RFID: Technology and Applications

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Outline

- Overview of RFID
  - Reader-Tag; Potential applications
- RFID Technology Internals
  - RF communications; Reader/Tag protocols
  - Middleware architecture; EPC standards
- RFID Business Aspects
- Security and Privacy
- Conclusion

Product Marketing – 75 years ago

You can have any color, as long as its black !

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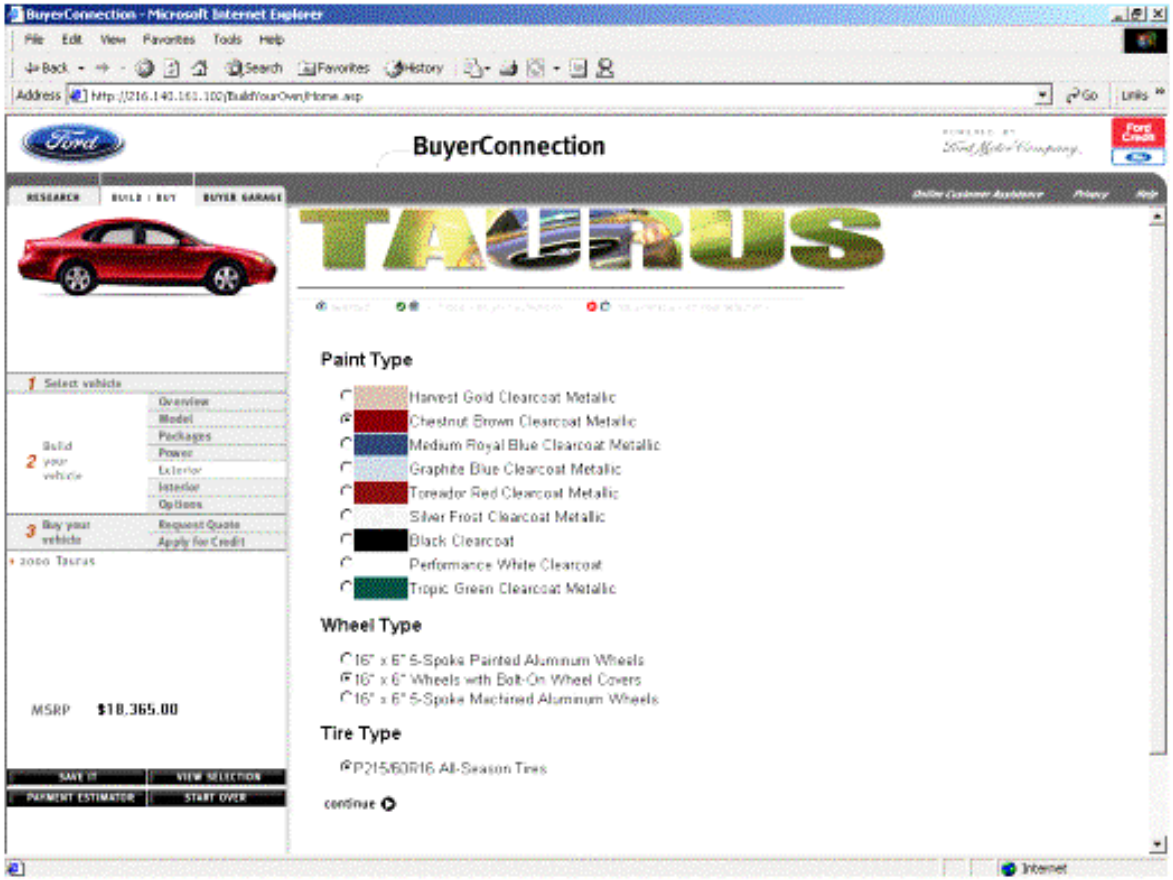
Product Marketing - Today

Add consumer flexibility, courtesy of robotics, computers …

Customer window into final stage of manufacturing



Effect on manufacturing

- Need to ensure error-free, custom assembly
- Need inventory of components for the various customization options

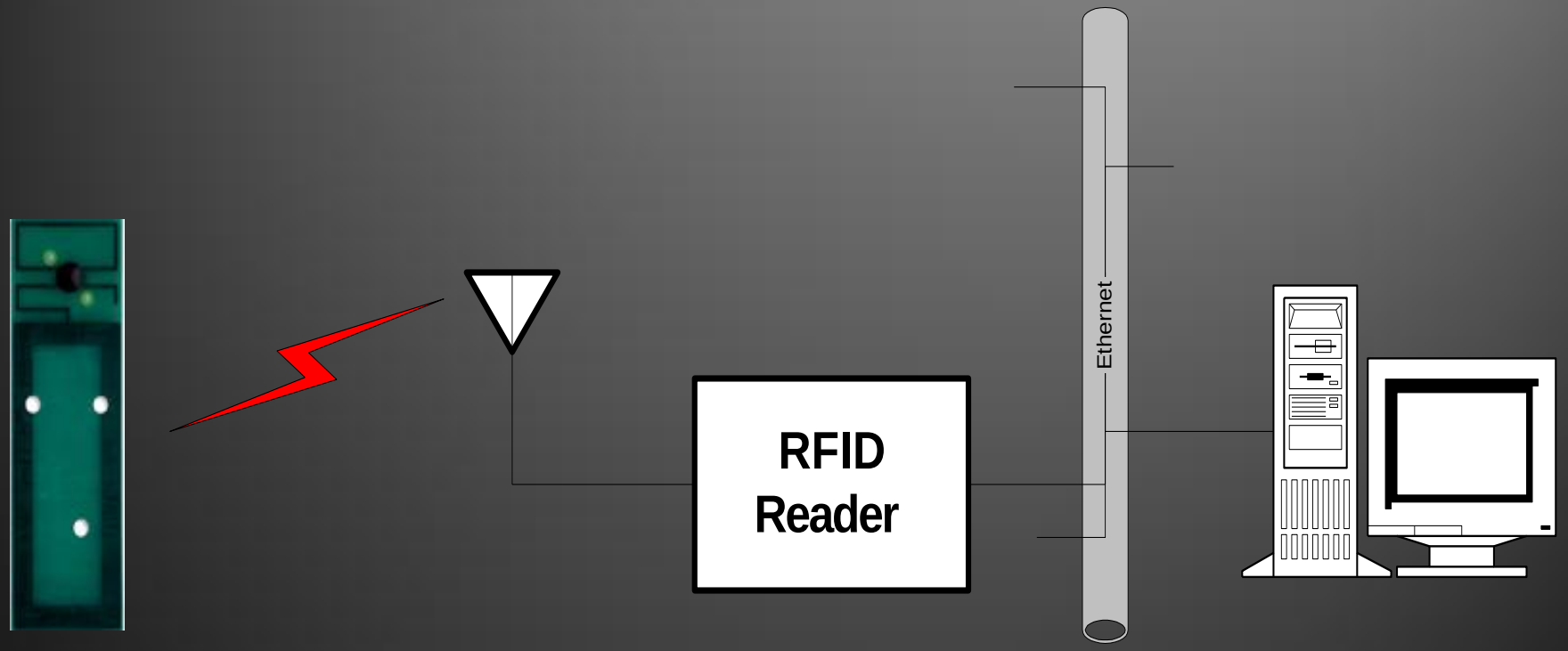
- Critical Issues
  - Assembly process control
  - Inventory management
  - Supply chain integration
  - Customer insight

- One solution: RFID

What is RFID?

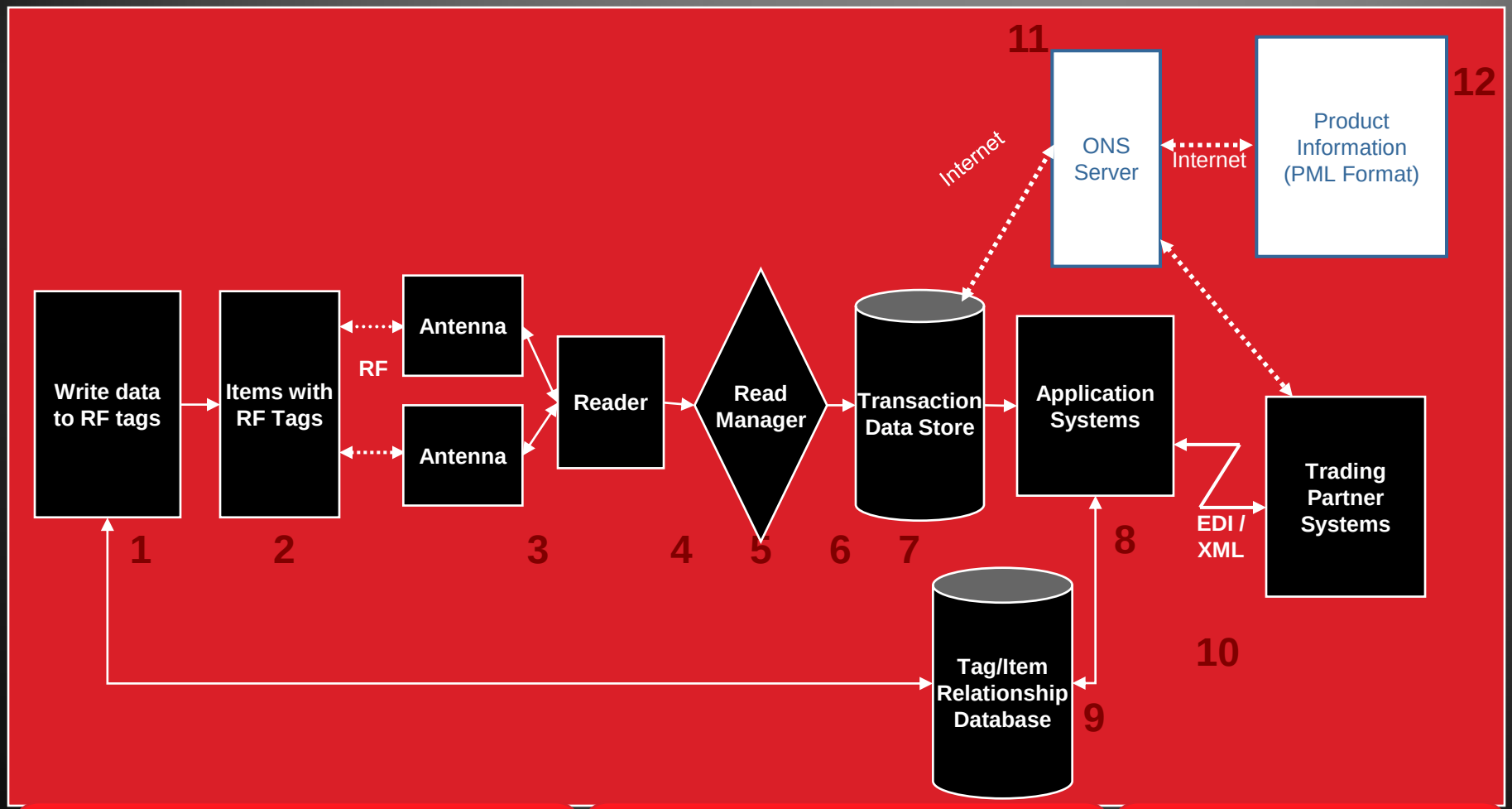
- RFID = Radio Frequency IDentification.
- An ADC (Automated Data Collection) technology that:
  - uses radio-frequency waves to transfer data between a reader and a movable item to identify, categorize, track..
  - Is fast and does not require physical sight or contact between reader/scanner and the 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.

RFID system components

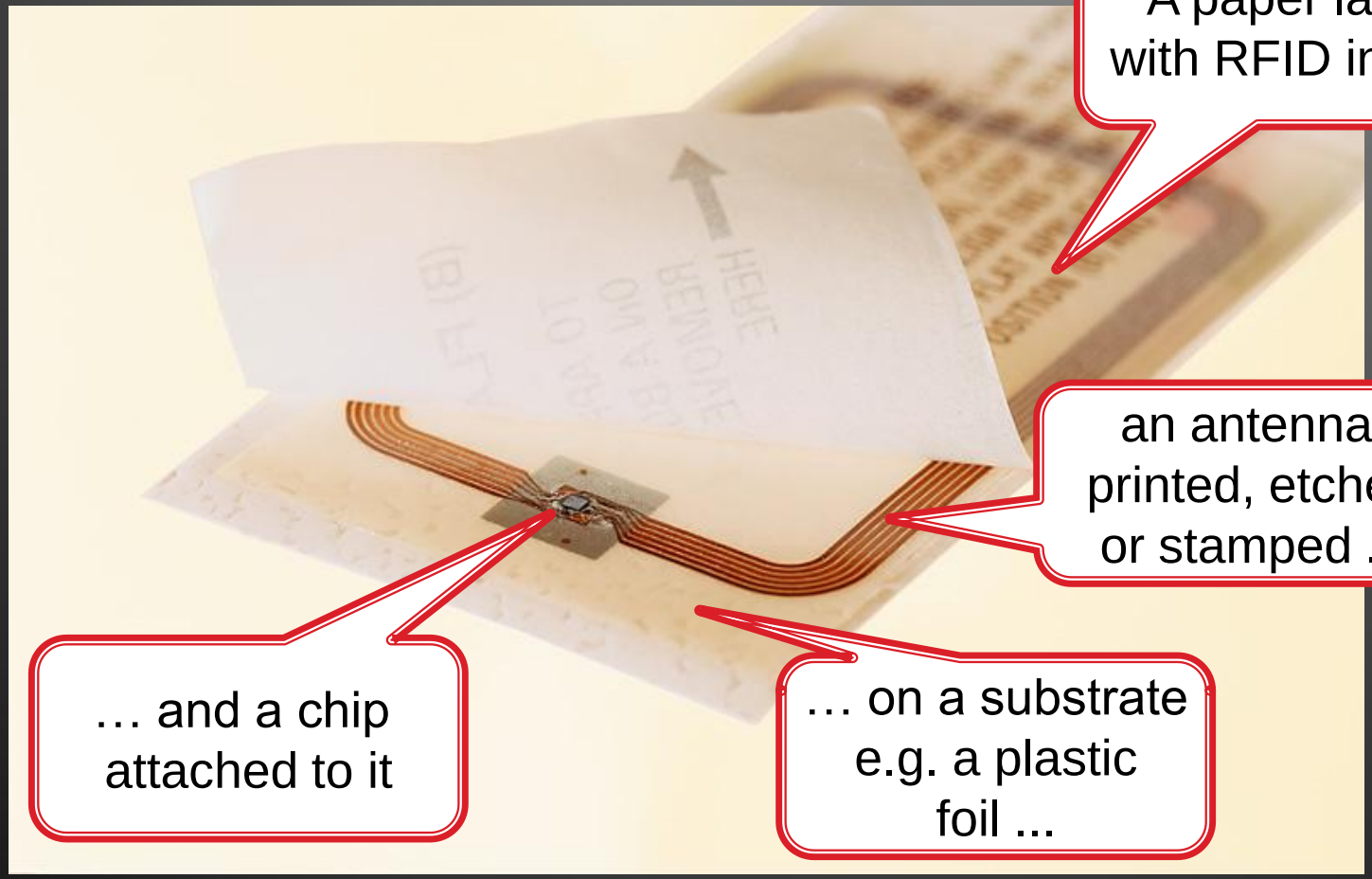


RFID Tag RF Antenna Network Workstation

RFID systems: logical view

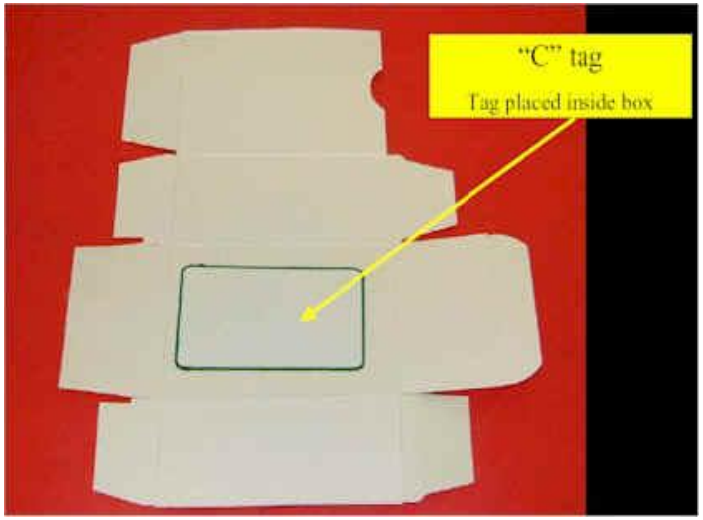


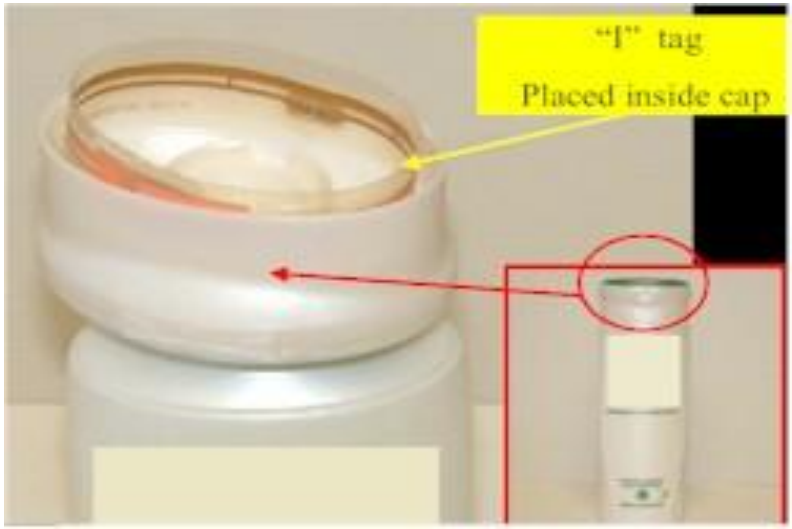
RFID tags: Smart labels



Source: **www.rfidprivacy.org**

Some RFID tags



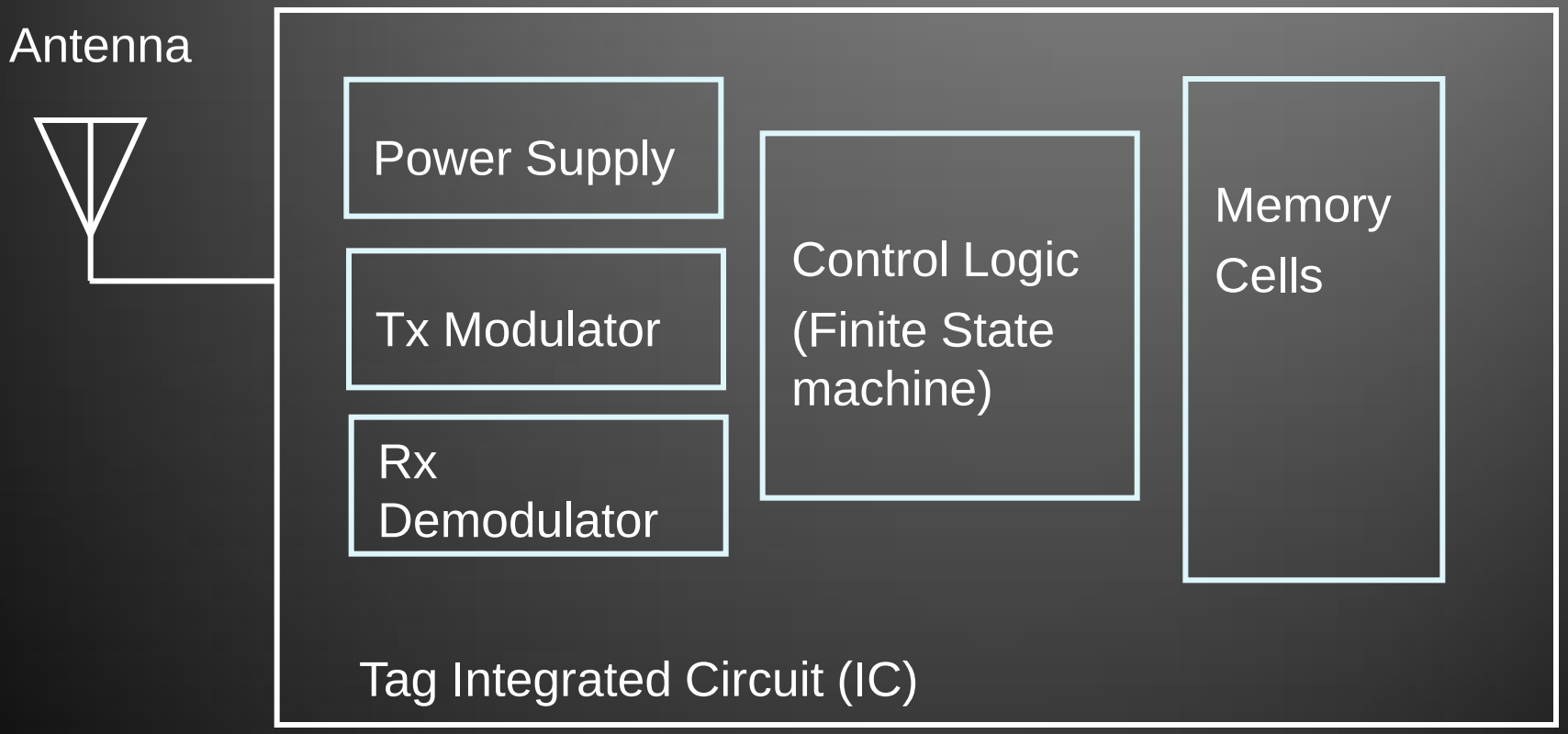


Source: **www.rfidprivacy.org**

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

Tag block diagram



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

RFID readers

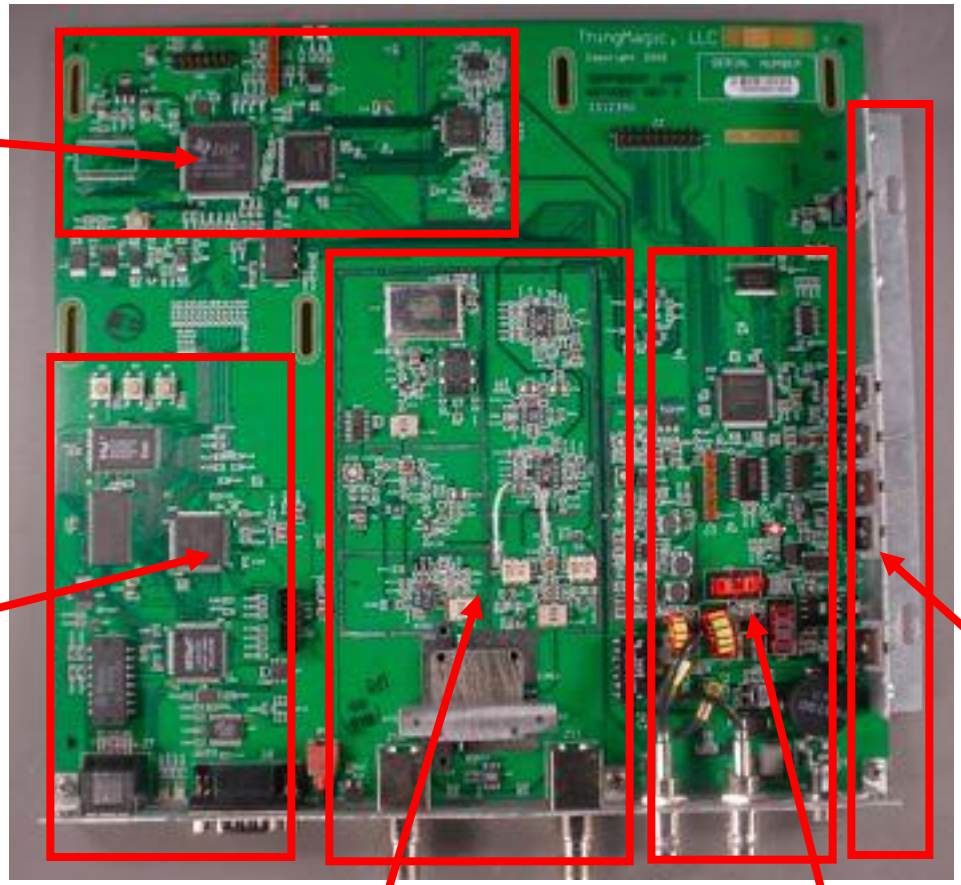
- Reader functions:
  - Remotely power tags
  - Establish a bidirectional data link
  - Inventory tags, filter results
  - Communicate with networked server(s)
  - Can read 100-300 tags per second

- Readers (interrogators) can be at a fixed point such as
  - Entrance/exit
  - Point of sale
- Readers can also be mobile/hand-held

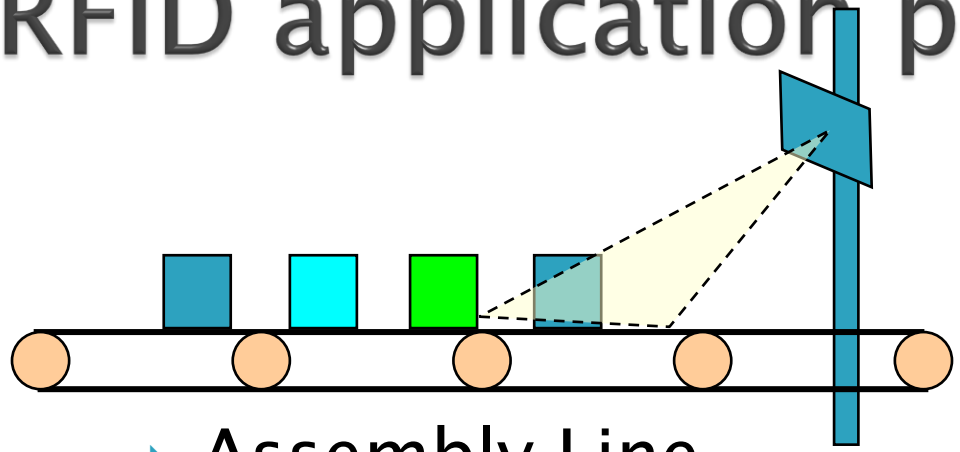
Some RFID readers

Source: **www.buyrfid.org**

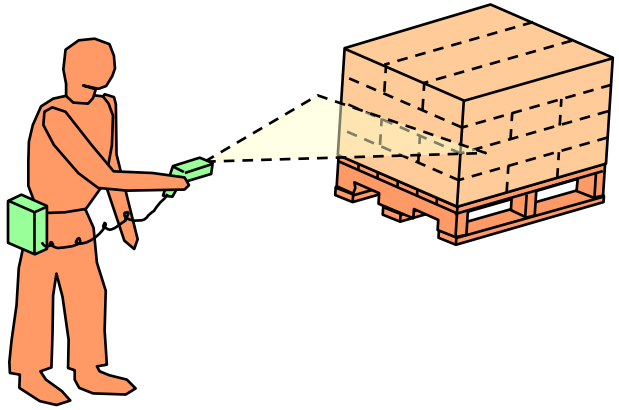
Reader anatomy



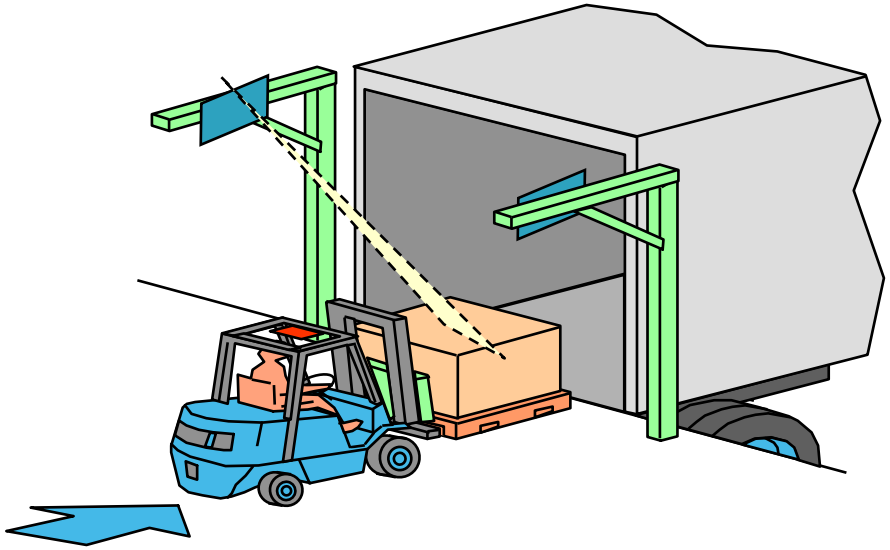
RFID application points



- Assembly Line



- Handheld Applications



- Shipping Portals

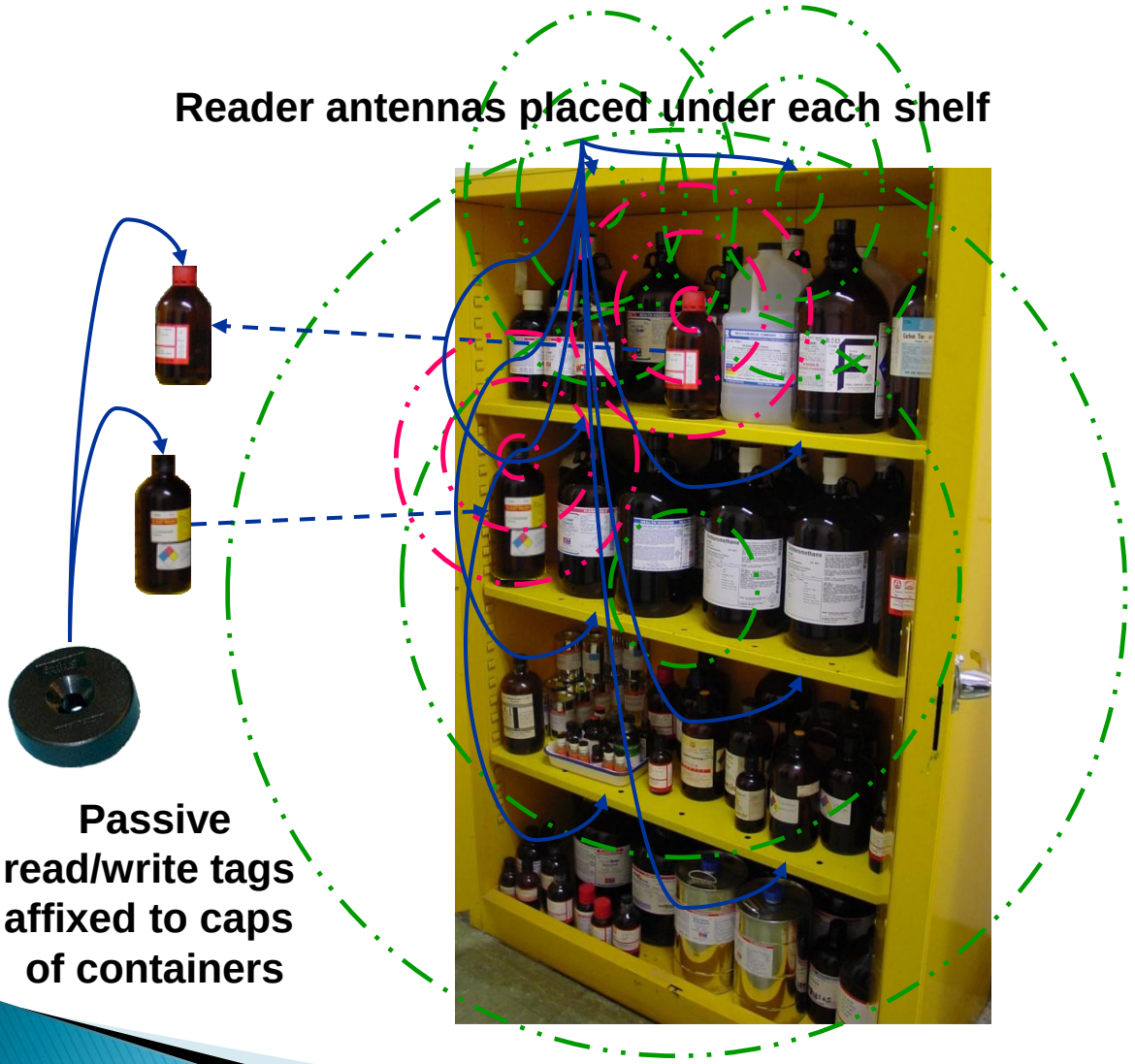
RFID applications

- Manufacturing and Processing
  - Inventory and production process monitoring
  - Warehouse order fulfillment
- Supply Chain Management
  - Inventory tracking systems
  - Logistics management
- Retail
  - Inventory control and customer insight
  - Auto checkout with reverse logistics
- Security
  - Access control
  - Counterfeiting and Theft control/prevention
- Location Tracking
  - Traffic movement control and parking management
  - Wildlife/Livestock monitoring and tracking

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.

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)

Source: **How Stuff Works**

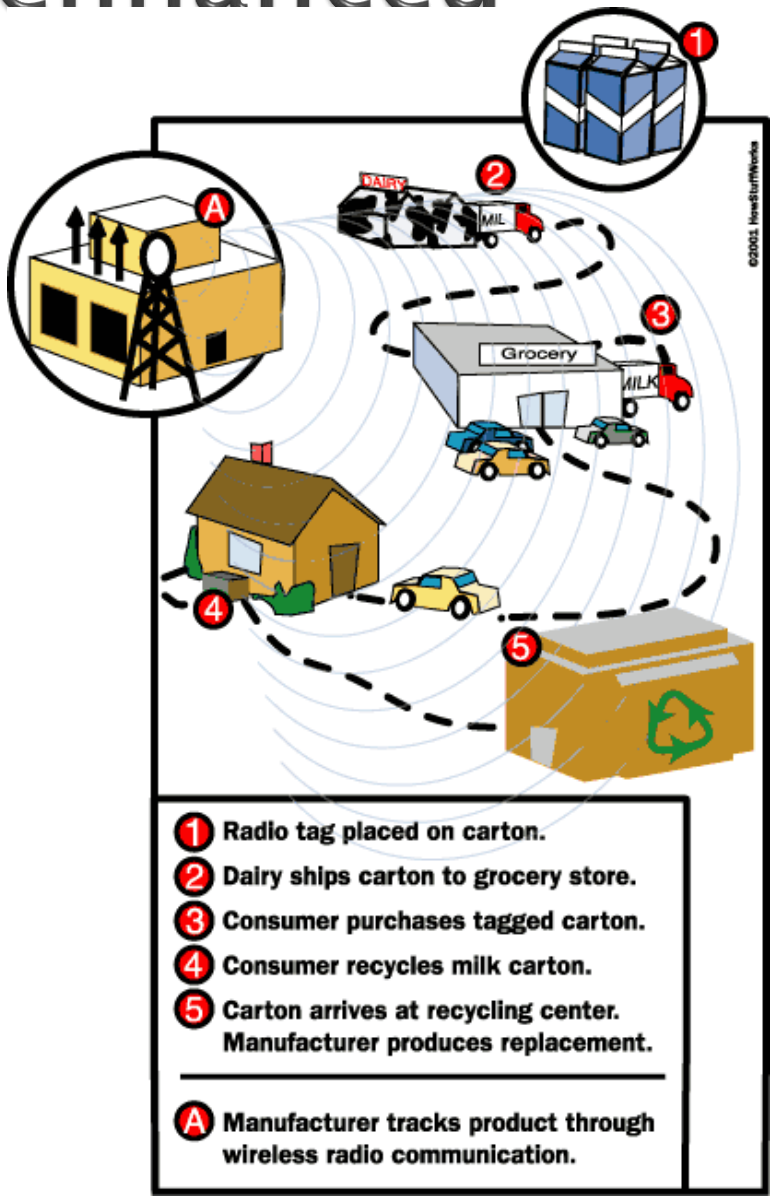
Smart fridge

- 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

Smart groceries enhanced

- Track products through their entire lifetime.



Source: **How Stuff Works**

Some more smart applications

- "Smart" appliances:
  - Closets that advice on style depending on clothes available.
  - Ovens that know recipes to cook pre-packaged food.
- "Smart" products:
  - Clothing, appliances, CDs, etc. tagged for store returns.
- "Smart" paper:
  - Airline tickets that indicate your location in the airport.
- "Smart" currency:
  - Anti-counterfeiting and tracking.

- "Smart" people ??

RFID advantages over bar-codes

- No line of sight required for reading
- Multiple items can be read with a single scan

- Each tag can carry a lot of data (read/write)
- Individual items identified and not just the category

- Passive tags have a virtually unlimited lifetime
- Active tags can be read from great distances

- Can be combined with barcode technology

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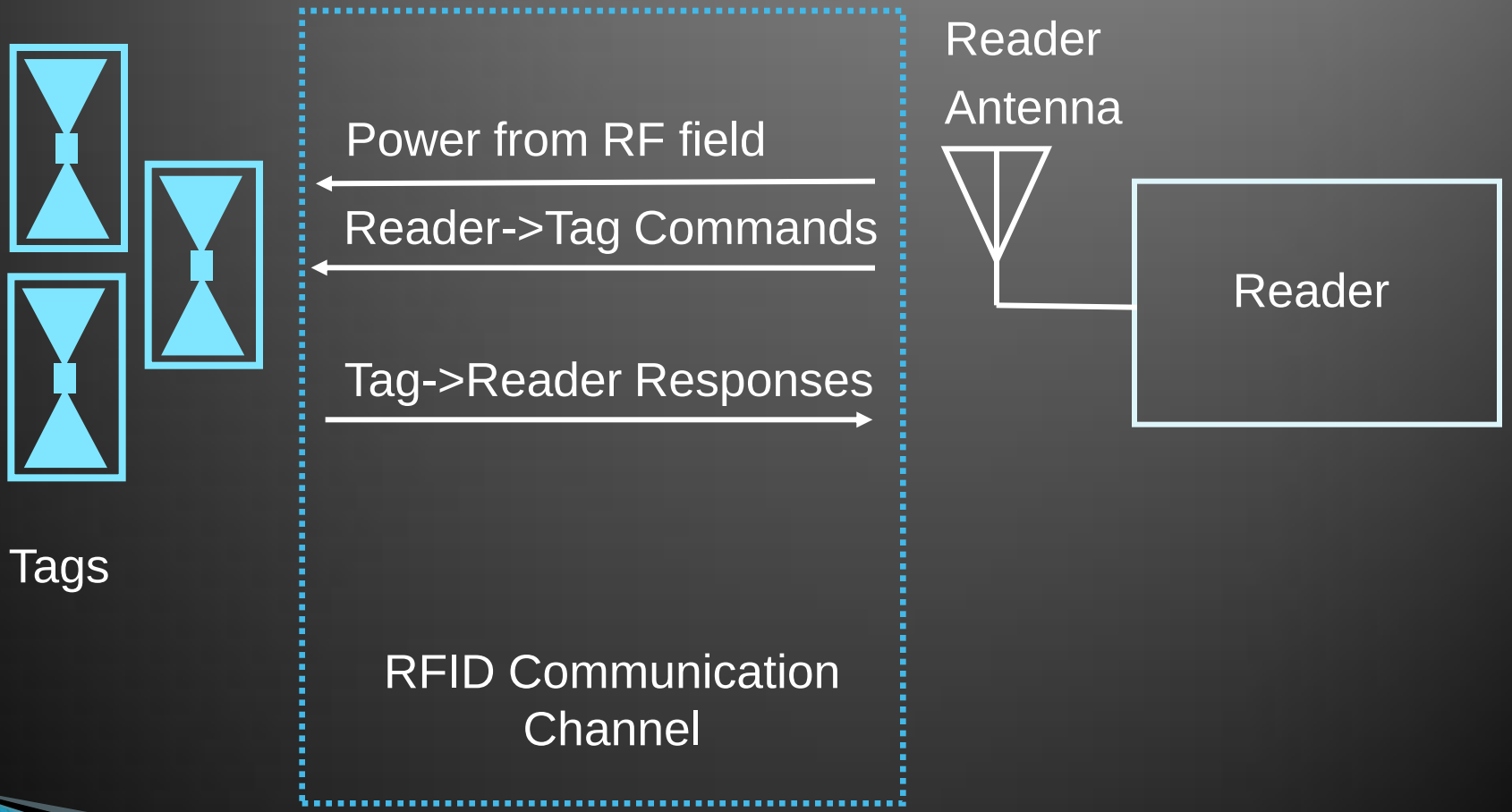
RFID communications



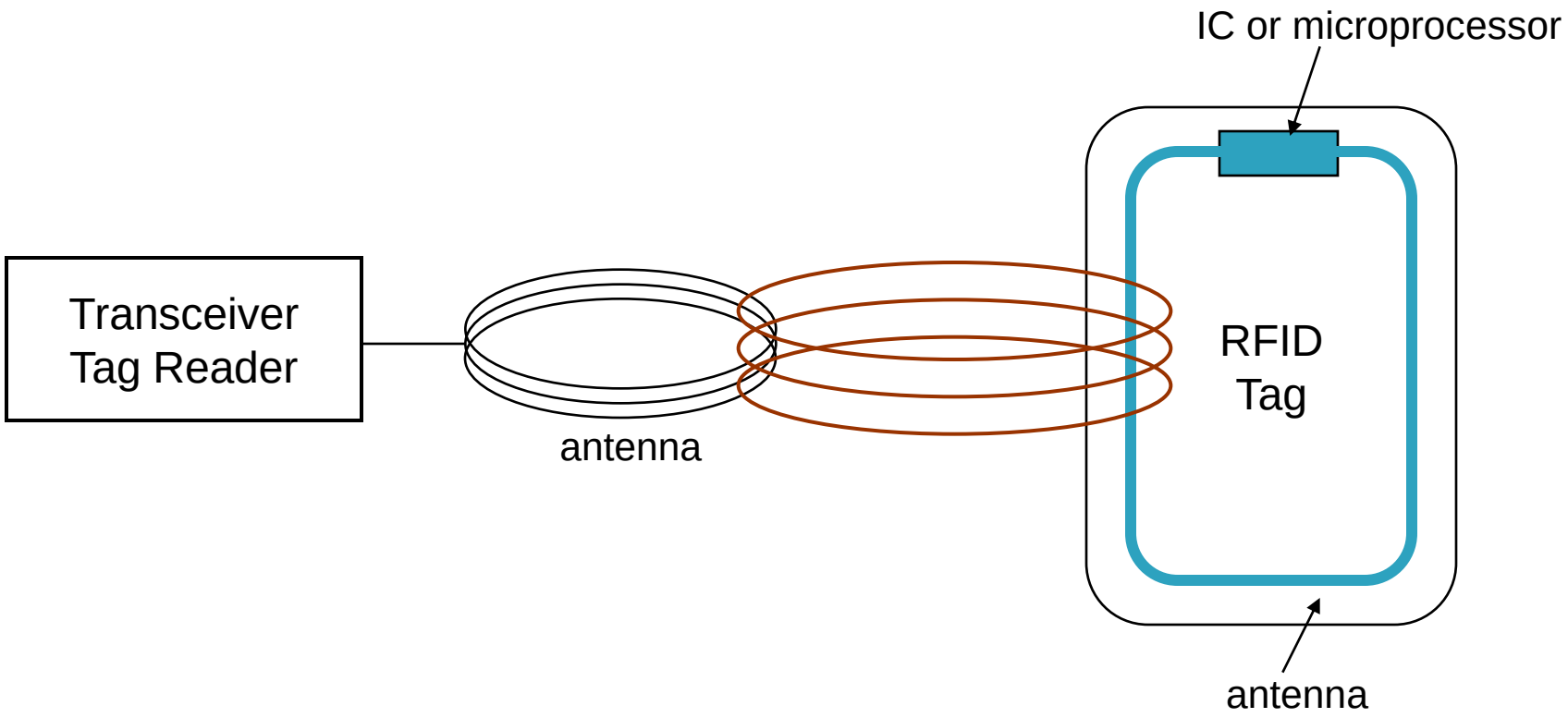
RFID communication

- Host manages Reader(s) and issues Commands

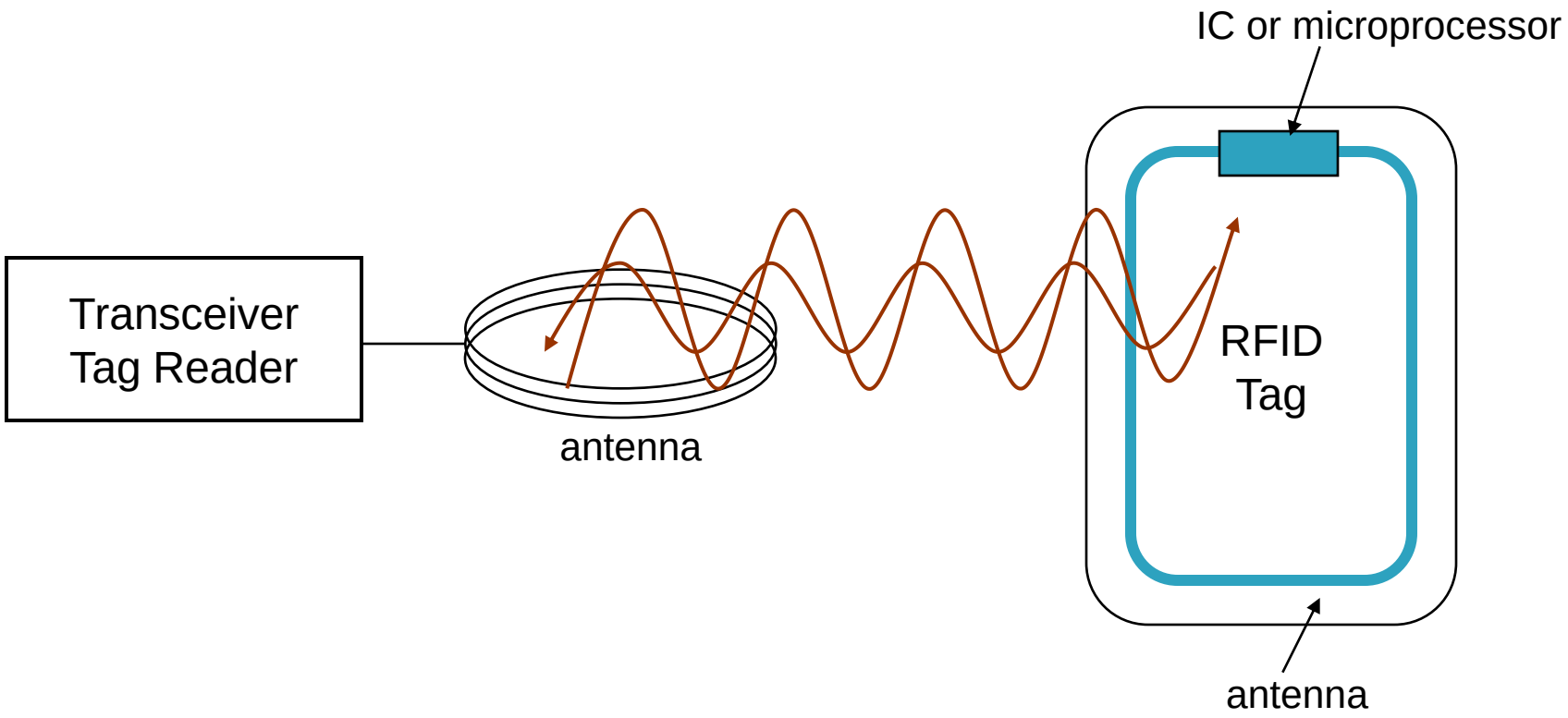
- Reader and tag communicate via RF signal
- Carrier signal generated by the reader
- Carrier signal sent out through the antennas
- Carrier signal hits tag(s)
- Tag receives and modifies carrier signal
  - "sends back" modulated signal (Passive Backscatter – also referred to as "field disturbance device")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

- Reader decodes the data
- Results returned to the host application

Antenna fields: Inductive coupling



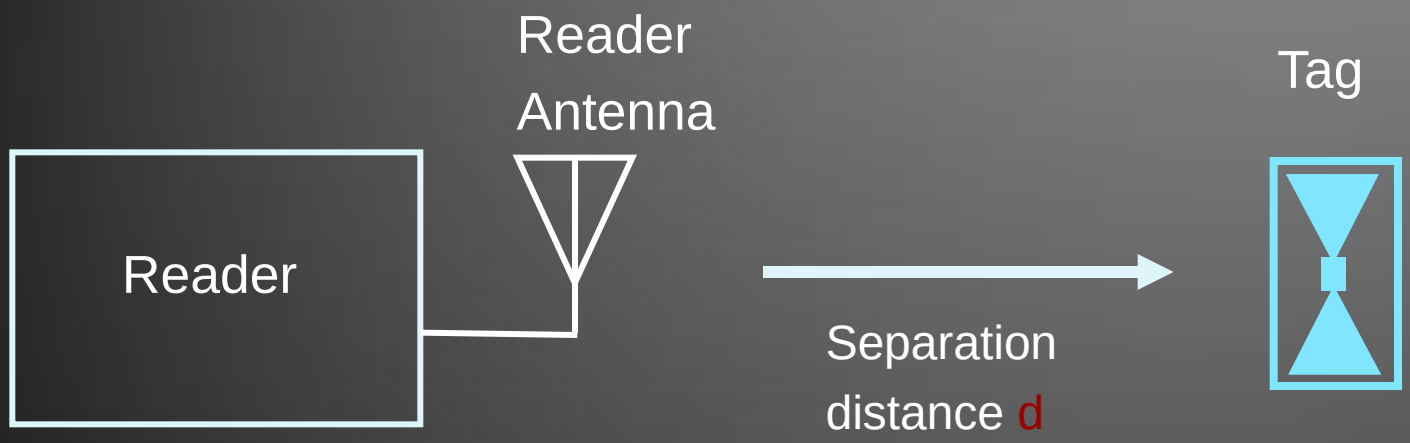
Antenna fields: Propagation coupling



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

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 : $Pt \propto 1/d^6$

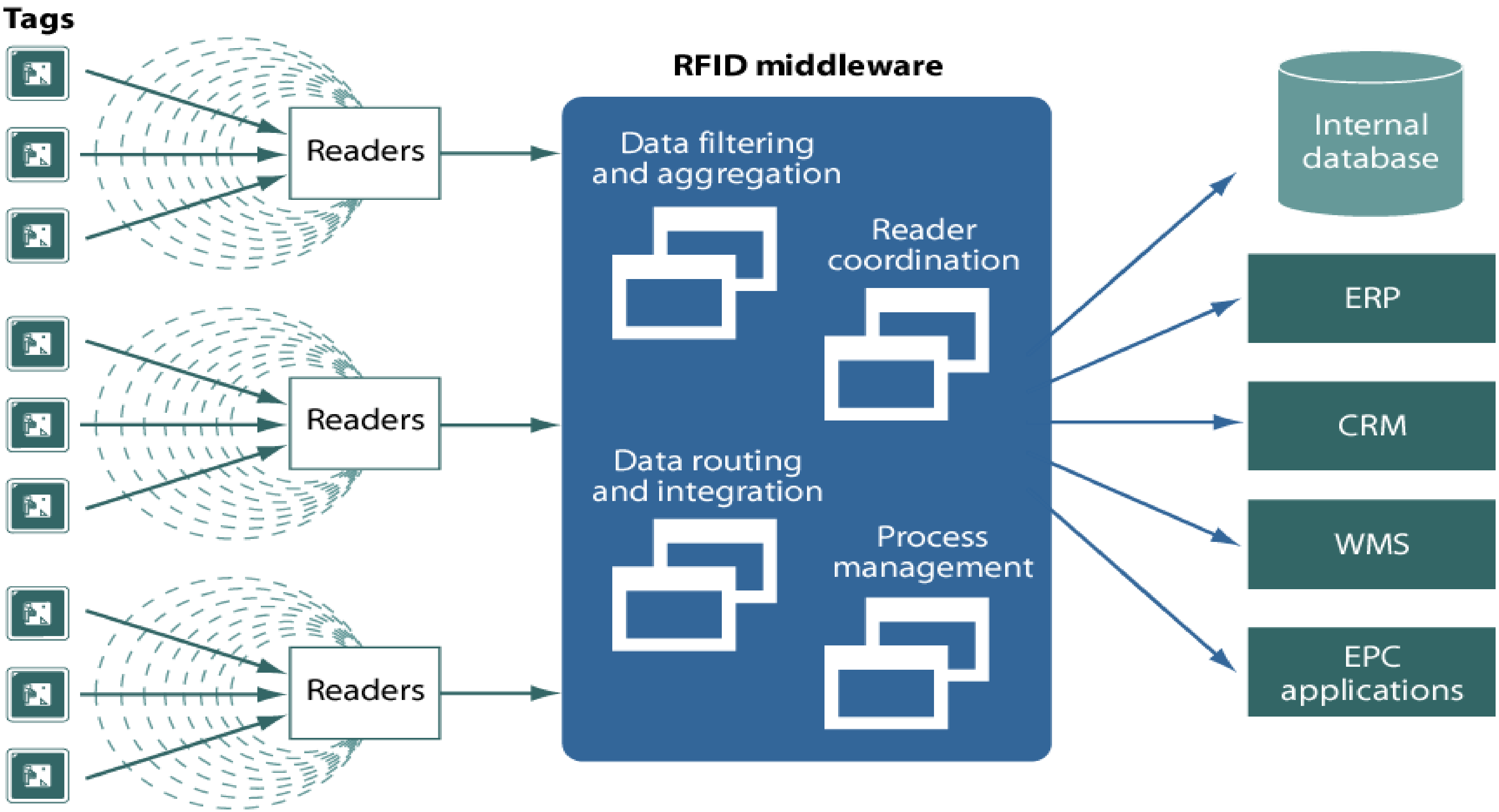
How much data?

Consider a supermarket chain implementing RFID:

- 12 bytes EPC + Reader ID + Time = 18 bytes per tag
- Average number of tags in a neighborhood store = 700,000
- Data generated per second = 12.6 GB
- Data generated per day = 544 TB
- Assuming 50 stores in the chain,
  - data generated per day = 2720 TB

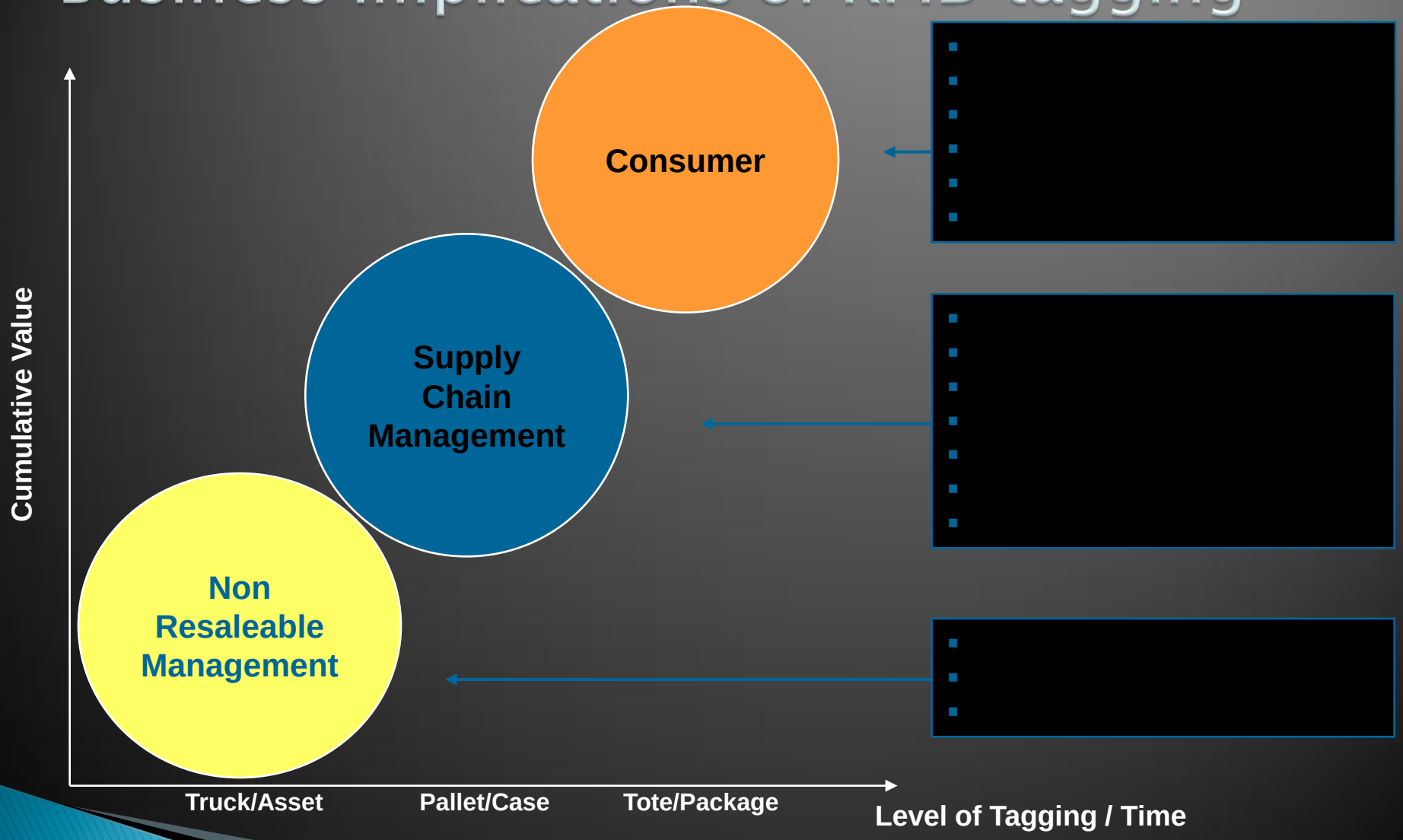
- Stanford Linear Accelerator Center generates 500 TB

RFID middleware



Source: **Forrester Research: RFID Middleware**

Business implications of RFID tagging



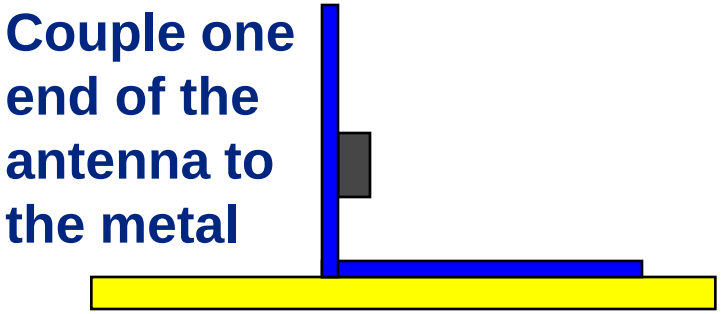
Source: **www.accenture.org**

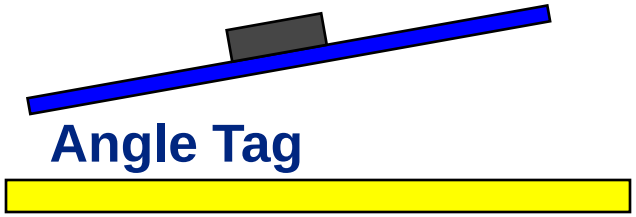
RFID deployment challenges

- 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

Using tags with metal

- Tags placed directly against metal will negatively affect readability





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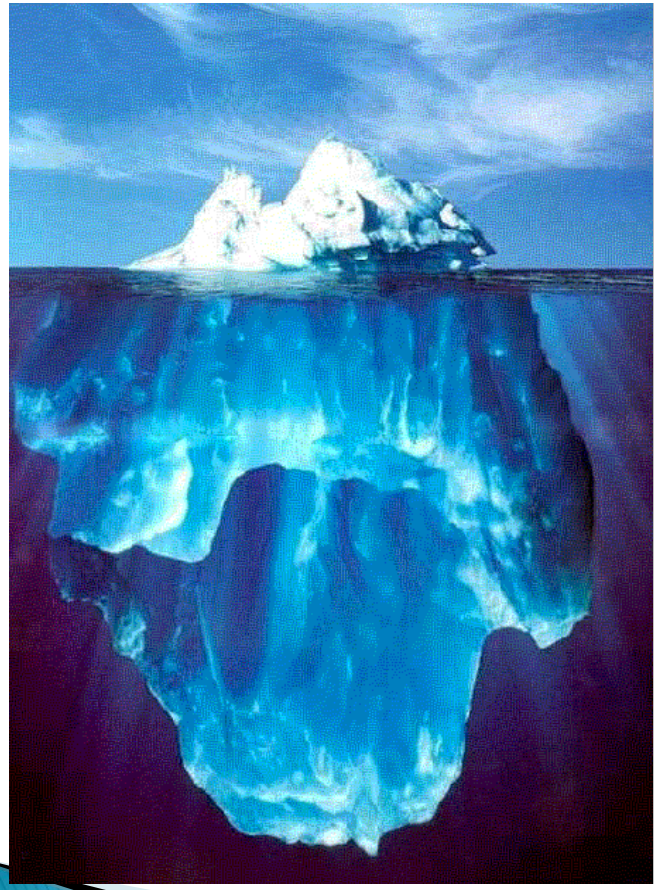
RFID: The complete picture



Tags and Readers

Identifying Read Points
Installation & RF Tuning
RFID Middleware
Connectors & Integration
Process Changes
Cross Supply-Chain View

Points to note about RFID

- RFID benefits are due to automation and optimization.
- RFID is not a plug & play technology.
- “One frequency fits all” is a myth.
- Technology is evolving but physics has limitations.
- RFID does not solve data inconsistency within and across enterprises.
- Management of RFID infrastructure and data has been underestimated.

RFID Summary

Strengths	Weaknesses
➢ Advanced technology ➢ Easy to use ➢ High memory capacity ➢ Small size	➢ Lack of industry and application standards ➢ High cost per unit and high RFID system integration costs ➢ Weak market understanding of the benefits of RFID technology
Opportunities	**Threats**
➢ Could replace the bar code ➢ End-user demand for RFID systems is increasing ➢ Huge market potential in many businesses	➢ Ethical threats concerning privacy life ➢ Highly fragmented competitive environment