Sensor Network Lab Exercises

Using Java and Sun SPOTs

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Abstract:

- MIT Technology Review lists wireless sensor networks as one of "Ten Emerging Technologies That Will Change the World".
- Our goal (supported by NSF) is to develop lab exercises that are suitable for activity-driven teaching of undergraduate students.
- We focus on the new SunSPOT nodes, programmed in Java.
- We here describe our lab exercises and experiences class-testing the lab exercises in winter quarter of 2008.

Why teach sensor network labs

- A wireless sensor network can create what Scientific American deemed a "macroscope" [1], a system of small devices that can collaboratively detect events in the physical world, such as temperature, sound, vibration, motion or pollutants.
- Named by MIT Technology Review's list of "10 Emerging Technologies that Will Change the World" [2], sensor networks have already been used to study seabird nests and redwood groves, as well as in nursing homes and oil tankers.
- Whereas sensor networks are poised to become an ubiquitous part of the computing landscape, sensor network education has been primarily offered at the advanced graduate level, only. The goal of our work is to develop lab exercises that are suitable for activity-driven teaching of undergraduate students.
- It is our hope that programming and deploying sensor networks raises students' excitement about computer science, in general.
- Unlike our previous papers which describe sensor network lab exercises using TinyOS, we here focus on the SunSPOT devices which are programmed in Java (and have been publicly available since April 2007).

Labs 1 & 2: Introduction

- "Bouncy ball" demo for familiarization.
- Deploy "Telemetry" with Netbeans IDE.
- Homework assignment: deploy "Airtext" and modify Telemetry such that each student's desktop host application only communicates with that student's SPOT.

Labs 3 & 4: Communication

- Write code to send & receive data over wireless radio.
- http connection to the Internet via base station
- Homework assignment: measure packet loss

Lab 5: Localization

- Centroid method using signal strength for weights.
- Given 4 fixed beacons, program SPOT to compute coordinates.
- Homework assignment: compute and graph error at different positions; consider algorithm improvements.

Lab 6: Power Management

- Explore functionality on SPOTs to take current and voltage measurements.
- Introduce, investigate, and understand sleep and deep sleep
- Take current measurements during various tasks, analyze and compare results
- Lab given as homework assignment (no in-class portion)

Lab 7: Security

- Experiment with Eschenauer-Gligor key management scheme
- Given key manager with 1000 keys, program nodes to request keys and explore the likelihood of key matches for different # of keys per node.
- Homework assignment to complete the lab, try brute-force.

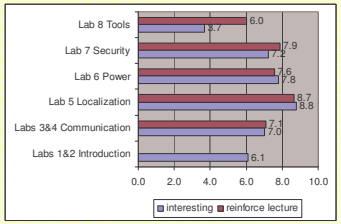
Lab 8: Alternative Platforms & Tools

- Introduce TinyOS and NesC; explore lessons 1, 2, 4, and 5 from TinyOS tutorials.
- Build and deploy Blink, CntToRfmAndLeds, RfmToLeds.
- Learn to use the TOSSIM simulator.

Lab 9: Contour tracking

- Implement a lightweight distributed algorithm where nodes compute the contours using purely local information
- Somewhat analogous to the contour tracking application described in the Abstract Regions macroprogramming framework.

Class-testing & Student Feedback



rank									avg
Labs 1&2 Introduction	5	5	4	6	5	5	5	4	4.78
Labs 3&4 Communication	4	3	5	4	4	4	4	2	3.44
Lab 5 Localization	1	2	1	1	1	3	1	2	1.56
Lab 6 Power	3	4	2	2	3	2	2	1	2.33
Lab 7 Security	2	1	3	3	3	1	3	4	2.78
Lab 8 Tools	6	6	6	5	6	6	6	6	5.89

Discussion

What went well

- Students responded well to the SunSPOTs; they were engaged and motivated to experiment on their own.
- The Java-programmable SunSPOTs allow for concentration on concepts over language-details.
- Our labs cover may of the core sensor network topics [3]

What can be improved

- Develop a macroprogramming lab, possibly TinyDB
- Expand listing of background material resources for each lab.
- Make lab 4 more challenging; transition to requiring more coding of the student as in later labs.
- Find a way to introduce TinyOS that is engaging and neither too overwhelming nor too basic.

Acknowledgements & References

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[1] Scientific American, "Smart Sensors to Network the World", June 2004

[2] MIT Technology Review, "10 Emerging Technologies That Will Change the World", http://www.technologyreview.com/Infotech/13060/page2/, Feb. 2003

[3] Nirupama Bulusu,and Sanjay Jha, editors, "Wireless Sensor Networks", Artech House, 2005