Chapter 4

RFID

What is RFID?

- Radio Frequency Identification (RFID)—describes technologies that use radio waves to automatically identify people or objects.
- RFID tags can be applied to or incorporated into a product, animal, or person, for the purpose of identification using radio waves.
- 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..
  - Is fast and does not require physical sight or contact between reader/scanner and the tagged item.
  - Performs the operation using low cost components.
  - Attempts to provide unique identification and backend integration that allows for wide range of applications.
- Other ADC technologies: Bar codes, OCR.

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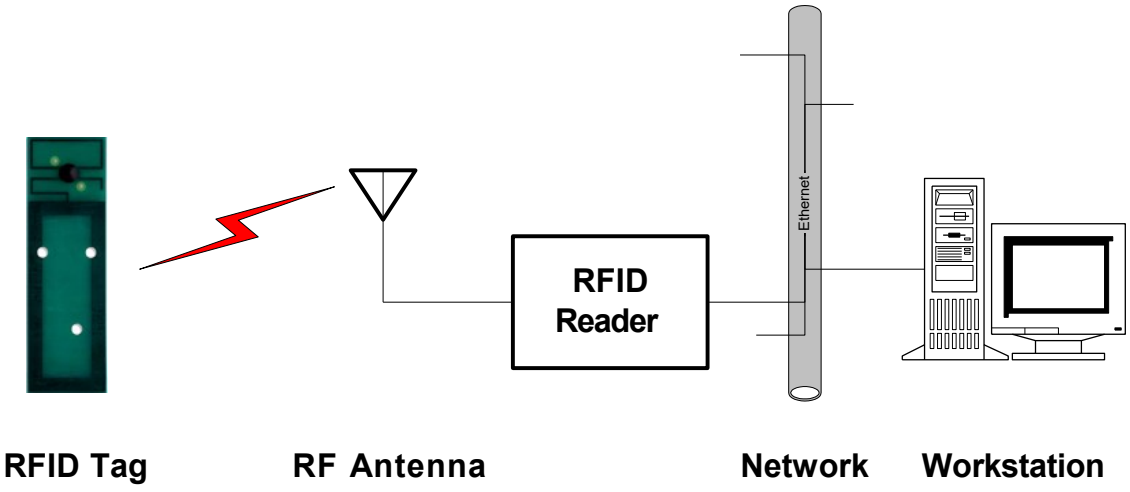
RFID system components



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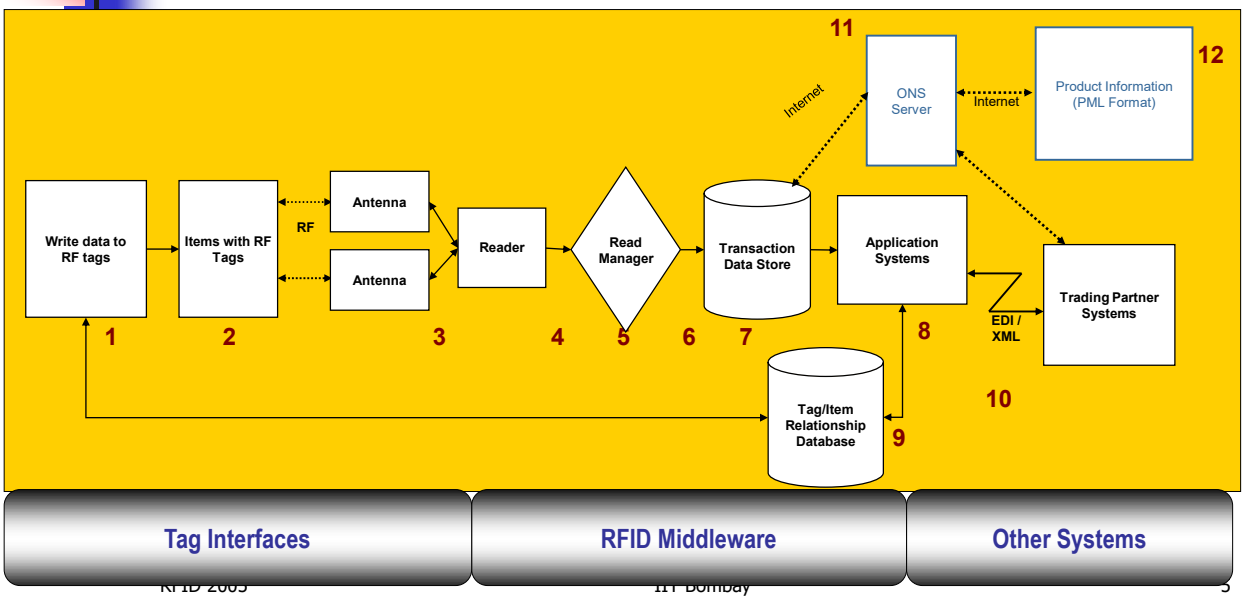
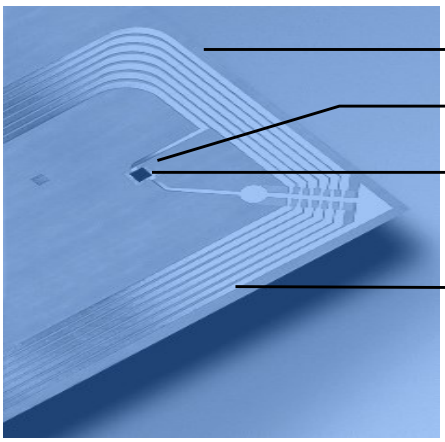
- There are three parts to a RFID system:
  1. Antenna
     - Provides a means of communication and energy to communicate with RFID tag
     - RFID tag passes through field of the antenna and the RFID tag detects the activation signal from the antenna causing the RFID tag to transmit the information on the microchip to the transceiver.
       - Permanently affixed to a surface or handheld
  2. Transceiver
     - Has a decoder to interpret the data
  3. RFID Tag (Transporter)
     - Programmed with information

RFID systems: logical view



What is Radio Frequency Identification (RFID)?

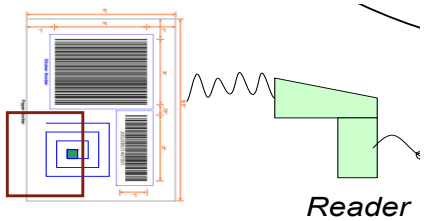


Substrate

Die attach

Tag IC

Antenna



- Can be Passive or Active
- Can be Read-only or Read-Write

RFID vs. Bar Codes

- How is RFID different from Bar Codes?
  - Tag does not need to be on the surface of the object because they do not need a direct line of sight, tags can be embedded or hidden.
  - Tags are applicable in harsh environments, such as outdoors, around chemicals, moisture and high temperatures.
  - RFID tags can be read at a rate of forty or more tags per second; Bar Codes usually take half a second or more per bar code.
  - RFID tags can be read at distances up to 300 feet; Bar Codes no more than 15 feet.
  - RFID Tags can be re-programmed; Bar Codes do not have the read/write capability

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Some Claimed Advantages of RFID vs. Barcode

- No requirement for line-of-sight
- Many tags can be read at the same time
- High memory capacity if needed
- Dynamic information carrier (read/write)
- Robust and reliable
- Performs in rugged, harsh environment
- Cheaper in long term
- No human intervention
- Reader virtually maintenance free

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RFID vs. Bar Codes

	Manual Process	Bar Code	RFID
Data Accuracy	Least Accurate	Most Accurate	More Accurate
Data Collection Time/Labor	Most Time/Labor	Some Time/Labor	Least Time/Labor
Data Input Time/Labor	Most Time/Labor	Some Time/Labor	Least Time/Labor
Equipment Costs (tags, readers/scanners)	N/A	Some	More
Ability to Track Assets Out of Line of Sight	No	No	Yes
Amount of Data Storage on Tag	N/A	Less	More
Ability to Exchange Information Two Ways	No	No	Yes
Ability to Reprogram Tags	N/A	No	Yes

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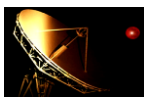
RFID: The History

RFID TIMELINE

Pre-50's

- 1926: Baird's radio object detection patent
- 1935: Watson-Watt's radar patent
- WW II: Radar refined



- 1948: Harry Stockman - Communications By Means of Reflected Power

1950's

- 1952: Vernon "Application of the Microwave Homodyne"
- Harris patent: "Radio transmission systems with modulatable passive responder"

1960's

- Harrington "Active & Loaded Scatterers"

- 1966: Sensor-matic & Check-point EAS

- 1969: Mario Cardullo RFID concept

1970's

- 1973: Cardullo patent
- 1975 LASL releases research to public sector
- LASL spins-off IDX & Amtech
- Fairchild, RCA & Raytheon initiate pgms
- 1977: Electronic license plate for motor vehicles

- 1979: RFID animal implants

1980's

- Over 350 direct - reference patents

- 1984: IDX/Allen Bradley install GM System
- Multiple early adopter installations

- 1st Toll Collection System - Norway

1990's

- MIT Auto-ID Center formation
- EPC™ introduced
- National & international standards emerge

- 1991: AAR standard

- 1994: All US railcars outfitted
- 1997:US Army rolls out TC-AIMS II
- Vast number of companies enter RFID marketplace

- Texas, Georgia / Oklahoma Tolls

2000's

- Smart shelves
- 2003: RFID prominent in Iraqi Freedom
- EPCglobal formed 2003

- 2004: TREAD
- 2005: Walmart initial deadline

- Wide-scale US Roll-out

Adapted from Interaction Design Institute RFID Project Presentation - 2002

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History

- 1940-1950
  - First work exploring RFID by Harry Stockman
  - Followed advances in radio & radar
- 1950-1960
  - Era of exploration, laboratory experiments
- 1960-1970
  - First and most widespread commercial use
    - Electronic article surveillance, Sensormatic
- 1970-1980
  - Explosion of RFID development work
    - Animal and vehicle tracking, factory automation

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History

- 1980-1990
  - Commercial implementation enters mainstream
  - Transportation, personnel access, & animals
- 1990-2000
  - Emergence of Standards
  - Becomes part of everyday life
    - Electronic highway tolling system
- 2000-
  - Exciting times await in the advancement of RFID

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Electronic Product Code

In 1999 at the **Auto-ID Center** of the Massachussets Institute of Technology, the **EPC (Electronic Product Code)** was born.

Massachusetts Institute of Technology

The barcode technology allows to item topology identification

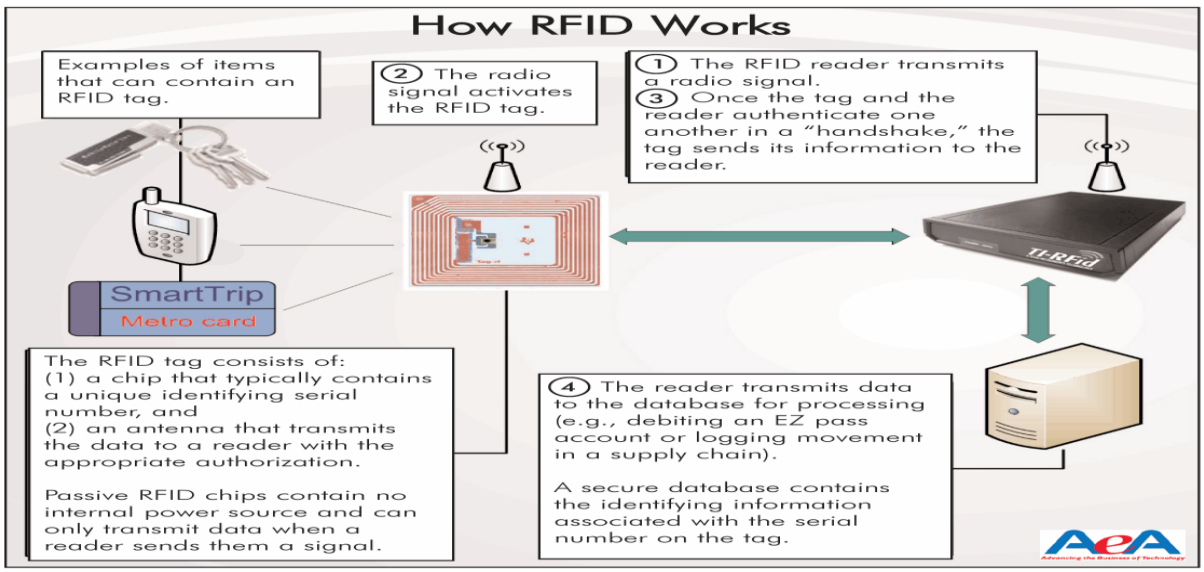
*The EPC allows **single** item identification*

01.0000A4F.001AD.000000001

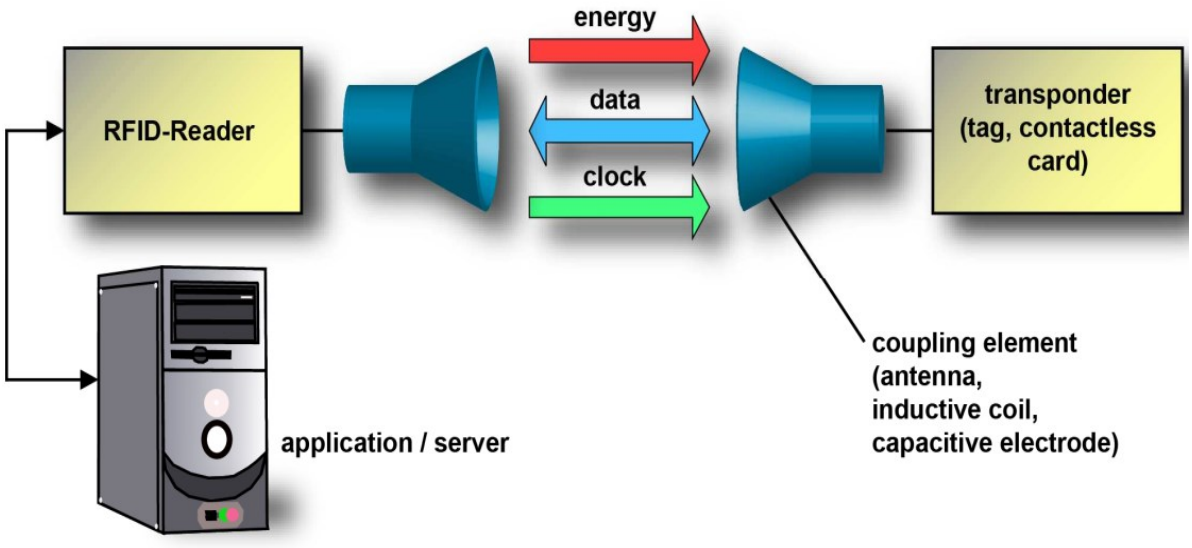
- HEADER (8 bit)
- EPC MANAGER (28 bit)
- OBJECT CLASS (24 bit)
- SERIAL NUMBER (36 bit)

- HEADER **defines the EPC length (from 64 to 256 bits).**
- EPC MANAGER **indicates tag producer**
- OBJECT CLASS **indicates tag topology**
- SERIAL NUMBER **indicates the unique identification number for each tag**

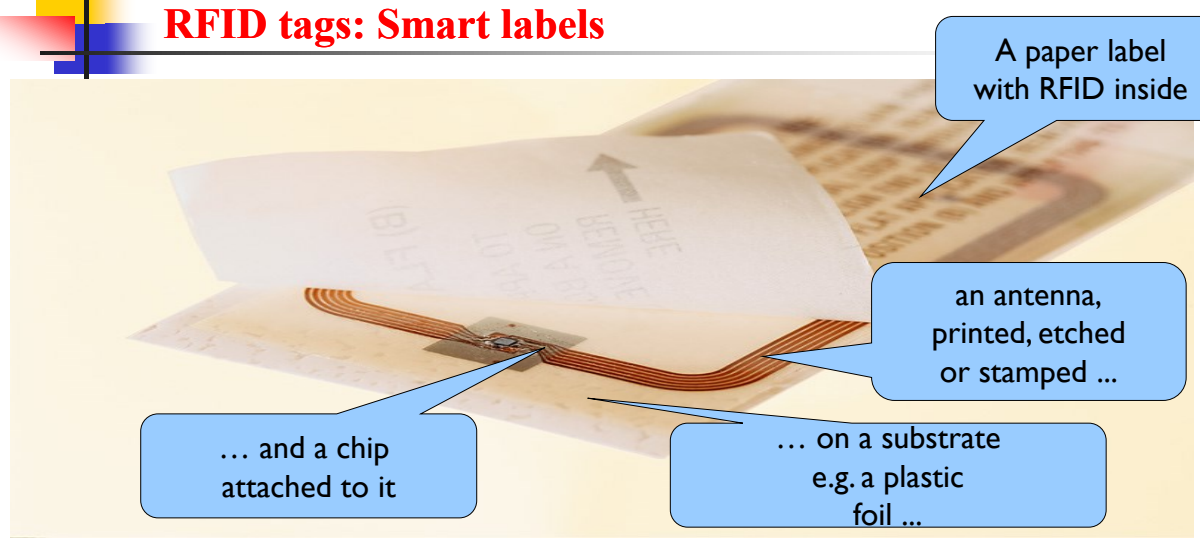
How RFID Works



Basic operating principles of an RFID system



RFID tags: Smart labels



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Tags vary significantly in their computational capabilities

- Passive tags have limited computational capacity, no ability to sense the channel, detect collisions, and communicate with each other
- They respond only at reader commands
- Semi-passive tags have an on-board power source that can be used to energize their microchip
- Active tags can sense the channel and detect collisions

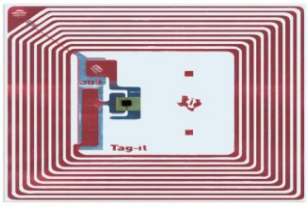
Passive tags

Semi-passive tags

Active tags

RFID devices may take different forms

- RFID systems operate in the Industry, Scientific and Medical (ISM) frequency band that ranges from 100 KHz to 5.8 GHz



RFID tags

- Tags can be attached to almost anything:
  - Items, cases or pallets of products, high value goods
  - vehicles, assets, livestock or personnel
- **Passive Tags**
  - Do not require power – Draws from Interrogator Field
  - Lower storage capacities (few bits to 1 KB)
  - Shorter read ranges (4 inches to 15 feet)
  - Usually Write-Once-Read-Many/Read-Only tags
  - Cost around 25 cents to few dollars
- **Active Tags**
  - Battery powered
  - Higher storage capacities (512 KB)
  - Longer read range (300 feet)
  - Typically can be re-written by RF Interrogators
  - Cost around 50 to 250 dollars

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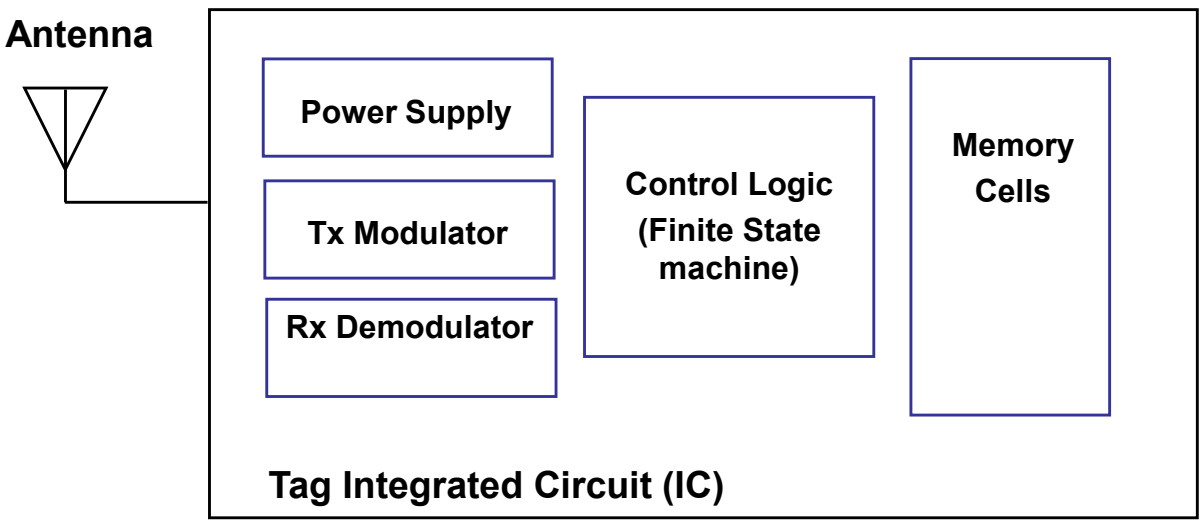
Tag block diagram



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RFID tag memory

- Read-only tags
  - Tag ID is assigned at the factory during manufacturing
    - Can never be changed
    - No additional data can be assigned to the tag
- Write once, read many (WORM) tags
  - Data written once, e.g., during packing or manufacturing
    - Tag is locked once data is written
    - Similar to a compact disc or DVD
- Read/Write
  - Tag data can be changed over time
    - Part or all of the data section can be locked

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RFID readers

- Reader functions:
  - Remotely power tags
  - Establish a bidirectional data link
  - Inventory tags, filter results
  - Communicate with networked server(s)
  - Can read 100-300 tags per second
- Readers (interrogators) can be at a fixed point such as
  - Entrance/exit
  - Point of sale
- Readers can also be mobile/hand-held

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Some RFID readers





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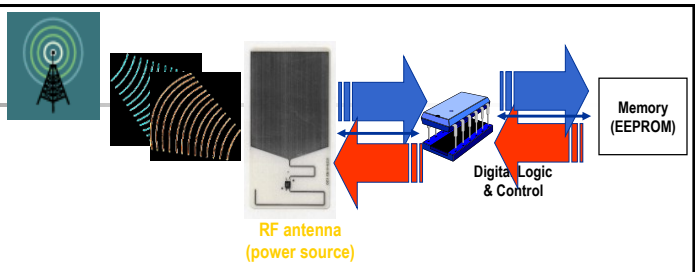
Tag Types: Passive



- Passive:
  - Standard: None/many, Mainly Manufacturers Proprietary Systems/Protocols (uses back scatter technology)
  - Range: Typically Measured in “Inches”, Working Toward “Meters” (dependant system layout, interference, etc.)
  - Used Predominantly in Retail Systems and Transportation Systems.
  - Characteristics: Small Tag Loaded with License Plate Data
  - Typically Mounted to End Item, Reader Captures Data as Item Moves Through Choke Point (door, pathway, frame, etc.).
  - Data Capacity Limited.

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Passive tags

Passive tags are mostly spread due to their low cost (<0,60 €)

Substrate: paper, plastic film, other

Chip:

- Tag identification code storage
- Converter of reader energy in tag feeding
- Modulator of the reflected power to communicate tag identification code
- Read Only (RO) memory or Read Write (RW) memory

Antenna:

- **Designed to collect as much energy as possible (chip feeding and communicating tag identification code**
- **Shape and size depending on operational frequency**

HF band

- *Loop antennas (inductive coupling)*
- *Reading range<0.5 m*


45x41.5 mm²

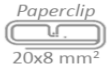

30x16 mm²

UHF band

- *Dipole antennas (electromagnetic propagation)*
- *Reading range* 2-5 m

Alien Squiggle ALN9640


96x9 mm²


Paperclip
20x8 mm²

Satellite


32x18 mm²

Passive Tags

Have no internal power supply,

Power supplied by the reader

Cost	Less Expensive--Few Cent to a Few Dollars
Size	Smaller
Power	Reader
Maintenance	None
Read Distance	A few feet
Life	Up to 20 years
Memory	Around 16K

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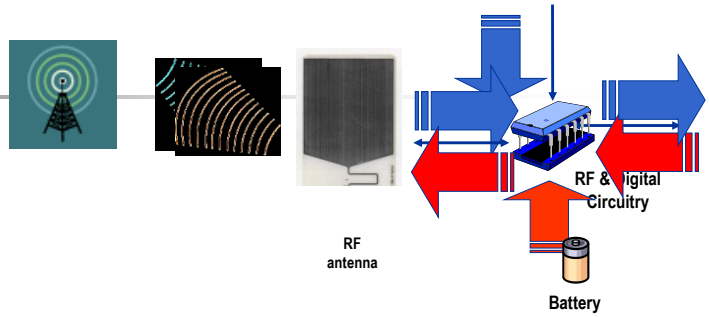
Tag Types: Active



- Active:
  - Standard: None, Mainly Manufacturers Proprietary Systems/Protocols
  - Range: Generally 300 Feet or less
  - Battery powered / limited life
  - Used Predominantly in Transportation Systems (rail, toll systems, trucking, container).
  - Characteristics: Tag with Internal Power Cell Mounted to Item or container/pallet/box, Interrogator Queries Tags, Uploads/Downloads Data. Does not transmit all of the time. Data Capacity Varies.

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Active Tags

Have their own internal power source,

Can have a replaceable battery

Cost	More expensive--often $20 or more
Size	Larger
Power	Provided by Battery
Maintenance	Replacement Required
Read Distance	Up to 100s of feet
Life	Depends on battery life
Memory	As high as 512K

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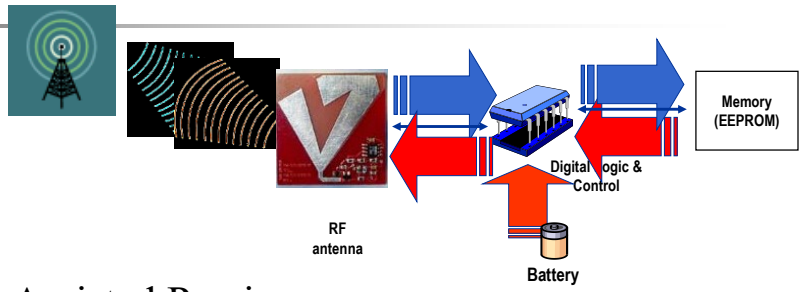
Tag Types: Semi-Active



- Semi-Active or Battery Assisted Passive
  - On-board battery power source
    - Uses Passive Technology (no transmitter)
    - Greater range but higher cost (less than active)
    - Requires less power from reader
    - Finite life
    - Can use thin batteries (little change to form factor)

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Semipassive tags and active tags

Semipassive UHF tag:

- Battery feeds chip and sensor (e.g. temperature sensor, humidity sensor, etc.)
- Antenna designed to maximize backscattering power (it is not required that it stores power)
- Saving power thanks to battery swicth on with a proper reader signal
- Cost of few euros
- Limited reading range as in passive system

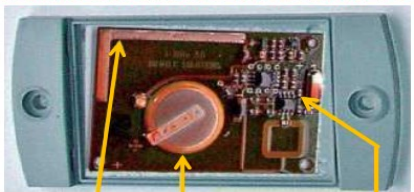
CAEN RFID A927Z (130x23 mm²)

CAEN RFID Semipassive UHF RFID tag with temperature sensor

CAEN RFID RT0005 (107x107mm²)

Active tag:

- Reading range of hundreds meters (transmitter equipped)
- Cost of tens euros
- UHF and SHF bands
- Life time depending on battery



Tag Types - Read vs Read/Write

- Read Only:
  - **Information can only be read from an RFID device – programmed at manufacture**
- User Programmable
  - **WORM - Write Once Read Many - Ability to initialize an RFID device outside of the RFID manufacturer's facility *after manufacture***
- Read/Write:
  - **Information can be read from or written to an RFID transponder during the time it is presented to a reader/writer**
  - **Typically asymmetric read and write operating range**

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Technical Considerations

- **Anticollision**
  - **Ability to communicate with several transponders *simultaneously***
  - **Important in longer range readers**
  - **Must be implemented in the silicon of the RFID device**
- **Who Talks First**
  - **Tag Talks First (TTF)**
    - **After the tag is energized, it sends out a signal that says "I am here"**
  - **Reader Talks First (RTF)**
    - **As reader sends out energization signal it says "who is there"**
  - **Problems**
    - **With TTF you can get tag pollution but slower total read time**
    - **Compatibility issues?**

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Protocol

- The method used to talk to a tag
  - **Modulation method**
  - **Error correction**
  - **Anti-collision technique**
  - **Message format**
  - **Commands**

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RFID Operating Frequencies

Low Frequency (125 – 134 kHz)

Used in Access control, livestock, race timing, pallet tracking, automotive immobilizers, wireless commerce

High Frequency (13.56 mHz) – Smart Labels

Used in supply chain, wireless commerce, ticketing, product authentication

Ultra-High Frequency – UHF (900+ mHz)

Emerging technology, applications still in development

Microwave (2.45 gHz)

Still highly experimental, chipless technology

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Inductive LF tags

125.5 KHz

Car Immobilizer

Tag with glass cover (injected under the skin)

134.2 KHz: Animal tracking

Tag with ceramic cover (animal stomach).

Ears tag

- Inductive coupling
- Mostly passive tags
- Reading range <0.5 m
- Low data rate (<10 kbps)
- Multiple readings (anticollision algorithm)
- Good performance with liquids and organic tissues

Inductive HF tags (13.56 MHz)

Smart labels

Baggage handling

Clothing

Logistics

Smart cards

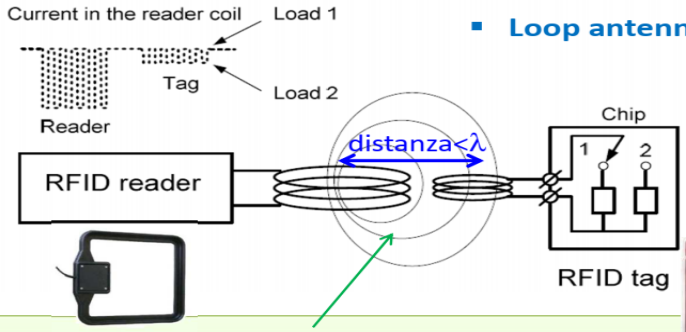
Skypass

Credit cards

- Inductive coupling
- Mostly passive tags
- Reading range~1 m
- Data rate up to 64 kbps
- Multiple readings (20-30 tag/s)
- Good performance with non-conducting liquids and organic tissues

Inductive coupling

The variable magnetic field induces current on the tag antenna (electrical transformer)



- **Loop antennas typically employed**

The tag communicates the identification code by varying its load impedance (load modulation).

Many coils are required (critical parameter)

System performance related to:

- Tag antenna (loops number)
- Reader antenna (loop sizes, loops number, maximum current)
- Mutual positioning and mutual coupling among antennas
- Tag Q-factor
- Distance among antennas (available power at the tag side proportional to $1/d^6$)

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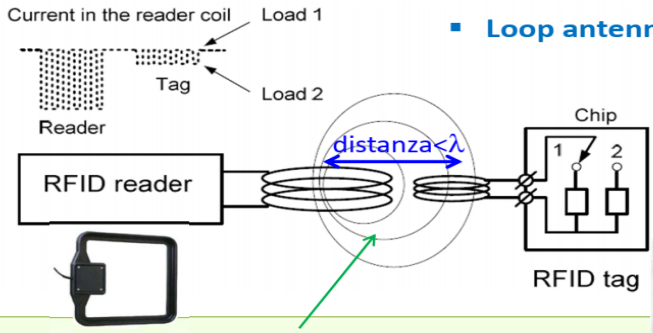

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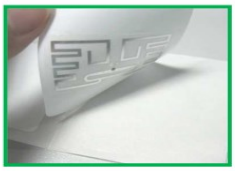
UHF tags

Logistics



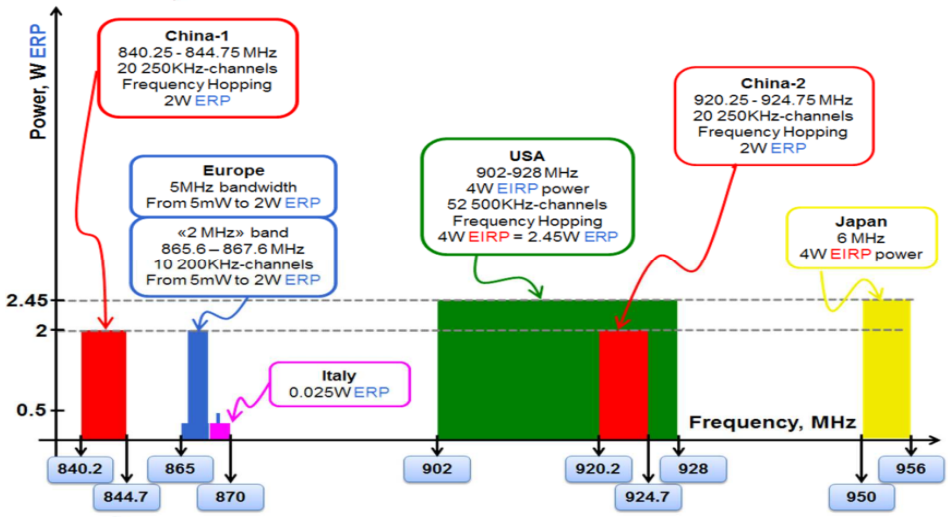
- Electromagnetic propagation as in communication systems
- Passive and active tags
- Reading range ~2-5 m
- Data rate up to 640 kbps
- Multiple readings (200 tag/s)
- Low performance in presence of liquids, organic tissues and metals

Metal tags

UHF tags

Frequencies employed within the UHF band are different from region to region

Interoperability problem



ERP=*Effective Radiated Power* (reference: ideal dipole)

EIRP=*Effective Isotropic Radiated Power* (reference: isotropic radiator)

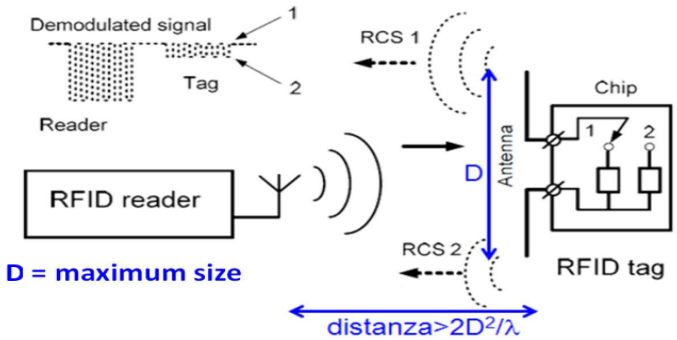
$$|E|^2 \propto \frac{1}{r^2} EIRP$$

$$EIRP = P_t \cdot G_t$$

Passive tags have wideband design at the expence of performance

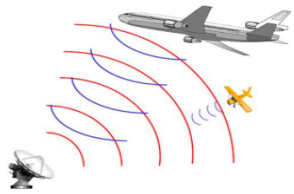
Electromagnetic propagation

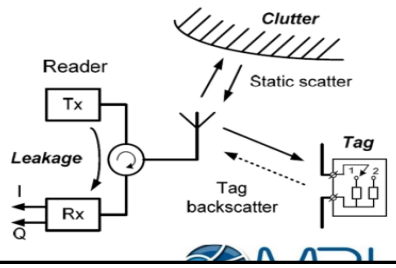
In UHF-RFID system the communication occurs through electromagnetic propagation



D = maximum size

The tag backscatters the received power (radar system principle)



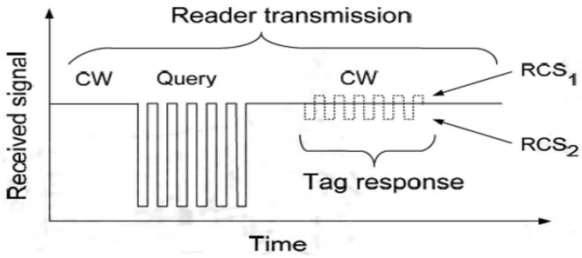


System performance related to:

- **Input power at the reader**
- **Tag and reader antennas (gain, mutual positioning)**
- **Indoor scenario (multipath can degrades performance)**

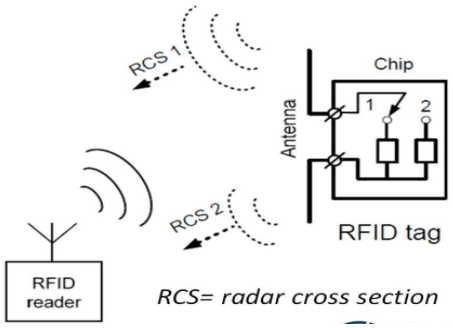
Electromagnetic propagation

Passive system:



The reader transmits the interrogation signal together with a continuous wave to feed the tag (passive system)

The received power is partially absorbed by the tag and partially reflected by the tag to communicate its identification code through a «modulated backscattering»



Frequency Selection Issues

- Desired Pattern
- Required Range
- Tag-to-Tag Spacing
- Data Rate
- Size Requirements
- Power Requirements
- Interference Issues
- Noise Environment
- Cost / Performance Tradeoffs

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RFID System Considerations

- **Read distance requirements**
  - Long read range
  - Short read range
- **Frequency**
  - All frequencies have their pros and cons
- **ISO standards**
  - Proprietary or standards-based
- **Government regulations**
  - Varies from country to country

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RFID System Considerations

- **Multiple Tag Reading in Same Field**
  - **Anti-collision**
- **Sensitivity to Orientation**
  - **A single orientation or omni-directional**
- **Hardware Set-up**
  - **Environment can affect performance**
  - **Tag Sensitivity to Metallic environments**

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Reader Characteristics

- Stationary or handheld
- Weather-proof or industrialized
- Typical read ranges vary from a few centimeters to a few meters
- Read Range is dependent upon:
  - Broadcast signal strength
  - Size of broadcast antenna
  - Size of transponder antenna
  - The environment – Metallic, Liquid
- Multi-frequency readers

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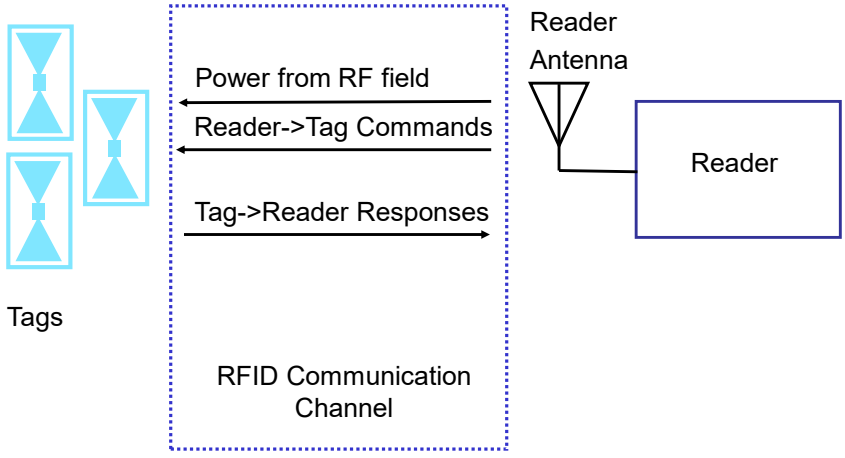
RFID Technology Internals

- RFID communications



RFID communication

- Host manages Reader(s) and issues Commands
- Reader and tag communicate via RF signal
- Carrier signal generated by the reader
- Carrier signal sent out through the antennas
- Carrier signal hits tag(s)
- Tag receives and modifies carrier signal
  - "sends back" modulated signal (Passive Backscatter – also referred to as "field disturbance device")
- Antennas receive the modulated signal and send them to the Reader
- Reader decodes the data
- Results returned to the host application

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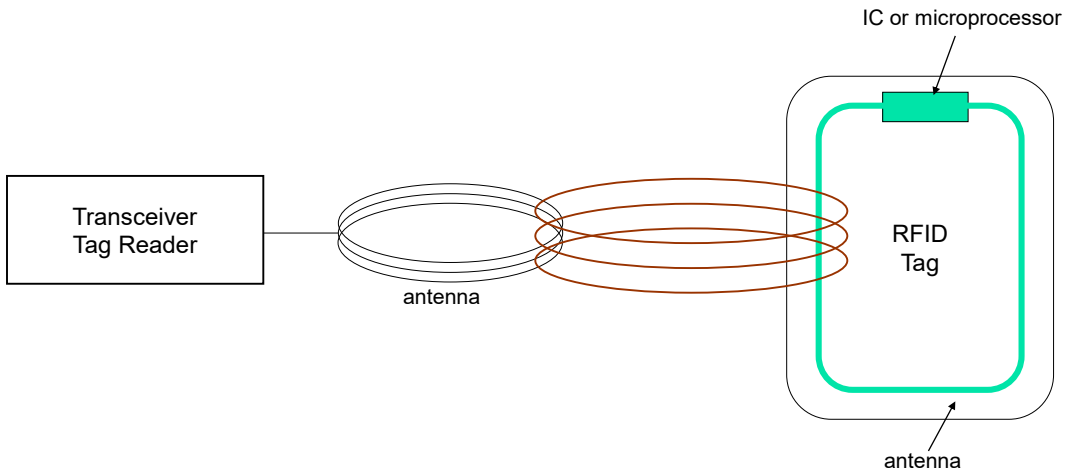
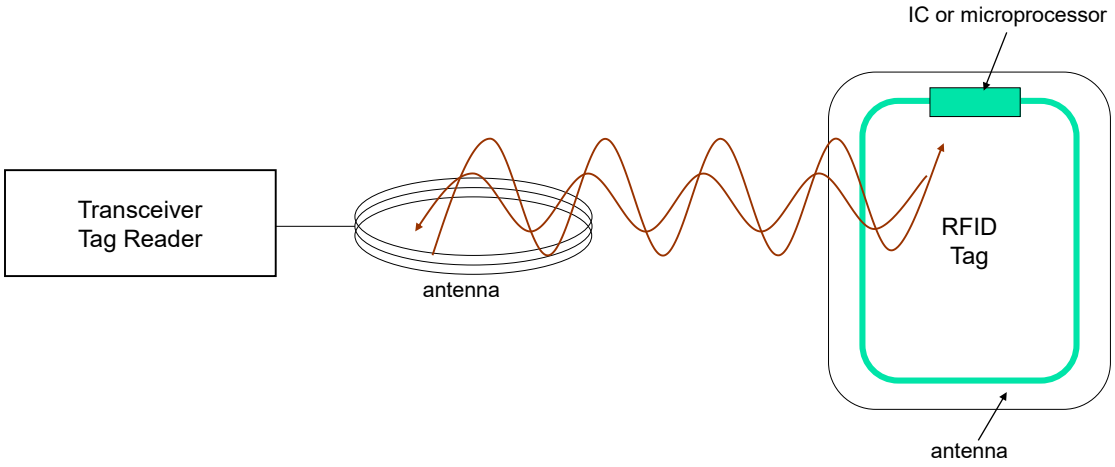
Antenna fields: Inductive coupling



50

Antenna fields: Propagation coupling



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Operational frequencies

Frequency Ranges	LF 125 KHz	HF 13.56 MHz	UHF 868 - 915 MHz	Microwave 2.45 GHz & 5.8 GHz
Typical Max Read Range (Passive Tags)	Shortest 1''-12''	Short 2''-24''	Medium 1'-10'	Longest 1'-15'
Tag Power Source	Generally passive tags only, using inductive coupling	Generally passive tags only, using inductive or capacitive coupling	Active tags with integral battery or passive tags using capacitive storage, E-field coupling	Active tags with integral battery or passive tags using capacitive storage, E-field coupling
Data Rate	Slower	Moderate	Fast	Faster
Ability to read near metal or wet surfaces	Better	Moderate	Poor	Worse
Applications	Access Control & Security Identifying widgets through manufacturing processes or in harsh environments Ranch animal identification Employee IDs	Library books Laundry identification Access Control Employee IDs	supply chain tracking Highway toll Tags	Highway toll Tags Identification of private vehicle fleets in/out of a yard or facility Asset tracking

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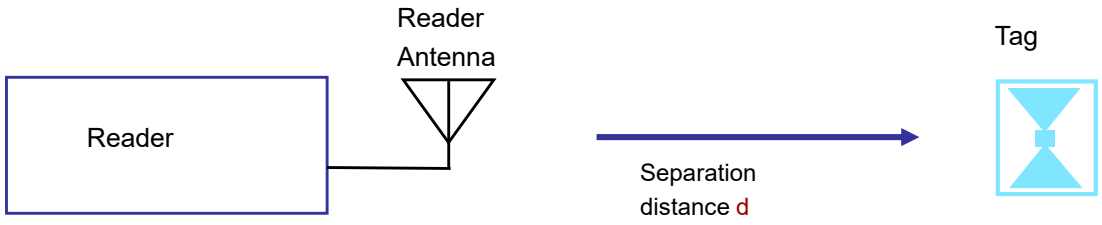
Reader->Tag power transfer



Q: If a reader transmits Pr watts, how much power Pt does the tag receive at a separation distance d?

A: It depends-

UHF (915MHz) : Far field propagation : $Pt \propto 1/d^2$

HF (13.56MHz) : Inductive coupling : $Pt \propto 1/d^6$

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Limiting factors for passive RFID

1. Reader transmitter power Pr (Gov't. limited)
2. Reader receiver sensitivity Sr
3. Reader antenna gain Gr (Gov't. limited)
4. Tag antenna gain Gt (Size limited)
5. Power required at tag Pt (Silicon process limited)
6. Tag modulator efficiency Et

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Implications

- Since $Pt \propto 1/d^2$, doubling read range requires 4X the transmitter power.
- Larger antennas can help, but at the expense of larger physical size because $G\{t,r\} \propto Area$.
- More advanced CMOS process technology will help by reducing Pt.
- At large distances, reader sensitivity limitations dominate.

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How compare to 2D barcodes

	RFID Tag	2D Barcode
Line of sight	Not required	Required
Capacity	Low to high	Low to medium
Security	High	Low to Medium
Change Information?	Yes – Read/Write	NO – new label
Cost (today)	$0.40 - $1.00 (in millions)	$0.05 or less

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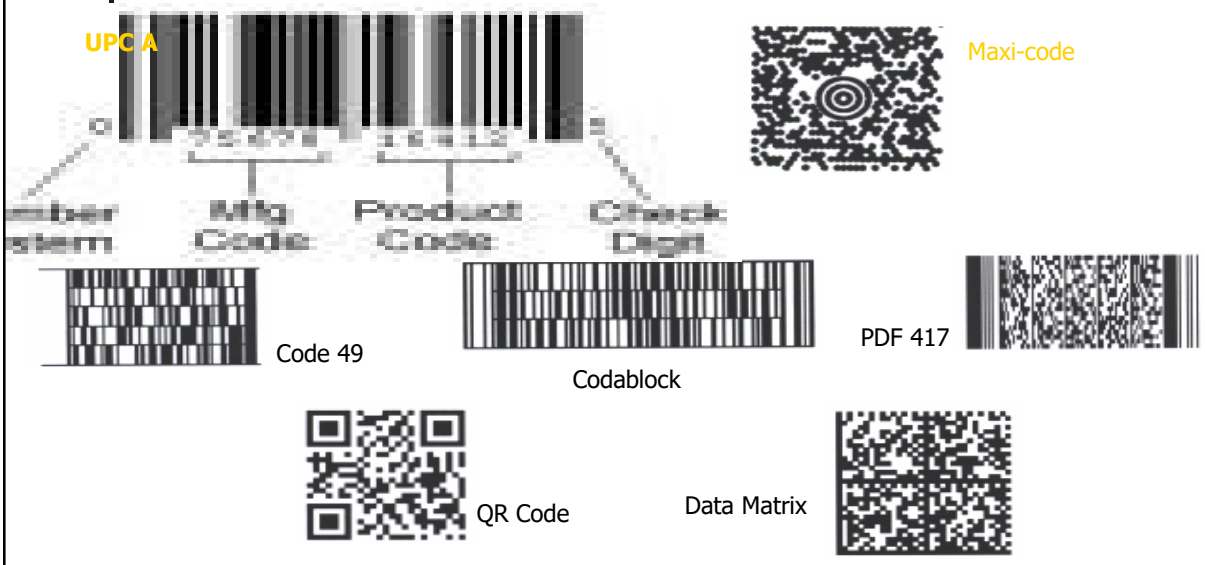
Barcode Examples – Many types



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Current Technology: Bar-coding

- **UPC A code**
  - 18 digit alphanumeric code used for identifying flow of package and billing information
  - Large database used to support this system – 18 terabytes
- **Maxi-code**
  - Determined by the locations of bars around a central dot
  - Contains information for the destination address of the package as well as weight and size specs.
  - requires special equipment and a stable environment free from movement to obtain a read of the information

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RFID vs. Bar-coding

- Bar-coding Disadvantages
  - Code must be clearly readable
    - free from dirt, smudging or other damage
    - This is problem with the constant movement of packages
  - Code must be in a position that can be easily read by a scanning device
    - Optical lasers are usually used for scanning
  - Code must be within a short distance to be read
    - Typically within 3 feet
  - Only one code can be scanned at a time
  - Codes must be a reasonable distance apart
- The use of RFID can eliminate many of the problems associated with bar-coding technology.

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RFID in Action …

Pay for Gas at Exxon/Mobil with Speedpass

Buy Burgers at McDonald's

Get a Coke from a vending machine at the Olympics

Check out library books with 3M system

Race timing at most major Marathons

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Toll tags, parking lot access

Building access control, security

Event access, ticketing

Anti-theft for automobiles

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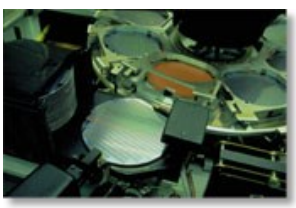
Product authentication

Chip wafer Manufacturing



Warehouse, supply chain, logistics

Livestock, asset tracking

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Electronic Article Surveillance (EAS)

Electronic Article Surveillance (EAS)

- Already exists
- RFID technology detects if an item is removed from a store without tag being deactivated
  - Amorphous magnetic strips
  - Destructible tuned circuits
- But - Existing technology cannot uniquely identify goods
- New RFID technology provides significant features:
  - Able to write SKU number into transponder
  - Automatic inventory with a hand held reader
    - Anti-collision mandatory for this feature
  - Cash registers can automatically ring up merchandise

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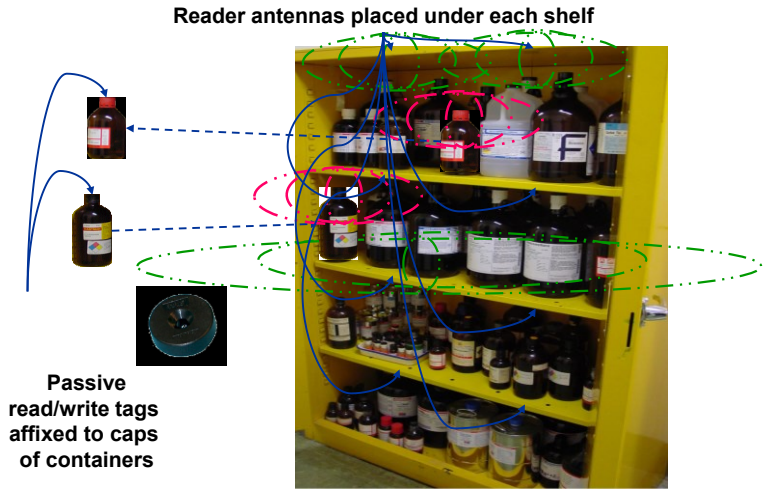
Smart groceries

- Add an RFID tag to all items in the grocery.
- As the cart leaves the store, it passes through an RFID transceiver.
- The cart is rung up in seconds.

64

Smart cabinet



1. Tagged item is removed from or placed in "Smart Cabinet"
2. "Smart Cabinet" periodically interrogates to assess inventory
3. Server/Database is updated to reflect item's disposition
4. Designated individuals are notified regarding items that need attention (cabinet and shelf location, action required)

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Smart fridge

- Recognizes what's been put in it
- Recognizes when things are removed
- Creates automatic shopping lists
- Notifies you when things are past their expiration
- Shows you the recipes that most closely match what is available

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Smart groceries enhanced

- Track products through their entire lifetime.

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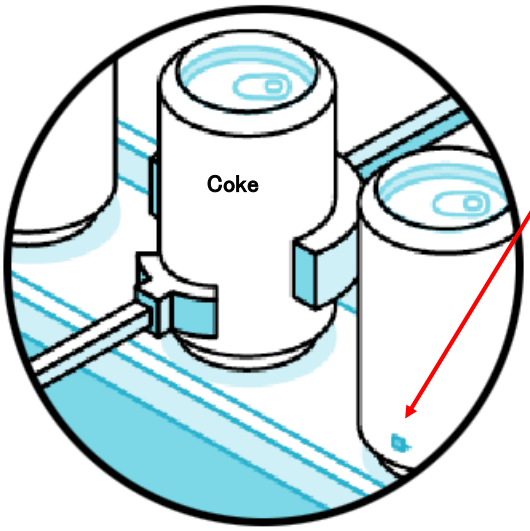
RFID – Supply Chain Perspective

"A Manufacturer of soft drinks can identify with the click of a button how many containers of its soda cans are likely to reach their expiration date in the next few days and where they are located at various grocery outlets."

How easy / realistic is this?

What infrastructure must exist?

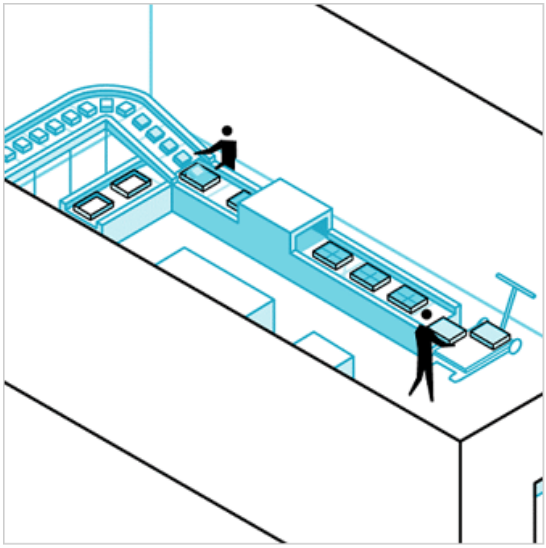
68



how it works...

Adding Identity to Products

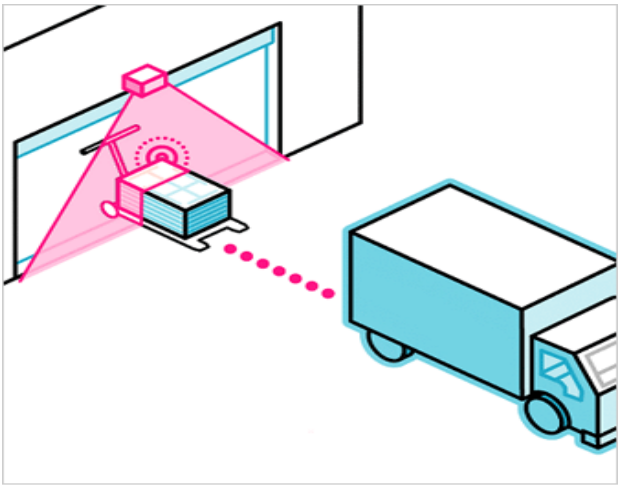
69



how it works...

Adding Identity to Cases:
Assembly line applications

70



how it works…

Reading Tags:

Portal applications:
Shipping validation &
Confirm routing

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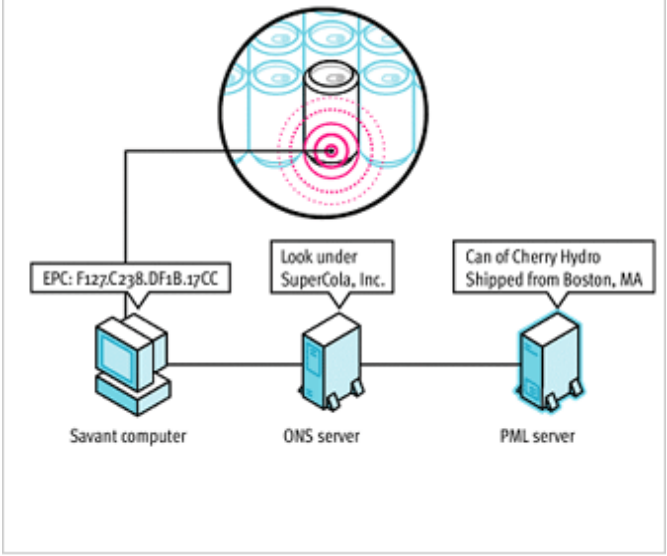


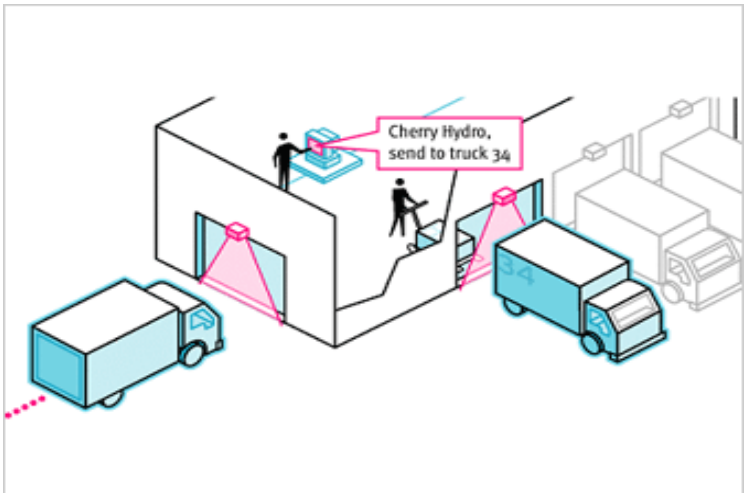
how it works…

–**Savant**
(middleware software for EPC)

–**ONS**
(Object Naming Service)

–**PML**
(Physical Markup Language)

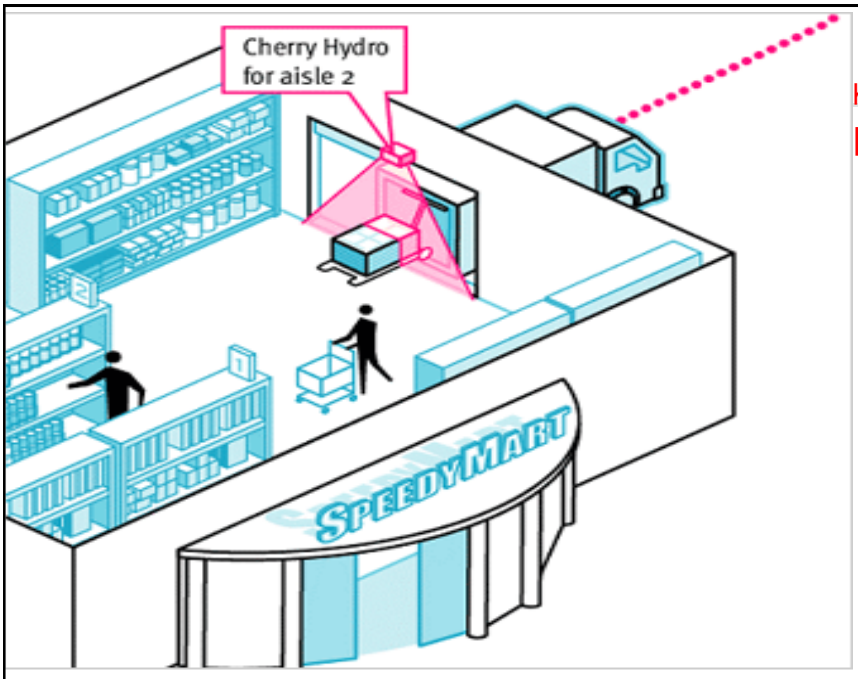
72



how it works...

Efficiency in Distribution

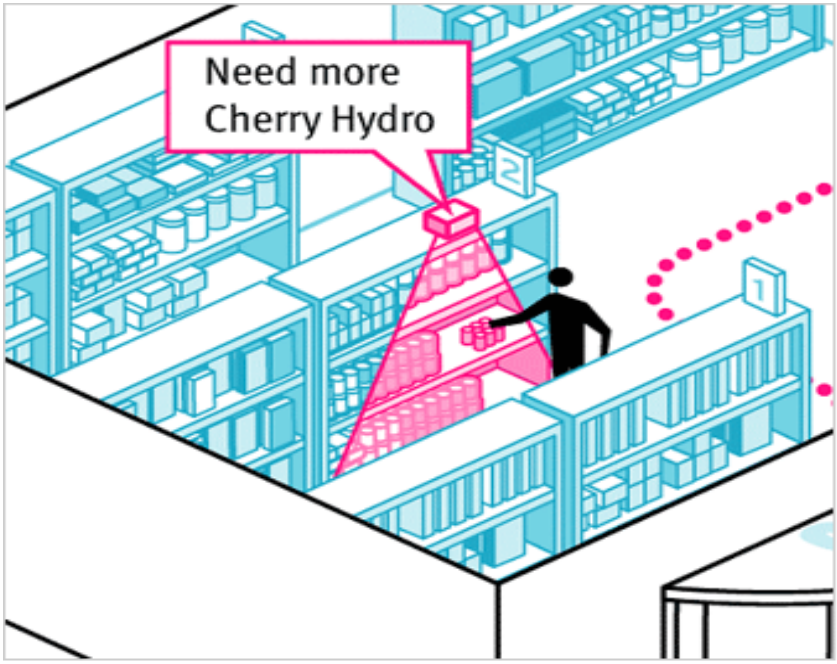
73



how it works...

Efficiency in Inventory

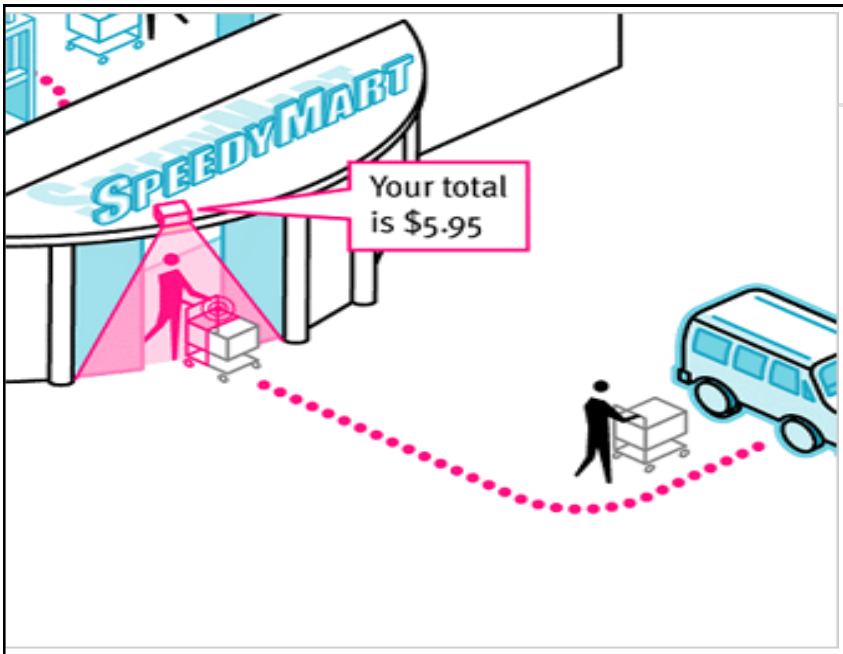
74



how it works...

Overstocking and
Out of Stock Eliminated

75



how it works...

Consumer
Convenience

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Supply Chain Reality

METRO

LOWE'S Improving Home Improvement

UNITED STATES DEPARTMENT OF DEFENSE

TESCO Every little helps

WAL★MART ALWAYS LOW PRICES. Always

MARKS & SPENCER

Albertsons

TARGET

Carrefour

The Home Depot, Inc.

It is happening ...

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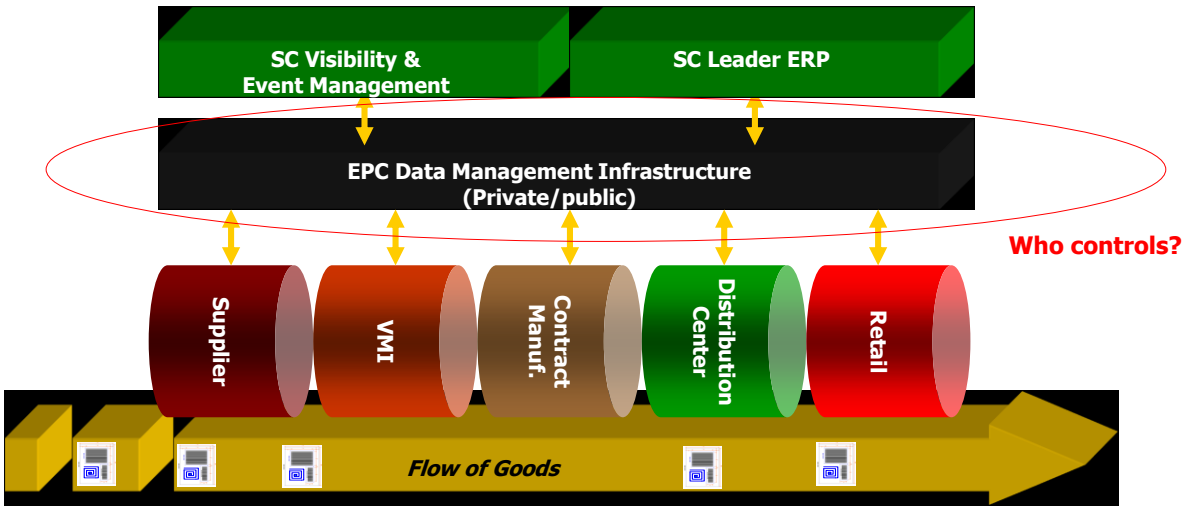
RFID in the Supply Chain



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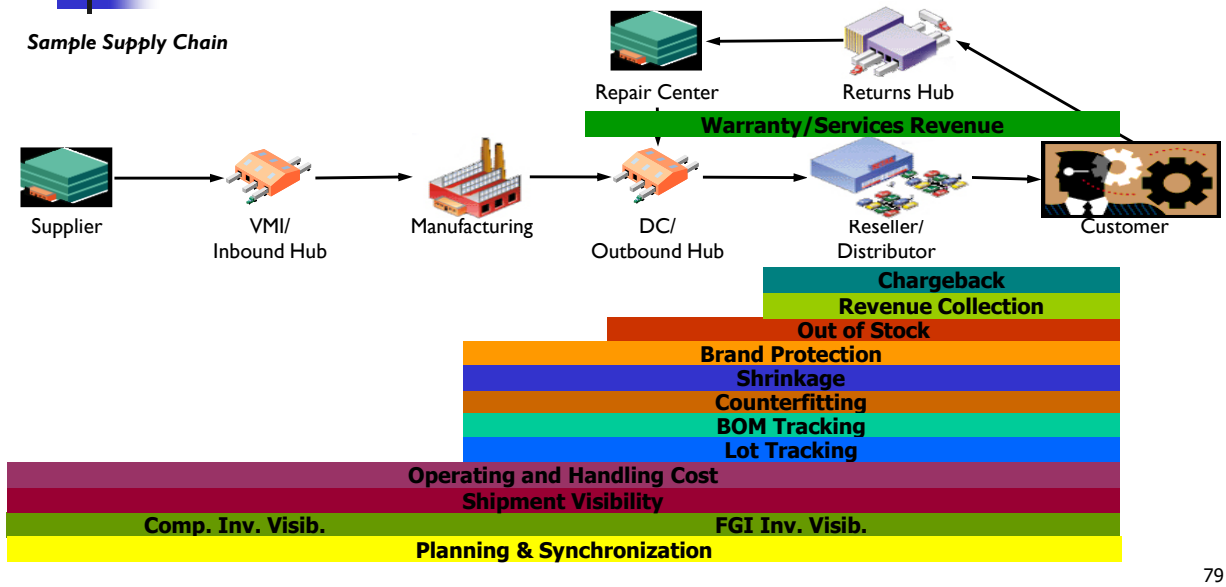
Understanding RFID's Potential



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Why do people buy RFID?

- Traditional Reasons:
  - Reduction of direct labor (80%)
    - Hand-held reader vs. Fixed reader
  - Protection and tracking of assets
    - Animals – Inventory – Tires – Access Control - etc.
  - Cost Structure reduction
    - Out of stock - 7.8% – "walk aways"
  - Only technology that will work
    - When bar codes don't work
      - (dirty / line of sight)
- New Reason:
  - Mandated

WAL*MART RFID

UNITED STATES DEPARTMENT OF DEFENSE

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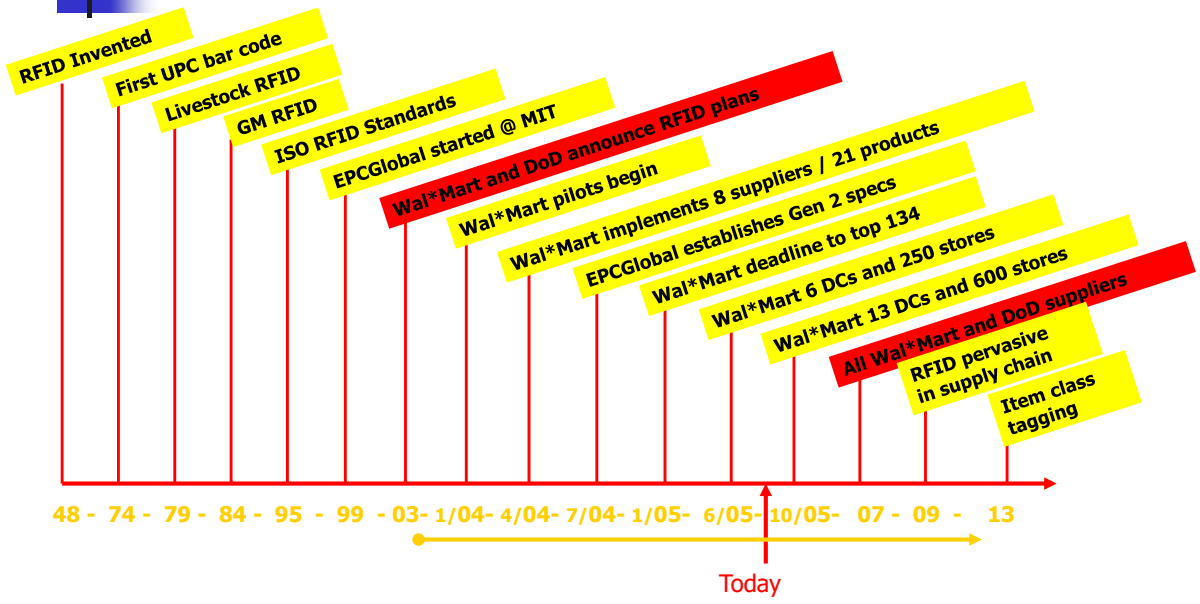
RFID Timeline (goals)



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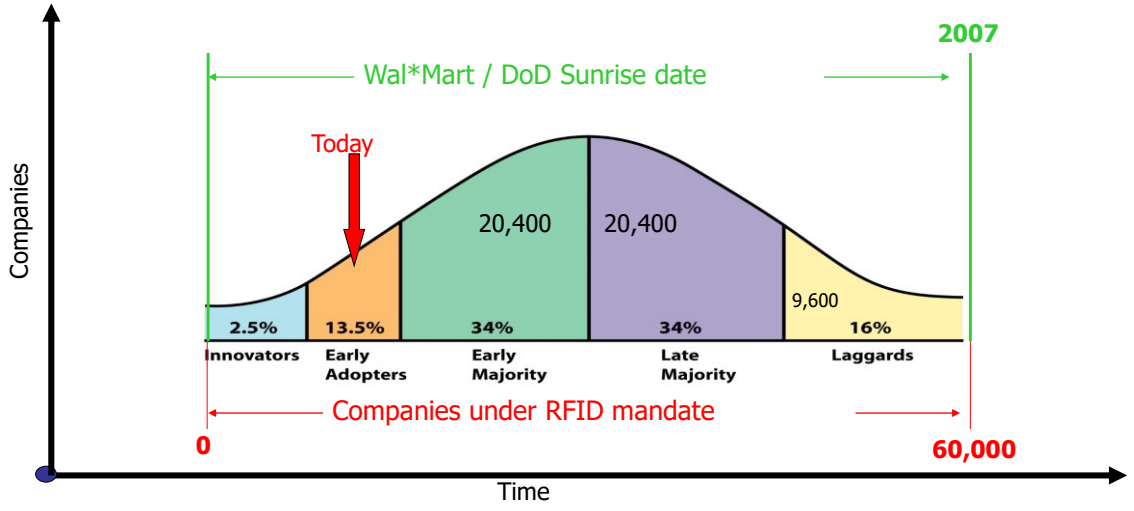
Technology Adoption Life Cycle



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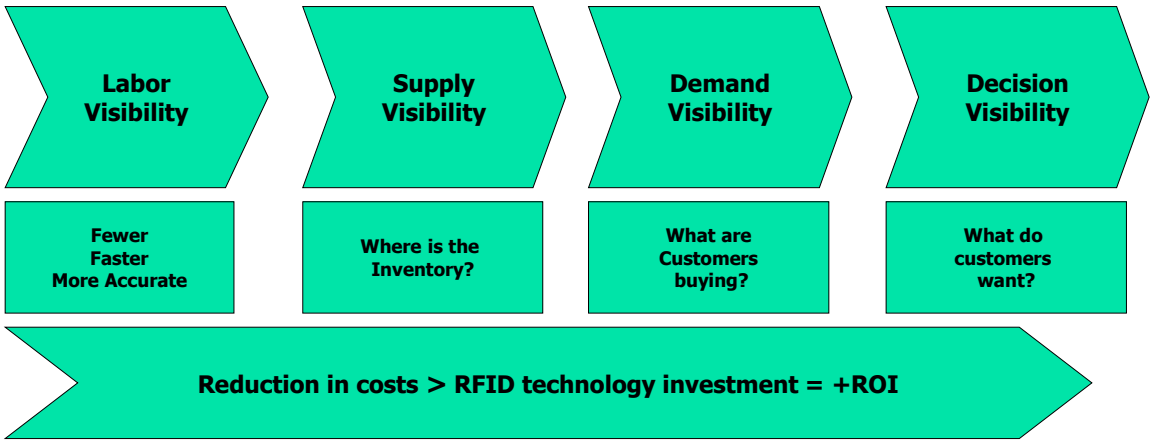
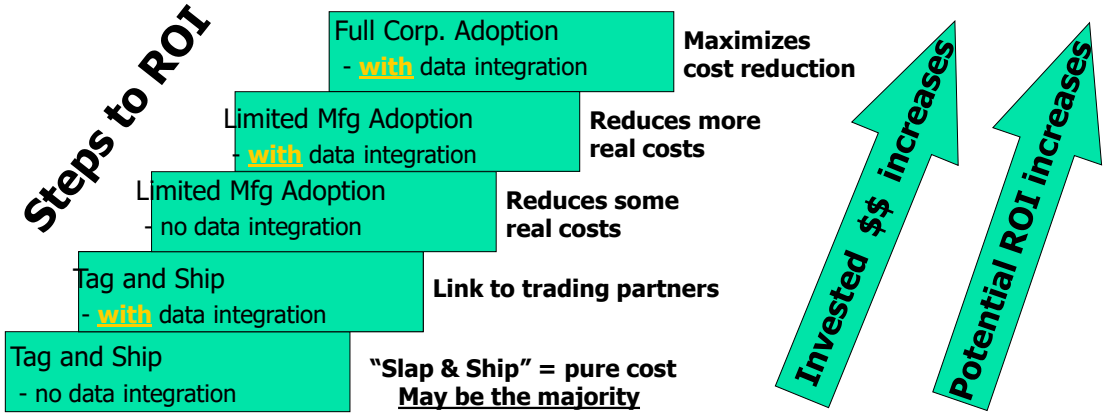
Two primary concerns for Supply Chain users:

- Concern #1: Return on Investment - ROI



83

- Concern #1: ROI – *Easier said than done*



Note importance of data integration (addressed in part 2)

- Challenging within a large company
- Very challenging between/among multiple companies

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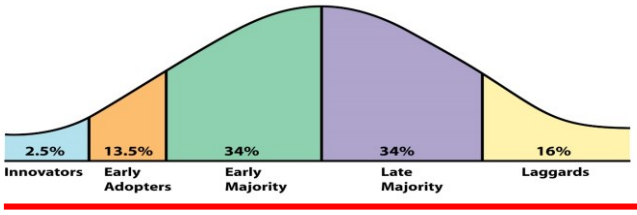
Two primary concerns for Supply Chain users:

- Concern #2: Partnerships

Let's do the math



- One of the largest RFID S.I. ("handle maybe 100")
- <100 RFID Vendors & S.I.s * - 100 x 50 = 5,000
- Must mobilize >1000 new RFID Solution Providers

just to meet the demand for partnerships

* RFID Journal

85

Winners & Losers ?

- AT Kearney study
- Retailers benefits
  - Reduce inventory by 5%
  - Reduce store & warehouse expenses by 7.5%
  - Reduce "out of stock" $700,000 per $1B
- Manufacturers costs
  - High impact (expensive) v. low impact (cheap)
  - Low impact: $155M in capital costs

(assuming $.15/tag, 10 year horizon, 12% cost of capital

86

What about "closed loop" & Enterprise applications?

- RFID technologies have been available for a decade
- For many applications the tag cost was too high
- Supply Chain volume reduce tag costs
- All those applications are still waiting for an RFID solution

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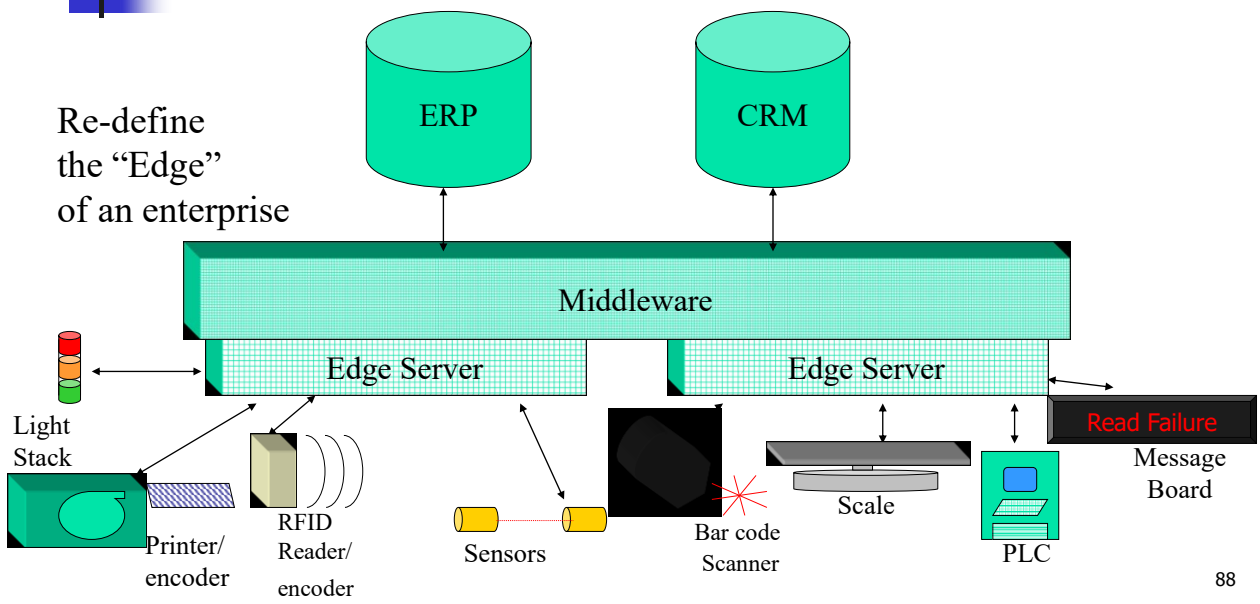
Enterprise Level Applications

Re-define
the "Edge"
of an enterprise



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Problems with RFID

- Technical problem with RFID
- Problem with RFID standard.
  - RFID has been used in different ways by different manufacturers. The frequencies used for RFID in the USA are currently incompatible with those of Europe or Japan. This can cause problems for companies.
  - Moreover, consumer have problems with RFID standard. For example, Exxon Mobil's SpeedPass system is a proprietary RFID system; if another company wanted to use the convenient SpeedPass, they have to pay to access it. If every company had their own SpeedPass system, a consumer would need to carry many different devices with them.

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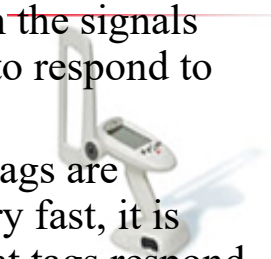
Problems with RFID

- RFID systems can be easily disrupted
  - Since RFID systems make use of the electromagnetic spectrum, they are relatively easy to jam using energy at the right frequency. This problem could be disastrous in business where RFID is increasingly used, like hospitals or in the military in the field.
- RFID reader collision: Reader collision occurs when the signals from two or more reader overlap. The tag is unable to respond to simultaneous queries.
- RFID tag collision tag collision occurs when many tags are present in a small area; but since the read time is very fast, it is easier for vendors to develop systems that ensure that tags respond one at a time.



90

Problems with RFID

- Cancer risk

  Veterinary and toxicology studies spanning the last ten years surfaced indicating that RFID chips induced malignant tumors in laboratory animals. However, there are some controversies. VeriChip Corp. maintains that the chips are completely safe and that they were unaware of the studies.

- Security and privacy problems with RFID
  - Loss of privacy: How would you like it if, one day your realized your underwear was reporting on your whereabouts?
  - Tag can be read at a distance, it become possible to gather sensitive data about individual without consent. For example, an RFID tag can be read after the item leaves the supply chain, this allows anyone to see the contents of your purse as pocket as you walk down the street.

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Security and privacy problems with RFID

- RFID tags with unique serial numbers could be linked to an individual credit card number.
- At present, each individual item has its own number. When the item is scanned for purchase and is paid for, the RFID tag number for a particular item can be associated with a credit card number

Future of RFID

- RFID will replace barcode.
  - RFID is a great tool for the supply chain and companies wishing to better track their products and inventory. As a result, it will definitely become a requirement for all suppliers to use RFID tags when the tag become affordable.
- RFID's price will reduces
  - With mass production, their price eventually reduces to perhaps a cent.
- RFID chips are no bigger than grains of sand.
- Every item in house will eventually come from the store with a tiny, almost invisible RFID tag attached.

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RFID deployment challenges

- Manage System costs
  - Choose the right hardware
  - Choose the right integration path
  - Choose the right data infrastructure
- Handle Material matters
  - RF Tagging of produced objects
  - Designing layouts for RF Interrogators
- Tag Identification Scheme Incompatibilities
  - Which standard to follow?
- Operating Frequency Variances
  - Low Frequency or High Frequency or Ultra High Frequency
- Business Process Redesign
  - New processes will be introduced
  - Existing processes will be re-defined
  - Training of HR
- Cost-ROI sharing

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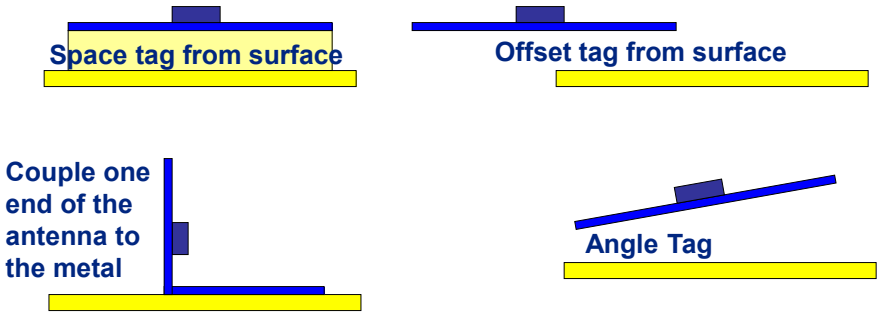
Using tags with metal

- Tags placed directly against metal will negatively affect readability



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Getting ready for RFID

- Identify business process impacts
  - Inventory control (across the supply chain)
  - Manufacturing assembly
- Determine optimal RFID configuration
  - Where am I going to tag my components/products?
    - Surfaces, metal environment and handling issues
  - Where am I going to place the readers?
    - Moving from the lab environment to the manufacturing or distribution center can be tricky
  - When am I going to assemble the RFID data?
- Integrate with ERP and other systems

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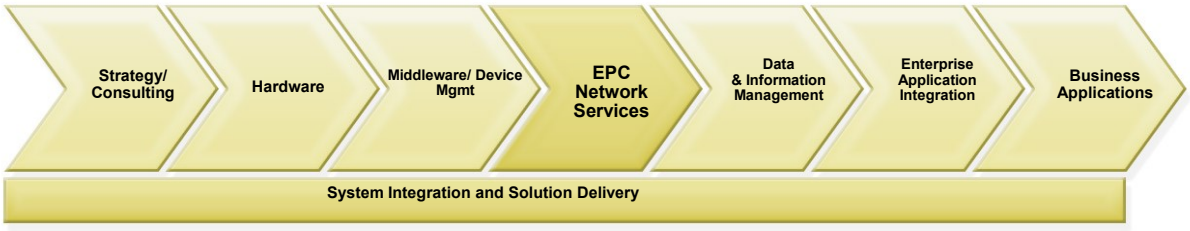
RFID services value chain



- Business Process Integration
- Solution Framework
- Network Setup
- RF aspects

- Tags
- Readers
- Label Printers

- Event Monitoring
- Data filtering
- Reader coordination
- Policy Management

- Directory Services
- Discovery Services
- Authorization/ Authenticatn Framework

- Product Catalog and Attribute Managemnt
- Data Synchro-nization

- ETL Services
- Legacy Application Integration

- Supply Chain Execution
- ERP
- Warehouse Management
- Store Management
- Distribution Management

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Privacy: The flip side of RFID

- Hidden placement of tags
- Unique identifiers for all objects worldwide
- Massive data aggregation
- Unauthorized development of detailed profiles
- Unauthorized third party access to profile data
- Hidden readers

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