Introduction to RFID and AutoID Technologies

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Agenda

- What is RFID?
- The origins of RFID in inventory tracking
- Tracking goods with EPC codes
- RFID Physics and EPC Protocol Analysis
- RFID tags
- Bar codes, Stacked Bar Codes, Contact Memory Buttons
- RFID Benefits

What is RFID?

- RFID: Valuable business and technology tool
  - Potential Bar-Code Replacement

- Strategic advantages:
  - Track inventory in the supply chain
  - Real-time in-transit visibility (ITV)
  - Monitor general enterprise assets

EPC codes

- Goods today have bar codes
- RFID systems use the electronic product code (EPC)
- EPC is a modern day replacement of the Universal Product Code (UPC)
- Each product tag has a unique embedded EPC number

EPC protocol

- Developed at MIT's Auto-ID Center in 2000
- Tells how data is to be segregated and stored on the tag (numbering scheme)
- Determines how the tags and readers communicate

Benefits of RFID

- Tracking individual items with serialized data
- Reducing human intervention
- Moving more goods through the supply chain
- Capturing information in real time
- Increasing security

Tracking items with serialized data

- Very accurate account of each item in the supply chain or property list
- Which item was produced where, in companies that produce the same item at multiple plants
- Prevent counterfeiting and diversion

Reducing human intervention

- Fewer human hands involved means reduced errors

- Dramatic reduction in operating costs

Moving more goods through the supply chain

- Higher throughput supply chains
  - reduce processing time
  - reduce costs
  - higher turnaround for billing customers
  - improved cash flow

Capturing information in real time

- Know, in real time, where everything is:
  - Reduce errors and increase customer loyalty
  - Reduce waste
  - Optimize materials use
  - Directly impact the tactical (departmental) and strategic (corporate and division-level) bottom line
  - Allow machine-to-machine communication and automated decision-making

Increasing security

- Permanently affix a tag to every item of value in a location and know exactly where that item is at all times
- RFID's ability to track and trace property can help everything from the war on terrorism to anti-fraud and anti-counterfeit measures.
- Examples
  - pharmaceutical industry
  - Gray market items
  - taging the assets of sensitive facilities

The Physics of RFID

- An RFID system is just a reader and a tag communicating over the air at a certain frequency
- Parts:
  - Readers
  - Antennas
  - Tags

RFID readers

- RFID reader is a radio that picks up analog signals
- The reader not only generates the signal that goes out through the antenna into space, but also *listens* for a response from the tag
- Receives analog waves and then turns them into bits of digital information
- Each reader is connected to one or more antennas

RFID tags(1)

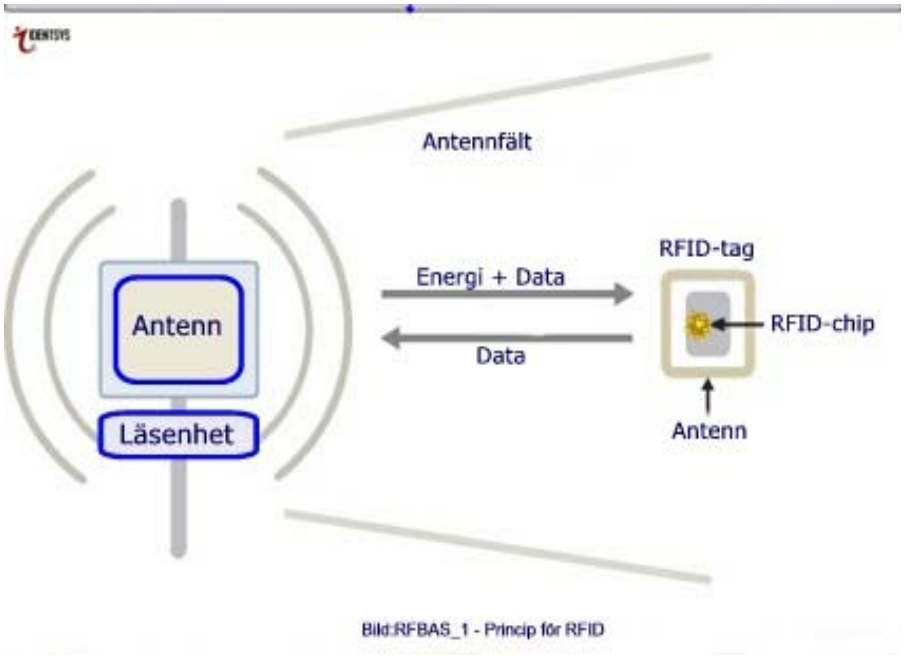
- An RFID tag is made up of two basic parts:
  - the **chip**, or integrated circuit, and
  - the **antenna**.
- The **chip** is a tiny computer that stores a series of numbers unique to that chip
- The **antenna** enables the chip to receive power and communicate , enabling the RFID tag to exchange data with the reader

RFID tags(2)

- ***Active tags*** *have* a battery that powers their communication
- ***Passive tags*** communicate when they are in the close presence of a reader
  - Being in the presence of a reader means that they are sitting in an electromagnetic field
  - When a passive tag enters an electric or magnetic field, the tag draws enough energy from that field to power itself and broadcast its information

RFID tags(3)

- The reader sends out an electromagnetic wave at one specific frequency.
- That wave hits the RFID tag, and the tag then “scatters back” a wave at a different frequency with the chip’s information encoded in those Backscatter waves



Principal stages of RFID deployment

- Planning
- Physics
- Pilot
- Production

Planning(1)

- **Global RFID policy**
  - Requires a lot of research so that you understand all the available options in technology, business processes, and costs
  - Addresses how to roll out the plan throughout your organization, what frequencies to use, data synchronization methods, and so on

Planning(2)

- **Execute an application analysis**
  - Covers the rationale and reasons for the RFID deployment and how RFID will be used

Planning (3)

- **Develop a cost/benefit breakdown.**
  - Examine the tangible and intangible ROI (return on investment)
- **Develop an implementation model (timeline)**

Planning (4)

- **Design a deployment plan.**
  - Going through each step in the implementation model
  - Assigning roles and responsibilities seeing what parts are dependent on successful completion of other parts,
  - Understanding the scope of the entire project

- **Manage the change and potential impact on the enterprise**

Physics(1)

- **Full Faraday Cycle Analysis to understand the environment**
  - time-based analysis of ambient electromagnetic noise (AEN)
  - RF path loss contour mapping (PLCM).

Physics(2)

- **Product or SKU testing for tag selection and placement**
  - RF waves, like light waves, can be reflected and absorbed
  - Must ensure the right tag and placement of products to avoid as much as we can these phenomena.

Physics(3)

- **Selection of the RFID hardware based on scientific testing**

Pilot

Table 1-1	Phases of an RFID Pilot	
Phase	*Percent of Total Pilot Timeframe*	*Key Tasks*
Planning	40 percent	Designing a single RFID interrogation zone to work in concert with business processes and systems Testing for proper hardware choice; the better the planning, the fewer the changes after deployment
Setup and installation	30 percent	Putting together the hardware, configuring it, integrating it with existing systems, and then training users
Testing and redesign	30 percent	Evaluating the performance of the design and process and making modifications to increase performance

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Production

- Managing the health and performance of the network
- Integrating your RFID data into existing systems
- Testing your system with outside partners
- Educating the users

AutoID Technologies Comparison

	Bar codes	*Contact memory*	*Passive RFID*	*Active RFID*
Modification of data	Unmodifiable	Modifiable	Modifiable	Modifiable
Security of data	Minimal security	Highly secure	Ranges from minimal to highly secure	Highly secure
Amount of data	Linear bar codes can hold 8–30 characters; other 2-D bar codes hold up to 7,200 numbers	Up to 8MB	Up to 64KB	Up to 8MB
Costs	Low (pennies or fraction of a penny per item)	High (more than $1 per item)	Medium (less than 25 cents per item)	Very high ($10–$100 per tag)
Standards	Stable and agreed	Proprietary; no standard	Evolving to an agreed standard	Proprietary and evolving open standards
Life span	Short unless laser-etched into metal	Long	Indefinite	3–5-year battery life
Reading distance	Line of sight (3–5 feet)	Contact required	No contact or line of sight required; distance up to 50 feet	No contact or line of sight; distance up to 100 meters and beyond
Potential interference	Optical barriers such as dirt or objects placed between tag and reader	Contact blockage	Environments or fields that affect transmission of radio frequency	Limited barriers since the broadcast signal from the tag is strong

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Bar Codes

- Maximum throughput in any bar code system is one
  - You can scan only one object at a time

- Bar code reader has to be able to “see” the bar code marking to read it

Bar Codes

- Modification of data:
  - Can’t change the orientation of the markings after the symbol has been printed or etched.
- Security of data:
  - Not encrypted for security
- Amount of data:
  - Linear bar codes can have up to 30 characters of data.

Bar Codes

- Costs:
  - The cost can be a fraction of a penny or several cents if the bar code is etched into an item.
- Standards:
  - Lack of a true universal protocol
  - Good news: Many of these standards are quite stable and are adopted by many end user

Bar Codes

- Life span:
  - Life span is fairly low because they are usually printed. However, if they are etched, they can last a very long time.

- Reading distance:
  - Linear bar codes require line of sight to be read and have a range of a few feet.

Bar Codes

- Number that can be read at a time:
  - Only one item can be scanned at a time
- Potential interference:
  - Linear bar codes become unreadable when vertical damage occurs.
  - Such damage occurs when a black bar is completely eliminated or altered or when a white bar is filled in
  - In the event of vertical damage to the symbol, there is typically no possibility of recovering the data.

Other types of Bar Codes

- Stacked bar code (also called a *2-D bar code*)

- Matrix symbols

Stacked Bar Code

- A stacked bar code comprises multiple rows of very short linear bar codes, arranged in a specific manner to ensure correct decoding

- Commonly used:
  - PDF 417

Stacked Bar Code

- Security of data:
  - Stacked bar code symbologies employ a specification called ***Reed-Solomon*** *erasure and error correction*
  - Allows part of the tag to be destroyed while retaining all the original information

- Amount of data:
  - Stacked bar code symbols can contain more data than linear bar code symbols — up to a full kilobyte.

Stacked Bar Code

- **Standards:**
  - PDF 417 is an ISO standard
  - PDF here stand for *portable data file*

- **Potential interference:**
  - more tolerant of localized damage than linear bar codes
  - significant amounts of obscuring material or abrasion can still render them unreadable in spite of their error correction capabilities

Matrix Symbols

- Composed of discrete modules (typically round or square) arranged in a grid pattern.

Contact memory buttons

- Specific type of Auto-ID that requires a wand to make physical contact with a button tag to read the data on the tag.

- Each button tag is about the size of a quarter.

Contact memory buttons

- **Modification of data:**

  - Contact memory buttons can be written to and read many times.

  - They are robust because they can withstand vibration and harsh environments and still be read.

- **Security of data**:

  Contact memory buttons can have their data encrypted.

Contact memory buttons

- **Amount of data:**
  - Data storage can be up to 8MB.
- **Costs:**
  - Start at just over $1
- **Standards:**
  - There is no universally accepted standard; contact memory buttons are proprietary technologies

Contact memory buttons

- **Life span:**
  - The physical contact required for communication with the reader limits the usable life of that reader
- **Reading distance:**
  - Because the tag reader has to come in physical contact with the button tag, the reading distance is essentially zero

Contact memory buttons

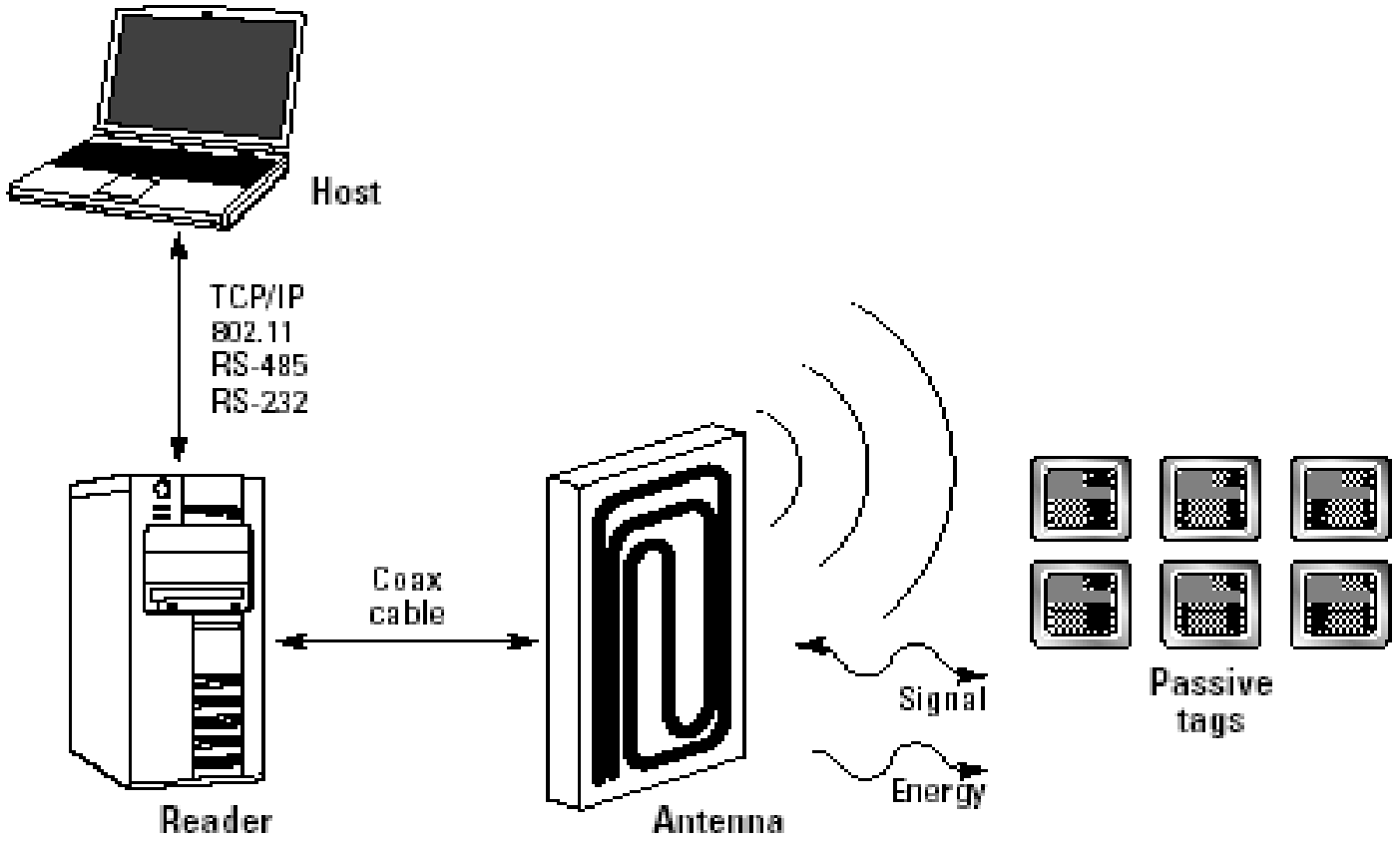
- **Number that can be read at a time:**
  - You can read these only one at a time
- **Potential interference:**
  - The physical contact required also limits the efficiency with which the contact memory button can be read

RFID

- An RFID solution uses a radio frequency (RF) signal to broadcast the data captured and maintained in an RFID chip

- An RFID system is composed of three components: a programmable transponder or tag, a reader (with an antenna), and a host

RFID


Host
TCP/IP
802.11
RS-485
RS-232
Coax
cable
Signal
Energy
Passive
tags
Reader
Antenna

RFID tags

- Active tag:
  - Has its own battery power to contact the reader
  - Power from the battery is used to run the microchip's circuitry and to broadcast a signal to a reader
- Passive tag:
  - Does not require a battery
  - Derives its power from the electromagnetic field created by the signal from the RFID reader
  - Responds to the reader with its information

RFID

- Modification of data:
  - The ability to modify data depends on the standard that you use
  - Using the electronic product code standard (EPC), the two classes are:
    - **Class 0 tags**: read-only
    - **Class 1 tags**: write once, read many (WORM).

RFID

- **Security of data:**
  - Depending on the class and generation of the RFID tag, they have the ability to be encrypted so that others with standard RFID readers cannot read the actual data on the tag

- **Amount of data:**
  - Depending on the manufacturer, these tags can contain 64, 96, 128, 256, or 512 bits of information.

RFID

- **Costs:**
  - Costs, which range in volume from 20–50 cents per tag, are falling fast

- **Life span:**
  - Having no need for a battery makes the passive tag's life virtually unlimited. Active tags and semi passive tags last as long as their batteries.

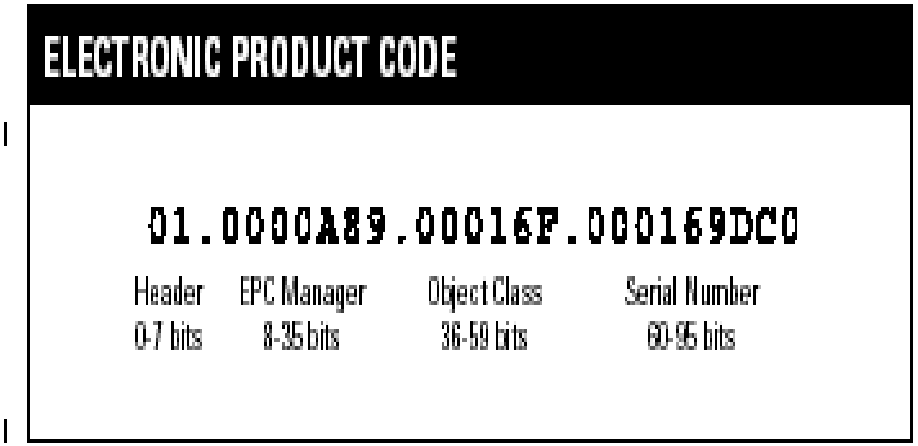
RFID

- **Size:**
  - **Passive tags** range in size from a pin head to the size of a lette envelope
  - **Active tags** range in size from the size of a piece of hard candy to about the size of a carton of cigarettes
- **Reading distance:**
  - Passive tags communicate in ranges from a few millimeters (called the *near field*) all the way out to tens of meters. Active tags can communicate more than 100 meters.

RFID

- **Number that can be read at a time:**
  - A reader can read hundreds of tags nearly simultaneously
- **Potential interference:**
  - Passive tags: interference with various materials such as metals and liquids
  - Active tags are less susceptible to interference but still can have issues inside metal containers.

EPC


ELECTRONIC PRODUCT CODE
01.0000A89.00016F.000169DC0
Header
0-7 bits
EPC Manager
8-35 bits
Object Class
36-59 bits
Serial Number
60-95 bits

EPC

- **Header:**
  - This tells the RFID reader what type of number follows
- **EPC Manager Number:**
  - **I**dentifies the company or company entity
- **Object class:**
  - Next is the object class, similar to a stock-keeping unit, or SKU

EPC

- **Serial number:**
  - Lastly (and most importantly) is a serial number, which is the specific instance of the object class being tagged
  - It identifies the item with the specific tag as *that* item (not just a type of item)

EPC functionality

Table 2-2 RFID Interface Protocols				
Protocol	*Corresponding Frequency*	*Capabilities*	*Pros*	*Cons*
Generation 1 Class 0	UHF	This is a read-only preprogrammed tag, which means that the end user can't write a new number to the tag.	Fast data communication protocol.	Preprogrammed tags increase administrative and logistics cost of affixing the correct tag to the correct item and also minimize a tag's flexibility.
Generation 1 Class 1	UHF and HF	Write once, read many (WORM)	Keep data in sequential order; manage data easier.	Can be written to only once.
ISO standard	LF, HF, and UHF	Read Only Tag Identifier with read, write, and lockable user memory to store object identifier and information.	Keep data in sequential order; manage data easier.	Does not account for the data structure but only how the tag and reader communicate.
Generation 2.0 Class 1	HF and UHF	WORM	Keep data in sequential order; manage data easier. More globally accepted protocol.	Can be written to only once.

Patrick J. Sweeney,"RFID For Dummies" April 2005