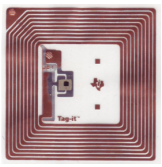
University of Massachusetts Amherst

Lecture 12– Radio-Frequency Identification

ECE 197SA – Systems Appreciation

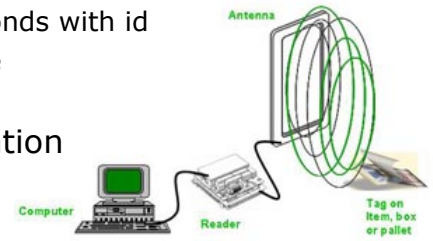
Cyber-Physical Systems

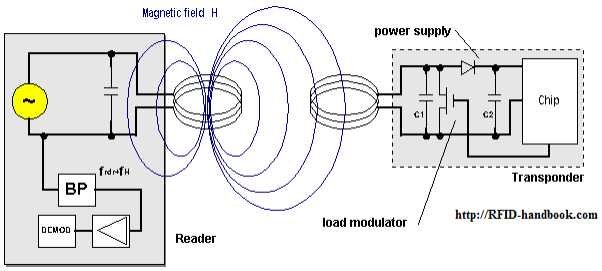
- Cyber-physical systems (CPS)
  - Combination of physical and computational elements
  - Relationship between physical world and cyberspace
- Examples:
  - Robots / drones / etc.
  - Power grid / home energy management
  - Manufacturing
  - Robotic surgery
  - Environmental sensing
  - …
- Today:
  - Identification of physical objects
  - Radio-frequency identification (RFID)



Radio-Frequency Identification

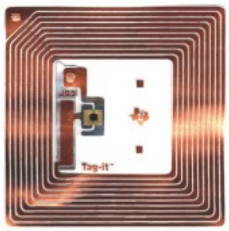
- Basic RFID operation
  - Reader transmits power and identification request
  - Tag absorbs power and responds with id
  - Reader receives tag response
- Many different coupling techniques and communication protocols

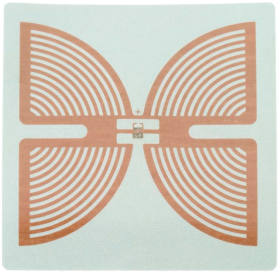


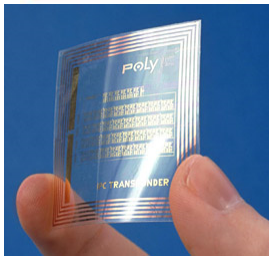


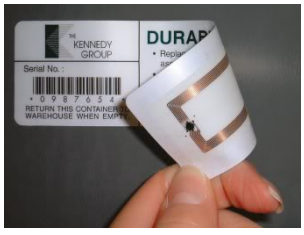
RFID Tags

- RFID tags
  - Passive: antenna to harvest energy; active: battery
  - Chip for storing identifier and performing computation







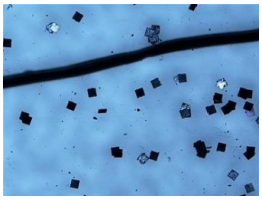


RFID Readers

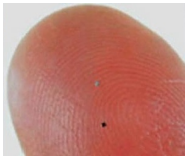
- RFID readers
  - Bigger antenna provides longer range

RFID Capabilities

- Basic functionalities
  - Store data and respond to requests
  - Implement medium access protocol
  - Example: Hitachi RFID "powder"
    - » 0.05mm x 0.05mm with 128-bit ROM



- Advanced functionalities
  - Perform computations
    - » Sensing
    - » Cryptographic operations



  - Example: Intel WISP
    - » Microcontroller, EEPROM, accelerometer, temperature sensor, analog voltage sensing, capacitance sensor

RFID Standards

- Large number of different standards
  - Different frequencies
  - Different communication protocols
- RFID tag often specific to application
  - Active vs. passive
  - Size vs. range
  - ID vs. computation

Frequency Range	LF (Low Frequency)	HF (High Frequency)	UHF (Ultra High Frequency)	Microwave
	125-135 KHz	13.56 MHz	860-960 MHz	2.45 GHz
Read Range	10 cm	1m	2-7 m	10m
Applications	Security/ Access, Asset Tracking and Animal Tracking	Anti theft, baggage, libraries, transport, apparel	Transportation vehicle ID, Access/Security, large item management, supply chain	Access control, electronic toll collection, supply chain
Multi Tag Read Rate	slow ← → fast			
Ability to read near metal or wet surfaces	better ← → worse			
Tag size	larger ← → smaller			
Usage	Highest ← → Lowest			
Cost	High ← → Low			

Source: Frost & Sullivan

Identifying Physical Objects

- What are possible applications for RFID?

RFID Applications

- Supply chain management

- Livestock tracking / pet identification

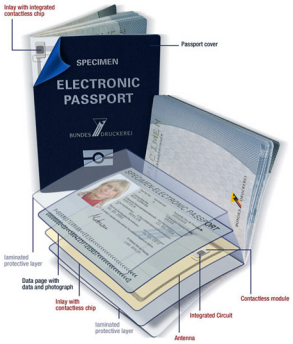
RFID Applications

- Transportation (e.g., MTA Fastlane)

- Forgery prevention (e.g., event tickets)

RFID Applications

- Passports



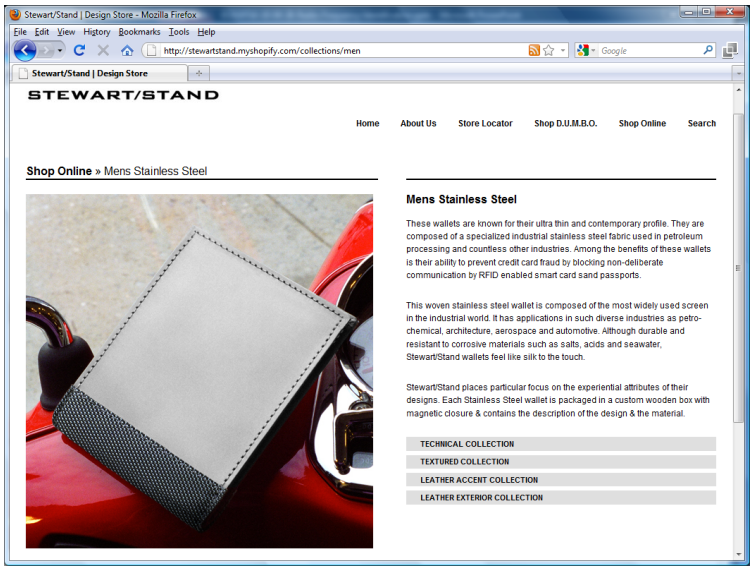
- Human implantation (e.g., VeriChip)

RFID Concerns

- What are concerns with RFID?

Privacy Solutions

- "Tin foil wallet"



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Courses in ECE Curriculum

- ECE 415 – Senior Design Project I
- ECE 416 – Senior Design Project II
- ECE 697AB – Security Engineering

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The End...

- We have covered:
  - MP3 player (audio signal processing)
  - Cell phone (wireless communication)
  - Computer (microprocessors)
  - Solar cells (power generation)
  - Power grid (power distribution)
  - Air traffic control (radar)
  - Global Positioning System (navigation)
  - Digital camera (optical sensor)
  - Internet (network protocols)
  - Information security (cryptography)
  - Cyber-physical systems (RFID)

SRTIs