Wireless Agricultural Sensor Network

Project Proposal | ECE480 SS13 Team 2
Agenda

● Background
● Project Description
● Design Constraints
● Conceptual Designs
● Proposed Solution

● Project Enhancements
● Risk Analysis
● Budget
● Conclusion
● Questions
Background

- MSU's previous involvement in the Arusha Region of Tanzania
  - Solar electricity
  - Computing technology

- Need for agricultural technology
  - Economic importance

- Importance to Maasai people
Project Description

● Agricultural applications
  ○ Irrigation
  ○ Fertilization

● Sensor System
  ○ Mobile
  ○ Ad hoc wireless network
Design Requirements

- Robust enclosure
- Power constraints
- Scalable
- Nodes
  - Send, receive, and forward data
- Central hub
  - Receive and process data
- Notify user when to water and fertilize crops
Project Timeline

● Phase One
  ○ Research design constraints
  ○ Preliminary node/hub designs
  ○ Identify needed parts

● Phase Two
  ○ Build a test network
  ○ Basic hub functionality

● Phase Three
  ○ Add moisture sensor capabilities
  ○ Preliminary Packaging testing
  ○ Develop GUI

● Phase Four
  ○ Finalize design for nodes, hub and packaging
  ○ Consider Delighters
Conceptual Design Overview

● Four Major Components to Design
  ○ Wireless Network Technology
  ○ Base Station
  ○ Soil Sensors
  ○ Structure/Enclosure
Wireless Network Technology Options

1. Zigbee
   - Open source technology for multiple node communication
   - Inexpensive
   - 250 Kbit/s bandwidth
   - 28 Kbyte protocol stack size
   - 70 meter range

2. Bluetooth
   - Short to medium range wireless communication
   - More expensive
   - 1 Mbit/s bandwidth
   - 250 Kbyte protocol stack size
   - 100 meter range

3. WiFi
   - Common standard wireless communication
   - Complex setup and most expensive
   - 200 Mbit/s average useable bandwidth
Base Station Options

1. **Raspberry Pi**
   - System-on-a-chip device that functions as an open source computing device
   - Inexpensive and flexible

2. **Existing Computer Station**
   - Pre-existing computer station located at elementary school
   - No additional cost, but increased risk due to not having access to station during design phase
Soil Fertility Options

1. Nitrogen
   - Not directly correlated to soil fertility
   - expensive

2. Phosphorous or Potassium
   - Not directly correlated to soil fertility

3. Soil pH
   - Not directly correlated to soil fertility

4. Soil Temperature
   - Not directly correlated to soil fertility
Soil Moisture Sensor Options

1. Vegetronix VH400
   - Soil moisture sensor
   - Inexpensive

2. Decagon 5TE
   - Soil moisture and conductivity sensor
   - More expensive

3. Team-Designed Sensor
   - Sensor created by our team to monitor soil moisture and soil nitrogen
   - May take additional time and resources to construct
Structure/Enclosure Options

1. Waterproof Enclosure with Modular Components
   - Provide safe housing for electrical components
   - Most flexible

2. Waterproof Enclosure with Hard-Wired Components
   - Also provides safe housing for electrical components
   - More stability, but less flexibility
Proposed Design Solution

- Zigbee receiver
- Microcontroller
- Power supply

- Waterproof Enclosure
  - Keep system from moving
  - Elevate enclosure above ground

- Grounding Claws

- Moisture Sensor
  - Samples moisture level in soil
Proposed Solution Diagram

Crop Sensor Network Diagram

Base Station
- Power Supply
- ZigBee Receiver
- Raspberry Pi
  - Linux Based Web Server
  - Data Logger
  - System Settings
- Ethernet

Sensor Node
- ZigBee Receiver
- Battery
- Microcontroller
- Power Supply
- Moisture Sensor
- Probe in Soil

Additional Sensor Node
- Additional Sensor Node
  - x10 Total Sensor Nodes
Proposed Design Solution - Network

- Zigbee Node
- Coordinator

School
Proposed Design Solution - Network

- Broadcast/Forward Mode
- Zigbee Protocol packet composition
- Receive Mode
Proposed Design Solution-GUI 1

- Jboss AS7 Server
- JVM
- Java / Javascript
- Browser Interface
- Ajax / periodic polling
Proposed Design Solution-GUI 2

- Jquery API
- jqPlot / flot
Project Enhancements

- **Accuracy**
  - GPS functionality

- **Aesthetics**
  - Enhance GUI for software
  - Enhance case for sensor

- **Functionality**
  - Battery charge indication
# Risk Analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Analysis</th>
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<tbody>
<tr>
<td>Node Communication</td>
<td>Syncing between nodes could be difficult and could drain battery</td>
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<tr>
<td>Alert User</td>
<td>Medium chosen must be available to a user</td>
</tr>
<tr>
<td>Robust Casing</td>
<td>Moisture must be sensed but kept outside of circuitry</td>
</tr>
<tr>
<td>Robust Casing</td>
<td>Theft and Animal/Insect damage possible</td>
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</table>
## Budget

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture Sensor</td>
<td>6</td>
<td>$30/unit</td>
</tr>
<tr>
<td>Zigbee Module</td>
<td>7</td>
<td>$10.51/unit</td>
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<tr>
<td>Raspberry Pi</td>
<td>1</td>
<td>$47</td>
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<tr>
<td>Raspberry Pi Case</td>
<td>1</td>
<td>~$10</td>
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<tr>
<td>Print Circuit Board (PCB)</td>
<td>6</td>
<td>X</td>
</tr>
<tr>
<td>Casing Material</td>
<td>6</td>
<td>X</td>
</tr>
<tr>
<td>XBee to USB Adaptor</td>
<td>1</td>
<td>$25</td>
</tr>
<tr>
<td>Lithium Batteries</td>
<td>~12</td>
<td>$6 /4 units</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$353.57</strong></td>
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Summary

- **Project:** Develop a wireless ad hoc network to relay data from soil sensors and alert an end user when to attend crops.

- **Solution:** Utilize Zigbee technology along with a simple moisture detector and Raspberry Pi computing solution to address end user needs.
Questions?
Appendix

- Layout of Raspberry Pi