Integrating LabVIEW, TinyOS and Expansion Modules to the PHOTONS Sensor Platform

Daniel Wessling[*1], Stephen So[2], Frank K. Tittel[2]
[1]UMBC, [2]Rice University

Abstract:

We have developed basic sensor networking software which provides an interface for TinyOS based sensor networking motes connected to laser spectroscopic sensors via LabVIEW. An expansion card is used to manage the charging and usage of a Li-Ion battery powerful enough to drive high efficiency QCLs through small solar panels and to store large amounts of long term data and/or high temporal resolution measurements by storing data onto a built in 'microSD' card interface over a SPI bus.

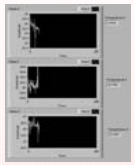
Introduction

The advantages of making a sensor small and inexpensive range from having them affordable for home use as breath analyzers to enabling scientists to utilize hundreds of sensors to collect wide area data for air pollution studies. One issue is how to implement different types of sensors for research purposes without requiring full reimplementation of the sensor software and electronics. In this work we are developing expansion modules and software for the PHOTONS platform being developed at Rice. The software implemented in the wireless motes uses Time Division Multiplexing (TDM) to collect and parse data for Virtual Instruments in LabView.

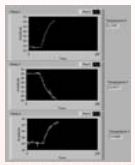
Data

Graphs of the temperature changing on the motes microcontroller can be seen below. All the motes began in a room that was at room temperature and then placed in different environments such as a refrigerator, outdoors in the shade, and outdoors in the 'Houston Sun'. Data was sent every second over the radio into a LabVIEW Virtual Instrument. The graphs were printed every four minutes to demonstrate that the motes using the TDM algorithm were successful working with LabVIEW.

2:24 PM – Room Temperature



2:28 PM - Different environments

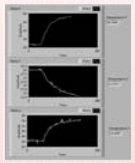


Outdoors in the Houston Sun

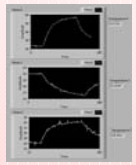
Inside a refrigerator

Outdoors in the shade

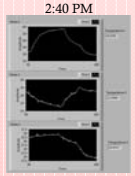
2:32 PM



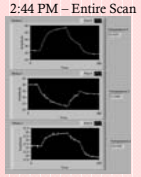
2:36 PM – Back at Room Temperature



2:40 PM



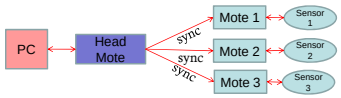
2:44 PM – Entire Scan



Methodology

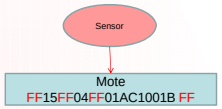
To have a functioning wireless sensor network, a mote must be plugged into a computer via USB. The diagrams below explain how the computer, motes, and sensors use the NesC program installed on the motes to control the data flow with the TDM algorithm in order to transmit data in the network.

Step 1 – Synchronization packet is sent



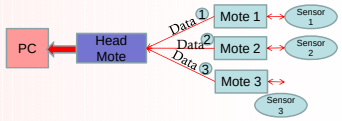
1) A command from the computer will be sent serially via USB to the Head Mote.
2) The Head Mote uses the 2.4 GHz IEEE 802.15.4 RF transceivers to send a synchronization packet over the radio to all the motes in the network.
3) Each mote synchronizes a timer implemented in NesC and starts to communicate serially with the sensor attached.

Step 2 – Receiving and Parsing Data



1) The sensor collects data from the environment and sends the data serially to the mote.
2) The NesC program puts together a package with delimiters so that the LabVIEW program may parse the data.
3) In this case, the delimiter 'FF' is used to separate the packet size, which sensor the packet originated from, and the actual data from the sensor.

Step 3 – Transmission of multi-node data (TDM)

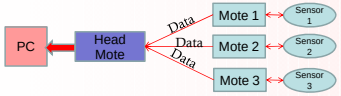


1) Data is sent over the radio using Time Division Multiplexing (TDM). TDM is a method of allowing multiple nodes in a network to share one channel over the radio.
2) Mote 1 sends its data first, and once Mote 1 is done, Mote 2 sends its data and finally Mote 3 sends its data.
3) Each mote will take its turn, sending data back to the Head Mote

Step 4 – Collect More Data

Once data is sent over the radio, the sensor collects more data and waits until it is time to send more data. This scheme applies to all sensors in the network.

Step 5 – Send Data Serially to PC and Parse Data



1) The Head Mote sends data to the computer via USB.
2) LabVIEW collects the data and checks to see if the data is valid.
3) The valid data is then parsed and represented in graphs and numbers.
4) All invalid data is thrown away.

Step 6 – Head Mote sends a command to a designated sensor

1) User decides which sensor to send a command to in LabVIEW
2) Command is sent serially to the Head Mote.
3) When the Head Mote is allowed to send data over the radio, it sends the command to the designated sensor

Power Expansion Board

Purpose: Driving lasers using battery power for wireless deployments.
Large storage capacity for mobile use.
Accurate positioning with GPS module

Functions: Manage the charging and usage of a Li-Ion batttery powerful enough to drive high efficiency QCLs and solar panels, and provide energy management date to sensor networking modules

Features: GPS module with positional accuracy down to 5 meters.
microSD module for extra portable data storage

Conclusion

With LabVIEW having the ability to control individual sensors, the wireless network can be customized to fit a researchers project. Detailed information about each sensor and the health of the network can be monitored in LabVIEW with the use of the data packets created in TinyOS, similar to the interface shown below which was used for single sensors. The addition of the expansion board broadens the range of applications for the sensors. The expansion board allows the sensor to store large amounts of long term data and/or high temporal resolution measurements by storing data onto a built in 'microSD' card interface over SPI bus. In the future, since a GPS module is attachable to the expansion board and is capable of altitude measurements, a complete sensor is small and light enough to where it can be attached to unmanned aerial vehicles (UAV).