CSE/EE 461: Introduction to Computer Communications Networks
Winter 2009

Module 3
Direct Link Networks – Part C

John Zahorjan
zahorjan@cs.washington.edu
534 Allen Center

This Module's Topic: RFIDs

- RFIDs are passive, wireless devices
  - Power is harvested from the RF emitted by a reader
  - Communication/sensing is possible only from a few inches to perhaps a few meters
What Are They For?

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What Are They For?

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What Are They For?

**Technology**

**In Texas, 29,000 Students Test an Electronic Eye**

(Please provide the full text of the article as it appears in the image.)
What Are They For?

The New York Times

High Tech, Under the Skin

Abbreviated

By

Published: February 2, 2006

WILLIAM DONELSON's left hand gripped the paper-covered arm of an antique barber chair at a tattoo and piercing shop in Cambridge, Ontario. His face turned gently on the chrome footrest as he waited for his implant. At last he would be able to do what he had long imagined: enhance his body's powers through technology.

Implanting the chip was a relatively simple procedure but highly symbolic to Mr. Donelson, a 21-year-old computer networking student so enamored with the link between technology and the body that he has tattoos of data-input jacks running down his spine. They are an allusion to an imagined future when people might be plugged directly into computers. His new chip, complete with a miniature antenna and enclosed in a glass capsule no bigger than a piece of long-grain rice, has a small memory where he has stored the words "Embrace Technology."

Mr. Donelson and three are part of a small group, about 30 people around the world, who have independently inserted radio frequency identification chips, known as "RFID" tags, into their bodies, according to Web-based forums devoted to what participants call getting tagged.
Company requires RFID injection
Published: 2006-02-10

Two employees have been injected with microchips this week as part of a new requirement to access their company's datacenter.

Cincinnati based surveillance company Liquid Data created the policy with the hope of increasing security in the datacenter where video surveillance tapes are stored. In the past, employees accessed the room with an RFID tag which hung from their keychains, however under the new regulations an implanted microchip the size of a Rice Krispie cereal from Verichip must be injected into the biops to gain access, a release from Verichips.com said on Thursday.

Although the company does not require the microchips be implanted to maintain employment, anyone without one will not be able to access the datacenter, according to a spokesperson.

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Wisconsin law bars forced RFID implants
Measure takes effect this week; other states considering limits on technology
Marc Songini

June 12, 2006 — Wisconsin this week will become one of the first states to ban the forcible implantation of radio frequency identification (RFID) tags into humans.

The ban begins on Wednesday, when legislation signed on May 30 by Gov. James Doyle goes into effect. The act dictates that no person may force another to have a microchip implanted in his body. Violators face fines of $10,000 each day until the chip is removed.
**PC user fined $222,000 for sharing copyrighted music**

By JOSEPH PRIED

THE ASSOCIATED PRESS

DULUTH, Minn. -- The recording industry won a key fight Thursday against illegal music downloading when a federal jury found a Minnesota woman shared copyrighted music online and levied $222,000 in damages against her.

The jury ordered Jammie Thomas, 30, to pay the six record companies that sued her $9,250 for each of 24 songs they focused on in the case. They had alleged she shared 1,702 songs online in violation of their copyrights.

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**Technology**

Report of Cancer Hurts Maker of Chip Implants

Published: September 11, 2007

Shares of SynMed Digital Solutions and of its publicly traded subsidiary Vertiview, which makes an implanted microchip for identifying people, fell sharply yesterday as investors reacted to a report this weekend linking the tiny radio device to cancer.

The report, by The Associated Press, suggested that Vertiview and federal regulators had ignored or overlooked animal studies raising questions about whether the chip or the process of injecting it might cause cancer in dogs and laboratory rodents.

"If there are any cancers from the chips, they are so rare that losing pets is far more serious," said Dr. Lawrence D. McGill, a veterinary pathologist at Animal Reference Pathology, a veterinary laboratory in Salt Lake City.
Anyone there?
Physical Constraints

- They have almost no memory
  - Memory is bit addressable!

- They have almost no compute
  - They’re hardware implementations of simple state machines, not von Neumann computers

- They have almost no transmit power
  - In fact, they have none – they backscatter a carrier transmitted by the reader
    - Low bandwidth, high bit error rate

- Result: communication is largely under control of the reader. (Tags never speak unless spoken to.)

A Few Specifics

- We’ll use the specific instance of the tags implemented for the next assignment.
  - They’re based on the spec for the Class 1 Generation 2 UHF RFID (860-960 MHz)

- Storage on the tag:
  - EPC: electronic product code (48-256 bits)
  - SL: selected bit (settable by reader)
  - INV: inventoried bit (settable by reader)

- Bandwidth is O(100Kbps)

- Bit error rate (BER) is (okay, no one knows for sure, but we’re saying) 0.1% - 1%
The Flavor of RFID Communication

Select  Directive from reader to conditionally modify SL or INV bit. The condition is a bit string that must match memory at a specified location.

Query  Reader supplies tags with a guard condition and a window size value. Tags meeting the guard choose a random slot. Any that choose slot 0 reply; others wait.

RN16 / ACK  Short temporary identifier supplied by tag, then used by reader to request the EPC.

Example

Reader

Select set SL, mask = 0, at = 0

Query( SL ~ INV, Q = 4 )

Ack( rand... )

RN16( rand... )

Query( SL ~ INV, Q = 4 )

Tags

QSlot = U[0,15]

if (QSlot == 0)

if rand... = rand...

State

Ready

Reply

Acked

Ready

SL

false

true

Arbitrate

INV

false

true
Protocol Issues

- What approach to collision resolution should be used?
  - Goal, say, is to obtain EPCs of all tags during the small time that the pallet is next to the reader

- What should be done to protect against bit errors?
  - What is the argument for transmitting error detection bits?
    - Against?

- Should you use ACKs and/or ARQ?
  - The spec defines the rules, and there are no ACKs. (Why?)
  - There are some situations where repeating a request is possible and makes sense.

Collision Resolution

- What the tags do in response to received frames is part of the spec
  - Not under software control

- Software decides what frames to send to them, though

- More on frames/tags in a second, but first let’s try to relate this to what we’ve seen before
Ethernet vs. 802.11 vs. RFID Link Layers

<table>
<thead>
<tr>
<th></th>
<th>Bandwidth</th>
<th>BER</th>
<th>Collision resolution runs in...</th>
<th>CR is part of spec?</th>
<th>Carrier Sense possible</th>
<th>Collision Detect possible</th>
<th>ACKs / ARQ</th>
<th>CRC</th>
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<tr>
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<td>Low</td>
<td>Sender</td>
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<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
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<td>Medium</td>
<td>Medium</td>
<td>Sender</td>
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<tr>
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<td>High</td>
<td>Reader (Receiver)</td>
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<td>No</td>
<td>Yes</td>
<td>?</td>
<td>Depends on frame</td>
</tr>
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</table>

RFID Collision Resolution Approaches

- The reader needs to somehow distinguish (any) one tag from all the others

- To do this, it has to make use of something on a tag that distinguishes it from the others:
  - The tag’s EPC
  - The tag’s randomly selected slot number
A Slot-based Scheme (Appendix D of the Spec)

Figure D.1 – Example algorithm for choosing the slot count parameter $Q$

EPC-based Query Tree

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Frames (Tag “Instructions”)

- **Select**
  - Set or invert SL or INV iff what is in a tag's memory starting at a particular bit matches a (variable length) bit string in the Select frame

- **Query**
  - "Selects" tags with particular value of SL and INV
  - Provides a “backoff window” size
  - Tags pick a random slot in backoff window and respond if slot = 0

- **QueryRepeat**
  - Tags participating in the current round decrement their slot counter by 1
  - Respond if updated slot = 0

- **QueryAdjust**
  - Tags in the current round double, halve, or leave unchanged, the current backoff window
  - They then pick a new random slot and respond if slot = 0