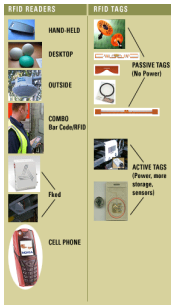
Radio Frequency Identification (RFID)

What is RFID?

- Radio Frequency Identification

RFID

- RFID is an ADC (automated data collection) technology that uses radio-frequency waves to transfer data between a reader and a movable item to identify, categorize, track...
- RFID is fast, reliable, and does not require physical sight or contact between reader/ scanner and the tagged item
- A close cousin to sensor network technology
- Generally, RFID tags are cheaper, but less "intelligent" than sensor nodes
- As things evolve the line between the two technologies is blurring



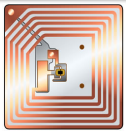
Historical Background

- Identification Friend or Foe (IFF) Used by Allied bombers during World War II
- In 1948, concept of "passive RFID" systems introduced by Harry Stockman
- In 1972, Kriofsky and Kaplan designed and patented an "inductively coupled transmitter-responder" (2 antennas)
- In 1979, Beigel designed/patented "identification device" which combined both antennas into one
- In the 1970s, a group of scientists at the Lawrence Livermore Laboratory (LLL) build a handheld receiver stimulated by RF power for secure access to nuclear facilities

RFID Systems

Main components:

- Tags (transponders)
  - microchip & antenna

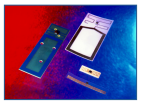


- Tag reader
  - decoder & antenna
  - the RFID reader sends a pulse of radio energy to the tag and listens for the tag's response to instructions
  - RFID readers are either continuously on or they send the radio pulse only in a response to an external event

Tags

Variations:

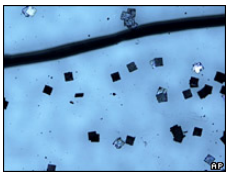
- Memory
  - Size (16 bits - 512 Kbytes)
  - Read-Only, Read/Write or WORM
- Arbitration (Anti-collision)
  - Ability to read/write one or many tags at a time
- Frequency
  - 125KHz - 5.8 GHz
- Price ($0.10 to $250)
- Physical Dimensions
  - Thumbnail to Brick sizes



"Mission Impossible"

Tiny Tags

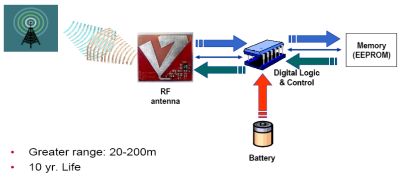
- 2007 Hitachi produced RFID device measuring 0.05×0.05 mm, and thin enough to be embedded in a sheet of paper. The data contained on them can be extracted from as far away as a few hundred metres. Human hair comparison.



Active versus Passive

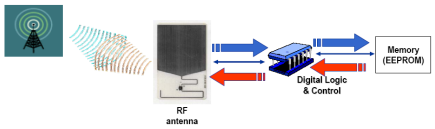
	Active RFID	Passive RFID
Tag Power Source	Internal to tag	Energy transferred using RF from reader
Tag Battery	Yes	No
Required signal strength	Very Low	Very High
Range	Up to 100m	Up to 3-5m, usually less
Multi-tag reading	1000's of tags recognized – up to 100mph	Few hundred within 3m of reader, about 3 sec per read => at most 3 mph.
Data Storage	Up to 512 KB	16 bits – 1 KB

Active Tag



- Greater range: 20-200m
- 10 yr. Life
- Limited sensor capabilities
- "Self-powered" uses interrogator RF beam for wake-up and communication

Passive Tag

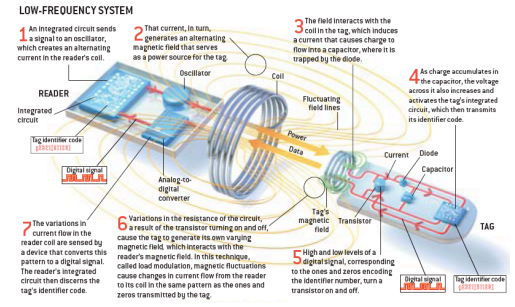


- Limited range: <10m (frequency dependent)
- Communication & power from interrogator RF beam

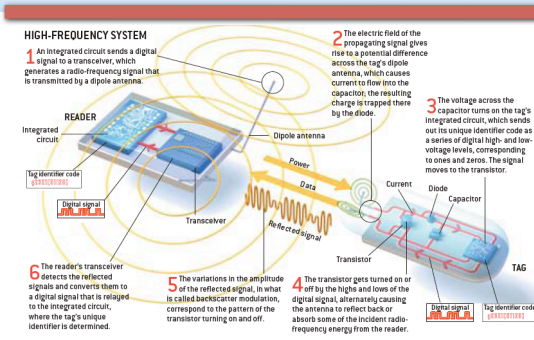
Frequency Ranges

FREQUENCY BAND	CHARACTERISTICS	TYPICAL APPLICATIONS
LOW 100-500 KHz	SHORT TO MEDIUM READ RANGE INEXPENSIVE LOW READ SPEED	ACCESS CONTROL ANIMAL IDENTIFICATION INVENTORY CONTROL
HIGH 10-15MHz 850-950MHZ	SHORT TO MEDIUM READ RANGE POTENTIALLY INEXPENSIVE MEDIUM READING SPEED	ACCESS CONTROL SMART CARDS
ULTRA-HIGH 2.4-5.8 GHZ	LONG READ RANGE HIGH READING SPEED LINE OF SIGHT REQUIRED EXPENSIVE	RAILROAD CAR MONITORING TOLL COLLECTION SYSTEMS VEHICLE IDENTIFICATION

Low Frequency: Load Modulation



High-Frequency: Backscatter Modulation



Codes

Bar Code

EPC: Electronic Product Code

EPC

The Electronic Product Code

S-GTIN: 01. 000389. 000162. 00169740

Header (8 bits)	EPC Manager (28 bits)	Object Class (24 bits)	Serial Number (36 bits)
Identifies the EPC's version number and allows for the evolving of different lengths or types of EPC.	Identifies the manufacturer of the product which it derives from the company's prefix.	Refers to the exact type of product which is the GTIN without the prefix or the item reference.	The specific serial number of the individual item.

Communication and Collisions

- Very simple packet formats
  - General structure:

Sync	Header	Command	Data	CRC

  - Usually reader-to-tag and tag-to-reader format somewhat different.
  - Typically 2 byte CRC

Collisions

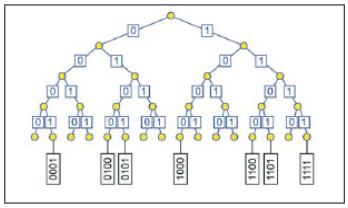
- When multiple tags receive a query from the reader, they will all respond.
  => Responses will "collide" at the reader
- Many readers feature "simultaneous read" capabilities
  - Must resolve collisions
- Basic link layer problem (e.g., Ethernet)
  - But here the algorithm must be very simple
- Problem in wireless in general: collision detection at sender not possible
- Problem in RFID: no "carrier sense" of tag possible

Collision Resolution for RFID

Two common approaches:

Slotted Aloha (with back-off)

Binary tree algorithm (reader polls tags "bit by bit")

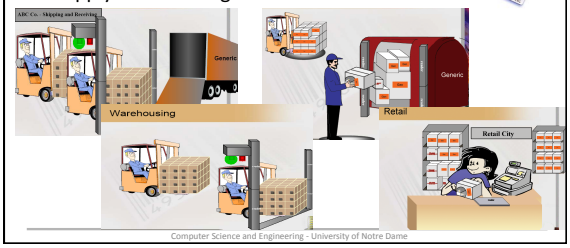


Application Scenarios

- Track the movement of consumer product goods
- Animal identification/tracking/counting
- Toll collection
- Implantation of RFID chips into people, e.g., Alzheimer patients

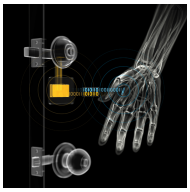
Applications

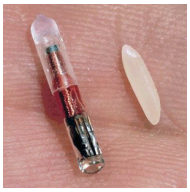
- Keyless entry
- Proximity cards
- Supply chain management



Implants

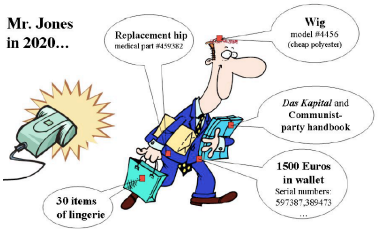
- It is the most controversial application
- Small glass cylinders approximately 2 or 3mm wide and between 1 and 1.5cm long
- Consists of a microchip, a coiled antenna, and a capacitor
- Implanted typically under the skin of arm or the back of the neck





Concerns

- Clandestine tracking
- Inventorying



Benetton Controversy (2003)

Walmart Controversy (2003)

Instant Checkout

"Chip to remove shopping blues"
—Post-Courier, January 1994

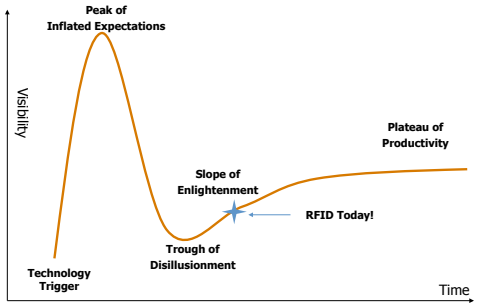
"1.5¢ electronic bar code announced"
—San Francisco Chronicle

"Tiny microchip identifies groceries in seconds."
—Chicago Tribune

"Scanning range of four yards"
—NY Times

"Checkout in one minute"
—The Times, London

The Hype Cycle



Walmart

- In 2003, Walmart made the retail industry's initial steps with a Radio Frequency Identification (RFID) supplier requirement when it announced a pallet and case level tagging initiative. Currently, over 600 suppliers are participating in the initiative. Today, Walmart requires that its top suppliers must be RFID compliant, at the pallet and outer case level. Many suppliers have already been notified regarding their target compliance dates. As time progresses RFID benefits will continue to surface as well as the technology will become cheaper and easier to integrate.

Case Studies

- AIRBUS A-380
  - The world's largest passenger aircraft has been equipped with 10,000 radio frequency tags which will help speed up maintenance and improve safety.
  - The double-decker plane which accommodates 555 passengers has passive RFID chips on removable parts such as seats, life jackets, brakes and other parts, which are subject to routine service or replacement. RFID tagging will make the checking of these parts quicker and more accurate and provide a database of information about each item.

Case Studies

- Volkswagen
  - Volkswagen is Europe's largest producer of cars, and the fourth largest in the world, and each year over 35,000 vehicles are displayed at and collected from the company's unique Autostadt (Auto City) facility at Wolfsburg in Germany.
  - When Volkswagen wanted a way to quickly locate a car in the holding lot and then track its progress through pre-delivery, it was decided to adopt a system using RFID tags. All tasks involved in the delivery process are recorded and stored on the tag, which is hung from the rear view mirror. Every time the car moves through a process station, workers know its location and current status –automatically.

Conclusion

- Invented during World War II, but it took 55 years for it to become consumer friendly, compact, easy to integrate, and low cost.
- Although the technology is still considered young and emerging, it is based on electronics, therefore remaining technological challenges will be overcome, leading to new mobile services & applications, smart objects, …

IBM RFID Ad