CSE 303
Concepts and Tools for Software Development

Magdalena Balazinska
Winter 2010 - Lecture 25
Impact of Computer Engineering Solutions: RFID
Radio Frequency IDentification (RFID)

Using radio frequency (RF) signals
To identify (ID) objects
Does not require line-of-sight

Can serve for location tracking
Existing RFID Applications

- Supply-chain management
- Package tracking
- Airline tickets, luggage
- Pharmaceuticals
- Medical: patient id
- Asset tagging, archiving
- Identifying pets
- Tracking library books
- RFID tags inside passports
- Enhanced driver’s license
- Toll collection (highways)
6 of top 7 retailers worldwide support RFID
- > $1 trillion revenue
- 100s of manufacturers and retailers
Other Useful Applications?

- Elder care (UW & Intel Seattle)
  - What objects people use is a good indicator of what they are doing
- Study human social dynamics (UW & Intel Seattle)
  - How social groups form and evolve with time
- Woodland Park Zoo: track visitors
- Speed pass at gas stations (Exxon Mobile)
- Help people monitor their outdoor workout
  - iPod with reader
  - Nike shoes with active RFID tags
RFID Components

RFID Reader

RFID Antennas

Active Tag

Passive
RFID Basics

RFID systems comprise tags and readers
- Tags are placed on objects
- Readers placed in the environment interrogate tags

Tags can be active or passive
- Active tags: longer read-range (up to 300 feet)
  - Battery powered, expanded capability, expensive
- Passive tags: shorter read-range (1 foot to a few meters)
  - Receive power from RF field, limited capability, cheap

- Each tag has a unique ID (typically 64 to 128 bits)
- Tags can include other information besides ID (< 2KB)
A Wide Variety of Tags
Communication Between Reader and Tag

**HIGH-FREQUENCY SYSTEM**

1. An integrated circuit sends a digital signal to a transceiver, which generates a radio-frequency signal that is transmitted by a dipole antenna.

2. The electric field of the propagating signal gives rise to a potential difference across the tag's dipole antenna, which causes current to flow into the capacitor; the resulting charge is trapped there by the diode.

3. The voltage across the capacitor turns on the tag's integrated circuit, which sends out its unique identifier code as a series of digital high- and low-voltage levels, corresponding to ones and zeros. The signal moves to the transistor.

4. The transistor gets turned on or off by the highs and lows of the digital signal, alternately causing the antenna to reflect back or absorb some of the incident radio-frequency energy from the reader.

5. The variations in the amplitude of the reflected signal, in what is called backscatter modulation, correspond to the pattern of the transistor turning on and off.

6. The reader's transceiver detects the reflected signals and converts them to a digital signal that is relayed to the integrated circuit, where the tag's unique identifier is determined.
Communication Between Reader and Tag

<table>
<thead>
<tr>
<th>tag</th>
<th>time</th>
<th>location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bob</td>
<td>10:01</td>
<td>A</td>
</tr>
<tr>
<td>Bob</td>
<td>10:02</td>
<td>B</td>
</tr>
<tr>
<td>Bob</td>
<td>10:03</td>
<td>C</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

How RFID Works

RFID Reader
Reader antenna
RFID tag
Example of RFID Deployment

RFID Reader

RFID Antenna

Missed Reading

Duplicate Readings

RFID Tag

RFID Reader

RFID Antenna
Elements of an RFID System

- **Tags**: carry unique identifiers
- **Readers**: detect tags in their vicinity
- **Networking infrastructure**
  - Reader is connected to a network and communicates tag IDs to interested parties
- **Databases**
  - Collect the “read events” and log them with time/place
- **Applications and their user interfaces**
  - Use the data in various ways
RFID Ecosystem

• Building-scale deployment
  - 7 floors and 8,000 square feet
  - 47 readers and 160 antennas
  - 67 participants and > 300 tags
• Study technology but also societal and business issues
• In particular, RFID data management challenges
  – Lahar query engine
  – Scenic event specification system
RFID Ecosystem Applications

Facebook

Friend finder

Event notification

Digital diary

Enhanced desktop search
Implications of RFID

- As previous examples show, RFID enables many apps that can make our lives better
- But, there are serious security problems
  - Possible to intercept communication between reader and tag (need cryptography)
- There are very serious privacy problems
  - Opportunities for mining and surveillance
  - Example: Nike+iPod story
- There are also great reliability problems
  - What are the implications of wrong information?
Many Privacy Challenges

GOOD AFTERNOON, MR. HENFENNEL! HEMORRHOID CREAM AISLE SIX!

TOO MUCH INFORMATION IN MY MEDICAL I.D. CHIP.

DON'T FORGET MOUTHWASH, I FIGURED THAT ONE OUT BY MYSELF.

TOLFs
April 10, 2004 The Washington Post
Other Implications of RFID

- **Health considerations**
  - Must stay at least 9" away from an RFID antenna

- **What are the implications**
  - For technology, business and society
  - Of having a “number on everything”?

- **RFID Enables**
  - Merging physical and virtual worlds
  - Every object is an index into a world-wide database
  - Every object has its own history
  - Tracking objects over their entire lifetime
  - Analyzing trends in user habits
Extra Information

- Google for: RFID
- RFID Ecosystem project: http://rfid.cs.washington.edu/
- iPod + Nike security analysis project
  http://www.cs.washington.edu/homes/yoshi/papers/
- EPCGlobal http://www.epcglobalinc.org/home
- RFID ConsortiUm for Security and Privacy
  http://www.rfid-cusp.org/