



Introduction to RFID Technology

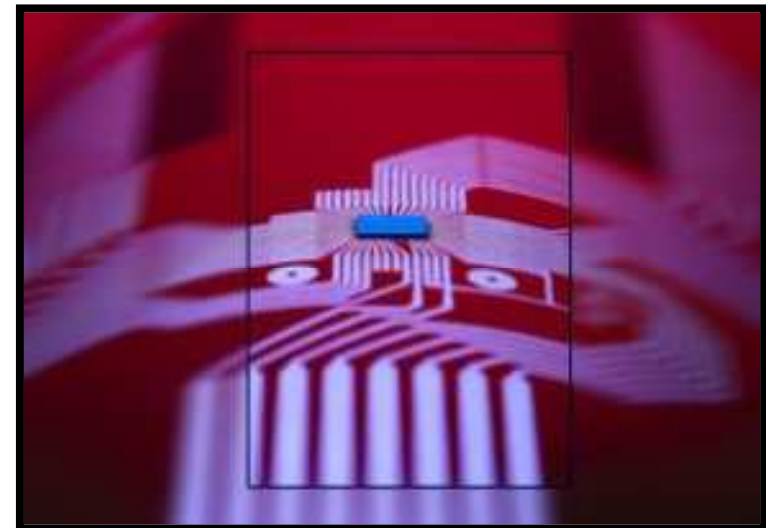
Athens Information Technology





Riding the Time-Machine (1)

- The AUTO-ID consortium
- AUTO-ID can track
 - Products,
 - Containers,
 - Vehicles,
 - Animals,
 - as well as their condition





Riding the Time-Machine (2)

- EPC against UPC and EAN
- What are EPC Protocols needed for?
- Main Driving Forces of today
 - Auto-ID consortium
 - EPCglobal organization





What Is (Not) RFID (1)

- A RFID System is a valuable Business and Technology Tool comprising
 - An Electronic Product Code (EPC)
 - A NVRAM storing User Data
 - A RF system allowing wireless EPC & User Data exchange
- A RFID system engages a set of Tags, Interrogators as well as controlling Middleware





What Is (Not) RFID (2)

- RFID Tags have a unique EPC and store a piece of USER Data
- RFID Interrogators access USER Data on RFID Tags
- What is the function of a RFID System
 - A distributed Data Base?
 - A Network (Internet of Things)?



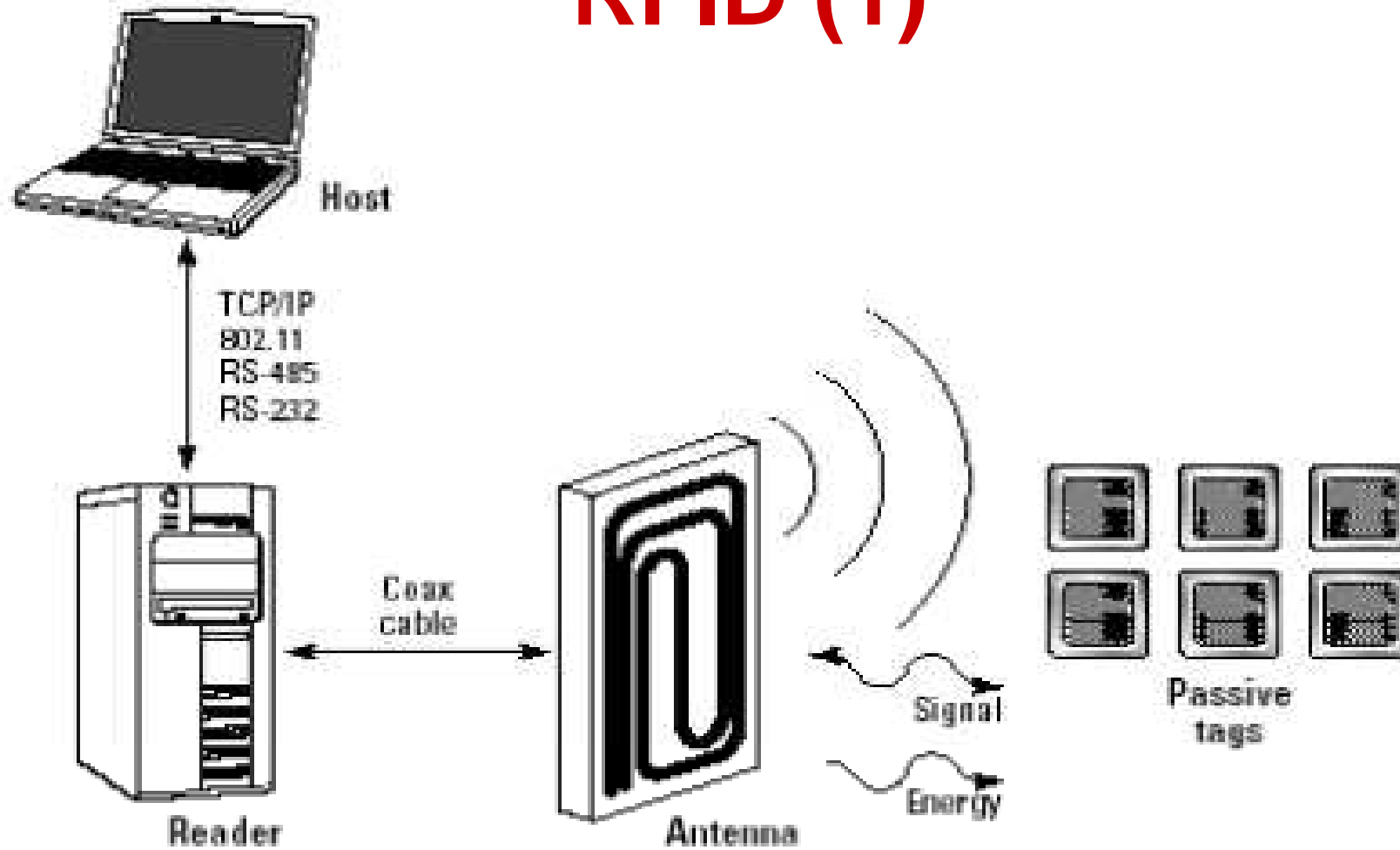


The Physics of RFID

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



RFID (1)





RFID (2)

- 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 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)

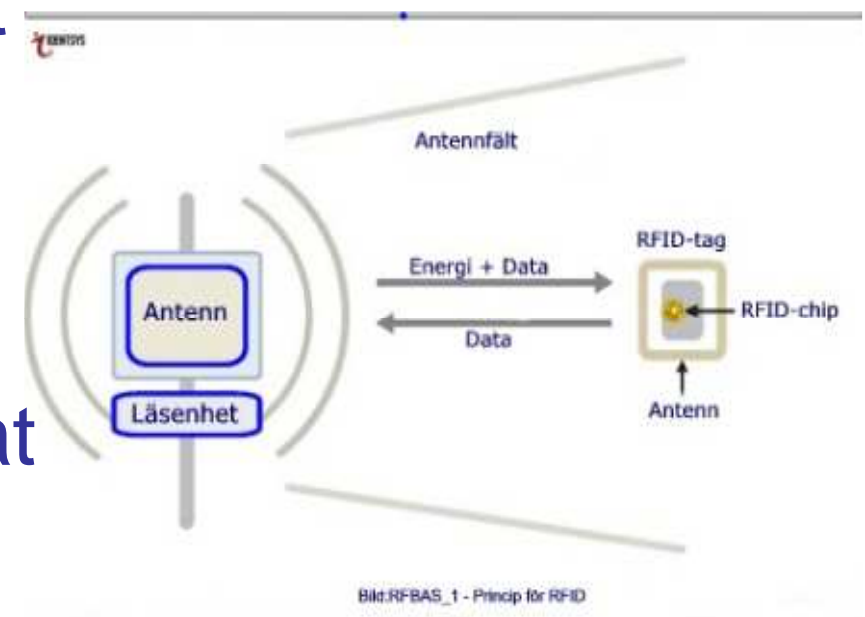
- Active tags have a battery that powers their communication
- Passive tags communicate when they are in the close presence of a reader
 - Being in the presence of a reader means that they are sitting in an electromagnetic field
 - When a passive tag enters an electric or magnetic field, the tag draws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





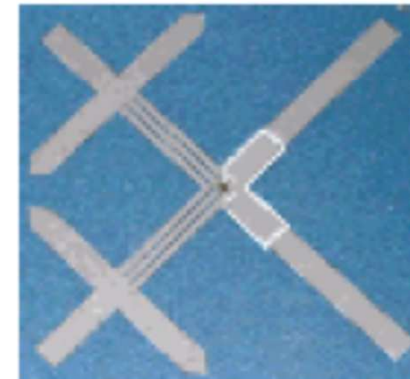
RFID Tags (3)

- 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





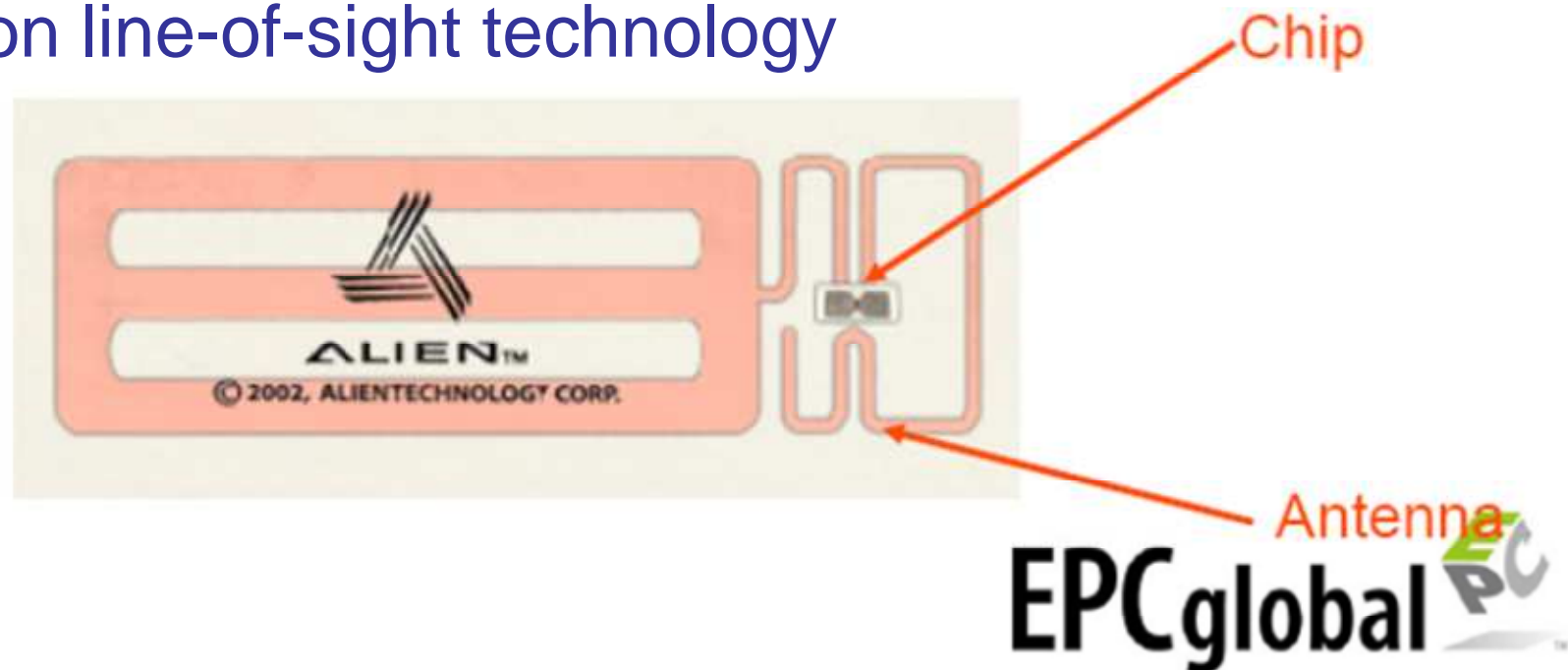
What Do Tags Look Like?





Tags and Readers

- Radio Frequency Identification - RFID
 - Chip + antenna + packaging substrate = Tag
- Readers use radio waves
 - non line-of-sight technology





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





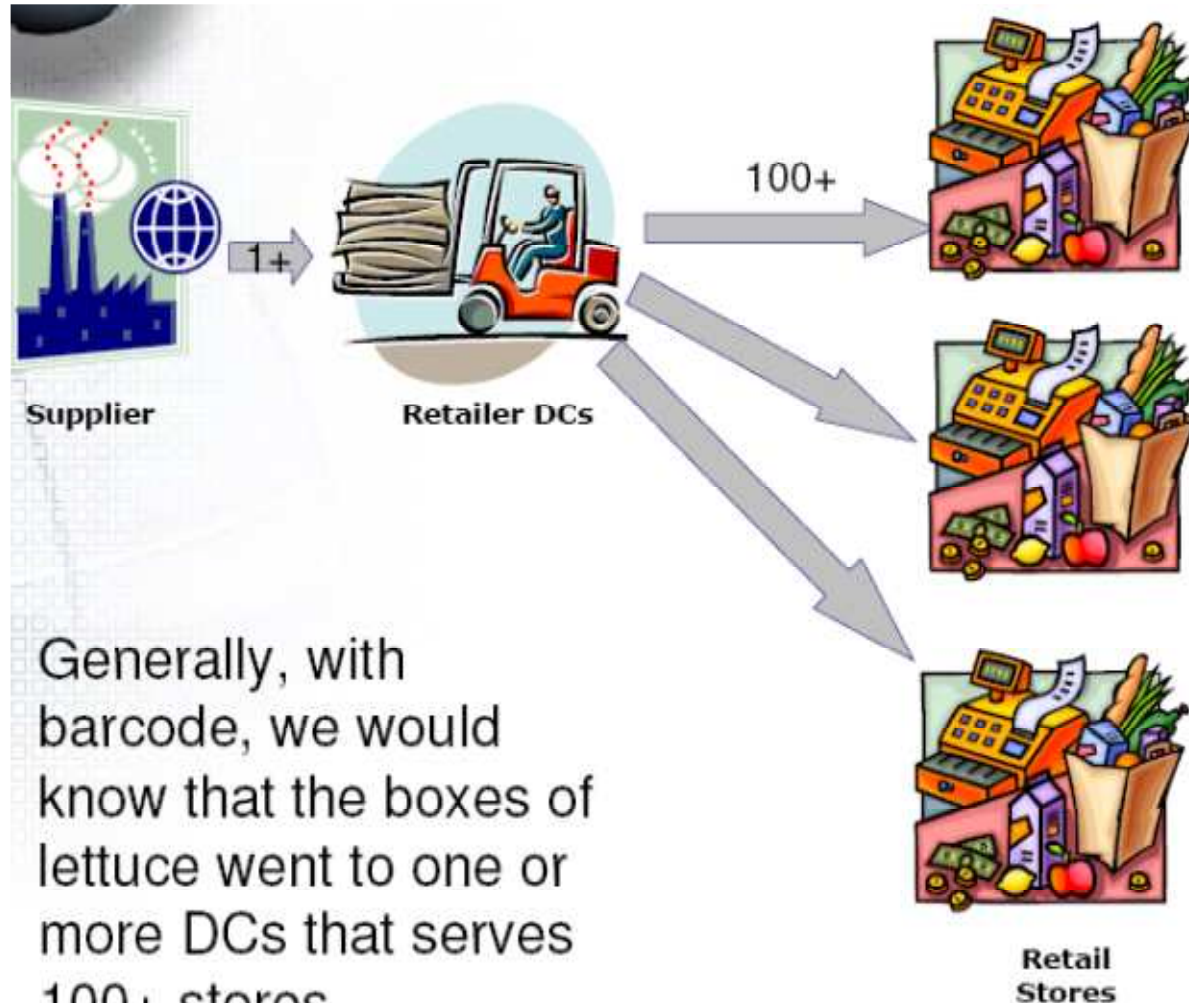
Barcode Against RFID

Performance Data	Barcode	RFID
Data Modification	No	Unlimited
Data Security	Limited	Secure
Capacity	138 Characters	64 kbit
Cost	E0.01 <	E0.1
Standards	Stable (EAN, UPC)	EPC (in development)
Reading Distance	5m >	10m >
Life Span	Short	Large





Serialization Makes the Difference...



Generally, with barcode, we would know that the boxes of lettuce went to one or more DCs that serves 100+ stores.

With RFID, we would know which DC received the product and which stores received the cases in question.





Let's Talk About RFID Tags...

Classification	Performance Data
Passive Identity Card	Passive Identity Tag Passive tag containing only the Electronic Product Code (EPC) in an unalterable form and a CRC for transmission error detection. Also referred to as a "license plate"
Passive Functional Tag	Broad category that includes any tag with functions over and above the elementary tag. Examples of such functions or features include User Writable memory, sensors, and encryption
Semi - Passive Tag	Any tag that embeds battery technology to assist in providing power for the tag (i.e., the battery is not the sole source of energy for the tag)
Active Tag	Any tag where a battery is the sole source of energy for the tag





Use of EPC in UHF C1G2 Tags (1)

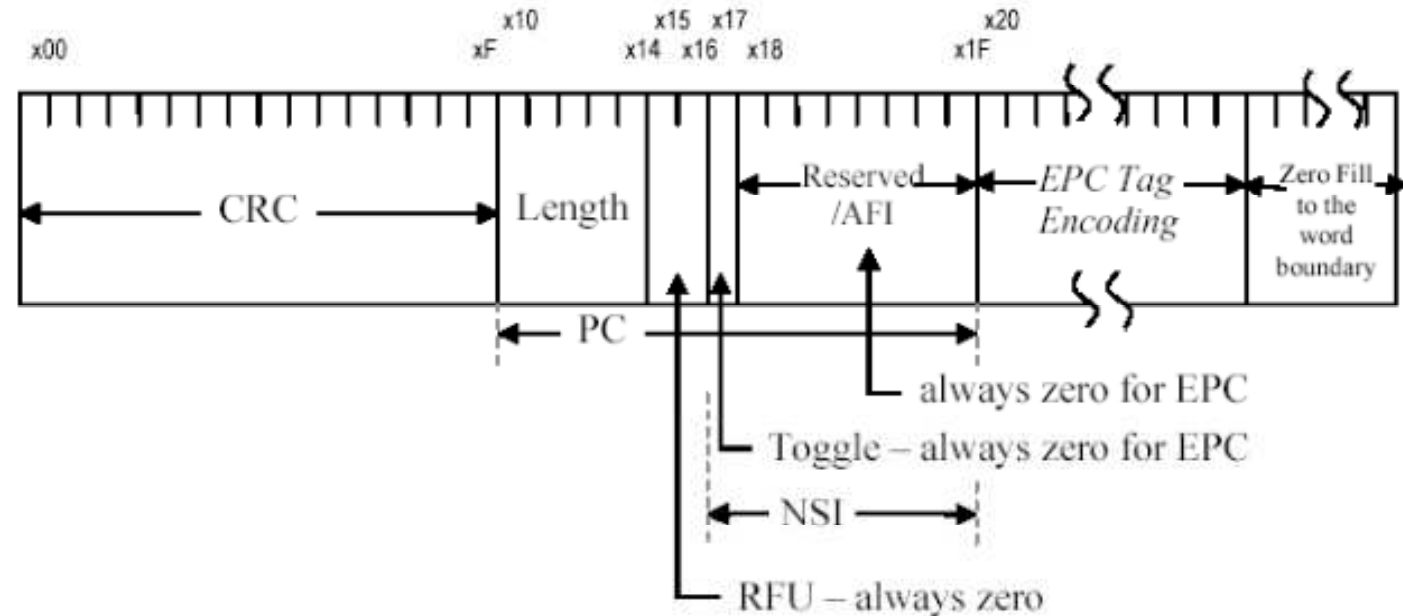
- EPC C1G2 Tags have 4 distinct memory banks
 - EPC
 - Stores the EPC and protocol information
 - TID
 - Stores information regarding the capabilities of the tag
 - Reserved
 - User
 - Stores User Data, such as sensor readings





Use of EPC in UHF C1G2 Tags (1)

- EPC memory bank contents
 - CRC: Error checking code
 - PC: Protocol information
 - EPC





Riding EM Waves: Protocols and Frequencies (1)

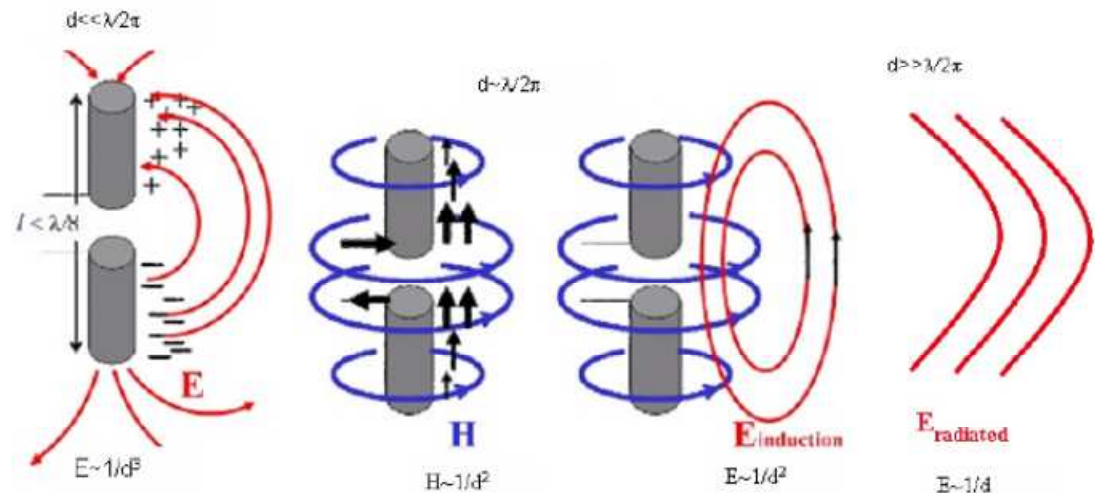
- Class 0 and 1 Tags
 - Read Only
 - WORM
- Class 2 Tags
 - Read / Write capability
- Class 3 and 4
 - Active and Semi-Passive Tags





Riding EM Waves: Protocols and Frequencies (2)

- HF RFID
 - Range: 13.553 – 13.567 MHz
 - Magnetic Coupling (ISO 15694)
 - Range < 1m
- UHF (Europe)
 - Range 865 – 868 (ETSI 302208)
 - EM coupling (EPC C1G2)
 - Range < 10m





Sizing Up the Benefits of RFID (1)

- Serialized Data
 - Keep accurate account of items and their properties
 - Know what, where, and why
 - Prevent counterfeiting
- Reduced Human Intervention
 - Do not process one but many
 - Enhance Traceability





Sizing Up the Benefits of RFID (2)

- Higher-Throughput Supply Chains
 - People dislike empty shelves
- Real-Time Information Flow
 - Information in security
- Security – Counterfeiting Prevention
 - Pharmaceuticals
 - Grey Market





Sizing Up the Benefits of RFID (3)

- Added Value Services
 - Cold Chain Management
 - Location based services



*“Get it to the customer **where** they want, **when** they want it, in the **condition** they want it.”*

Galleria Kaufhof - Essen (1)



- ESSEN, GERMANY - Sep 20, 2007: METRO Group's Galleria Kaufhof department store announced a breakthrough item-level tagging retail apparel implementation
- The implementation is a milestone for the retail industry, delivering consumer-facing RFID applications that are integrated from the distribution center to retail smart shelves and cashier checkout stations





Galleria Kaufhof - Essen (2)



- Around 30,000 items in the menswear department have been tagged with RFID transponder chips
- RFID readers installed in the receipt area, at all transition points, as well as inside the dressing rooms and at the checkout desk read the EPC without requiring physical or visual contact



Galleria Kaufhof - Essen (3)



- The Smart Dressing Rooms and Smart Shelves in the Gardeur shop have been installed as a special service for the customers
- RFID helps enhance the efficiency of business processes, reduce costs and offer the consumer individualized services
- "With the deployment of innovative technologies we are actively advancing the modernization process in the retail sector"





The “Store of the Future”



- Inbound goods receipt
- Back room real-time inventory management
- Fixed and handheld readers tracking real-time sales floor inventory
- A Smart Mirror showing complementary clothing choices or accessories
- Smart Shelves with monitors indicating available garment size and style choices
- In-aisle product information triggered by scanning items
- RFID-enabled point-of-sale terminals delivering efficient checkout





Apparel Supply-Chain (1)

Lemmi Fashion

- Lemmi Fashion, the Fritzlar, Germany-based company produces jackets, ski wear, t-shirts, and dresses offering a wide variety of size, fit options, styles, and colors
- The company produces 80.000 SKU's annually, in some cases making as few as 4 items of a given SKU
- Such small lots and multiple offering make inventory tracking and deliveries significantly difficult
- Though Lemmi used Barcodes, it relied on manual counts to take inventory and salespeople often sold merchandize that didn't exist or could not be located





Apparel Supply-Chain (2)

- The company needed better information from its manufacturing partners in China and Poland in transit to improve warehouse planning
- After the goods arrived at the distribution center, the company needed to quickly count, track, stock, and pick merchandize to better plan distribution
- In early 2005, Lemmi took the initiative to fully integrate RFID technology in its supply-chain from production to end consumer
- As item number of each SKU is small, item level tagging is the only viable solution: “We need to have information about these very small numbers of different garments within a single case”

Lemmi Fashion





Apparel WM Systems



- EPC Codes
 - Manager Number
 - Stock Keeping Unit – SKU
 - Serial Number
 - Other Information
- Transaction Messages
 - Quotation
 - Purchase Order
 - Invoice
 - Transport Status
- Data Pools & e-Commerce



- Branding



- Tracking



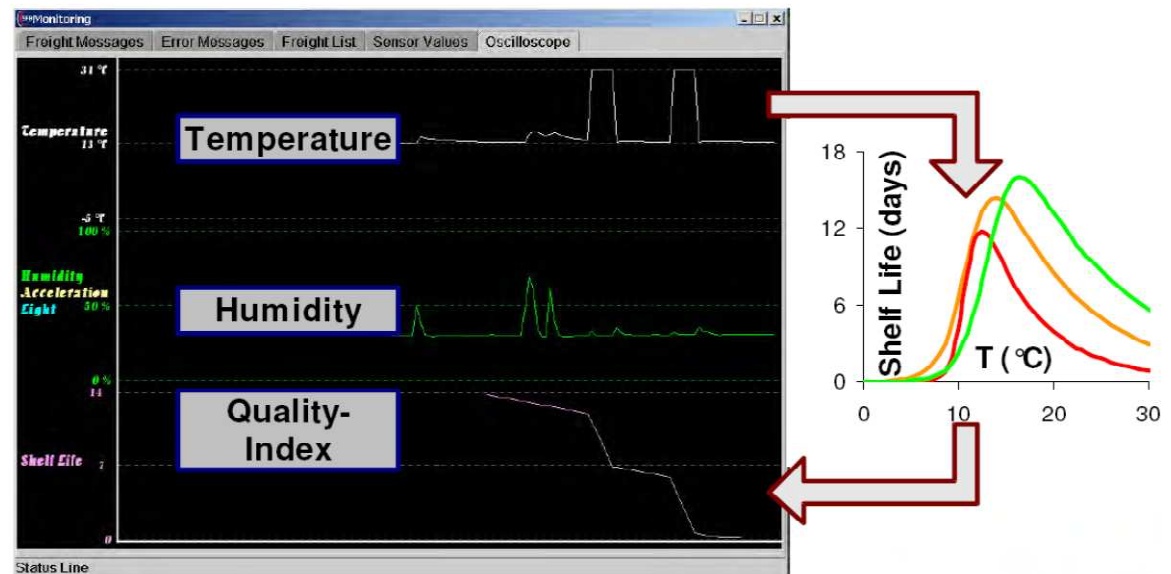
- Securing





Cold-Chain Management: Shrinkage & Shelf Life

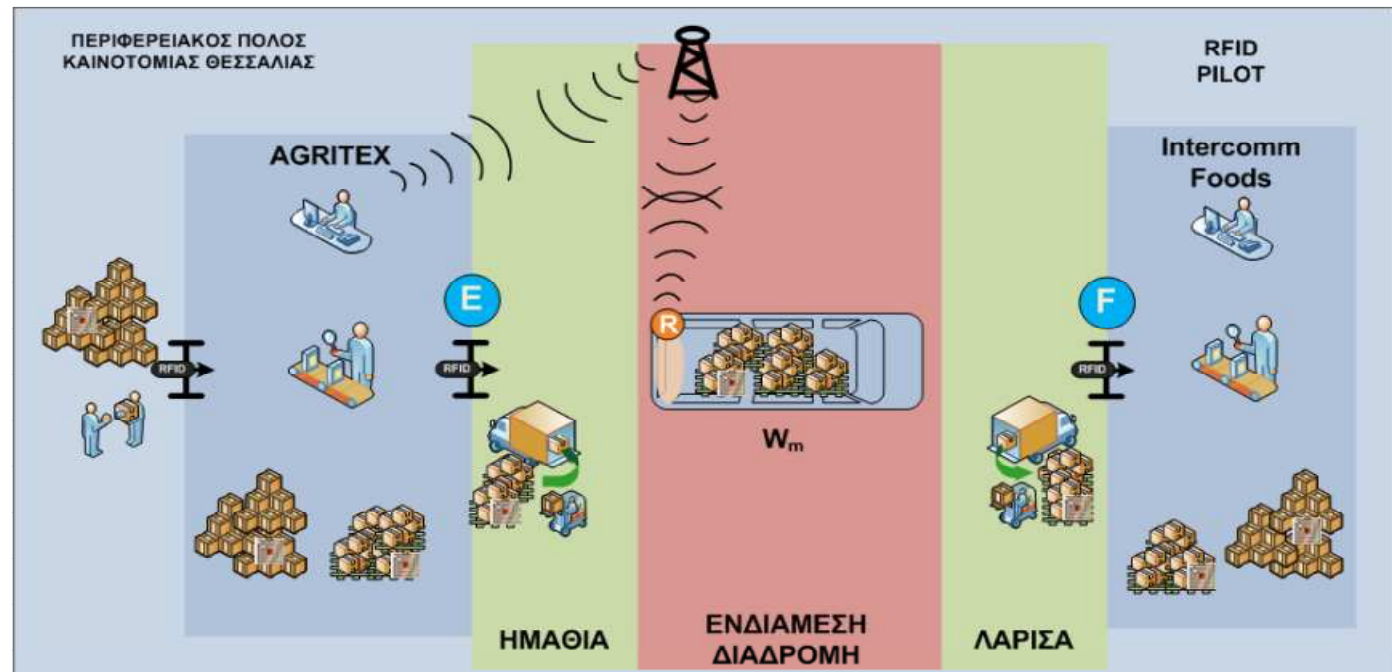
- FIFO to FEFO
 - 32% of customers cite dissatisfaction with shelf life or freshness of products as reasons to avoid shopping in certain stores
 - \$35 billion annual loss due to perishable spoilage
- Claims: Who is to blame?
- Reject all, partial, none of the load
- Rather than using heuristics only...
- Use temperature to precisely determine remaining shelf life and safety issues





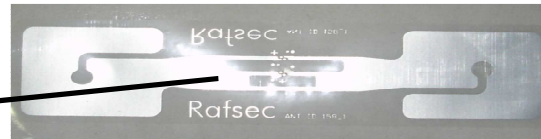
Bridging Supply Chains or Ubiquitous Sensing in Practice...

- Keep inventory tracking while goods are in transit (External Traceability)
- Monitor the condition of in-transit (or temporarily stored) goods
- Use low-cost RFID Interrogators with wireless networking capabilities
- Conform to EPC standards
- The Mobile Warehouse



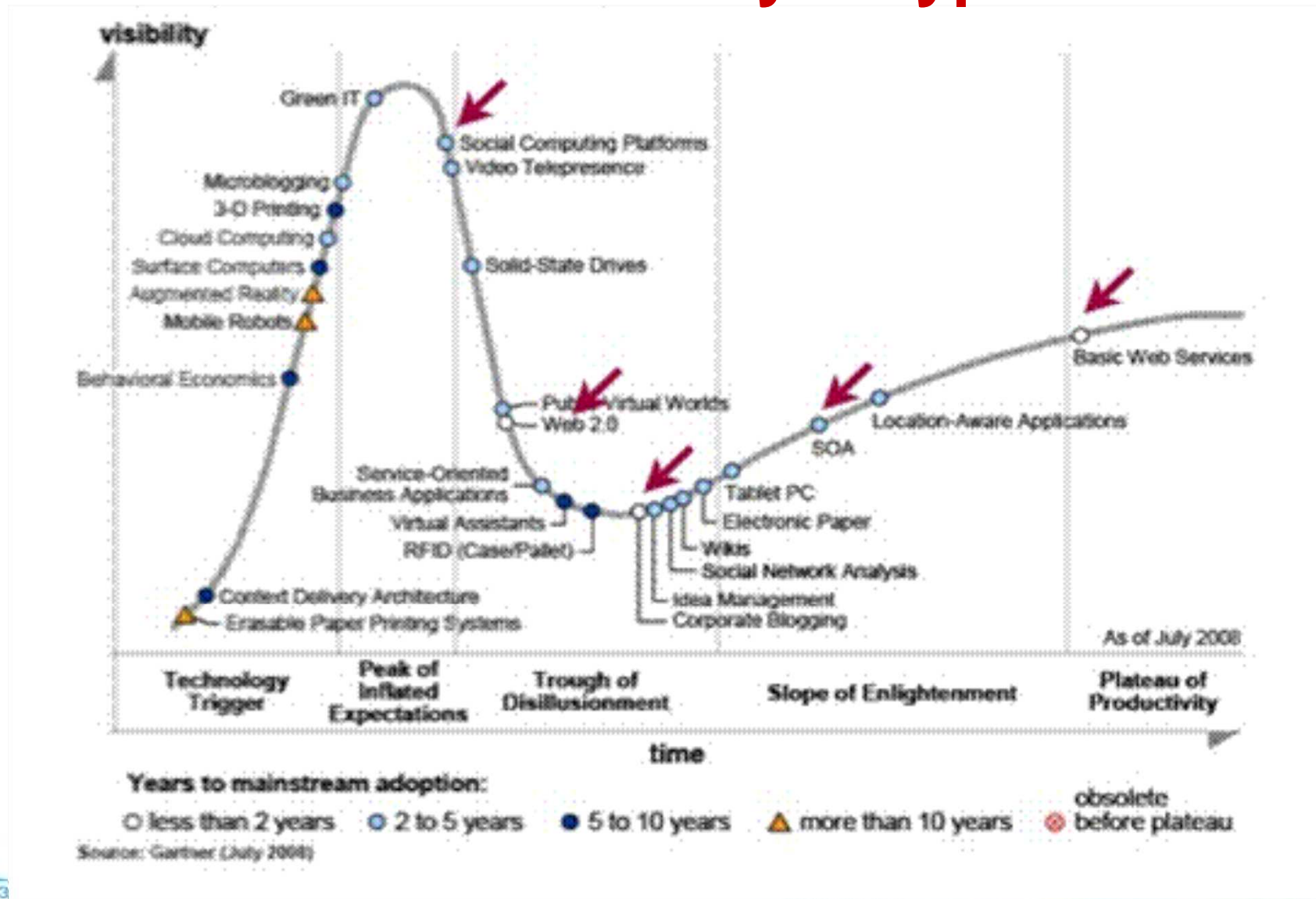


Item-Level and Palette-Level Tagging





Where We Stand Today – Hype Curve





The Privacy Challenge

May be a brake to large scale acceptance (then deployment)



ZOM, October 20, 2008



Big brother is scanning you !

From [Ari Juels 05]





References – Additional Reading

- Patrick J. Sweeney II, “RFID For Dummies”, Chapter 1: Taking the Mystery out of RFID, Wiley, April 2005

