CSE/EE 461: Introduction to Computer Communications Networks
Autumn 2007

Module 3
Direct Link Networks – Part C

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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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The New York Times **Technology**

In Texas, 28,000 Students Test an Electronic Eye

Published: November 17, 2004

(Page 2 of 2)

But on the morning Felipe and Christopher shared a seat on bus No. 38, the district experienced one of the early technology hiccups. When the bus arrived at school, the system had not worked. On the Web site that includes the log of student movements, there was no record that any of the students on the bus had arrived.

It was just one of many headaches; the system had also made double entries for some students, and got arrival times and addresses wrong for others. "It's early glitches," said Brian Weisinger, the head of transportation for the Spring district, adding that he expected to work out the problems.

Enlarge This Image

Michael Stravato for The New York Times

Sandra Martinez, 10, uses her ID card to indicate that she is getting off her school bus in Spring, Tex.

ARTICLE TOOLS

E-Mail This Article

What Are They For?

First design looks to tag stray dogs

■ *Pongpen Sutharoj*
THE NATION

APART FROM PROVIDING development tools for local designers, the Thailand IC Design Incubator (TIDI) also develops the technology for various hi-tech devices and allows businesses to license the tehcnology to help build their products.

Currently, the incubator, which employs 15 IC designers, is developing core technologies for devices such as transceivers, radio frequency (RF) ID chips, serial communication devices including universal serial buses (USB) and micro-controllers.

Manop Thamsirianunt, head of IC design business development at TIDI, said that designing common core technologies would help build a foundation for the private sector to use for further development of their own products.

"Instead of starting from zero, businesses can licence our core technology to add more features to their products," Manop said.

In addition to technology licensing, the incubator plans to work with the private sector to help develop needed technology. It has joined with such a company to develop a USB transceiver interface to be built in to electronic products.

"Businesses can hire the incubator to do some of their design work," he said.

He added that the technology being developed by the incubator would certainly have commercial uses. One area under development is wireless identity chips and readers. Manop said this technology is designed to help identify individuals when accessing buildings or for keeping track of animals.

A prototype of the "radio-frequency" ID chip and its reader has been made and the incubator is presently testing them, a process expected to last around three months.

Manop said the TIDI has talked with the Bangkok Metropolitan Administration and the Livestock Development Department about the technology's use in animals.

"BMA has a plan to implant chips in street dogs to control the population, while the livestock department wants cows with ID chips for dairy-farms. So we think we can offer this technology to them as a substitute for more expensive imports," he said.

The incubator will also talk with the private sector about using the locally made ID technology in such areas as access control. It is expected that using this locally developed technology will help save the country 50 per cent or more on many imported products. Normally, imported RF ID chips used in smart cards cost around Bt80, but using local ones would cost half that.

As for the reader, it should cost Bt7,000 compared to Bt30,000 for an imported one. Manop said these locally made items were expected to be in big demand when they reach the marketplace.

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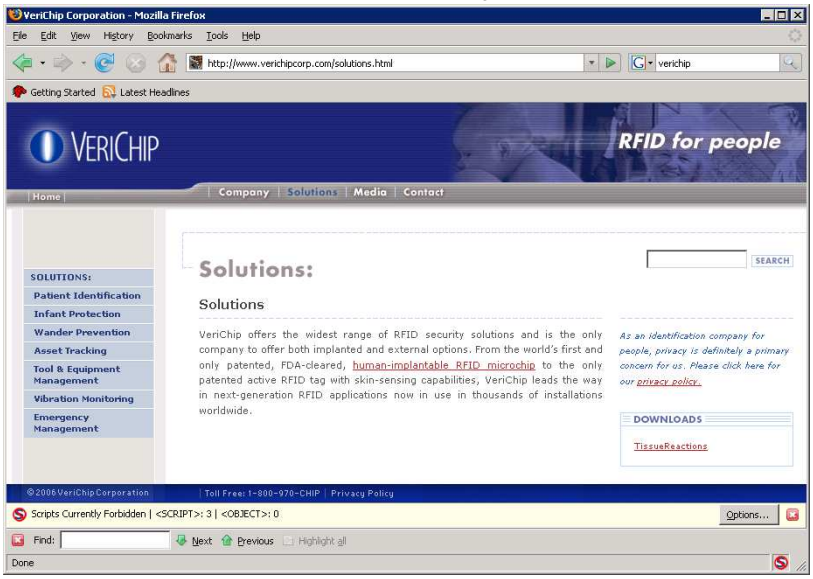
What Are They For?



The New York Times **Fashion & Style**

Abbreviated

High Tech, Under the Skin
By ANNA BAHNEY
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 feet bounced 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 enthralled 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 ampoule 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.

SecurityFocus™

Company requires RFID injection
Published: 2006-02-10

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

Cincinnati based surveillance company CityWatcher.com created the policy with the hopes 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 implantable, glass encapsulated RFID tag from VeriChip must be injected into the bicep to gain access, a release from spychips.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 Register article.

COMPUTERWORLD
Government

Abbreviated

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

June 12, 2006 (Computerworld) -- 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.

seattlepi.com

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BUSINESS

Abbreviated

Last updated October 4, 2007 7:36 p.m. PT

PC user fined $222,000 for sharing copyrighted music

By JOSHUA FREED
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.

The New York Times

Technology

Report of Cancer Hurts Maker of Chip Implants
By BARNABY J. FEDER
Published: September 11, 2007

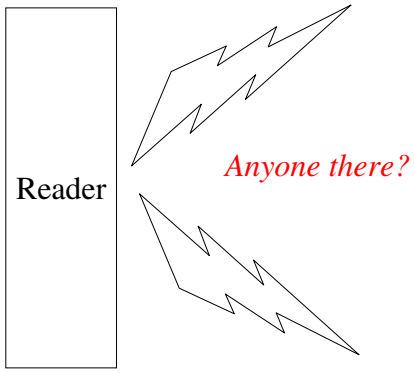
Abbreviated

Shares of Applied Digital Solutions and of its publicly traded subsidiary VeriChip, 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 VeriChip 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.

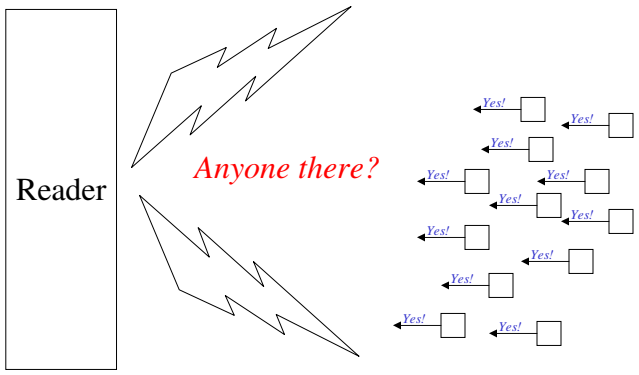
Blah blah blah…

"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.

The Inventorying Problem



The Inventorying Problem



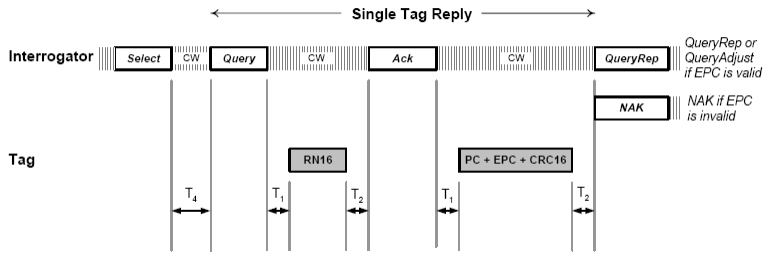
Physical Constraints

- 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

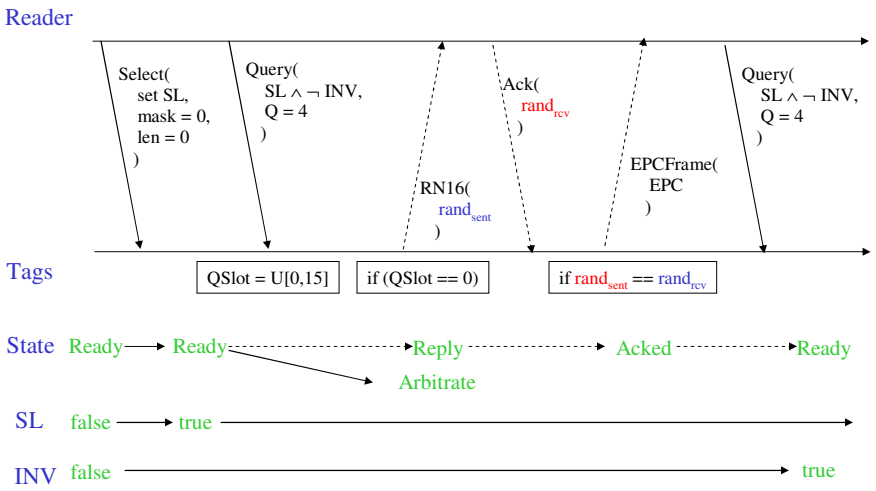
- We'll use the specific instance of the tags implemented for the next assignment.
  - They're based on the spec for the Class 1 Generation 2 UHF RFID (860-960 MHz)
- Storage on the tag:
  - EPC: electronic product code (48-256 bits)
  - SL: selected bit (settable by reader)
  - INV: inventoried bit (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



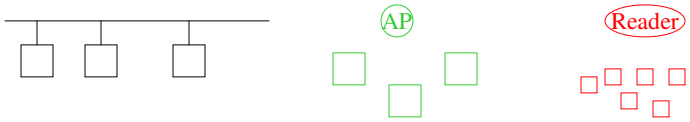
Protocol Issues

- 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



	Bandwidth	BER	Collision resolution runs in…	CR is part of spec?	Carrier Sense possible	Collision Detect possible	ACKs / ARQ	CRC
Ethernet	High	Low	Sender	Yes	Yes	Yes	No	Yes
802.11	Medium	Medium	Sender	Yes	Yes	No	Yes	Yes
RFID	Low	High	**Reader** (Receiver)	**No**	No	Yes	**?**	**Depends on frame**

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)

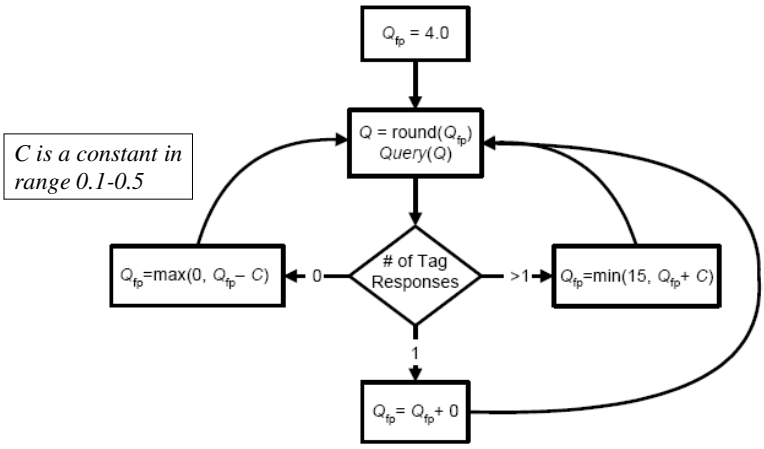
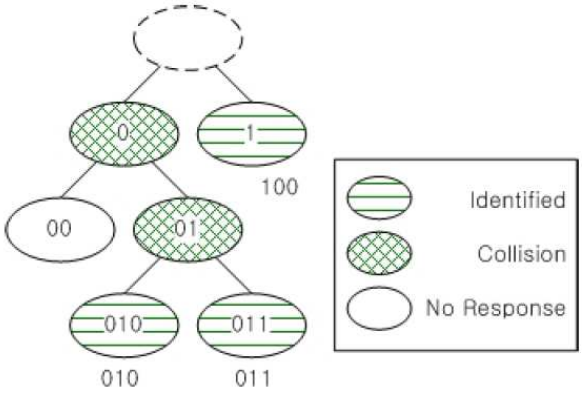


Figure D.1 – Example algorithm for choosing the slot-count parameter *Q*

EPC-based Query Tree



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