Wireless Sensor Networks

Chenyang Lu
Department of Computer Science & Engineering
Washington University in St. Louis
May 2008

Outline

- What are wireless sensor networks?
- Applications
- Course organization

Smart Dust

- Processor + Sensors + Wireless Interface
- Miniature hardware manufactured economically in large numbers

Mica2 Mote

- Intel PXA271 Xscale Processor
  - 13-416MHz
  - 32MB FLASH/32MB SDRAM
- 802.15.4 Radio (2.4GHz)

MTS420 Sensor Board

- GPS
- Accelerometer
- Light
- Temperature
- Humidity
- Barometric Pressure
- 2KB EEPROM Conf.

Imote2
Applications

- Smart sensors embedded in environments
- Wireless networking
- Fine-grained monitoring & control

Habitat Monitoring

- Redwood Trees
- Source: David Culler's MobiHoc'05 Keynote

Habitat Monitoring

- Great Duck Island
- Monitor
  - usage patterns of burrows
  - burrow and environmental changes
  - differences between nesting areas and others

Great Duck Island

- Requirements
  - 9-month season → low power → low duty cycle
  - Handle hash environment
    - Verification network
    - Health monitoring
  - Non-real-time, low data rate
    - 5-10 min: entry/leave
    - 2-4 hr: environmental differential
  - No in-network processing: data streaming

Surveillance

- Wireless Integrated Networked Sensors (WINS)
  - Reliability
    - Detection probability & false alarm rate
  - Energy efficiency
  - Real-time
  - Low cost
  - Solution: In-network processing in multi-tier network
WINS
Tiered Architecture

- Tiers
  - Low-power sensors provide continuous vigilance
    - Seismic, infrared, sound
  - High-power sensors
    - Cameras
  - Human operators (most expensive!)
- Phased execution
  - Low tier activate higher tier when necessary
  - Stop as soon as certainty threshold is reached

Power efficiency & reliability

Medical Care
CodeBlue

Wireless pulse oximeter sensor
Wireless two-lead EKG
Accelerometer, gyroscope, and electromyogram (EMG) sensor for stroke patient Monitoring

http://www.eecs.harvard.edu/~mdw/proj/codeblue/

CodeBlue
Requirements

- Security & privacy
- Reliability
- Real-time
  - Detect sudden change in patient conditions
- Mobility: Doctors, patients, equipments

Structural Health Monitoring
Golden Gate Bridge

- High sampling frequency
  - A tri-axial accelerometer: 100 Hz sampling → 4.8 Kbps
- Reliable data transfer
- Time synchronization
- Real-time: detect damage after earthquake

Diverse Requirements

- Requirements are highly application-dependent
- Need to optimize design for specific applications

<table>
<thead>
<tr>
<th></th>
<th>Real-time</th>
<th>Security</th>
<th>Reliability</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOT</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Very Low</td>
</tr>
<tr>
<td>WINS</td>
<td>High</td>
<td>High</td>
<td>None</td>
<td>Low</td>
</tr>
<tr>
<td>CodeBlue</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>GGB</td>
<td>Medium</td>
<td>None</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>
Global Sensing
Beyond a Single Sensor Network

Summary: Applications
- Wireless sensor networks have been deployed successfully in the real world.
- Tiered architecture is common
  - Sensing, communication
- Diverse, application-specific challenges
  - Energy, management, mobility, real-time, reliability, security, privacy……

Topics

<table>
<thead>
<tr>
<th>Date</th>
<th>AM (10-12)</th>
<th>PM (1:30-3:30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/26</td>
<td>Introduction</td>
<td>Operating System</td>
</tr>
<tr>
<td>5/27</td>
<td>Programming</td>
<td>Middleware</td>
</tr>
<tr>
<td>5/28</td>
<td>Media Access Control</td>
<td>MAC Layer Architecture</td>
</tr>
<tr>
<td>5/29</td>
<td>Minimum Power Configuration</td>
<td>Coverage &amp; Connectivity</td>
</tr>
<tr>
<td>5/30</td>
<td>Query Scheduling</td>
<td>Mobile Query</td>
</tr>
</tbody>
</table>

Pointers
- [http://www.cs.wustl.edu/~lu/ds08.html](http://www.cs.wustl.edu/~lu/ds08.html)
- Feel free to ask questions and discuss!