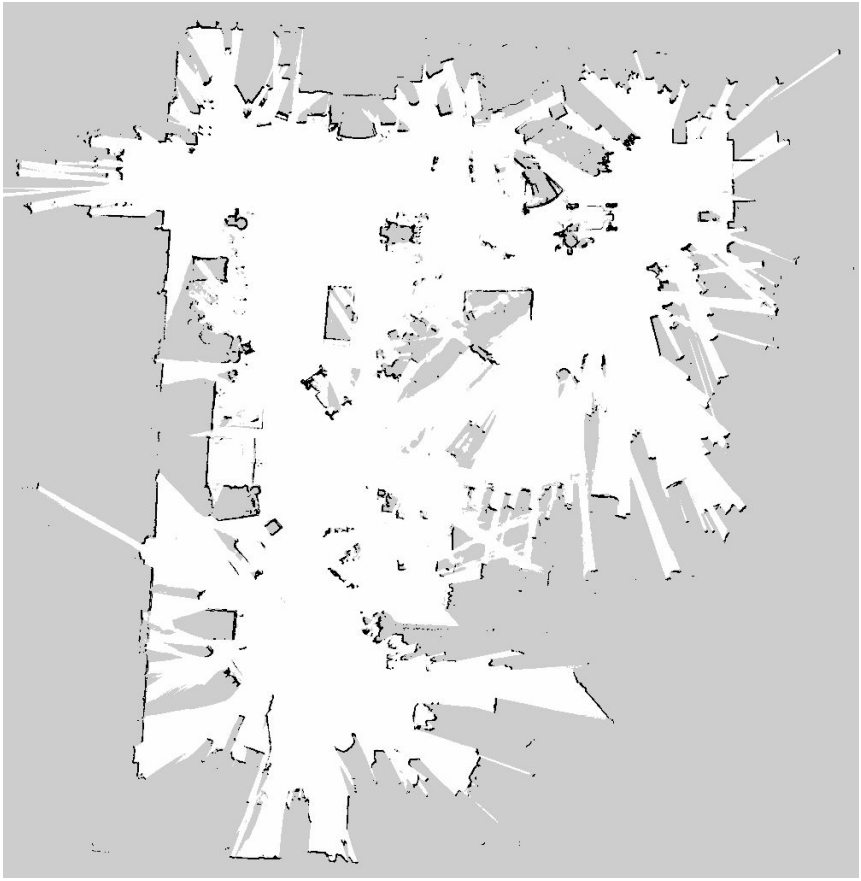
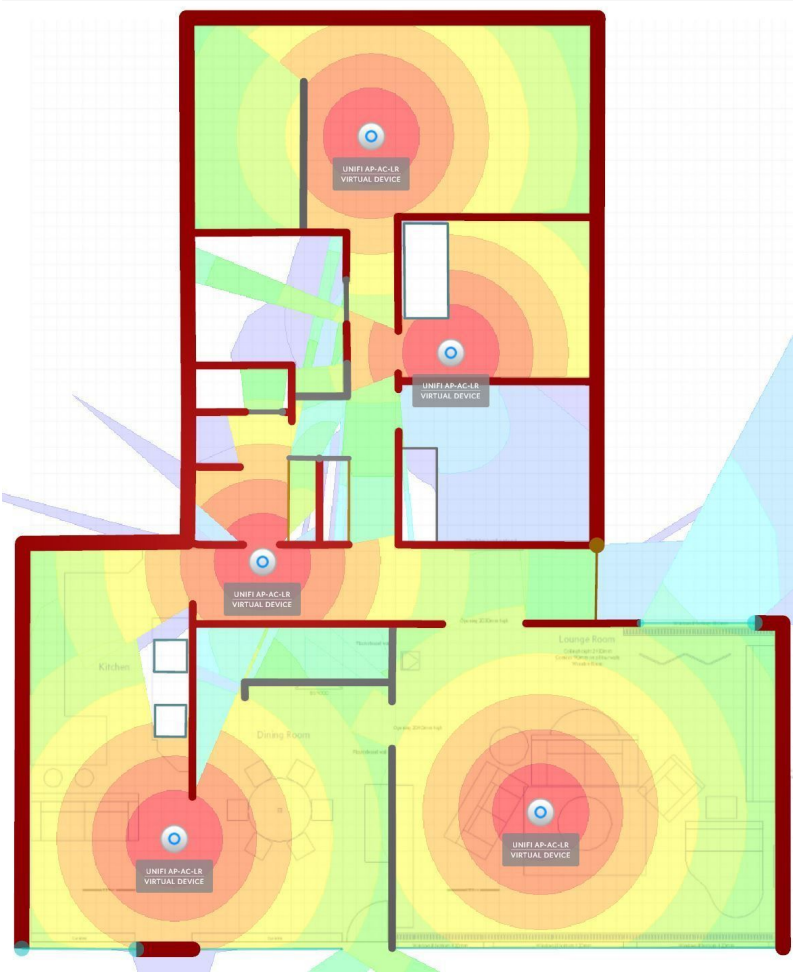


Fig. 5: Google Cartographer results without odometry source: example of drift

Computer Application

- Generate Heatmap
  - Combine calculated trajectory from SLAM with WiFi signal strength data
- Signal Booster Suggestion
  - Based on weak points of heatmap, suggest signal booster placement



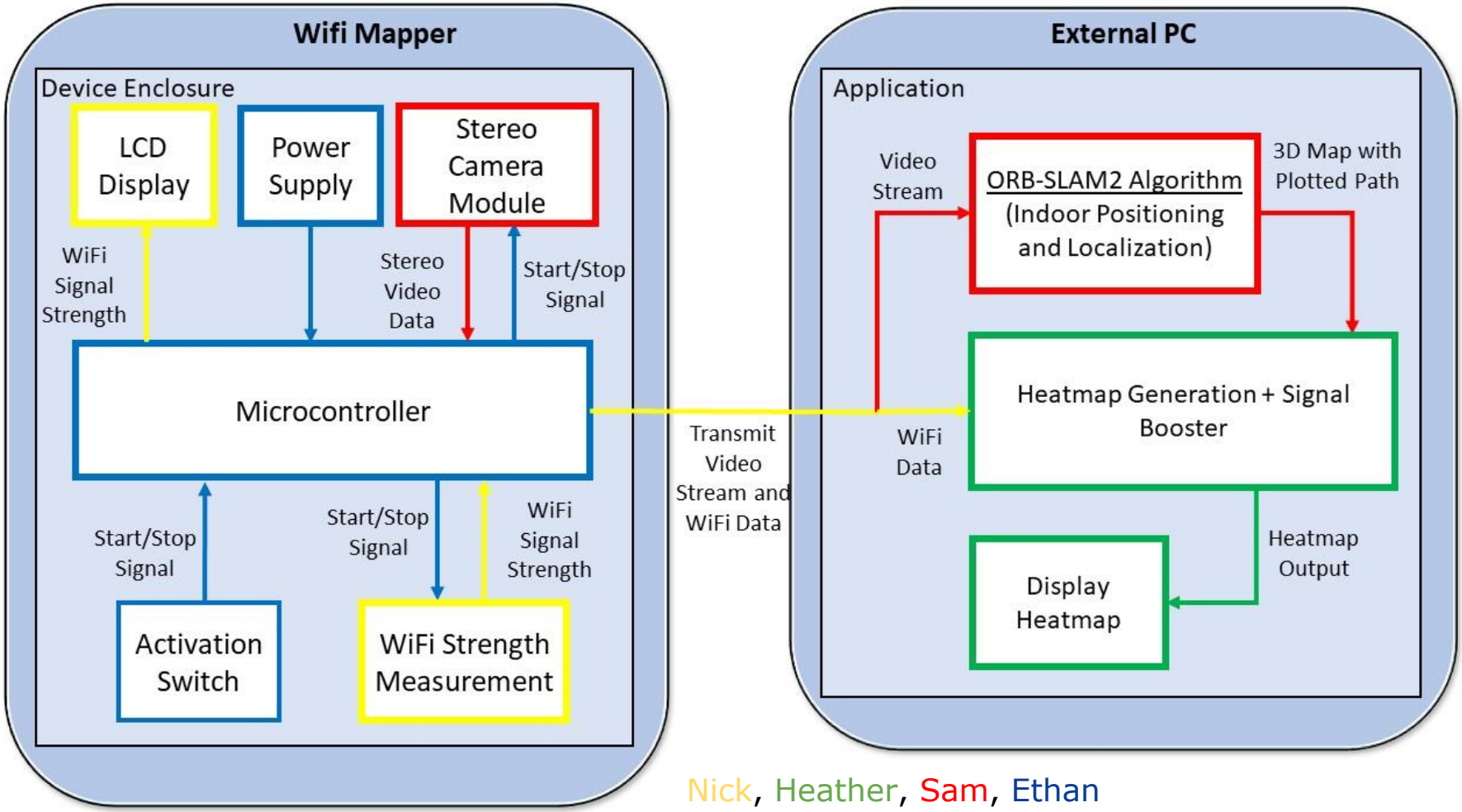
Budget

- StereoPi Microcontroller - $80
- Raspberry Pi Compute Module 3 - ~$40
- Sony IMX219 image sensor (2) - $60
- WiFi Breakout Board - $25
- Activation Switch - $1
- Power Supply - $25
- External PC - $0

Total = $231

($269 remaining for unexpected costs)

Roles: Block Diagram

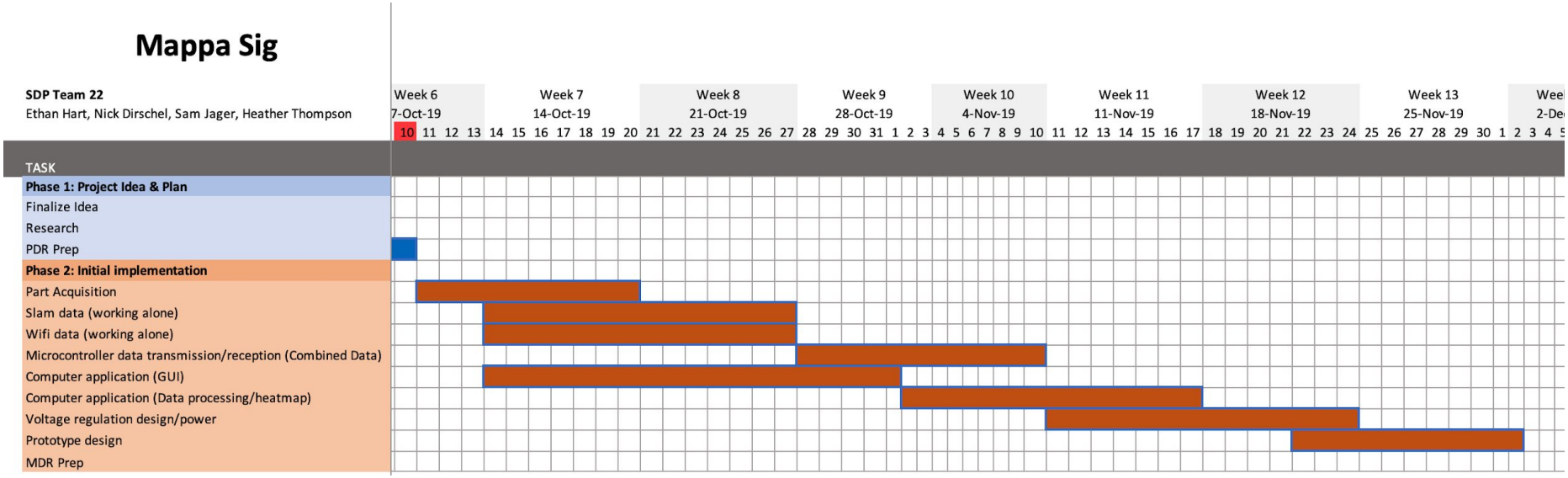


Nick, Heather, Sam, Ethan

Team Roles + Responsibilities

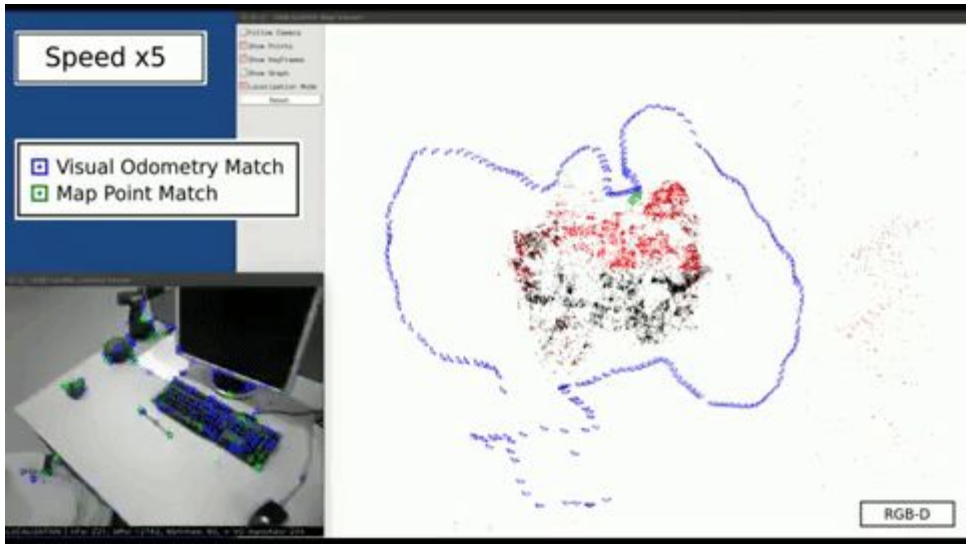
- Nick Dirschel (CSE)
  - WiFi Data Processing
  - PCB Development
- Ethan Hart (CSE)
  - Microcontroller External Component Integration
  - Power Management
- Samuel Jager (CSE)
  - SLAM Implementation
  - Stereo Video Data Processing
- Heather Thompson (CSE)
  - Heatmap Generation (Matlab)
  - Application Development: Signal Booster Placement

Gantt Chart/Timeline



MDR Prototype

- Creates map of environment using ORB-SLAM2
- Simultaneously captures WiFi
- Communicates with external PC to send information back in real time
- Combines both data sets to create heatmap of WiFi signal strength



FPR and Demo Day

- Final Product
  - Device encapsulated in comfortable form factor

- Demonstration of Mappa Signa
  - Create 2D map of current room (FPR room/Demo day room)
  - Generates heatmap from newly acquired data
  - Recommends best places on map to place a signal booster based on heatmap and amount of boosters user requests

Questions?