



# Radiofrequency Identification for Tracking Assets and Reducing Errors

Lab InfoTech Summit  
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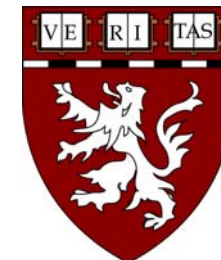
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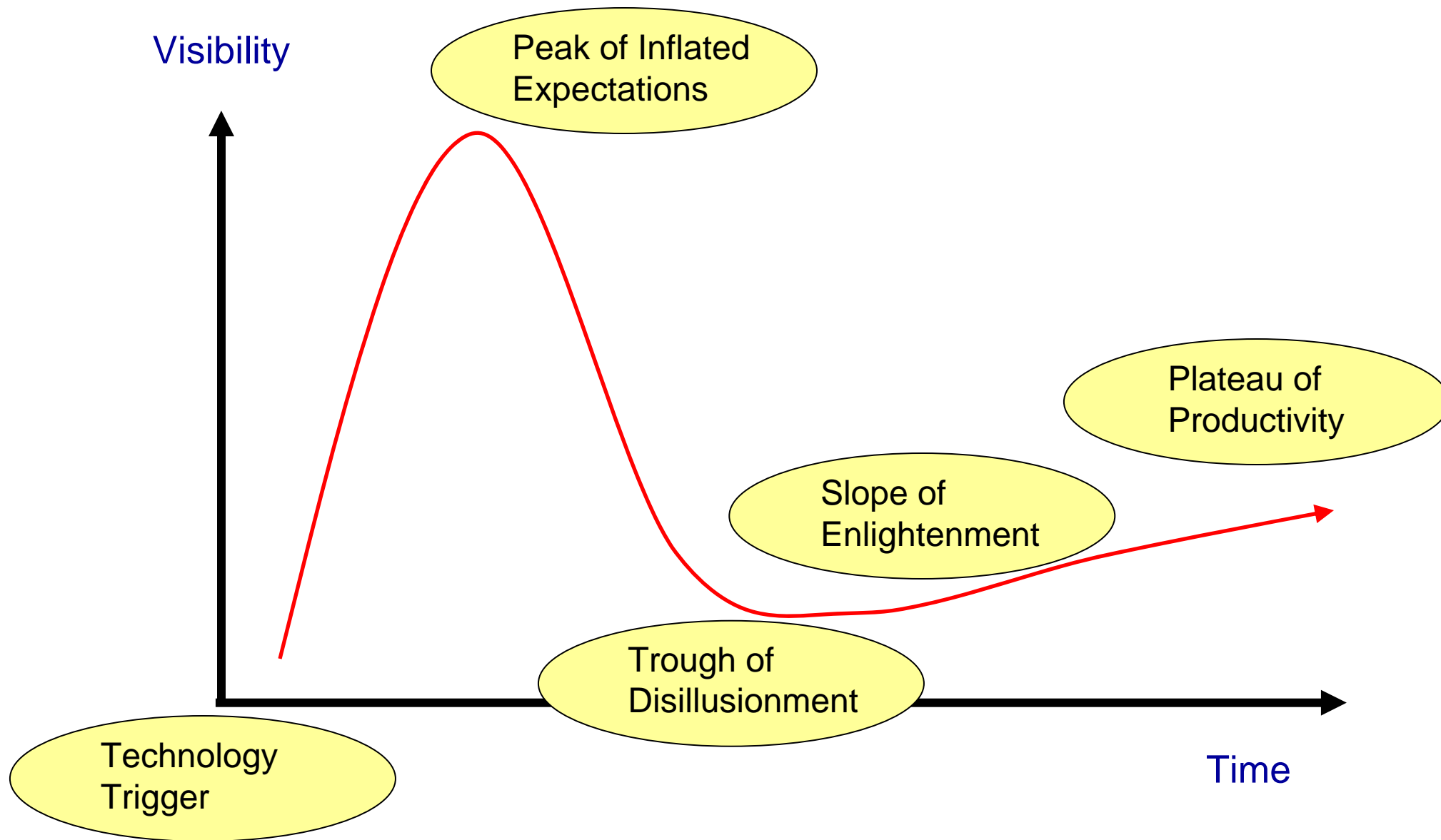
Boston, MA





Radiofrequency identification (RFID) is a technology that uses radio waves to automatically identify physical objects.

# The Hype Cycle





- RFID Explained
- RFID in Other Industries
- RFID in Healthcare
- RFID in Pathology
- Perspectives on the Future of RFID



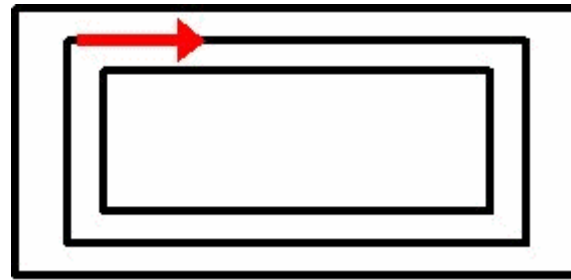
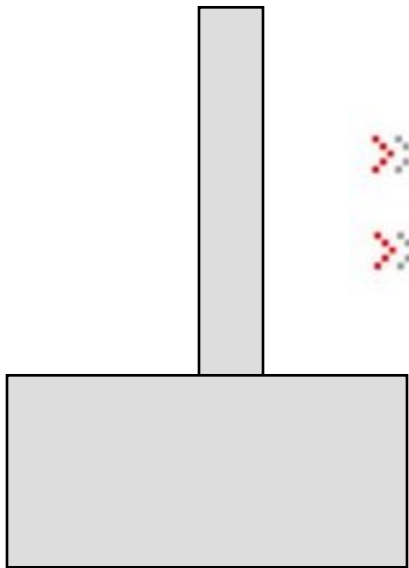
Auto Identification Technology: technology by which a physical object can be automatically identified

- Bar coding
- Magnetic stripe cards (credit cards)
- Biometric (fingerprint and retinal scans)
- Voice recognition
- Optical character recognition
- *Radiofrequency identification*

# RFID Basics: Coil in a Magnetic Field



In late 1800's Hertz and Maxwell determined that current could be generated by placing coils in an electromagnetic field



Copper Coils  
*RFID Tag*

Electromagnetic force generator

*RFID Reader*

For RFID this current supplies the power to:

- Access data on microprocessors
- Send a signal back to reader to tell the reader what the object is

# RFID is Becoming Pervasive



- Car (FastPass tolls)
- Gas (Mobil SpeedPass)
- Hospital (Door access)
- Train (Subway pass)

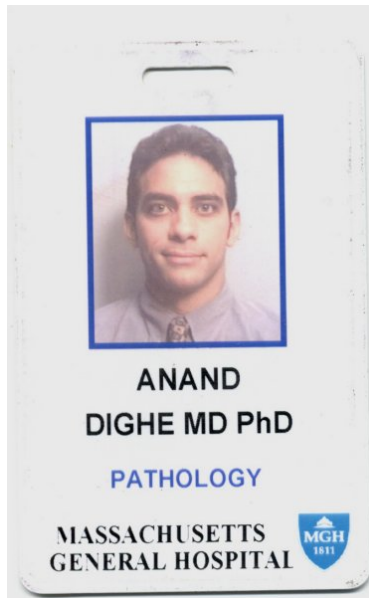
Toll booth transponder



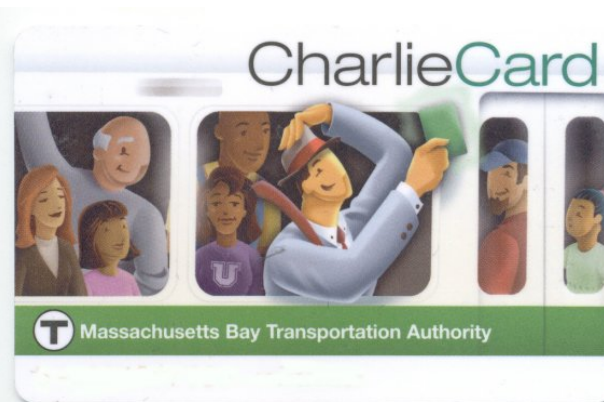
Mobil Speed Pass



Hospital ID



Boston Subway Pass

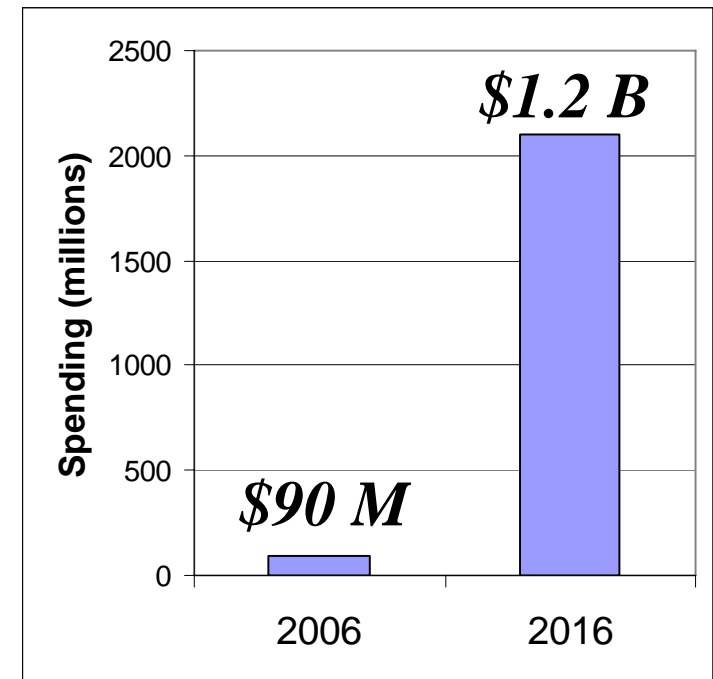


# RFID Market (2006)



- 2006 global RFID market is \$3-4 billion
- Healthcare market is small but growing fast
- 45% of hospitals have RFID spending planned for 2007 (up from 10% in 2005)
- Hospital applications
  - Equipment tracking
  - Patient tracking
  - Process/capacity management
  - Documentation enhancement

**U.S. Healthcare RFID Market**

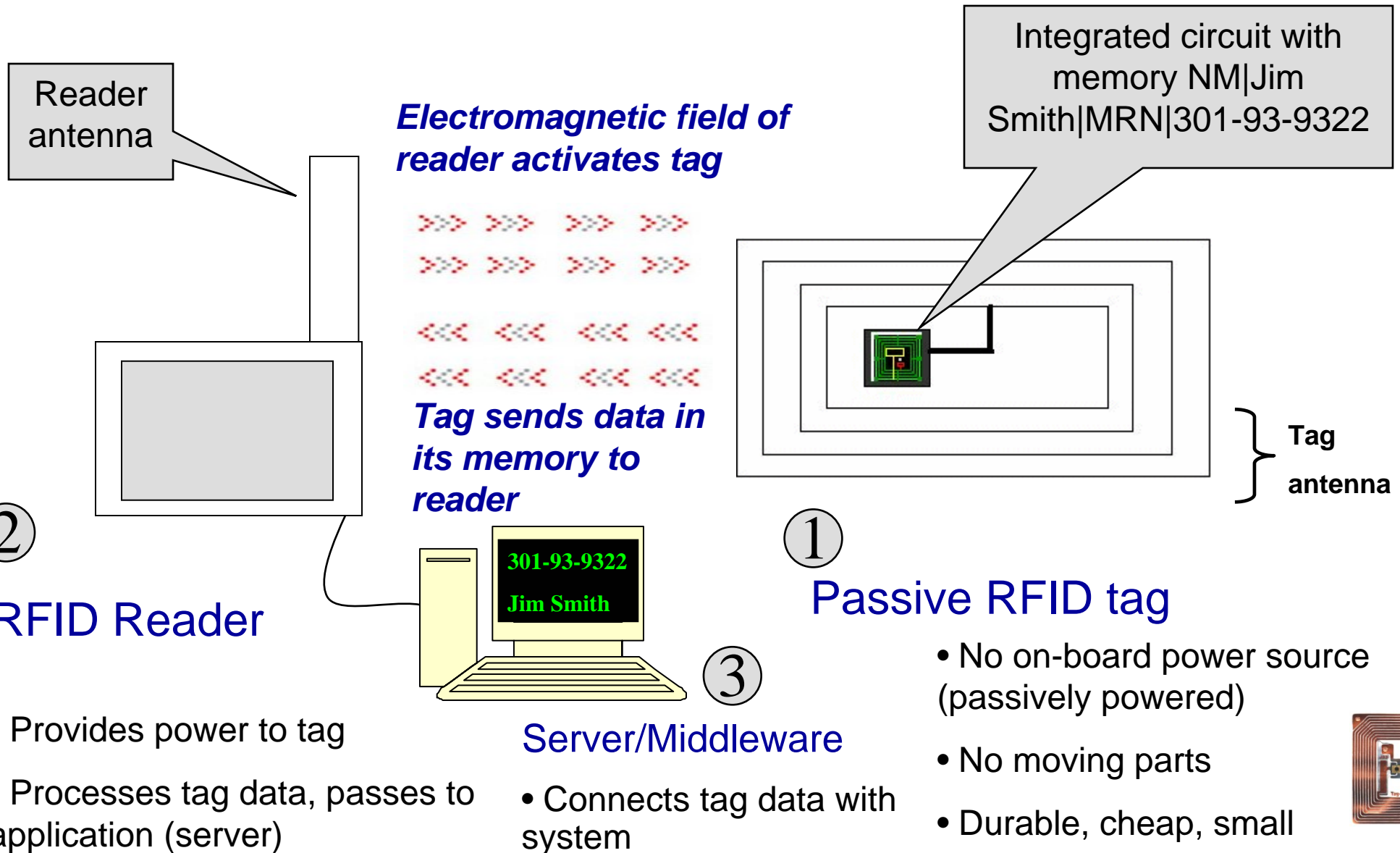




## 2 major types of RFID systems

- Passive RFID
  - Active RFID
- 
- Important to understand since each has different strengths and weaknesses
  - Essential to match the right technology to the job
  - Consider other auto-ID technologies such as bar codes

# Passive RFID (Tag, Reader, and Middleware)



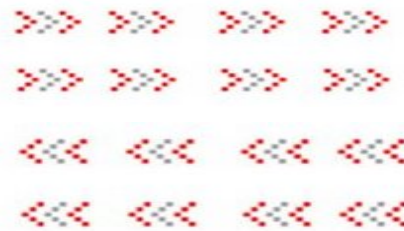
# Passive RFID Versus Bar Codes



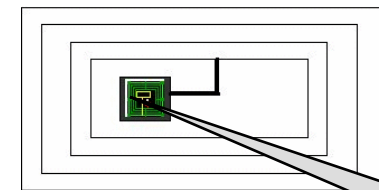
Both are Auto Identification technologies: technology by which a physical object can be automatically identified

RFID Reader

*“1234567”*



*Radiowaves*



Passive  
RFID Tag

1234567

Bar Code Scanner

*“1234567”*



*Laser light*

Bar code



1D bar  
code

*Why don't we just use a bar code?*

1234567



*Bar codes have been around since the 1970's. Why so poorly adopted in healthcare?*

## Retail

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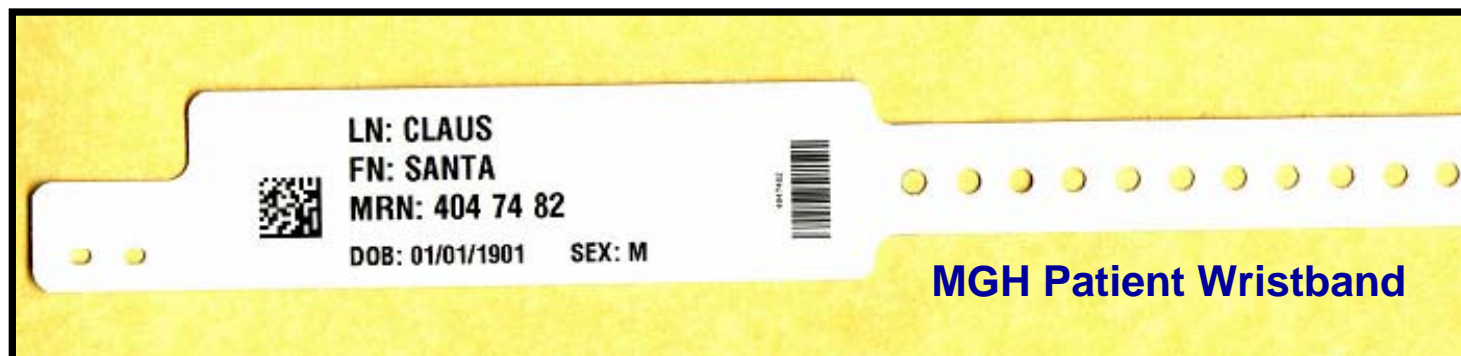
- Industry giant sets standards
- Bar codes on products
- Checkout
- Same work flow
- Minor monetary consequences of error
- Success: reduced labor costs, increased customer and revenue growth

## Healthcare

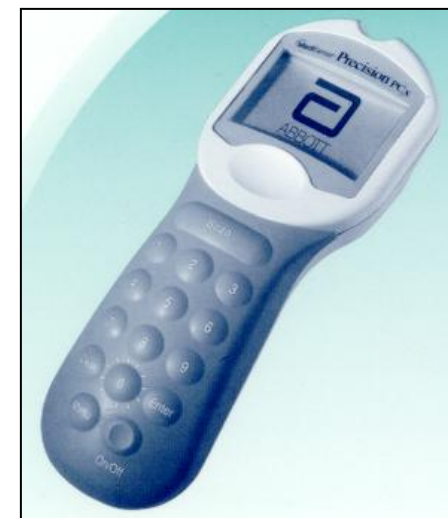
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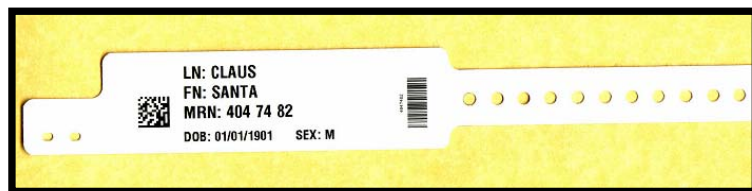
- No industry giant: no standards
- Bar codes on many things
- Point of care
- New work flow
- Life impacting errors are possible
- Success: better patient care, error avoidance

# Bar Coded Patient Wristbands Reduce Errors



- MGH patient wristband has 1D and 2D bar codes
- At MGH the 1D bar code is used for glucometry: scanning the bar code dropped the patient ID error rate from 1-3% to zero





## Bar Coded Wristband

- Find wristband under hospital gown sleeves
- Contact patient (nosocomial infection risk)
- Rotate wristband to find bar code
- Ensure wristband is flat (will not scan across curved surface) and scan
- Soiled or wrinkled wristbands will be difficult to scan and may require replacement
- 10-20% of time will not read the first time and additional tries are needed (may game system if problematic enough)





## RFID Wristband

- Point RFID reader within 3 inches of wristband
- Patient ID information is read through clothing with near 100% scan success rate.

# Comparison of Bar Codes and Passive RFID Tags



	Bar Code 	Passive RFID Tag 
<b>Ruggedness</b>	No	Yes
<b>Reliability</b>	Wrinkled or smeared labels will not be read	Nearly flawless read rate
<b>Readable through objects</b>	No, must be line of sight	Yes
<b>Passive (automated) data collection</b>	No	Yes (via portals and smart shelves)
<b>Orientation dependence</b>	Yes	No
<b>Data capacity</b>	< 20 characters with linear	100's-1000's of characters
<b>Read speed</b>	Slow	Very fast (ms)
<b>Simultaneous scanning of multiple codes/tags</b>	No	Yes (10-1000 tags per second)
<b>Updateable</b>	No	Yes
<b>Marginal Cost</b>	\$0.01 per label	\$0.05-\$1.00 per tag

# Passive RFID Tags Can Be Made In Many Forms



- “Smart labels”: ultra thin RFID tags embedded inside a label (tag programmed by printer as it prints the label)
- Attached to blood collection tubes (Maxell)
- Built into fabric of cardboard boxes (pilots by Georgia Pacific, International Paper)
- Human implantable passive RFID tags (VeriChip)



# Passive RFID Tags: WHAT is it (and where was it last)?



- Passive RFID tags encode an object's unique identity
- Passive RFID tags must be within a few inches to feet of their reader to be read
  - **Handheld scanners**
  - **Portal applications**
    - Supply chain management
    - Libraries, stores
  - **Smart shelves:** shelf with built in passive RFID reader that reads the RFID tags of items placed on shelves

*For real time, high resolution tracking must use active RFID*



Handheld passive RFID reader

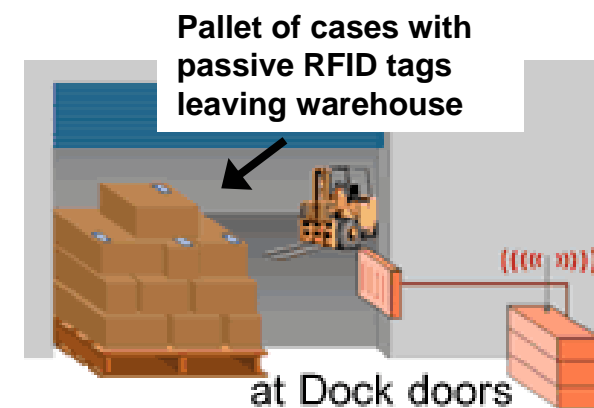


Smart Shelf

## Portals



Passive RFID in libraries, stores



Passive RFID at warehouse entry and exit points

# Active RFID Tags: WHAT is it and WHERE is it now?



- Active tags are bigger than passive tags, have an internal power source (battery)
- Active tag “checks in” at regular intervals

RFID Reader  
Network

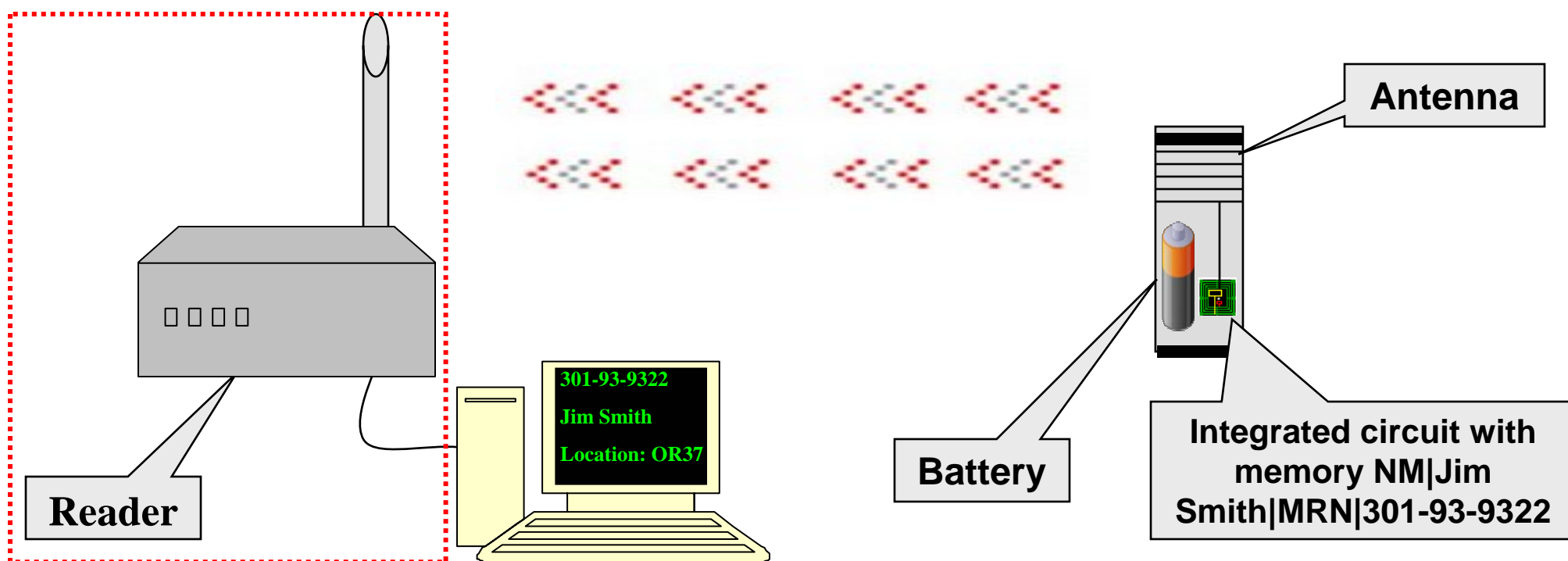


Tag sends ID. Location of tag can be determined by strength of signal and triangulation with other readers in the network (Jim Smith is close to Reader 21 → Jim Smith is in operating room 37)

Check in interval important determinant of battery life (generally 6 months-3 years)



## Two types of Active RFID reader networks:

- **802.11x network (Wi-Fi):** utilizes existing wireless infrastructure. Often requires additional access points (3x that needed for other wireless applications) to locate objects at desired resolution
- **Proprietary network:** requires installation of network of readers. Does not use existing wireless network. Cost ~\$1,000 per hospital bed.



# Comparison of Active and Passive RFID Tags



	Passive RFID 	Active RFID 
<b>System Cost</b>	Handheld readers cost \$500-1,500 per reader. Also need to consider interfaces, software, training.	Dedicated network: ~\$1,000 per bed for hospital wide implementation. 802.11x based systems may use existing infrastructure. Also need to consider interfaces, software, training.
<b>Tag Cost</b>	\$0.05-\$1.00	\$10-100 (cheaper tags are single use)
<b>Location Accuracy</b>	Not suitable for accurate location tracking. May be used in portal applications	Accuracy to 2 feet. Higher resolution dependant on number of readers, system and environmental variables
<b>Tag Life</b>	No battery. Virtually limitless.	6 months to 4 years; depends on "check-in" rate. Some batteries replaceable or rechargeable

# Classification of RFID Tags: Tag Frequency



Frequency	Type	Range	Applications	Advantages	Interferences
<b>Low Frequency</b> 125 KHz	Passive	< 2 inches	Animal tagging, Mobil Speed Pass	Penetrates water/tissue well	Metal blocks signal
<b>High Frequency (HF)</b> 13.56 MHz	Passive	< 3 feet	Access cards, Smart cards, surveillance tags, patient wristbands	Penetrates water/tissue well	Metal blocks signal
<b>Ultrahigh Frequency (UHF)</b> 433 and 860- 960 MHz	Active and Passive	10 to 30 feet	Inventory and supply chain management, patient tracking, equipment tracking	Effective around metals, fast read speed (1000's tags/sec)	Water blocks signal
<b>Microwave</b> 2.45 GHz	Active	10+ feet, some require line of sight	Toll collection	Effective around metals, long range	Potential for 802.11x network interference

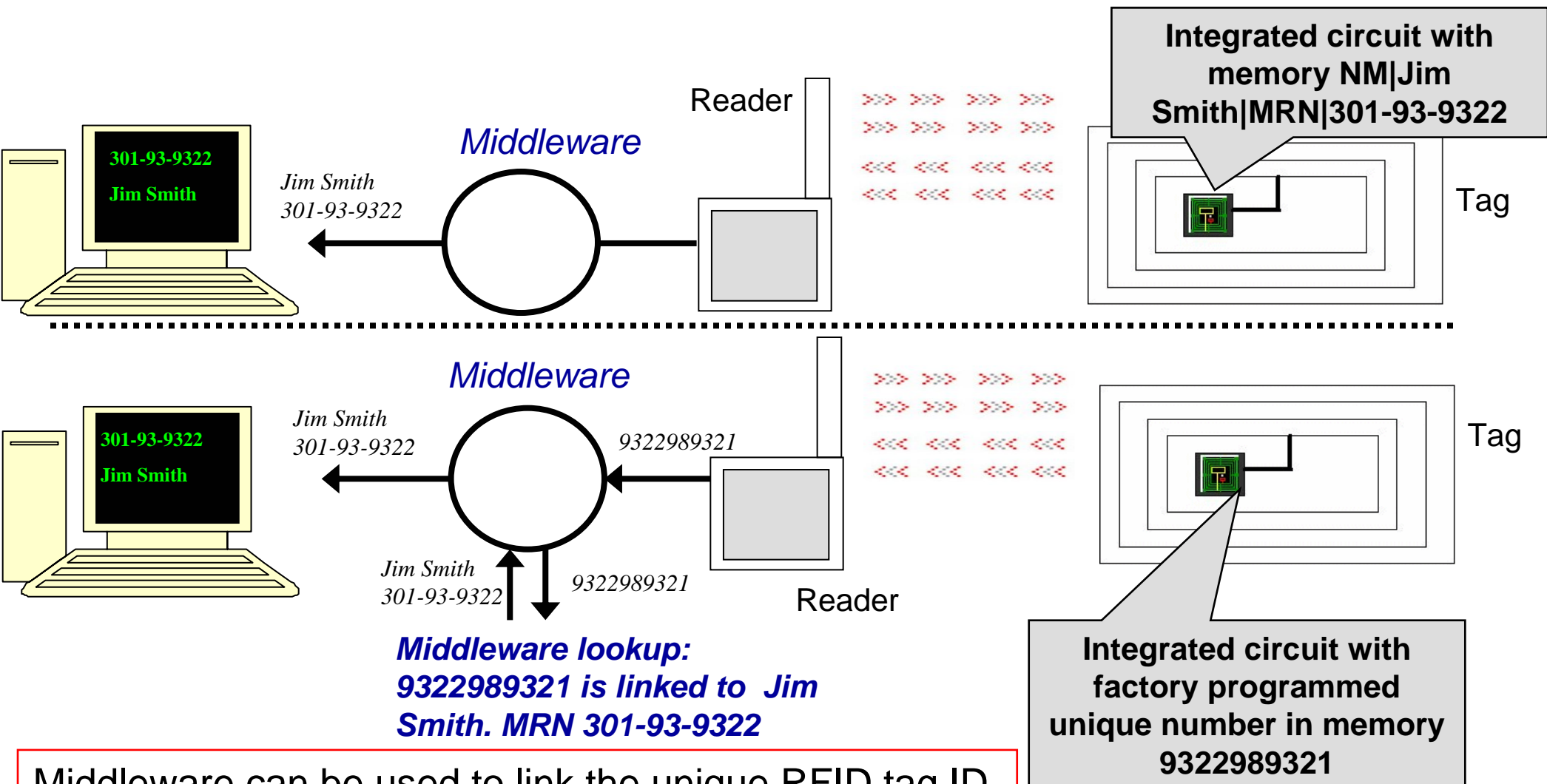
- **Read/write tags**
  - Amount of data that can be written to tag is limited only by memory size (typically 100-1000's characters)
  - Can update the tag any time that it is read (add/edit or delete data)
- **Read only tags:** typically contain only a factory programmed unique number.
  - A 96 bit tag can store  $8 \times 10^{28}$  unique numbers  
*(enough to uniquely identify every grain of sand on the planet)*
  - Read only tags are the most commonly used tag in supply chain management applications



Smart labels:  
write information  
to RFID tag and  
print information  
on label

How can a read only  
unique integer be used to  
identify an asset?

# The Role of Middleware in RFID

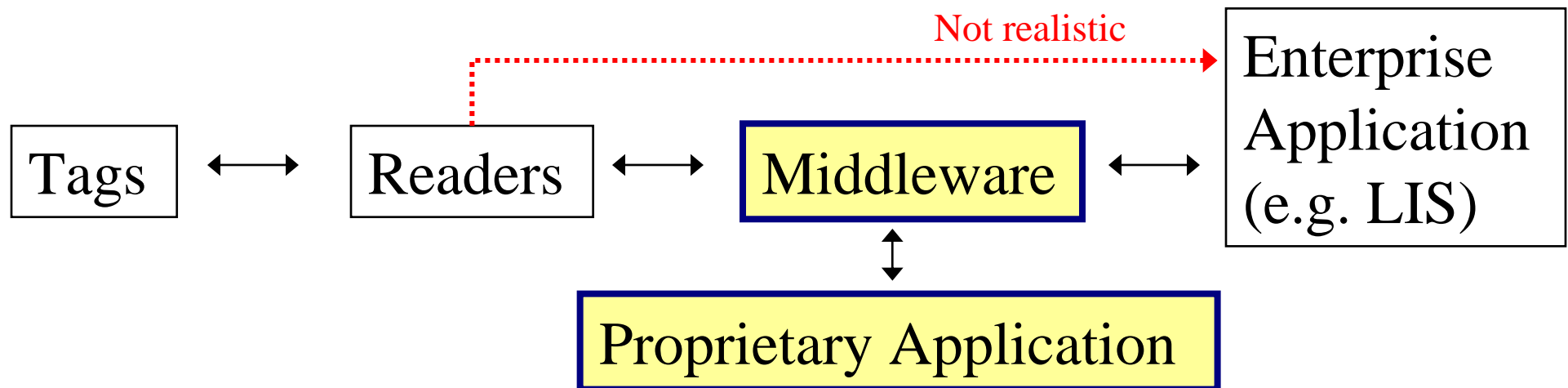


Middleware can be used to link the unique RFID tag ID to the description of the tagged object. Prior to this the tag must be “commissioned”, linking patient with tag.

# There's More to RFID than Readers and Tags



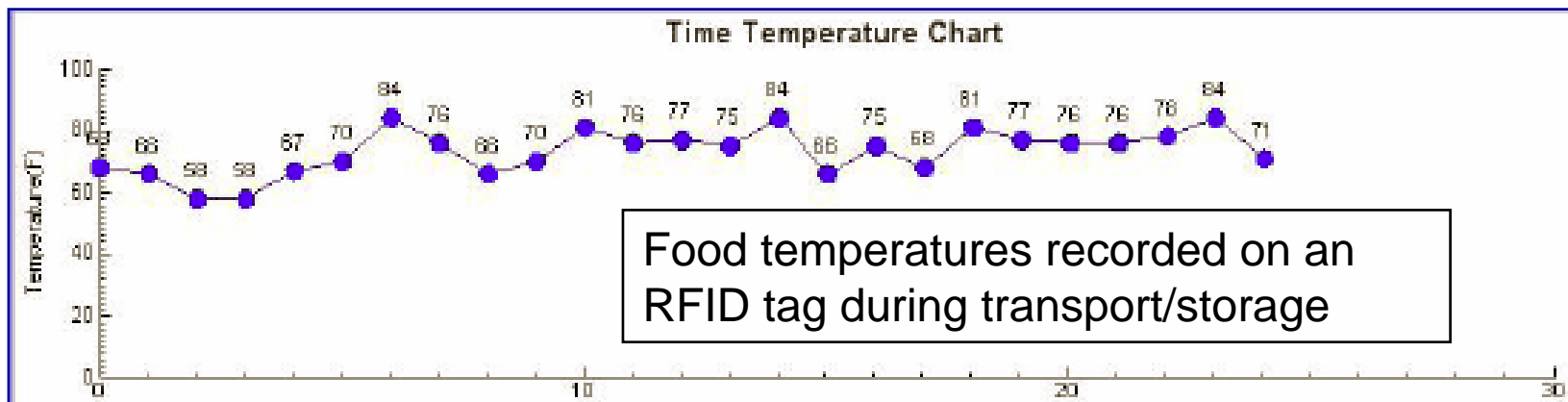
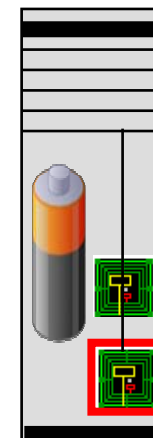
- Cost of tag receives undue focus
  - This is only the marginal cost
  - Tags and readers permit data capture but then networked software (middleware), user interfaces, and/or linkages with existing applications are needed to use the data
- Most vendors provide highly custom built software/user interface for data analysis



# Recent RFID Tag Developments



- This is still an immature market and today's tags are very likely to be replaced with improved versions
  - Semi-active (semi-passive) tags
  - Surface acoustic wave tags
- Tags can be fitted with sensors that detect changes in their environment. **Examples:**
  - Tags on hospital equipment that sense changes in acceleration
    - Broadcast their location only when moved (saves battery life)
  - Tags on fresh food shipping containers that sense temperature
    - Sensors used to monitor ambient temperature and write the temperature data to chip memory



# Industry Use of RFID: What Is It AND Which One Is It?



*The New Electronic Product Code (EPC)*

**01.0203D2A.916E8B.0719BAE03C**



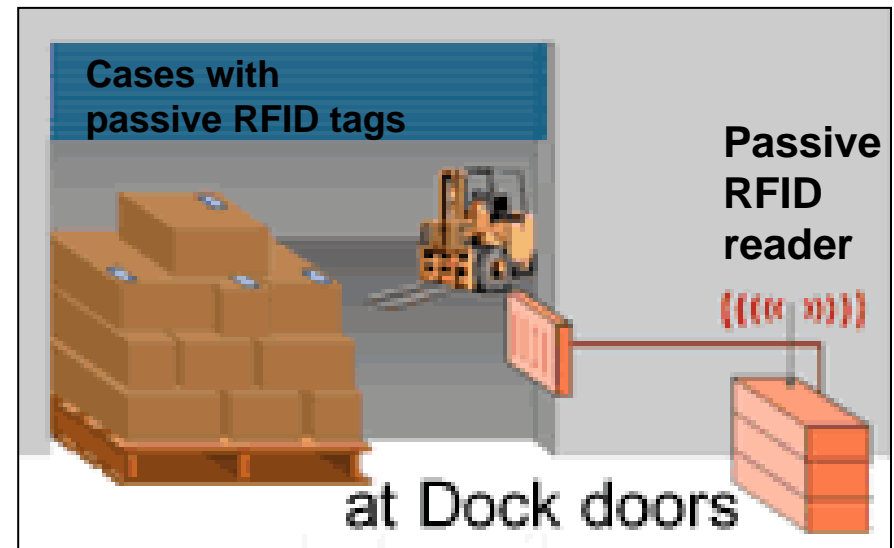
Header

EPC Manager

Class

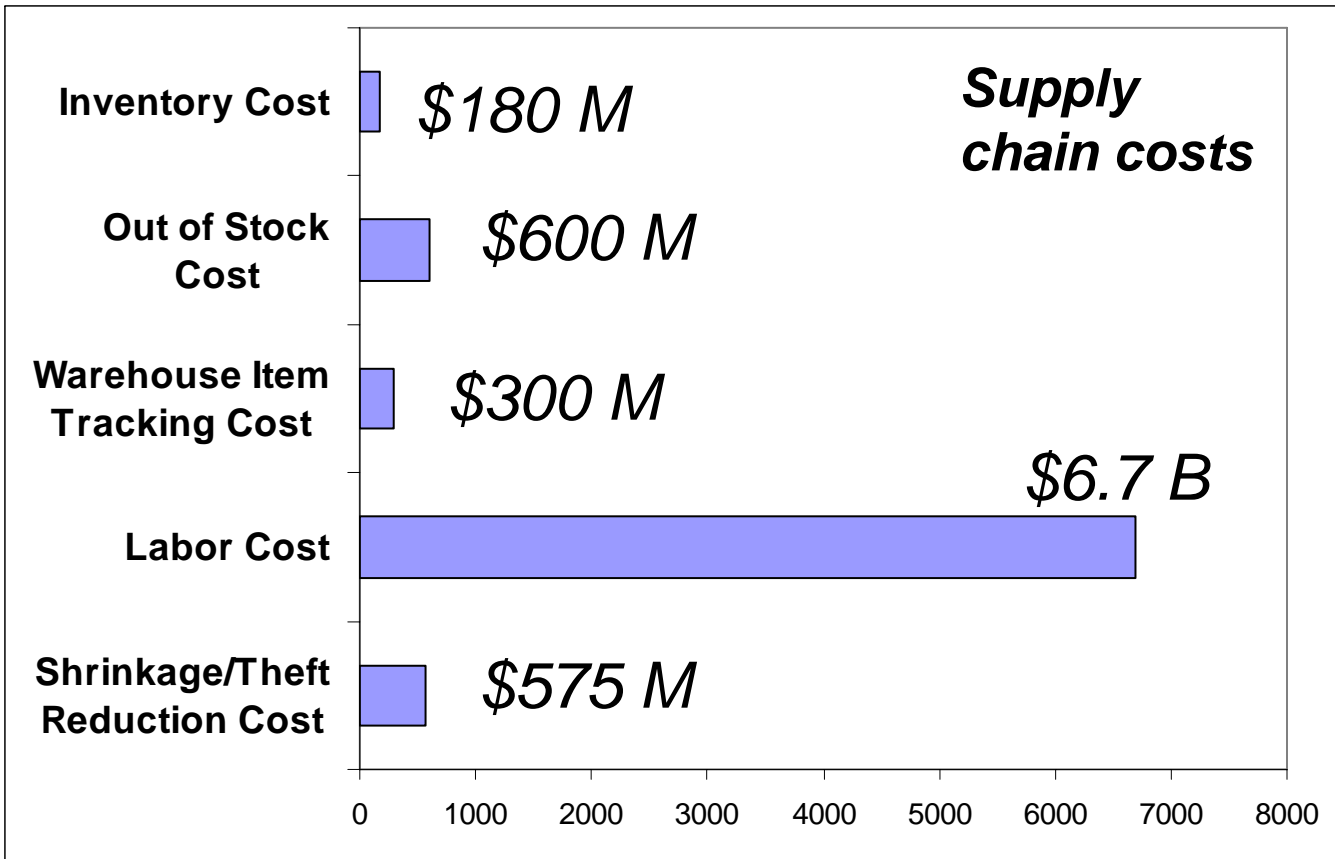
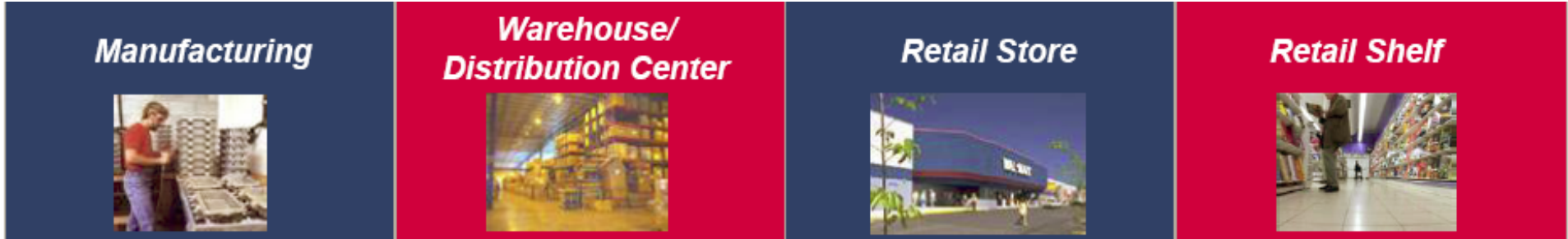
Serial number

- 95% of RFID tags used in industry are passive RFID tags
- Tag encodes the item's EPC: electronic product code
  - *A unique identifier of that specific item*
  - The EPC can uniquely identify 1,152,921,504,606,846,976 different items.
  - Bar codes (especially 1D bar codes) are not unique.
- The EPC code is used as the hook to connect to networked middleware (ALE, ONS) to obtain the stored name and description of the product
- Tagging started at the case level and is now moving to the item level (Wal-Mart, Target, Albertsons, DoD)



Supply Chain Management with Passive RFID tags

# Why is Wal-Mart So Interested in RFID Technology?



- 1000 of its 2600 stores are RFID enabled
- Wal-Mart has over 500 suppliers that currently send it RFID tagged items
- RFID enabled stores have reduced out of stock costs and inventory costs
- Early adopters in retail & consumer packaged goods have achieved cost savings of 1% of sales



*“One thorn of experience is worth a whole wilderness of warning.”*

*- James Russell Lowell*

- **Asset tracking and workflow management**
  - Operating room of the future, ED
    - Active tags (Radianse)
- **Blood transfusion safety**
  - Patient wristbands and blood products tagged
    - Passive tags (TagSys, Lattice)



- Test site for evaluation of new operative and peri-operative technologies including RFID
- Both a laboratory and a working operating room
- Operating rooms generate 40% of a hospital's revenues, cases rarely start on time
- Goal is to use RFID to improve operational efficiencies by revealing new relationships between things

# Active RFID: (Radianse Indoor Positioning System )



- Uses combination of active RFID (433 MHz) and infrared for high resolution (< 2 m) asset tracking
- Proprietary network (not 802.11x) of RFID readers installed in ORs
- Custom software to map assets



Tag  
(~\$10)



Reader

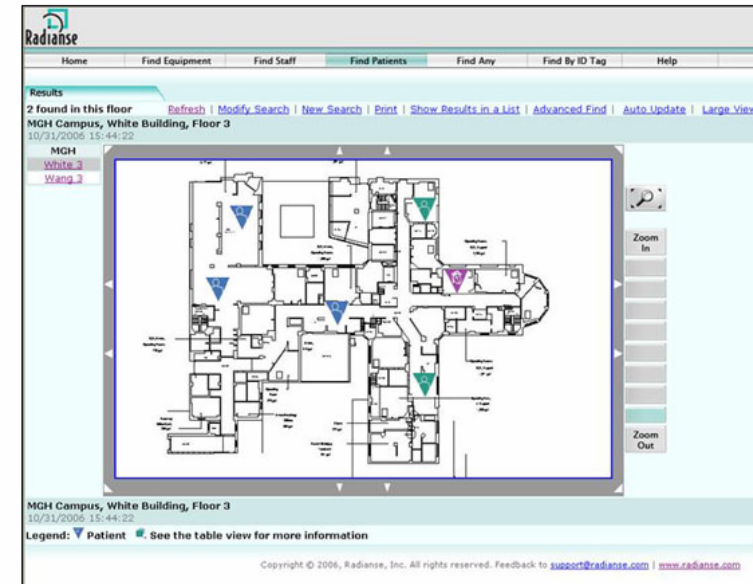
High value assets tagged with active RFID:

- Patients
- Surgical staff
- Cleaning crew
- Equipment (e.g. ultrasound machines)



The stream of real time location data must be tied to workflow changes and other applications to create real value:

- After patient and surgeon has left OR38 >> alert cleaning staff to clean OR38 via pager
- After cleaning crew has been present for 30 min and has left OR38 >> Room is clean, alert nurse via text message sent to cell phone
- If ultrasound machine is not in OR53 and needed for the next case >> Alert materials management via pager to find ultrasound machine and bring it to OR53



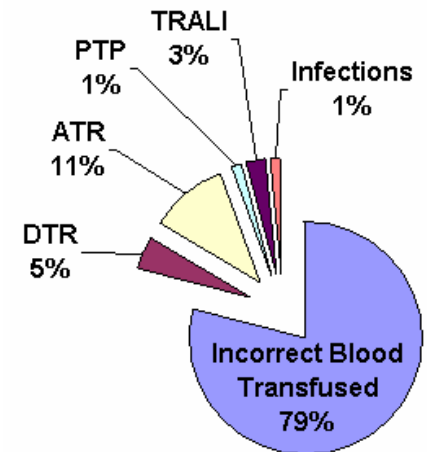
## Results (reduction of non-operative time)

- Time between cases in ORF is 28 minutes faster than conventional OR
- Thus, an additional 1 hour case can be done for each 3 cases done in the ORF

# Blood Transfusion Safety



- Transfusion of ABO incompatible blood occurs in 1 of every 38,000 transfusions
- Wrong Blood in Tube averages in 1 in 2,000 for pre-transfusion samples at a typical center
- Mistransfusions are typically slip errors: errors caused by distractions or failure to pay attention at a critical moment

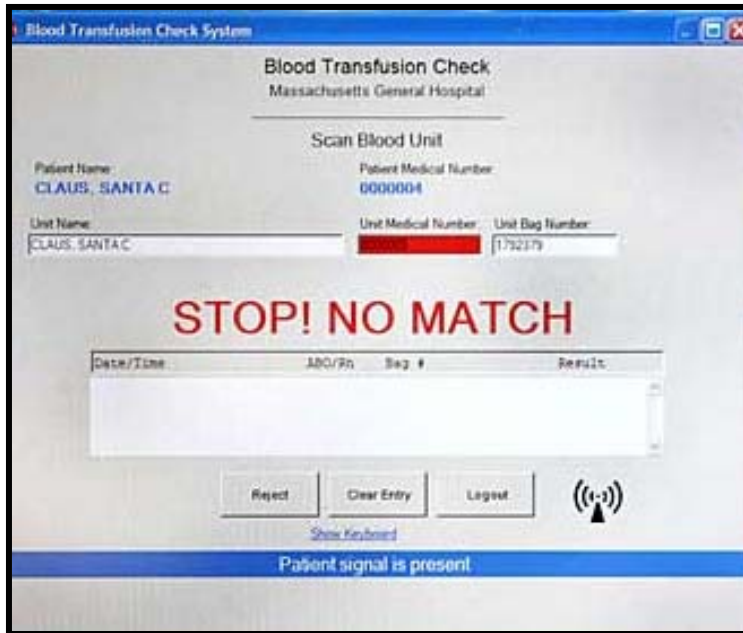


2005: [www.shotuk.org](http://www.shotuk.org)

→ *This category of error is often amenable to a technologic solution*



# Passive RFID for Transfusion Safety (Dr. Sunny Dzik, MGH)



- Bedside check is automated by reading passive RFID tag on blood product and passive RFID tag on patient wristband
- If no match during then system alarms and alerts user
- Combines auto identification with alerting software

**ISSUE:** wrong sided, wrong site of surgery is a serious patient safety concern

## ***Solution 1: SurgiChip™***



- RFID tag written to each patient with procedure information and site of surgery
- Patient is scanned prior to surgery with RFID reader

Cost \$100,000 start up costs with tag cost of \$2.50 each

Also: interfacing to HIS, maintenance, training

## ***Solution 2:***



Cost \$0.79



- Right technology for the right role
  - Active RFID/IR in operating rooms
  - Passive RFID wrist tags on wards
- Incremental roll out due to immaturity of technology
- Test and trial
  - All technologies need to demonstrate not only efficacy but effectiveness
- Important to understand the public perceptions of your RFID projects



“How would you like it if, for instance, one day you realized that your underwear was reporting on your whereabouts?”

– Debra Bowen, California State Senator

- 40% of Google results for “RFID” include the word “privacy”
- Boycotts of Gillette and Benetton due to planned uses of RFID

IF passive tags have a unique ID then every product you buy with a passive RFID tag is potentially traceable to you IF:

- A) At checkout the unique RFID tag ID is stored in a database with your name and credit card number
- B) Functional RFID tags are left on items leaving the store

RFID  
reader



*This is Jim Smith. He has artificial knee model #83M3, a copy of Marx's Das Kapital, Victoria's Secret lingerie, and an Armani suit*

- Potentially any unauthorized “rogue reader” could be used to read a tag
- Encryption of tag data is possible but adds complexity, cost, storage
- Storing only a unique ID is a common approach to security
  - Could potentially be read but not useful without access to applications
  - Could also detach or deactivate tag at point of purchase
- Important to address security and privacy in all settings due to risks and public perceptions

## Equipment

- Microtomes
- Cassette Printers
- Slide label printers
- Workstations
- Tissue processors
- Staining equipment

## People

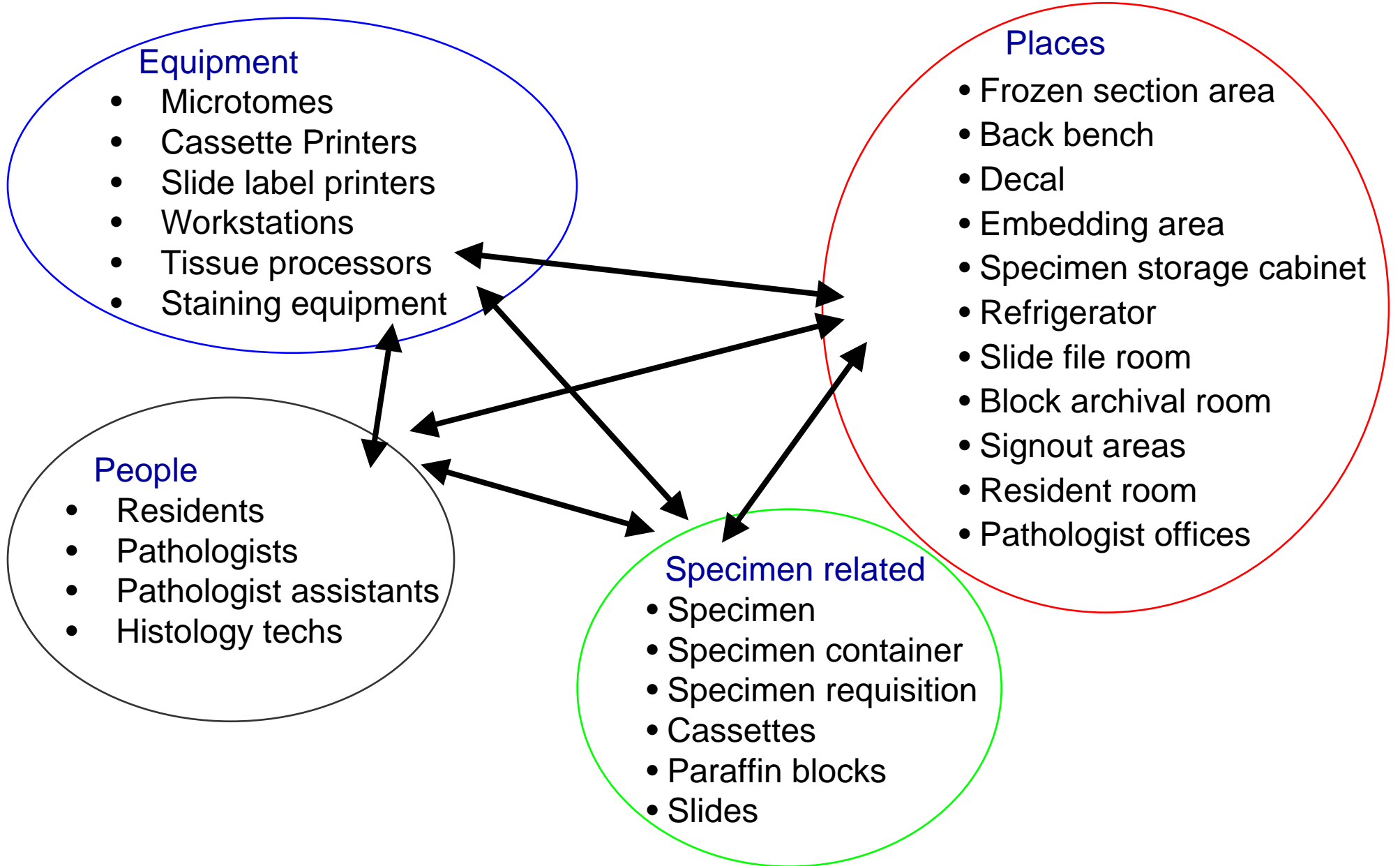
- Residents
- Pathologists
- Pathologist assistants
- Histology techs

## Places

- Frozen section area
- Back bench
- Decal
- Embedding area
- Specimen storage cabinet
- Refrigerator
- Slide file room
- Block archival room
- Signout areas
- Resident room
- Pathologist offices

## Specimen related

- Specimen
- Specimen container
- Specimen requisition
- Cassettes
- Paraffin blocks
- Slides



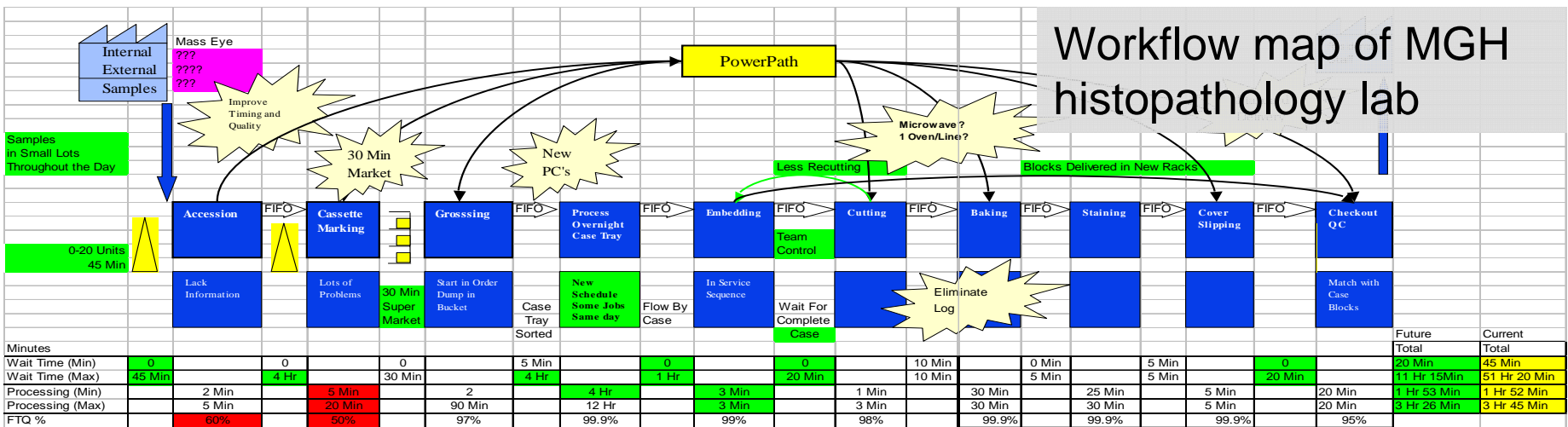


- Large number of high value assets (specimens, cassettes, slides) needing to be uniquely identified
- A large number of processes where patient ID is essential and errors may occur:
  - Specimen accessioning, cassette making, block cutting, slide labeling
- Many of the high value assets (cassettes, slides) are exposed to harsh chemicals and stains
- Step 1...Understand your process

# Before Considering RFID: Understand Your Process



- Map current process and identify steps where auto identification can assist
- Start measuring to determine where you are now and what you are trying to achieve
  - Patient safety, operational efficiency, reduced capital expenses, reduced waste?
- Assess whether bar codes can accomplish the same goal
- Consider interfaces to existing systems and applications
  - Autoidentification much less useful if siloed from core operation
- Who will monitor the data and act on it? Is it actionable data?



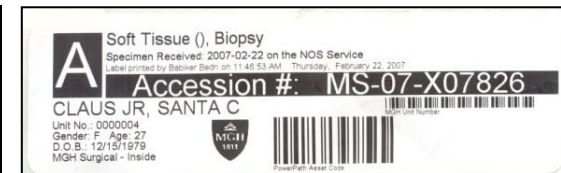
Receive Specimen    Accession Specimen    Make Cassettes    Fix Tissue    Embed Tissue    Cut Sections    Create Slides    Stain Slides

Modified the AP-LIS to permit tracking and verification of the identity of the specimen, cassettes, and slides throughout the process

- 1D bar coded labels generated for the specimen requisition and container
- 1D bar coded cassettes created by scanning specimen requisition bar code
- 1D bar coded slide labels created by scanning the specimen cassette bar code

## Important principles

- “Just in time” creation of bar coded cassettes, labels
- Not a data silo → each time a slide or cassette barcode is scanned data is uploaded into the AP-LIS
- Scanning drives workflow



Bar coded specimen label



Blocks with 1D barcodes



Slide with 1D barcodes

*What are the opportunities for improving this process with RFID?*





- High-volume, private anatomic pathology practice based in Dallas, TX
  - 550-650 cases per day, 32 pathologists
- Use Cerner Co-Path Plus for their AP-LIS
- Prior to working with RFID implemented widespread use of 1D and 2D barcodes to improve specimen tracking and patient safety
  - Requisitions, cassettes, slides, histotechs all barcoded

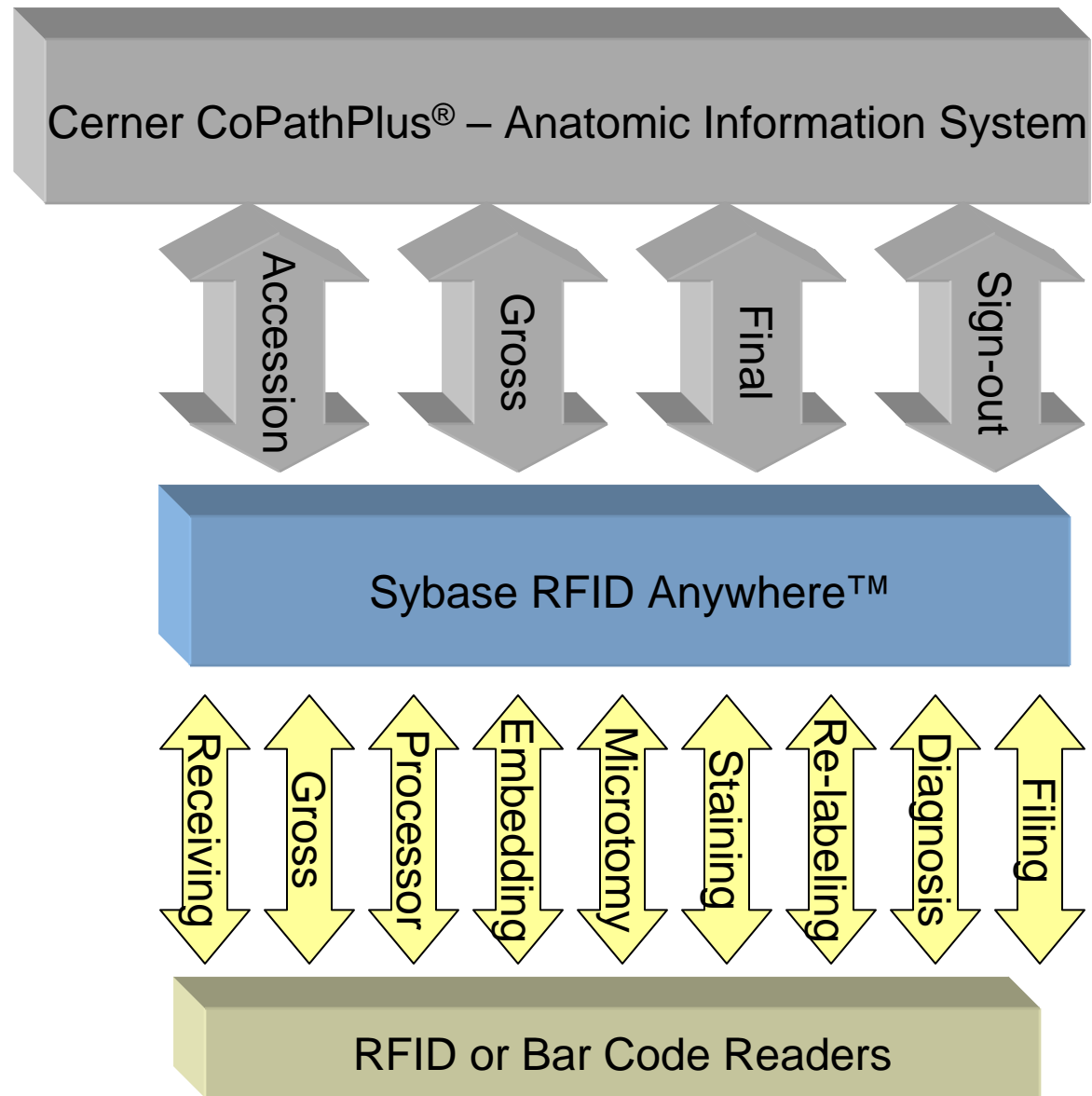


- RFID tag is a low frequency, glass encapsulated, passive RFID tag
- Tags currently cost ~\$1-2 per tag
- RFID tags come pre-encoded with unique serial numbers. They are not programmed on site and contain no patient specific information.
- An RFID tag is “commissioned” (associated with a case) by scanning the bar coded container label and then using an RFID reader to read the unique number of the RFID tag attached to the cassette
- The cassette RFID tag is read at numerous points throughout the tissue processing cycle to ensure positive patient ID, drive workflow, and create an audit trail for the specimen.

# ProPath: Use of RFID Requires Middleware



- AP-LIS tracks some steps in process but...
  - Not at necessary granularity for specimen tracking
  - AP-LIS cannot handle raw output of RFID tags/readers
- Solution: **Sybase RFID Anywhere** middleware
  - **Tracks specimens:** permits detailed tracking information to be stored and analyzed
  - **Drives workflow:** Middleware interacts with Co-Path system with calls into CoPath to retrieve list of orders for number of slides needed, special stains, etc.



*Information courtesy of Krista Crews, ProPath*



*RFID should be considered when there is either a value proposition or mandate*

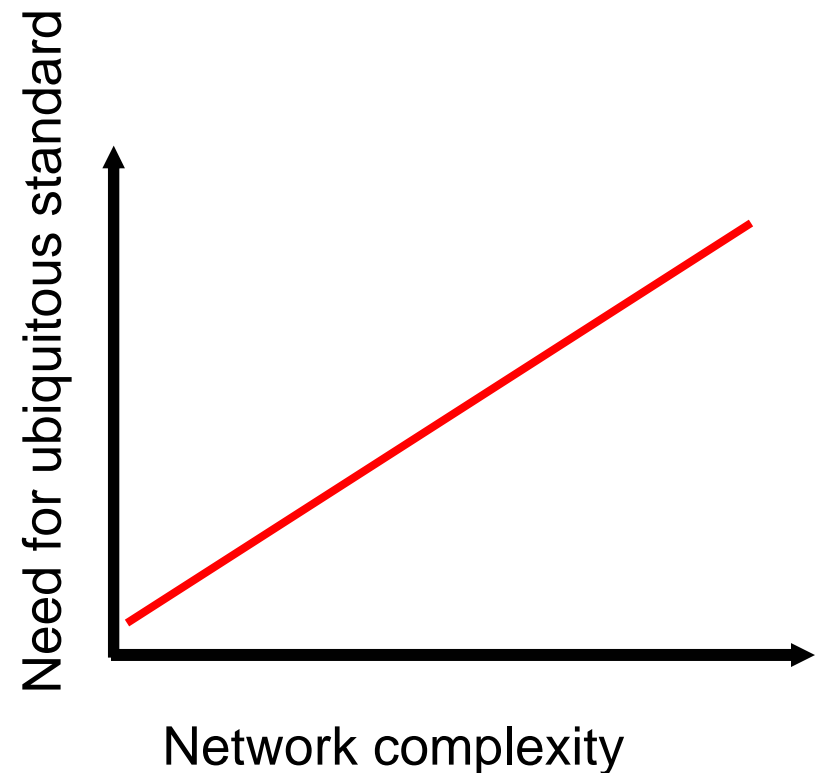
*What is the Value Proposition for RFID?*

- Hard Return on Investment
  - Savings or expense prevention due to reduced errors
  - Labor or material savings
  - Improved billing for services
- Soft Return on Investment
  - Improved staff efficiency
  - Improved documentation and accountability
  - Employee satisfaction
  - Regulatory compliance
  - Improved patient safety

Proposed JCAHO 2008 NPSG: The organization investigates and initiates planning for the use of technology to assist with patient identification.

*“It’s tough to make predictions, especially about the future.” - Yogi Berra*

- Industry-wide change in healthcare is difficult due to the fragmented nature of healthcare, lack of standards, and lack of accountability/leadership
- Need to accommodate healthcare’s parallel processes
  - Few assembly lines in healthcare
- Process re-engineering and standardization
  - Standardize and optimize workflow
- Data analytics are just as important as data gathering





# Thanks

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