Forest Fire Detection System

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INTRODUCTION

In 2015, there were 68,151 fires reported and 10,125,149 acres burned in America, according to the National Interagency Fire Center [1].

Hundreds of thousands of hectares are destroyed every year, which produces disastrous environmental, economical, social, material, and general infrastructure consequences, particularly for forests adjacent to urban areas (urban forests).

Often, the time at which a fire starts and when a fire is reported/responded to, minutes can be crucial, depending on weather conditions.

The work presented here offers a solution that may decrease the time between fire start/response, particularly important with fires in forests adjacent to urban development.

BACKGROUND

Forest fires are often detects/reported via the following:

1. Satellites [2-3]:
   - Able to take relatively clear pictures of landscapes with a thermal image overlay
   - Can provide firefighters with an accurate scale of the fire
   - Very expensive
   - Only able to take periodic readings
   - Clouds and rain absorb parts of the frequency spectrum and reduce spectral resolution of satellite imagery
   - Early detection is near impossible

2. Drones [4]:
   - Real time images
   - Able to control where you look
   - Cost of purchase
   - Battery life

3. Wireless Sensor Network [5-9]:
   - Able to provide real-time data
   - Current nodes can be costly but added easily
   - If one node is destroyed or lost, the whole network is not compromised
   - Custom sensors fit the environment best and add those to the system

A wireless sensor network could be useful architecture for the deployment of the sensors used for fire detection and verification if it can be done in a cost-effective manner.

MATERIALS AND METHODS

Microcontroller: Arduino Uno

Wireless Module: XBee 2mW Wire Antenna - Series 2 (ZigBee Mesh)

Sensors:

- DHT11 Temperature and Humidity Module
- MQ-7 Carbon Monoxide Detector
- KY-026 Flame Sensor Module

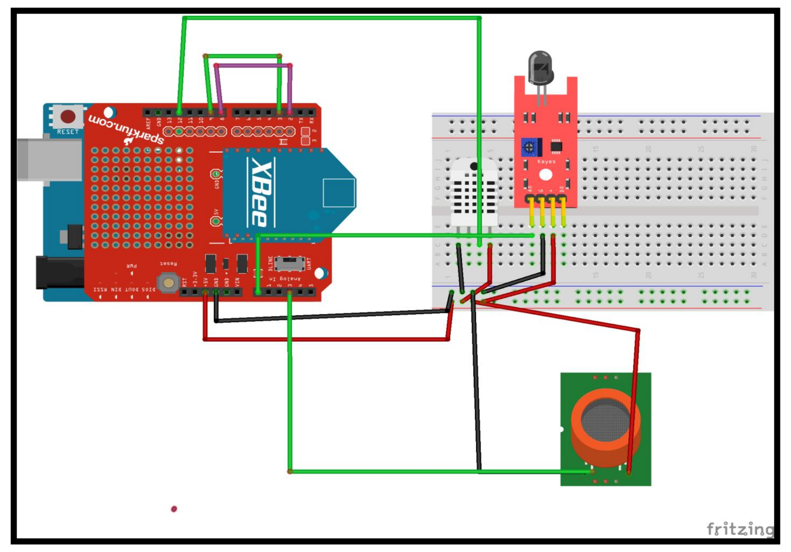

Figure 1. Circuit Diagram for Each End Node

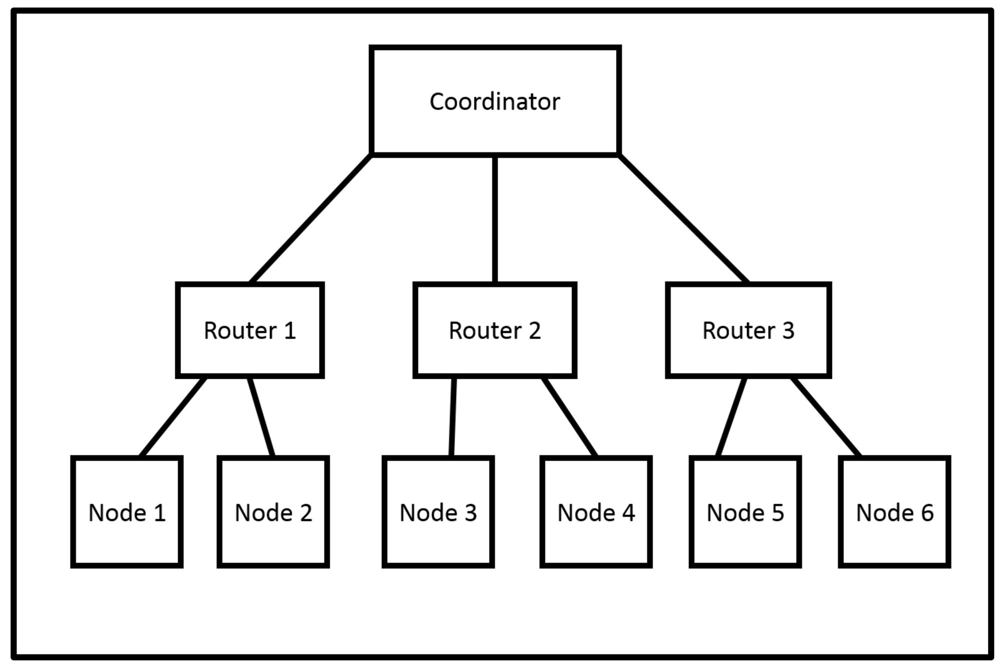

Figure 2. Tree Topology Wireless Sensor Network

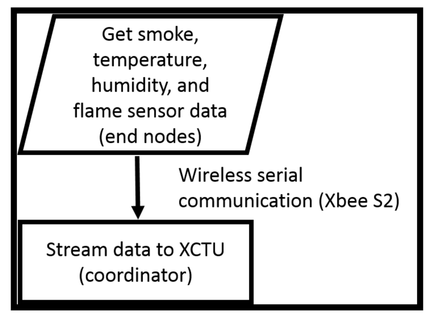

Figure 3. Current Communication Protocol

Each end node can relay information back to either Router or Coordinator.

XBees are configured to broadcast to specific nodes.

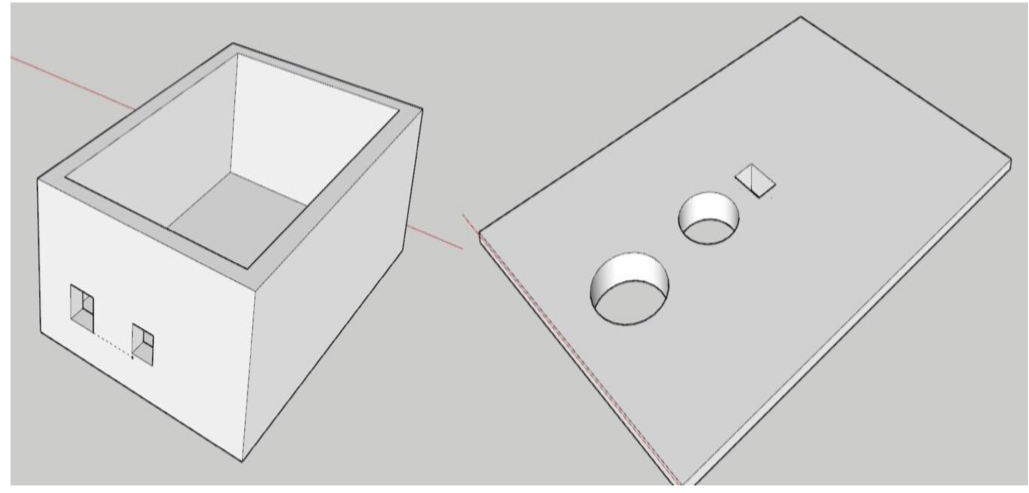

Figure 4. 3D Model of Custom Enclosure

RESULTS

Two sample Nodes are presented in Figure 5. Each Node consists of an Arduino Uno, XBee and three sensors previously mentioned.

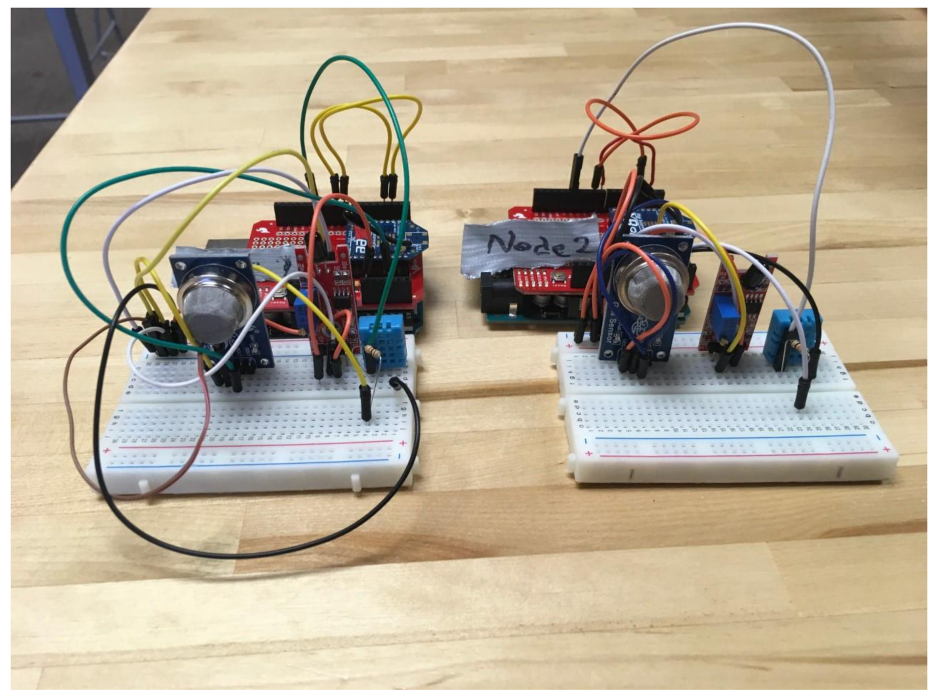

Figure 5. Two Remote Sensing Nodes

Nodes can successfully communicate to Coordinator/Base Station, alternating data flow. XCTU software was used to receive data packets as shown in Figure 6.

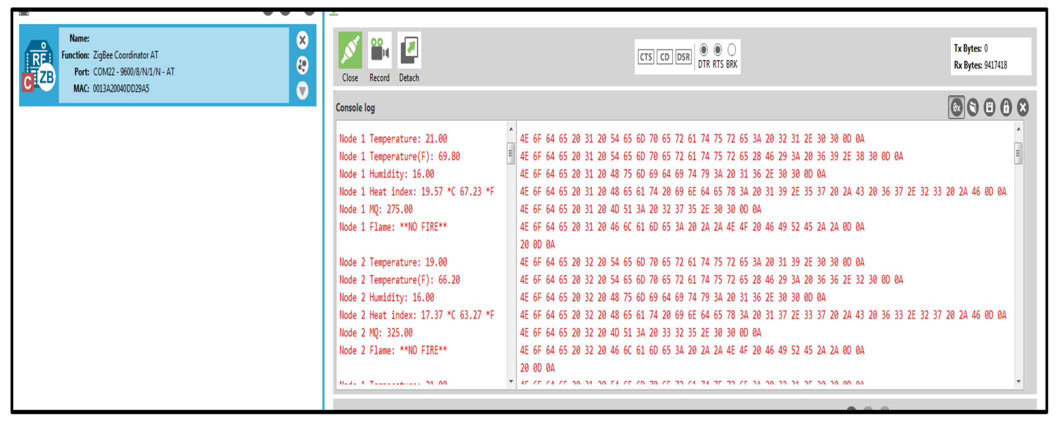

Figure 6. Sample Transmission from Nodes as Received by Coordinator/Base Station (XCTU)

The nodes are enclosed in custom 3D printed housing that enables sensors to access the environment while protecting the internal electronics (Figure 7).

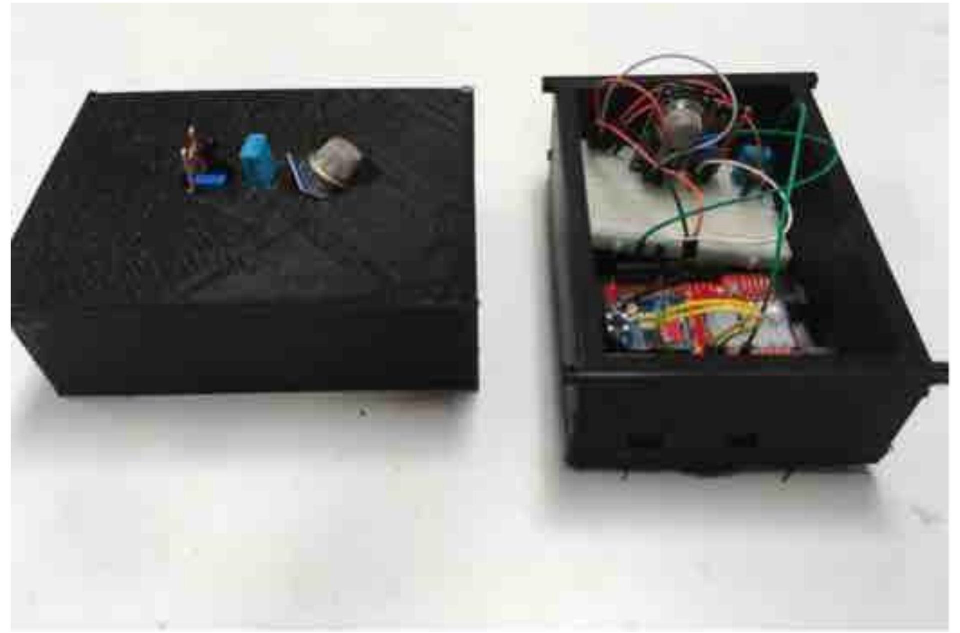

Figure 7. Two Remote Sensing Nodes

RESULTS

Preliminary range testing (range of reliable data transmission) was performed in an outdoor setting. Over 100 m range has been confirmed (Figure 8).

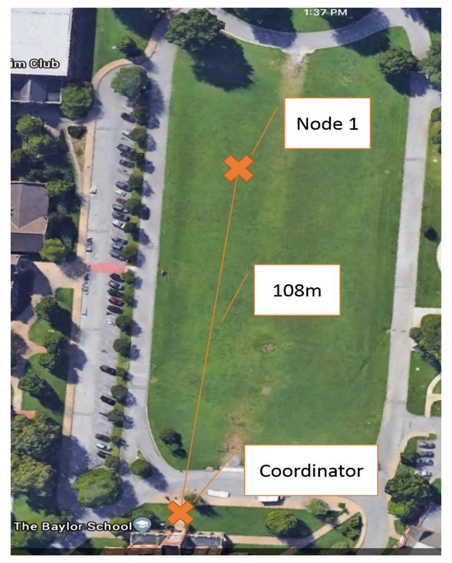

Figure 8 Preliminary Range Testing

DISCUSSION AND FUTURE DIRECTIONS

Wireless network and communication protocol has been successfully established. Working Nodes have been created and tested. Range of nodal communication has been verified.

With the current system, the following tests and improvements will be made:

- Further sensor calibration and sensitivity measurements
- Power consumption tests
- More robust protoboard design for each Node
- Weatherproof housing for each unit
- More Nodes will enable a full-network test.

WORK CITED

1. https://www.nifc.gov/
2. Schroeder W, et al. Remote Sensing of Environment 2014, 143, 85-96 (Satellites)
3. Schroeder W, et al, Remote Sensing of Environments 2016, 185, 210-220 (satellites)
4. Yuan C, et al. Can. J. For. Res. 2015, 45, 783-792 (review)
5. Lloret, J, et al. *Sensors* 2009, 9, 8722-8747,
6. Bouaabdellah, K, et al. *Procedia Computer Science 19*, 2013, 794-801
7. Triviedi, K, et al. *2014 IEEE International Conference on Computational Intelligence and Computing Research,*,
8. Demin, G, et al. *School of Computer Science and Engineering, Southeast University, Nanjing 211189, China*
9. Kumbhar, H, et sl. *Department of Computer Engineering Padmabhooshan Vasantdada Patil Institute of Technology,*

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