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**Problem:** Fire and smoke alarms may tell occupants that they need to leave the building, but will not direct them away from the fires toward an exit.

# Fire Escape

Team B8

# Use Case

- Existing solutions
  - Maps posted on the back of doors
  - Typically based on finding closest exit, despite potential hazards
- Our take
  - Distributed node system will output an optimal path based on smoke and temperature readings at different locations
  - Occupants guided step by step out of building
- ECE Areas
  - Software, Hardware/Circuits

# Use-Case Requirements (Hardware)

| Requirement | Reasoning |
| --- | --- |
| 100 second delay between node detection and occupant notification | NFPA requirement based on sprinkler system |
| Must run for 24 hours during power outage | The Pennsylvania Code General Fire Alarm Requirements |
| Operate in fire mode for 5 minutes after 24 hours of no hardwired power and completely recharge battery once the power returns | The Pennsylvania Code General Fire Alarm Requirements |
| Fire must be detected 95% of the time | Current spec of smoke detectors, from National Fire Prevention Association |

# Use-Case Requirements (Software)

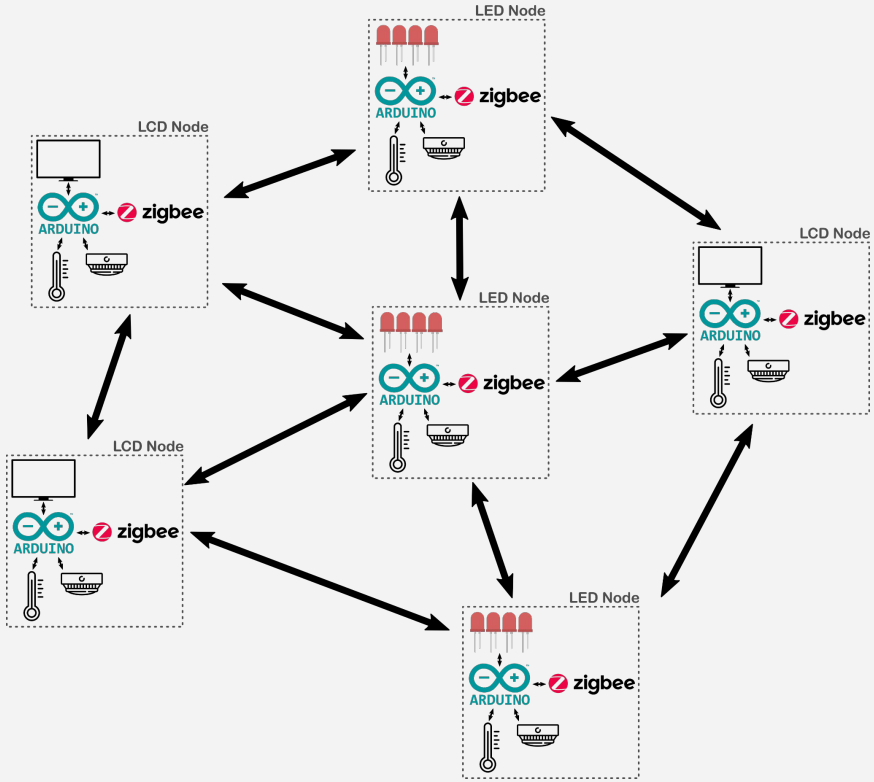
| Requirement | Reasoning |
| --- | --- |
| Planned paths are optimal and correct 100% of the time | Sending users toward a fire would mean project failure |
| Path planning will run and display on nodes in under 10 second for a system of 10 or less nodes | Time it takes to leave a room and therefore find a node |
| Distributed computation to allow scaling | System can be adapted to larger buildings |
| Recharge battery once power comes back on | Batteries must be recharged so that they will be ready for another fire |

# Technical Challenges

- Hardware
  - Display how to get to the next node that occurs along the optimal path out of the building
  - Switching to battery power after a power outage, and recharging the battery when the power returns
  - Figuring out how to display floor plan and generated path on display
- Path Planning
  - Obtaining floor plans of distinct buildings with measurements of hallways, stairwells, etc.
  - Identifying which paths accessible from each node
  - Maintaining up to date data between all nodes on the network

# Solution Approach

- PCB Fabrication for node structure
  - Node consists of LED/LCD, temperature/smoke sensors, XBee shield, arduino
- Distributed node system
  - LED Node
    - Only 2 or 3 possible directions
  - LCD Node
    - More in depth guidance on where to go next



# Solution Approach (cont.)

- Communication
  - Custom ZigBee 2.4GHz network for node mesh
  - Nodes spaced less than 30 meters away for best reliability on ZigBee network using XBee hat (based on spec)
- Path Planning
  - Distributed Path-Planning across all nodes
    - Dijkstra-Scholten Algorithm
    - Compute the shortest path from all nodes to each exit
    - Will remove offline nodes from graph

# Testing, Verification, and Metrics

| Functionality | Testing Strategy | Metrics |
| --- | --- | --- |
| Ability to detect fire | Place lit candles underneath sensors and watch for LED to light up | Fire should be detected 95% of the time |
| Path Finding | Calculate a path for a set of nodes and ensure that it is the shortest, and does not pass through “fire nodes” | A path should be found within 10 seconds for an average sized office building (19,000 sqft, from US Energy Information Association . |

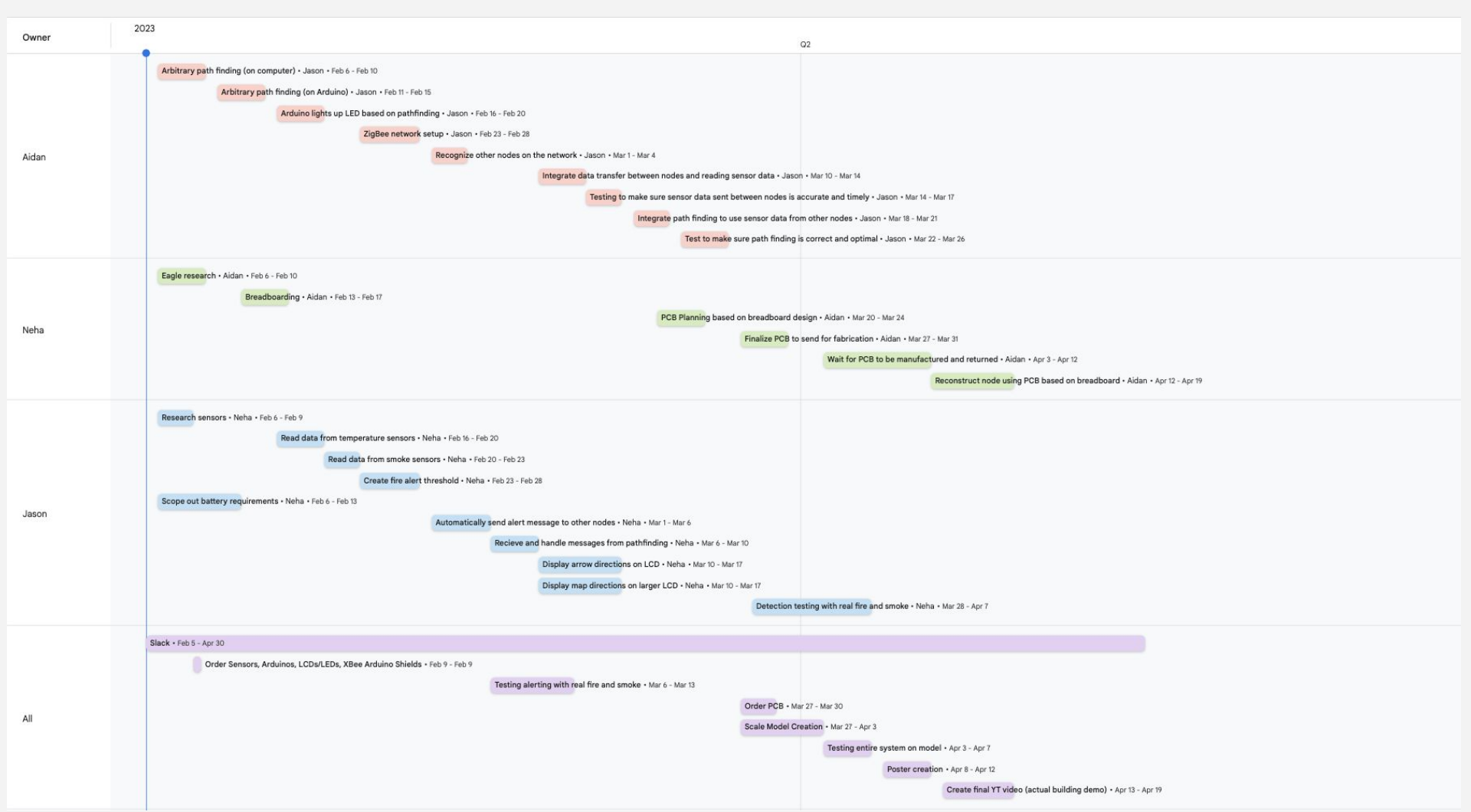
# Testing, Verification, and Metrics (cont.)

| Functionality | Testing Strategy | Metrics |
|---|---|---|
| Communication between nodes | Set up a heartbeat message that is sent between the arduinos and watch serial monitor to ensure messages are sent and received | Messages that are sent are received within 2 seconds to allow us to meet 10 second pathfinding |
| Display directions on nodes | Send direction instructions to nodes and ensure display looks correct | Should be able to be displayed for 5 minutes after 24 hours of idle. |

# Tasks and Division of Labor

- PCB Design
  - Aidan + Neha
- Node hardware
  - Neha + Jason
- Path Planning / Communication
  - Jason + Aidan
- Demo
  - All

*Specific task break down shown in Gantt Chart


Owner
2023
Q2
Aidan
Arbitrary path finding (on computer) • Jason • Feb 6 - Feb 10
Arbitrary path finding (on Arduino) • Jason • Feb 11 - Feb 15
Arduino lights up LED based on pathfinding • Jason • Feb 16 - Feb 20
ZigBee network setup • Jason • Feb 23 - Feb 28
Recognize other nodes on the network • Jason • Mar 1 - Mar 4
Integrate data transfer between nodes and reading sensor data • Jason • Mar 10 - Mar 14
Testing to make sure sensor data sent between nodes is accurate and timely • Jason • Mar 14 - Mar 17
Integrate path finding to use sensor data from other nodes • Jason • Mar 18 - Mar 21
Test to make sure path finding is correct and optimal • Jason • Mar 22 - Mar 26
Neha
Eagle research • Aidan • Feb 6 - Feb 10
Breadboarding • Aidan • Feb 13 - Feb 17
PCB Planning based on breadboard design • Aidan • Mar 20 - Mar 24
Finalize PCB to send for fabrication • Aidan • Mar 27 - Mar 31
Wait for PCB to be manufactured and returned • Aidan • Apr 3 - Apr 12
Reconstruct node using PCB based on breadboard • Aidan • Apr 12 - Apr 19
Jason
Research sensors • Neha • Feb 6 - Feb 9
Read data from temperature sensors • Neha • Feb 16 - Feb 20
Read data from smoke sensors • Neha • Feb 20 - Feb 23
Create fire alert threshold • Neha • Feb 23 - Feb 28
Scope out battery requirements • Neha • Feb 6 - Feb 13
Automatically send alert message to other nodes • Neha • Mar 1 - Mar 6
Recieve and handle messages from pathfinding • Neha • Mar 6 - Mar 10
Display arrow directions on LCD • Neha • Mar 10 - Mar 17
Display map directions on larger LCD • Neha • Mar 10 - Mar 17
Detection testing with real fire and smoke • Neha • Mar 28 - Apr 7
All
Slack • Feb 5 - Apr 30
Order Sensors, Arduinos, LCDs/LEDs, XBee Arduino Shields • Feb 9 - Feb 9
Testing alerting with real fire and smoke • Mar 6 - Mar 13
Order PCB • Mar 27 - Mar 30
Scale Model Creation • Mar 27 - Apr 3
Testing entire system on model • Apr 3 - Apr 7
Poster creation • Apr 8 - Apr 12
Create final YT video (actual building demo) • Apr 13 - Apr 19

# Conclusion

- MVP
  - Optimal path generation based on inputted floor plan and fire detection from distributed node system
  - Display easy to follow path to direct occupant out of building
- Value
  - Streamline fire safety protocol to avoid chaos during tense times
  - Insight into systems that not only detect hazards, but identify solutions as well