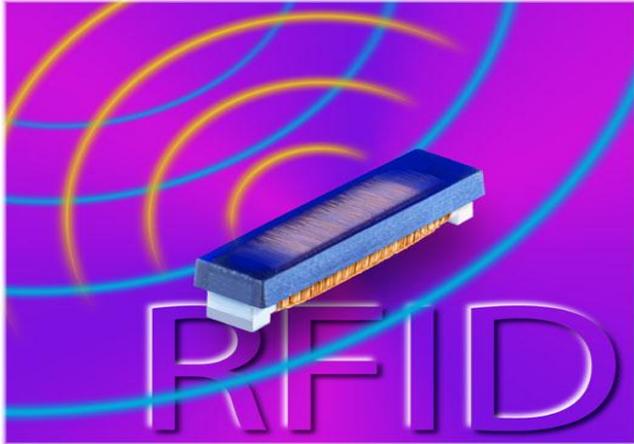# Introduction to RFID Technology

Definition

- RFID (Radio Frequency Identification) is a technology that enables the electronic and wireless labeling and identification of objects, humans and animals

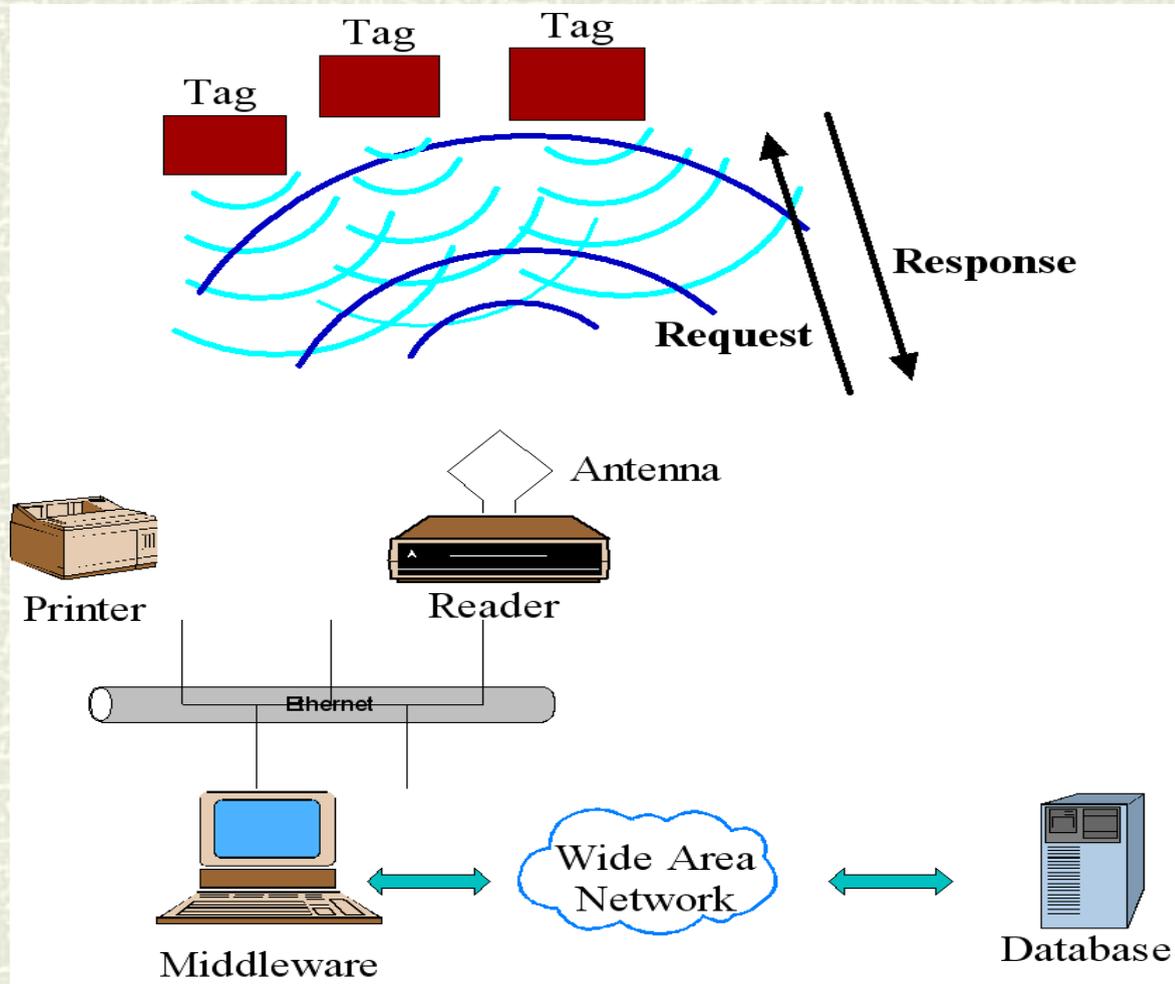# History of RFID Tags

- Radar
  - To warn of aircrafts
  - Could detect only presence of an aircraft
  - No friend or foe distinction
- First active RFID System
  - Watson-Watt: first active identify friend or foe (IFF) system
  - Each aircraft had a transmitter
  - After transmitter received a radar signal it broadcast a signal back identifying an aircraft as friendly

# RFID system

# RFID Components

- Tag
  - Microchip connected to an antenna
  - Can be passive, semi-passive, active
  - No battery: passive
  - Battery: semi-passive or active
  - Semi-passive: circuit is battery-powered except communication
  - Promiscuous (true for most) or secure
  - Can be "self-destructing" (see later)
- Reader
  - Interrogate/query tags via radio signals

Basic Tag Operational Principles

Inductive Coupling

Reader

TAG

Backscatter

Reader

TAG
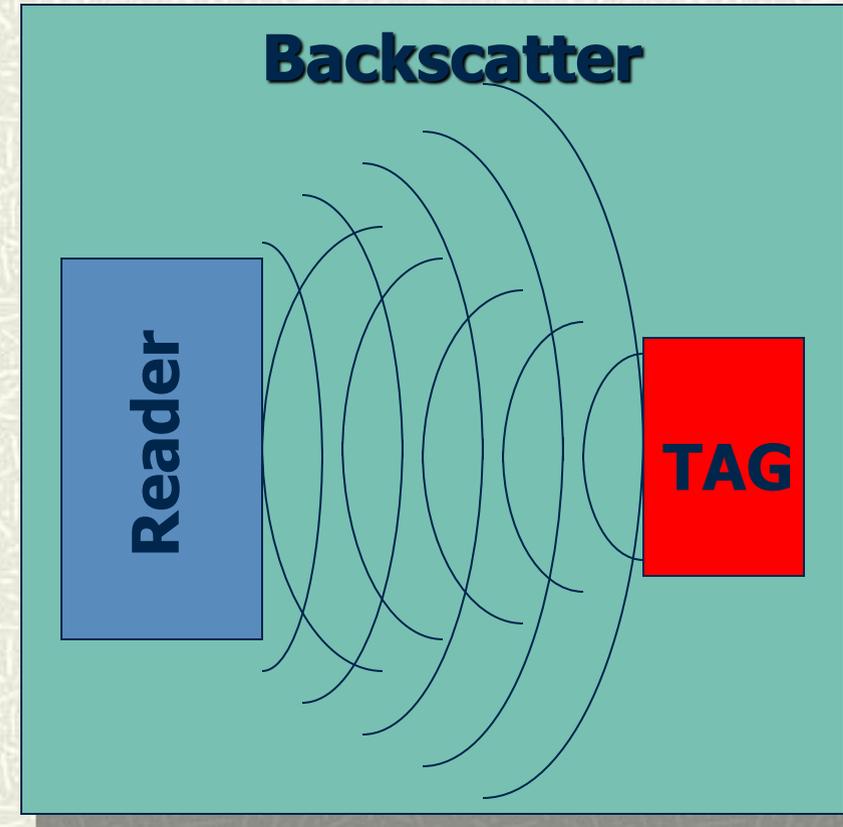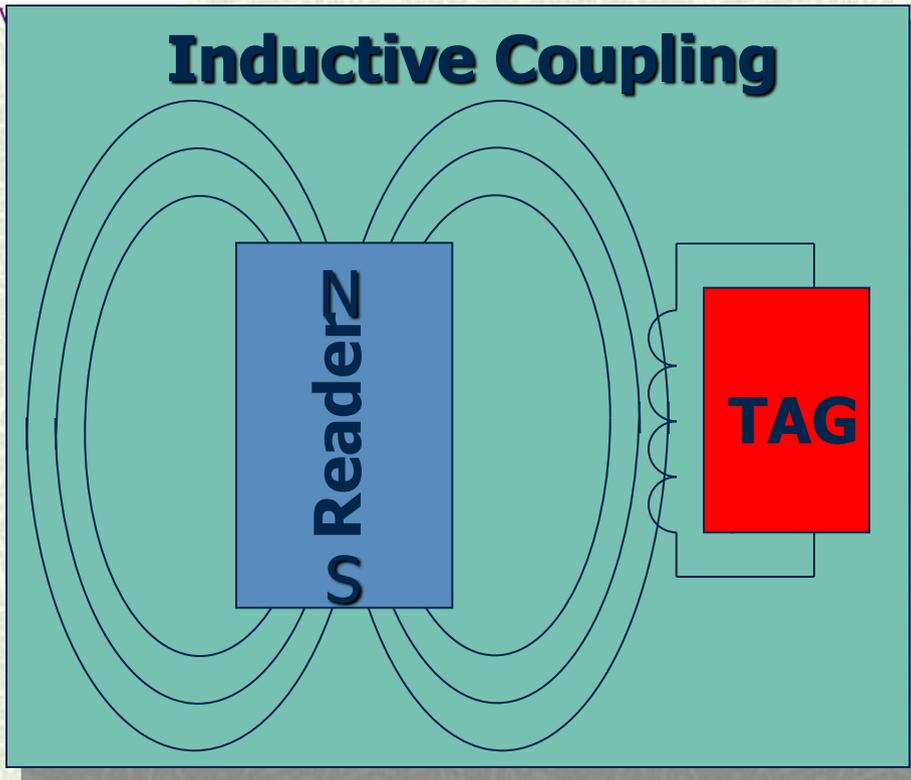
- Near field (LF, HF):   inductive coupling of tag to magnetic field circulating around antenna (like a transformer)
  - Varying magnetic flux induces current in tag. Modulate tag load to communicate with reader
  - Field energy decreases proportionally to $1/R^3$ (to first order)
- Far field (UHF, microwave):   backscatter.
  - Modulate back scatter by changing antenna impedance
  - Field energy decreases proportionally to $1/R$
- Boundery between near and far field: R = wavelength/2 pi so, once have reached far field, lower frequencies
   will have lost significantly more energy than high frequencies
- Absorption by non-conductive materials significant problem for microwave frequencies

RFID Technology

- RFID (radio frequency identification)
  - Reader (base station) sends a radio interrogation signal
  - RFID tag backscatters its ID
  - Proximity-based technology: determine the tag location by measuring the signal's time of flight (in theory)
- Characteristics
  - No line-of sight necessary (in contrast to barcodes)
  - Resist environmental conditions: frost, heat, dirt, …
  - RFID tags with read & write memory (nonvolatile EEPROM)
  - Smartcard functionality (JavaCard): cryptographic computations for personal contact cards

The Readers

- Readers (interrogators) can be at a fixed point such as
  - Entrance/exit
  - Point of sale
  - Warehouse

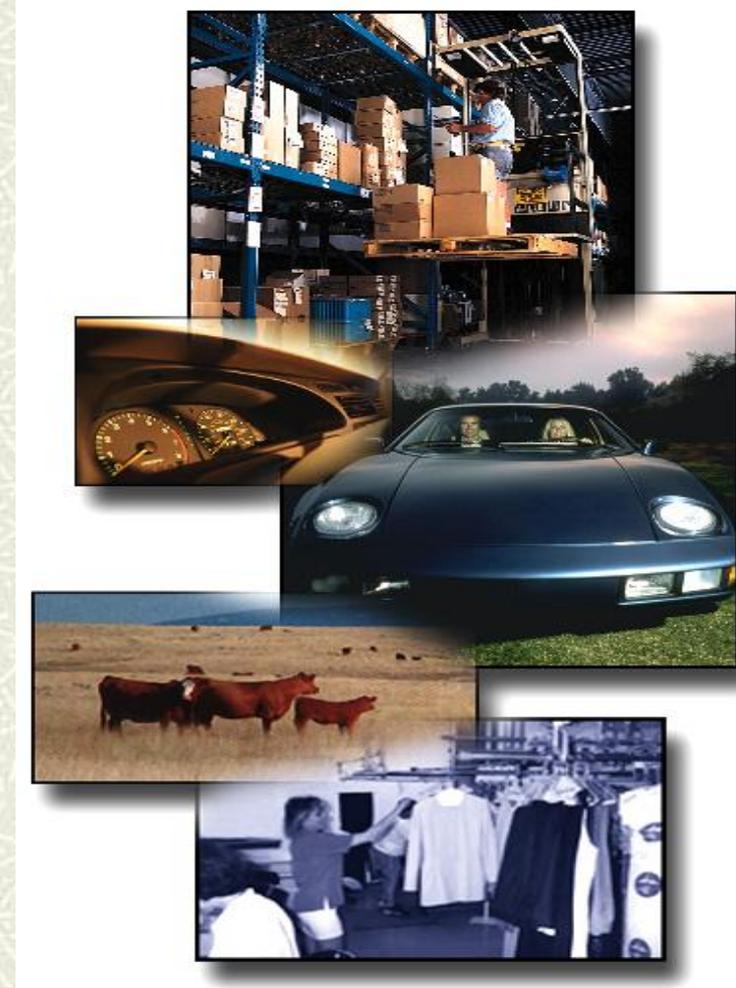- Readers can also be mobile -- tethered, hand-held, or wireless

The Tags

Tags can be attached to almost anything:

- pallets or cases of product
- vehicles
- company assets or personnel
- items such as apparel, luggage, laundry
- people, livestock, or pets
- high value electronics such as computers, TVs, camcorders

Passive RFIDs

Operation

- Do not need an internal power source
- Operating power is supplied by the reader
- Electrical current induced in the tag's antenna by the radio signal pulse of the reader

Features

- Can be used for distances of up to 3 meters
- Can be very small: 0.15 mm $\times$ 0.15 mm, 7.7µm thick (RFID powder, mu-chip from Hitachi)
- Very cheap (a few cents)

Active RFIDs

- **Operation**
  - Own power source (battery life expectancy: up to 10 years)
- **Features**
  - Cost: a few dollars
  - Size: as small as a small coin
  - Support read ranges up to 100 meters
  - Deployment in more difficult RF situations (water)
  - Tags have typically a higher scanning reliability

Tag Details

|	LF	HF	UHF	Microwave
Freq. Range	125 - 134KHz	13.56 MHz	866 - 915MHz	2.45 - 5.8 GHz
Read Range	10 cm	1M	2-7 M	1M
Market share	74%	17%	6%	3%
Coupling	Magnetic	Magnetic	Electro magnetic	Electro magnetic
Existing standards	11784/85, 14223	18000-3.1, 15693,14443 A, B, and C	EPC C0, C1, C1G2, 18000-6	18000-4
Application	Smart Card, Ticketing, animal tagging, Access, Laundry	Small item management, supply chain, Anti-theft, library, transportation	Transportation vehicle ID, Access/Security, large item management, supply chain	Transportation vehicle ID (road toll), Access/Security, large item management, supply chain

Substitute of bar code

☹ Item by item scanning

☺ Scanning of set of items

Electronic Article Surveillance (EAS)

EAS scanning field
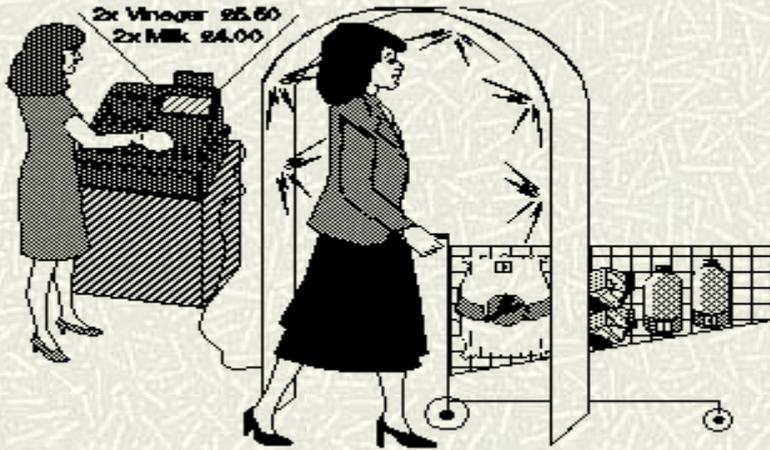
■ *Batch identification*
  - No handling
  - Fast identification
    - ✓ More than 200 tags per second

Anti-Collision & Singulation

- Problem
  - RFID tags are simple and cannot communicate with other tags
  - High probability that two tags in communication range respond simultaneously
  - Collision: response on the same frequency at the same time
- Anti-collision and singulation protocols
  - Algorithms to identify all tags (tag identification problem)
  - Anti-collision: trade time for the possibility to interrogate all tags
  - Singulation: identify (iterate through) individual tags

Reader-collision Problem

- Caused by having multiple readers and single or multiple tags.
- Reader-to-reader collision affects the reception of the tag signal by the desired reader
- Reader-to-tag collision occurs when the reception of the signal from the desired reader is affected.

WSNs *vs.* RFID Systems

Attribute	WSNs	RFID systems
Purpose	Sense parameters in environment or provide information on the condition of attached objects	Detect presence of tagged objects
Component	Sensor nodes, relay nodes, sinks	Tags, readers
Protocols	Zigbee, Wi-Fi	RFID standards
Communication	Multihop	Single-hop
Mobility	Sensor nodes are usually static	Tags move with attached objects

WSNs *vs.* RFID Systems

Attribute	WSNs	RFID systems
Power supply	Battery-powered	Tags are battery-powered or passive
Programmability	Programmable	Usually closed systems
Price	Sensor node — medium Sink — expensive	Reader — expensive Tag — cheap
Deployment	Random or fixed	Fixed, usually requires careful placement
Design goal	WSNs are general-purpose	Tags are optimized to perform a single operation, such as read

Integration of RFID and Sensors

- **Sensors and RFID are attached to the same object**
  - ❑ Ex: Both RFID and sensors are used to identifying objects or people

- **WSN is used for providing multi-hop communication and RFID is used to** identify and track objects and people.

- **WSN is used for providing location and RFID is used to identify and track** objects and people.