RFID

Low-Power Computing
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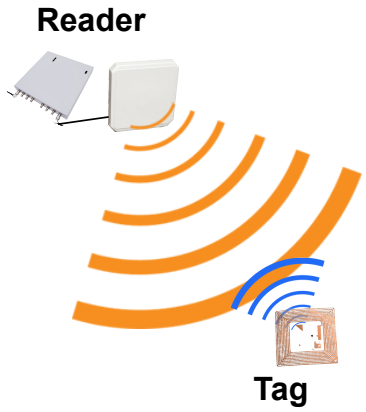
What is RFID?

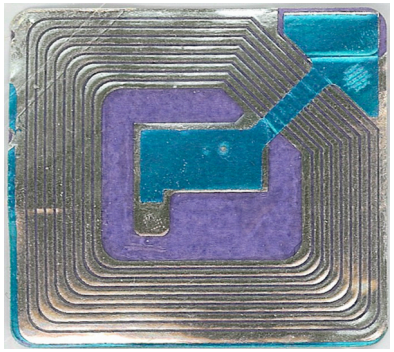
http://rfid.cs.washington.edu/

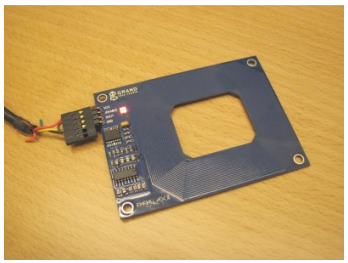
- Wireless ID and tracking
- Captures information on:
  - Identity
  - Location
  - Time
- *Unique* identification
- Passive (no batteries)



Slide Credit: Evan Welbourne, UW

Tags & Readers

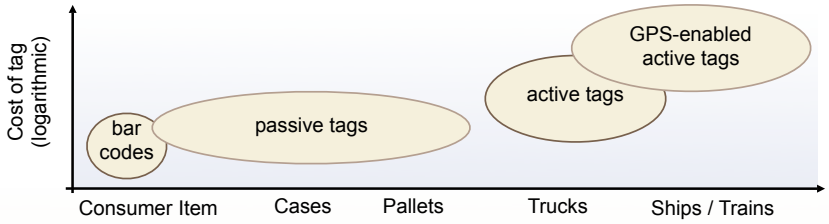




Not to scale!

RFID Tags – A Wide Variety

http://rfid.cs.washington.edu/

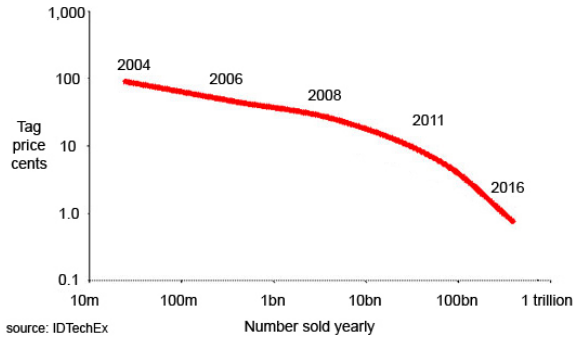


Slide Credit: Evan Welbourne, UW

Passive RFID Markets

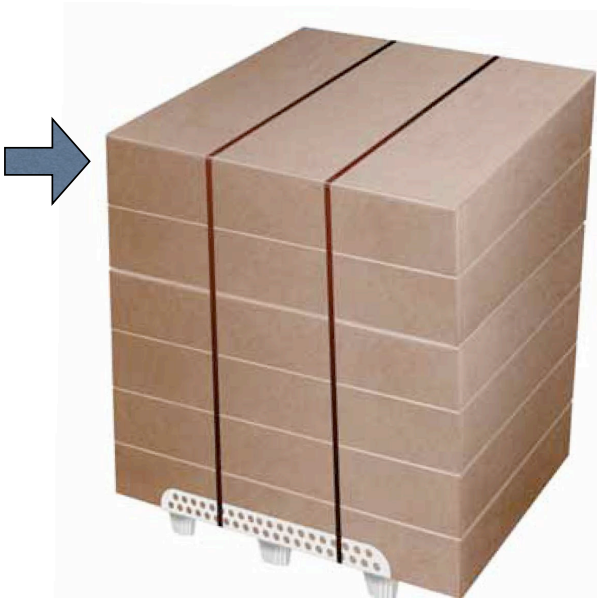
http://rfid.cs.washington.edu/

- Today: $5 B industry, 2 billion tags



- Cost *critical* to deployment success - consider tagging every tube of toothpaste...

Slide Credit: Evan Welbourne, UW



Shipping - goods as packets

40,000 of these floating around

RFID desires

- Track every {ship, container, pallet, box, item} at fine granularity
- *Monitor* those shipments, too - temp, orientation, location, ...
- Automotive uses - speedpass, etc;
- Bus/subway passes; passports; EDLs;
- Implants to let you in your house? :-)
  Real: FedEx drivers have wristbands to access back of truck / ignition

What's interesting?

- Fundamental questions inspired by RFID
  - Where do you need what functionality?
  - What do you trade off when you use extreme points in the design space (totally passive tags vs. sensor motes)?
  - How do you design protocols for extremely stupid/passive nodes?

Passive RFID tags

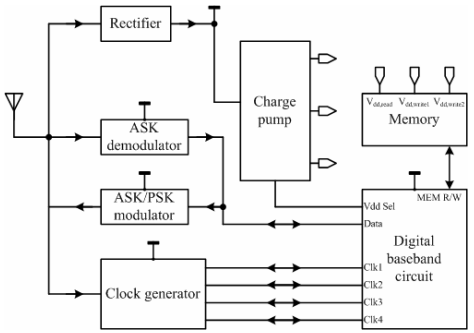
- Most basic: No computation. Tag echos back a pre-stored value.
  - Some tags can be updated, some are hardcoded.
- Think of these as barcodes (EPC tags)
  - A whole lot of use even with just that:

ID->Info DB | Reader | Tag

Passive RFIDs

- Key advance: Return signal is also passive - reflected RF or antenna impedance modulation
  (draw fig)
- Most basic: Antenna, guide ---| | | | reflector
- "Programmed" by adjusting the spacing of the reflectors -- ID is baked-in
- Less basic: Chip-based, transiently powered
  - Architecture much like the WISP but without big CPU and capacitor

RFID Tag Design



Slide Credit: Rafael Kleiman

Reading RFIDs

- Send out signal, listen to received signal.
- What happens if you've got an RFID tag in every book in a pallet?? Tag collision!
- If this were 802.11, use random backoff, etc.
- But these are very stupid tags... delaying in time requires energy storage.

Tag Collision - Smart Readers

- Two options
  - 1) Tags keep counter.
    Reader broadcasts "Crap! Collision!"
    Tags add 0 or 1 to their counter.
    Reader broadcasts "0*, talk to me!"
    recurse.
  - 2) Reader broadcasts "Tags with ID 0* talk!", recurse.
- Smarter readers remember rough histogram of tag ID distribution for the next time they squawk.

Tricks with passive RFID tags

- Can even do smart things here...
  - What direction is my pallet facing?
    - Mercury switch for an RFID tag on every side - same upper bits per tag, different low-order bits.
  - Did my peanut butter ever get too hot?
    - Low-temp fuse burns out > 70 deg F.

RF-Active Tags

- Paper discussion here!
- Show platform list from RC5 on WISP paper - useful categorization

Tag Security

- Cloning attacks straightforward against tags that always reply with same info
- "... at a distance of at least 50 meters ... down a long hallway, but within FCC limits" (UW/RSA study, cloning U.S. Passport RFID)

Trading Security & Power

- We've seen before - performance/power, range/power, sampling accuracy/power
- RFID shows up with security vs. power
- Cryptographic operations are expensive
  - 46MB/sec AES encrypt on c2 mobile
  - ~1000 rsa512 signs/sec, 10k verfies/s
    - 2M cycles to sign???
    - Estimated SSL/rsa1024 handshake time, TelosB: 5 seconds. -> 60mJ (12mW for 5 sec)

(Aside: Not just RFID)

- SSL web servers: ~100 connections/sec
- Non-SSL web server: ~5,000 reqs/sec

RFID eventually

- Powerful, active sensors
  - GPS tracking of individual pallets of goods
  - Today, possible at shipping container granularity

- Cost desires will likely keep much RFID simple
  - Retailers care about $0.02 per item...
  - It'll be a while before we have p2p shirts