WIRELESS EMBEDDED ROADWAY HEALTH MONITORING

Project Plan May 16-22

Team Members:

Shen Fu: Electrical Engineering (Team leader)
Matt Rose: Computer Engineering (Team Communication Leader)
Qichen Yan: Computer Engineering (Team Webmaster)
Darnell Melvin: Software Engineering (Team Key Concept Holder)

Adviser:

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Co-Adviser:

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1 Problem Statement

Structural health monitoring systems will evaluate the real-time safety of the roadway at a very low cost without an inspector. It can detect problems such as cracks much sooner than manual inspection, which is necessary to support a reliable and sustainable transportation infrastructure system.

In phase I of the project, the previous team finished the circuit design for the sensor which can be embedded into concrete to measure the temperature and humidity. The sensor can communicate wirelessly with a base station which will be a microcomputer such as a Raspberry Pi. In phase II, we need to achieve the same goal and improve the circuit design from phase I. The new board must be 50% smaller and uses less power than phase I, and the team will build an Android application for communicating with the base station(hub).

2 Deliverables

2.1 First Semester

- Research and Planning
  - Conceptual Sketch (Sep)
  - Previous project learning (Sep - Oct 10th)
  - Phase II Project Plan (Sep - Oct 2nd)
  - Potential replacements selection (Sep - Oct 10th)
  - Cost estimation (by Oct 10th)
  - Documentation (Sep - Nov 25th)
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- Design
  - Circuits redesign (Sep - Oct 31th)
  - Circuit organization (Oct 31th - Nov 15th)
  - Android app development (Oct - Nov 10th)
  - Hub design (Oct 15th - Oct 30)
  - Individual circuit and software testing (Oct 30th - Nov 15th)
  - Free-space testing (Oct 30th - Nov 20th)
  - System Assembly (Dec - Jan)

2.2 Second Semester

- Make adjustments to network (Jan- Feb)
- Test sensor survivability through mixing process of concrete (Feb)
- Software testing and tuning in free-space of full network (Jan-Feb)
- Full System Test in concrete (Feb-Mar)
- Troubleshooting (Mar)
- Final Product with expected deliverables (Mar)
- All documentation (Mar-Apr)

3 Systems Level Requirements

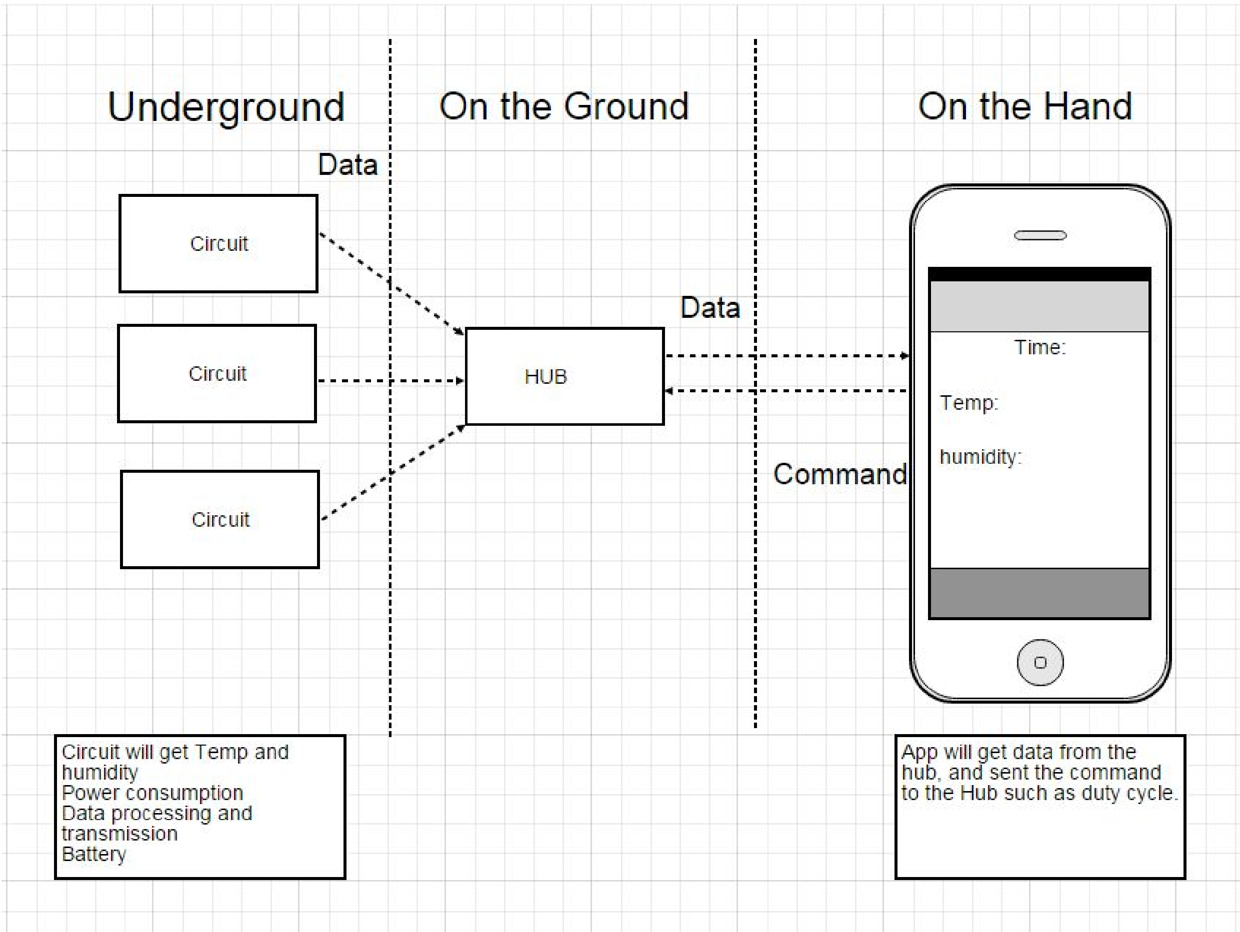
The system must meet the following criteria:

1. Sensor devices can communicate among themselves and the hub.
2. The hub needs to store all data until extraction via Android app.
3. The maximum distance between the hub and smartphone is approximately 100 meters.
4. The enclosure should be 50% smaller than phase I, which is also water/shock resistant and can handle pressures induced by the solidification of concrete and overhead traffic.
5. Handles temperature ranges from -20° F to 140° F.(-28.9°C to 60°C).
6. The size of battery must be smaller than phase I. The size should be less than 1”x1”.
7. The battery life of each unit will last a minimum of one year.
8. Must be able to transmit and receive data between nodes through concrete.
9. Must encompass full automation of data aggregation, transmission, & receiving.
10. The smartphone must store all data logs and do some basic analysis transferring from bit strings into the readable values in correct unit of humidity and temperature.
11. Log files must include date, time, nodes used, temperature and humidity reading data about the samples.

3.1 Design Assessment

The finished prototype will be comprised of a base station and six nodes; however, the network control software will easily be up-scaled to accommodate a larger network of up to one-hundred nodes. The routing algorithm that controls the network will maximize battery life of the nodes by ensuring that traffic distributes evenly through the network. The software will also be able to route around dead nodes so the network stays active if a device becomes damaged or the battery dies.

4 Conceptual Sketch/Mockup



4.1 Measurement Equipment

Data transmitted and received will be monitored accurately. Additionally, measurements of signal intensity through concrete will be analyzed. Power consumption will be monitored so that the users can know the energy condition of the sensor battery.

4.2 Software & Controls

All microcontroller code is written in C, developed in Texas Instrument's Code Composer Studio. All Android code will be written in Java, using Google's Android Studio.

4.3 Hardware

The circuit will be printed onto a PCB and the components will be surface mounted to decrease size and increase efficiency. The enclosure for the PCB will not allow water or concrete to seep inside also the enclosure will not crack due to the pressures of the road or chemical processes.

4.4 Control and Automation

System will autonomously collect data every 30 minutes and transmit once every 24 hours.

5 Interface Description

The Android application will have two different user interfaces, and two activities. The main activity will find and connect to a bluetooth device, which will be the base station. The UI for this activity will include a Button to search for devices and a ListView to display the nearby devices. When the user selects a device, he will connect to it and be sent to the second activity. The second activity will consist of the device information and a Button to harvest the base station's data and subsequently erase the data from the base station. The overall design of this application will be decided in the future. These are the only user interfaces.

6 Work Breakdown Structure

Every member is expected to remain up-to-date with all facets of the project. In order to ensure that the project plan is carried out successfully, each group member has been designated to a particular role as to preserve the group's stability and maximize work efficiency. The group member roles are designated as:

Shen Fu: Team leader
Matt Rose: Team Communication Leader
Qichen Yan: Team Webmaster
Darnell Melvin: Team Key Concept Holder

Project Focus:

All team members will participate in initial Circuit Redesign.

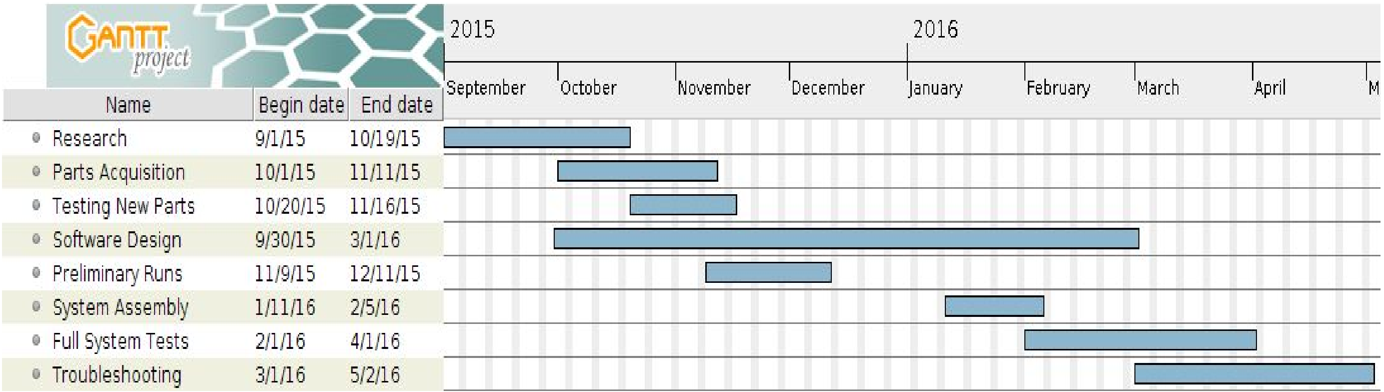
Shen Fu:
- RF circuit design
- Communication (Sensor to Hub)
- Microcontroller development
- Power supply development

Qichen Yan:
- Android app development
- PCB layout

Darnell Melvin:
- Android app development
- PCB layout
- Microcontroller Communication

Matt Rose:
- Android app development
- Microcontroller development
- Repository lead
- Hub design and development

7 Project Schedule



Name	Begin date	End date
Research	9/1/15	10/19/15
Parts Acquisition	10/1/15	11/11/15
Testing New Parts	10/20/15	11/16/15
Software Design	9/30/15	3/1/16
Preliminary Runs	11/9/15	12/11/15
System Assembly	1/11/16	2/5/16
Full System Tests	2/1/16	4/1/16
Troubleshooting	3/1/16	5/2/16

8 Risks

8.1 Risks To The Project Timeline

Our biggest obstacle and risk is how long it will take to communicate between two microcontrollers. If wireless communication is delayed, development of the network routing algorithm will be delayed until the wireless communication can be implemented. In addition, the enclosure could be a risk if it is not strong enough to resist the pressure of the concrete or the chemical reactions that take place during the curing process.

8.2 Physical Dangers

The main physical risks regarding this project is the possibility to be burned from soldering, possibly being shocked, and injuries with cutting tools.

9 Conclusion

Future applications of this project will help to maintain concrete integrity and decrease the need for manual inspections of civil structures. Implementation of this network will help to make wireless sensor networks for monitoring structures more feasible to implement in production. Economically, the use of wireless sensor networks is beneficial to owners of such structures in the sense that they can wait longer before having to replace a roadway. This sensor network will also allow for structurally unsafe buildings and roads to be fixed/replaced before becoming dangerous. For the reasons listed above, this project will be very beneficial in many ways and such sensor networks will continue to be used widely.