Node Health Diagnostics in Wireless Sensor Networks

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1. Introduction

Wireless sensor networks are commonly used to monitor important environmental information such as temperature or light level which may alert operators of hazardous conditions for themselves or machinery. However, wireless sensors typically have very limited power and memory and in combination with real-world conditions it is common for sensor nodes to malfunction and fail. A network of largely malfunctioning nodes can mislead operators analyzing the data of the nodes and may lead to dire consequences. Thus it is very important to monitor the health of the sensor nodes in the network in order to ensure they are properly functioning. The number of properly functioning nodes has a direct impact on the health of the wireless sensor network. This proposal details a network set-up, technical approach, budget plan, schedule of key milestones, and concluding remarks for implementing a wireless sensor network with health diagnostics.

2. Network Set-up

For simplicity of a semester long project, a wireless sensor network development kit will be purchased in order to get the network up and running as soon as possible. The wireless sensor network will be a star topology. The sensor nodes will be powered by RF energy and configured for extremely low power operation. Each sensor node will communicate directly with the cluster head. The cluster head will be responsible for relaying data to computer for presentation to the operator. Configuration and data of the sensor network will all be displayed in a graphical user interface (GUI) so that an operator can easily identify and solve problems within the network. In all, the network is designed to be quick to deploy in order to work on health diagnostics as soon as possible.

3. Technical Approach

In order to determine the health of a sensor network the network must be monitoring a number of environmental variables. The proposed development kit has sensor nodes that can monitor temperature, relative humidity, and light. It can also track received signal strength, time differential between received packets, sensor IDs, and packet numbers. All of these data streams will allow for development of precise metrics to provide the most relevant information in the timeliest manner. In order to scientifically determine the best set of metrics that indicate that a node is about to malfunction, is malfunctioning, and has malfunctioned a few algorithms will be tested which include but are not limited to:

- Majority voting
    - A group of sensors will be sampled in the same sector at the same time and compared amongst its peers for irregularities.
- Training based & thresholding
    - A sensor node will be tracked over time and a thresholding algorithm will be developed to determine when the received data is irregular.

In order to systematically induce failures into the network the operator will have the ability to turn manipulate specific sensors in each node through the GUI.

4. Budget Plan

The overall cost of this project simply includes a development kit for creating the wireless sensor network and additional sensor nodes. The proposed development kit, Powercast P2110-EVAL-01, costs $1250 and includes everything necessary to implement a wireless sensor network with two sensor nodes and a cluster head. The development kit comes with two sensor nodes but we would like to introduce a bit more complexity into the network by adding another sensor node at a cost of $500. Lastly, a supplementary $250 is required for engineering shop fees and additional sensors for a total of $2000.

5. Key Milestones

- Configure sensor network and verify correct sensor readings - 10/14/13
- Identify simple network health metrics - 11/10/13
- Develop graphical user interface for configuring sensor nodes – 11/15/13
- Select the most valuable health metrics – 11/22/13
- Finalize graphical user interface – 12/1/13
- Design Day - 12/6/13

6. Conclusion

This design depends upon a wireless sensor network development kit in order to configure a cluster head with two or three sensor nodes to monitor temperature, humidity, and light. The development kit will allow for tracking of hardware level information such as received signal strength and current level that could be invaluable in determining the health of the sensor network. The data received by the sensor will be checked for fidelity using majority voting or training based algorithm to check for failures among the sensors. Each sensor node will also be tracked for remaining battery life. Each sensor node will be able to be systematically failed through a GUI on the computer connected to the cluster head. An operator will have the ability to control which sensors get turned on and off at each node. Overall, this design should allow for enough simplicity to be accomplished over the course of a semester, but also be useful enough to provide insights into which metrics should be measured in order to determine the health of a wireless sensor network.