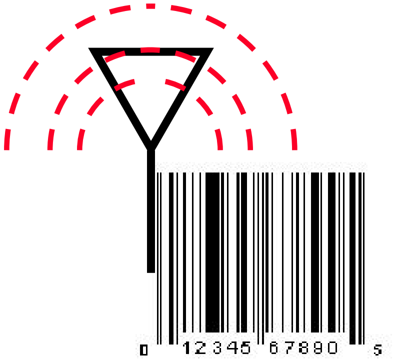
Radio Frequency Identification (RFID)



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These slides are available on-line at:

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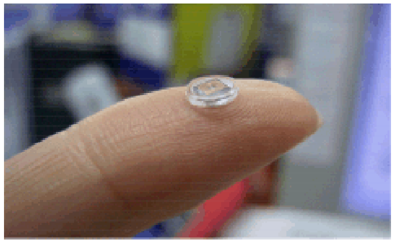
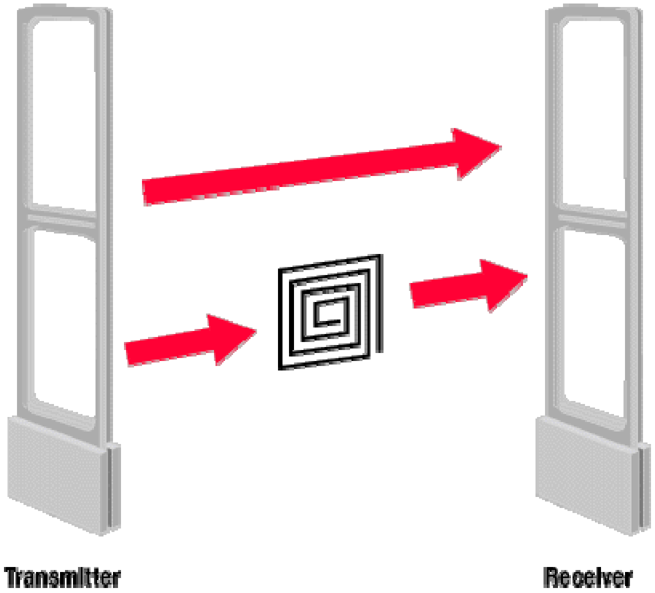
Overview

- What is RFID?
- RFID: Applications
- RFID Tags and RFID Readers
- Reader-Tag Coupling
- RFID Standards
- Security Issues

What is RFID?

- Radio Frequency Identification
- Reader queries using RF, ID sends its ID using RF
- Competes with Bar Code, Magnetic stripes, Magnetic Ink Character Recognition (MICR) on Bank Checks





RFID: Applications

- Pioneered by British during World War II to identify aircrafts
- 1960's US Government started using RFID on nuclear and hazardous materials
- Garage door openers use RFID
- Implants in human, horses, fishes, animals
  Animal ID Standards ISO 11784 and 11785 use RFID
- Automatic Toll Collection
- Access control, Equipment Tracking
- All shipments to DoD must be RFID tagged.
- Sensor+RFID can be used to monitor products inside sealed shipping containers

Applications (Cont)

- Warranty information on RFID tags
- Smart medical cabinets remind patients to take medications and call doctors if missed
- Retail loss prevention
- No need to unload grocery carts for checkout

BREAD
EGGS
Transmitter
Receiver

RFID Tags

- Tag = Antenna, Radio receiver, radio modulator, control logic, memory and a power system
- **Power Source**:
  - **Passive Tags**: Powered by incoming RF. Smaller, cheaper, long-life. Approx range 5m.
  - **Active Tags**: Battery powered. Can be read 100 ft away.
    More reliable reading.
  - **Semi-Passive tags**: Transmit using 'Backscatter' of readers' RF power. Battery for logic. Range like passive. Reliability like active.

Tags (Cont)

- **Size**:
  - Hitachi mu-chip is 0.4 mm on a side. Designed to be embedded in paper documents. Can be read within a few cm.
  - Verichip makes tags the size of grain of rice. Designed to be implanted in humans. Identify patients.
  - Semi-passive RFIDs used in E-Z Pass toll collection are paperback book size. 5-year battery.
- **Security:**
  - **Promiscuous Tag**: Can be read by any reader. Most tags.
  - **Secure Tag**: Need reader authentication. Usually manual passwords.

Tags (Cont)

- **Components**:
  - Simple tags with Serial #. 96-bit block of read-only storage (ROM).
  - Read-write memory.
  - Tags may have embedded sensors (tire pressure sensor)
- **Kill Feature**: Special code causes the chip to stop responding.
- Multiple tags can interfere
  ⇒ Need a **singulation** protocol
  ⇒ Reader interrogates one tag at a time.

RFID Readers

- Sends a pulse of radio energy and listens for tags response
- Readers may be always on, e.g., toll collection system or turned on by an event, e.g., animal tracking
- Postage stamps size readers for embedding in cell phones Larger readers are size of desktop computers
- Most RFID systems use License-exempt spectrum
- Trend towards high-frequency

Band	Frequency	λ	Classical Use
LF	125-134.2 kHz	2,400 m	Animal tagging and keyless entry
HF	13.56 MHz	22 m	
UHF	865.5-867.6 MHz (Europe) 915 MHz (USA) 950-956 MHz (Japan)	32.8 cm	Smart cards, logistics, and item management
ISM	2.4 GHz	12.5 cm	Item Management

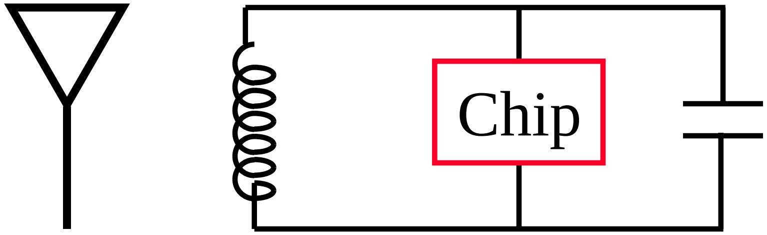
Reader-Tag Coupling

- Passive tags have capacitor to store energy for replying (TDD)
  - Can respond on another frequency while reader is still transmitting (FDD)
- Near-Field = Within a few wavelength
  Far-field = Beyond a few wavelengths
- Low-Frequency (large λ) system operate in near-field
  High-Frequency and UHF system operate in far-field

1. **Inductive Coupling**: In near-field
   - Both Antennas are coils (like transformers)
   - Reader sends a AM/FM/PM modulated wave.
   - Tag responds by varying its load on the reader.

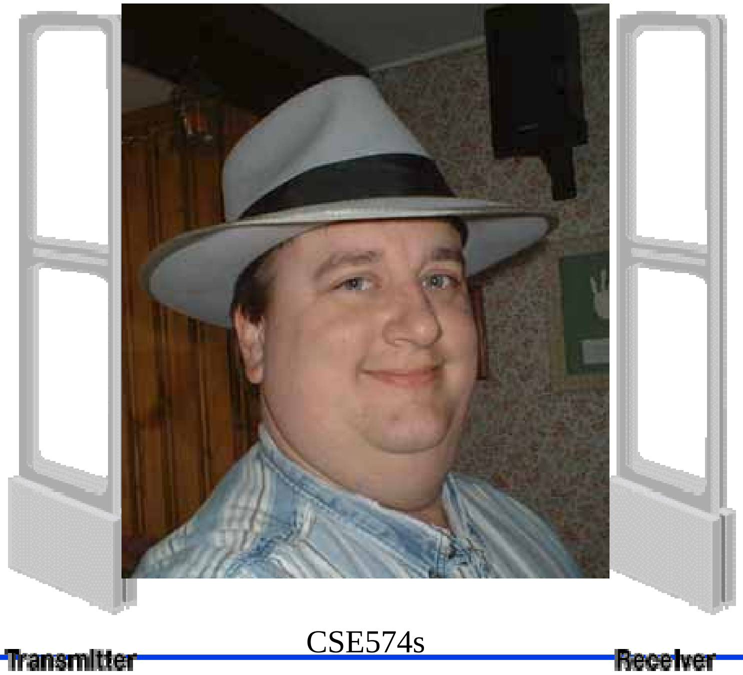
Coupling (Cont)

2. **Back Scatter**: In far-field
   - Reflecting the energy back.
   - Tag changes its reflection to respond.
3. **Capacitive Coupling**:
   - Charged plates as antennas on readers and tags
   - Can be easily printed.



RFID Range

- Reading range depends upon the transmitted power, antenna gains, frequency, reader receiver sensitivity.
- Affected by the environment: Metal objects (aluminum foil), Water (Wetness, salt water)



RFID Standards

- ISO/IEC JHC1/SC31/WG4
  - Automatic Identification and Data Capture Techniques
  - ISO (International Organization for Standardization) and
  - IEC (International Electro-Technical Commission)
  - Joint Technical Committee number one, JTC 1 (ISO/IEC)
  - Subcommittee SC 31
- Electronic Product Code (EPCGlobal) - Industry consortium
- JTC 1/SC 17 Identification Cards and related devices
- ISO TC 104 / SC 4 Identification and communication
- ISO TC 23 / SC 19 Agricultural electronics
- CEN TC 278 Road Transport and Traffic Telematics
  - Comité Européen de Normalisation
    (European Committee for Standardization)

RFID Standards (Cont)

- CEN TC 23/SC 3/WG 3 Transportable Gas Cylinders - Operational Requirements - Identification of cylinders and contents
- ISO TC204 Transport Information and Control Systems
- American National Standards Institute (ANSI) X3T6: RF Identification
- European Telecommunications Standards Institute (ETSI)
- ERO European Radio communications Office (ERO)
- Universal Postal Union
- ASTM International (Testing Materials)

Security Issues

- Unauthorized Reading:
  - Competitors can scan closed boxes and find out what is inside
  - Someone can read your RFID enabled credit card
- Unathorized Writing:
  - Can change UPC/price of an item
  - Can kill a tag
- Solution: Reader authentication.
  - Passwords can be sniffed.

Privacy

What can you do to prevent others from reading your RFID after you purchase the item?

- Kill the tag. Need authentication.
- Put the tag to sleep. Used for reusable tags. Libraries. Authentication to put to sleep and to awaken.
- Re-label: Customer can overwrite customer specific information. Manufacturer specific information can remain.
- Dual Labeling: One tag with customer specific information. One with manufacturer specific information.
- PIN: The reader needs to provide a PIN.
  The user can change the PIN.
- Distance-Sensitive: Tag is designed so that the information provided depends upon the distance
- Blocker: A device that generates random signal and prevents others from reading your RFIDs. Use aluminum foil.

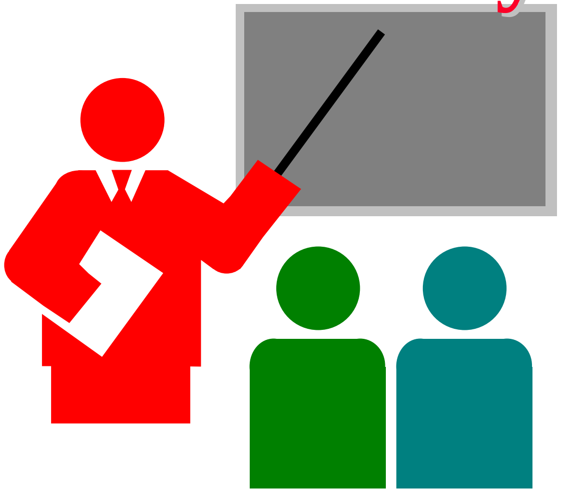
Range of Attacks

- Nominal reading range: Standard power reader
- Rogue reading range: More powerful readers can read from longer distance
- Tag-to-Reader Eavesdropping Range: Passively listen to response with a more sensitive receiver
- Reader-to-tag Eavesdropping Range: Passively listen to query with a more sensitive receiver. Can do this from very far.
- Detection Range: Can just detect the presence of a tag or a reader. Important in defense applications where important weapons or targets are tagged.

Types of Attacks

- Sniffing and eavesdropping: Passively listening with very sensitive readers. Competition can find what you are shipping/receiving
- Spoofing: Copy tag for use on other items
- Replay: Unauthorized access by recording and replaying the response. Garage door openers.
- Denial of Service: Frequency jamming
- Blocking: Aluminum foils

Summary



1. Three types: Passive, Active, Semi-Passive
2. Kill feature, secure and promiscuous tags
3. Low/High/Ultra High Frequency, ISM band
4. Near field and far field
5. Three Couplings: Inductive, Backscatter, Capacitive
6. Wireless security and privacy issues are even more severe with RFID due to limited tag capability.

Reading Assignment

- C. Jechlitschek, "A Survey Paper on RFID Trends," http://www.cse.wustl.edu/~jain/cse574-06/rfid.htm
- Introduction to Radio Frequency Identification (RFID), http://www.aimglobal.org/technologies/rfid/resources/RFIDPrimer.pdf
- Radio Frequency Identification, http://www.technology.gov/reports/2005/RFID_April.pdf
- How RFIDs Work, http://electronics.howstuffworks.com/smart-label.htm
- How Anti-shoplifting Devices Work, http://electronics.howstuffworks.com/anti-shoplifting-device.htm