Low Power Wireless Sensor Network for Motion Detection
Sponsor: Schweitzer Engineering Laboratories, Inc.
Mentor: Kenji Yamamoto
Daniel Carlson, Matthew Mauro, Jessica Waltz

Background
Schweitzer Engineering Laboratories provides solutions to make electric power safer, more reliable, and more economical. An area of interest that SEL is looking into is monitoring vibration and unwanted movement of large generators and industrial machines via a low power wireless sensor network.

Such a network could be used to report critical information about the physical state of the machines that are being monitored and shut down a machine that is in an unsafe state.

Another potential use case is placement on power poles to be able to detect the pole going down without a line fault occurring.

Objectives
Overall Objective
Create a lower power wireless sensor network of nodes that monitor and report acceleration in 3 dimensions. In the event of motion above a set threshold, the node sends an alarm message to the AP as soon as possible.

AP
- Check alarm status of each node
- Wirelessly set motion thresholds for a given node
- Display alarm data from nodes to LCD display

Nodes
- Monitor acceleration in the X, Y, and Z axis
- Transmit accelerometer data wirelessly to the AP in the event the configurable threshold is exceeded

Design Summary
The main focus of our design was the network architecture and ability to transmit alarm messages on detection of motion.

The secondary design goal was in making the network energy efficient in order to maximize battery life.

- TI CC2650 Development Kit, as AP & Nodes
  - 2.4 GHz open protocol radio
  - Arm Cortex-M3 Main CPU
  - Real Time Operating System

- Multi Node Network
  - Multiple nodes allowing greater monitoring coverage
  - Periodic monitoring of acceleration for each node

- TDMA Based Network Architecture
  - Network nodes have individual time slots
  - Wireless settings updates for motion threshold
  - Short frame time for prompt alarm reporting

Glossary of Terms
- **TDMA (Time Division Multiple Access)**: chosen network architecture
- **AP (Access Point)**: aggregates data from sensor network
- **TDMA Frame**: Time Period for one complete communication cycle

Analysis

![Node Power Consumption per TDMA Frame State](image)

- Power analysis shows that a network node is capable of lasting ~146 hours on 2 AAA batteries.
- The idle state in between time slots is the biggest energy draw
- Fast alarm reporting was achieved by using a frame time of 60ms.
- The on board timing method used was imprecise and power inefficient leading to greater energy use and a less robust network

Future Work

- Improve power consumption by utilizing lower power modes
- Improve TDMA timing for increased reliability and less energy usage
- Use on board, low power Sensor Controller for accelerometer monitoring
- Large "Free-for-all" time slot in TDMA architecture for faster alarm transmission without increased network overhead
- Improve network security through node validation and a join process

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Team Spinnaker

Wireless Sensor Network Concept