RFID: Technology and Applications

Outline

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

Effect on Manufacturing

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

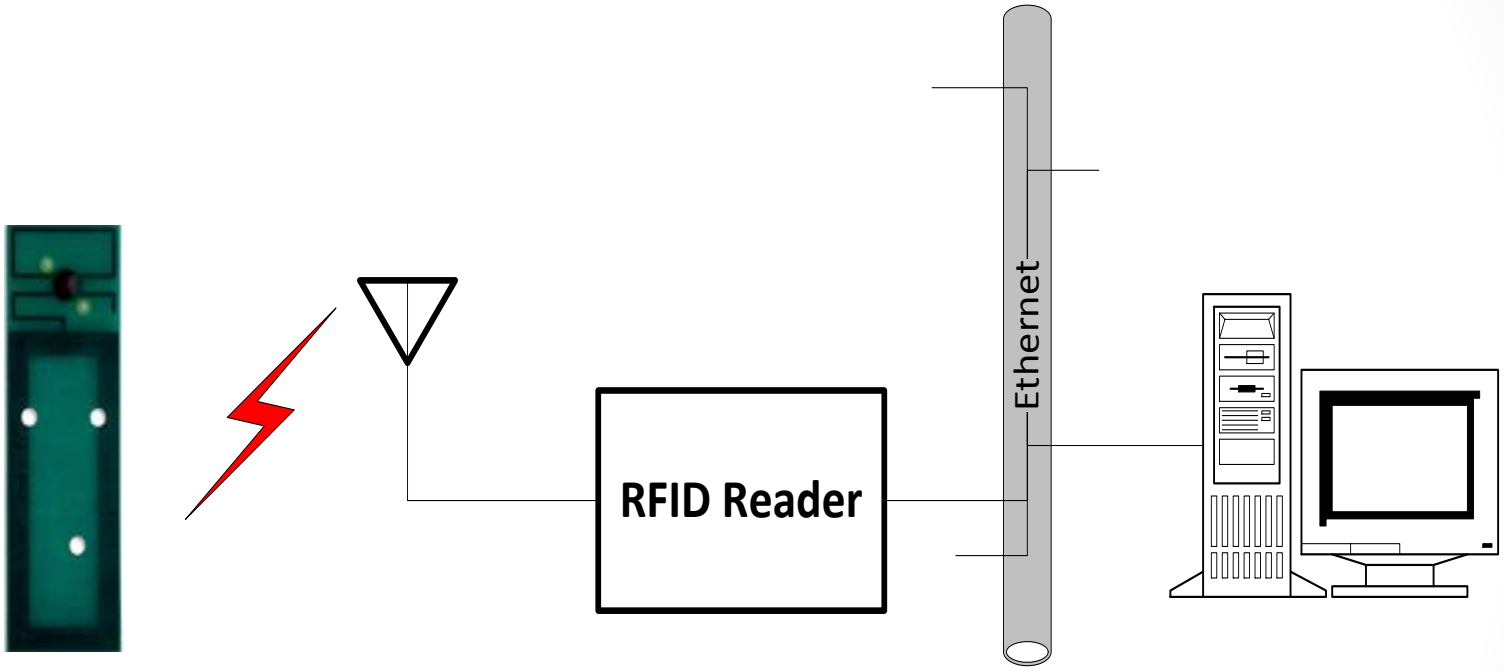
- Critical Issues
  - Assembly process control
  - Inventory management
  - Supply chain integration
  - Customer insight

- One solution: RFID

What is RFID?

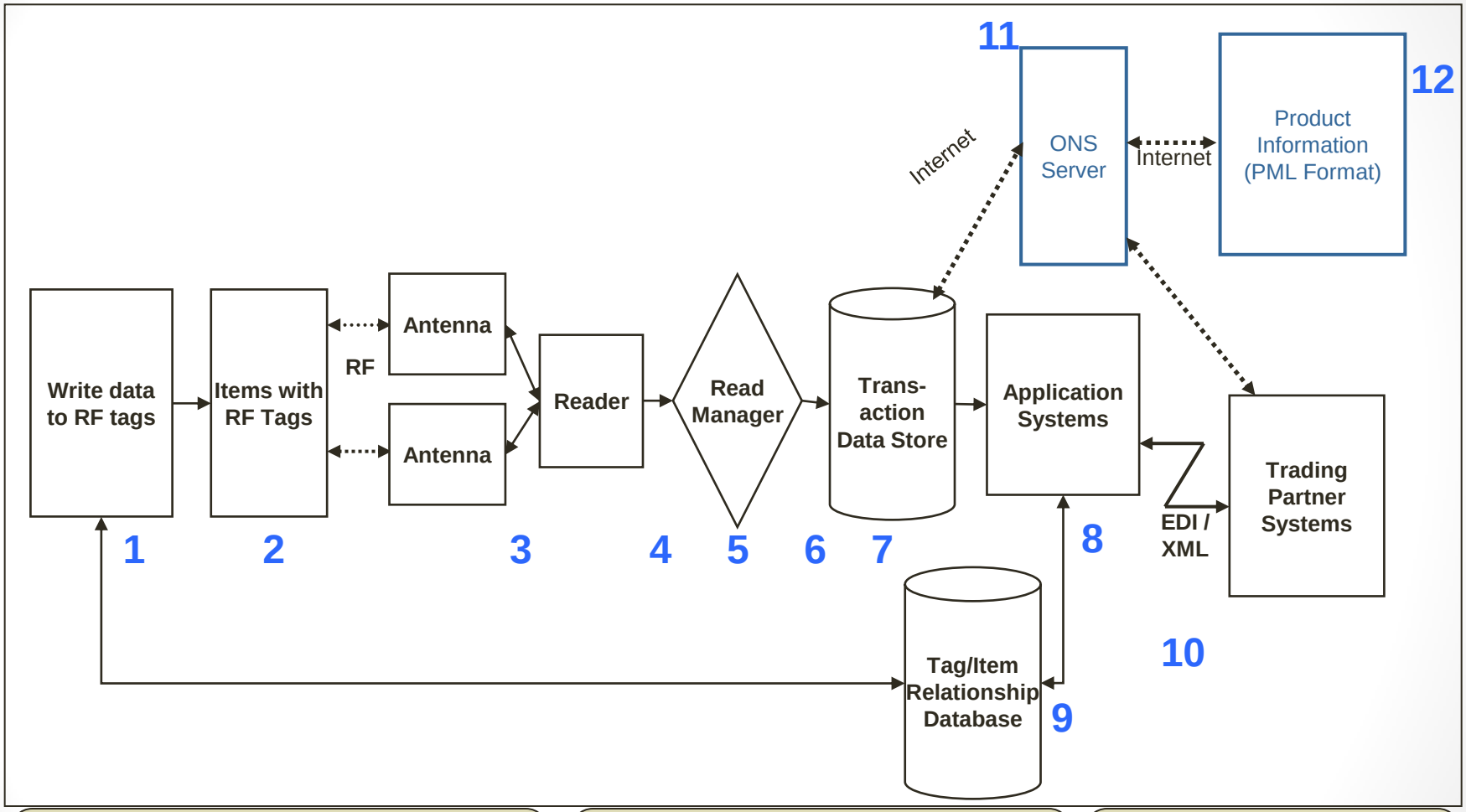
- RFID = Radio Frequency IDentification
- An ADC (Automated Data Collection) technology that:
  - Uses radio-frequency waves to transfer data between a reader and a movable item to identify, categorize, track
  - Is fast and does not require physical sight or contact between reader/scanner and the tagged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



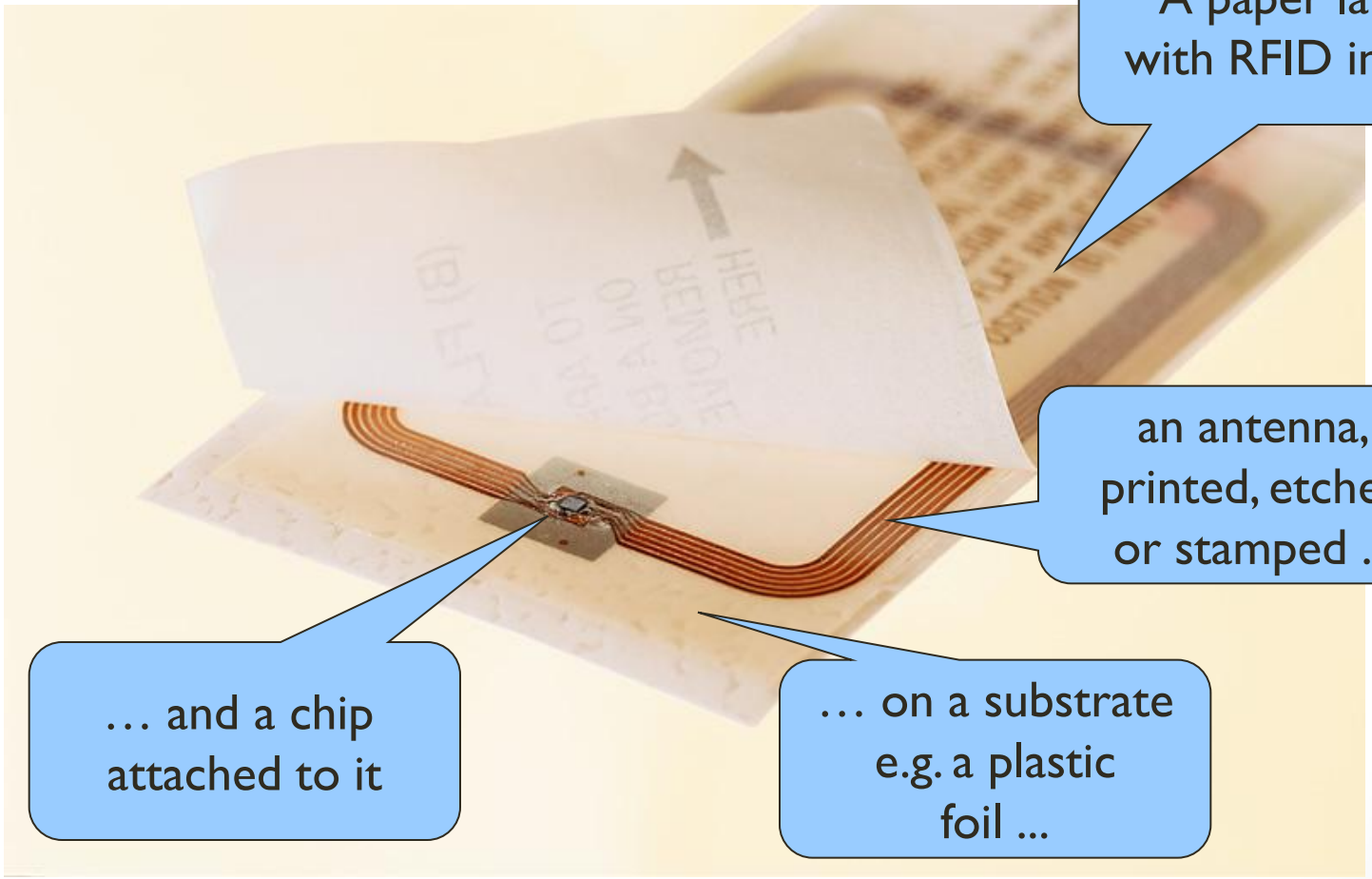
RFID Tag RF Antenna Network Workstation

RFID Systems: Logical View

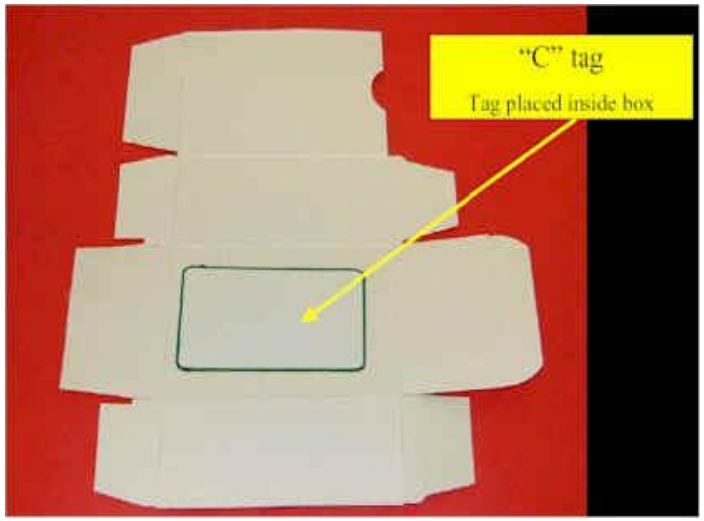


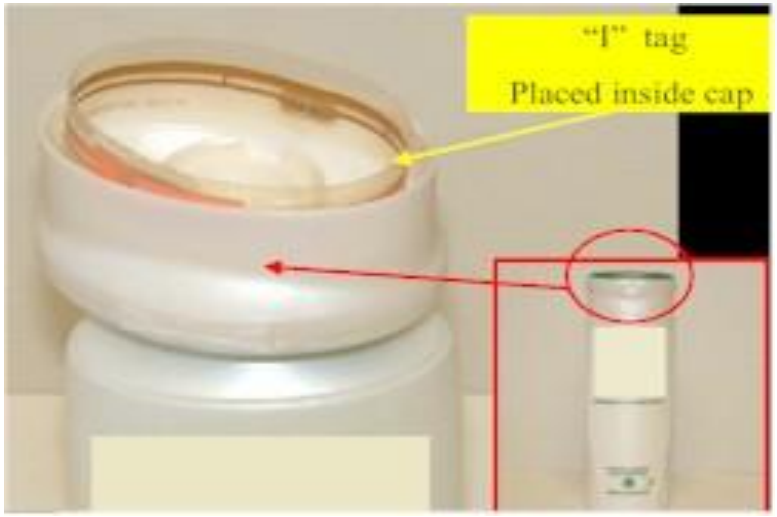
Tag Interfaces | RFID Middleware | Other Systems

RFID Tags: Smart Labels



Some RFID Tags

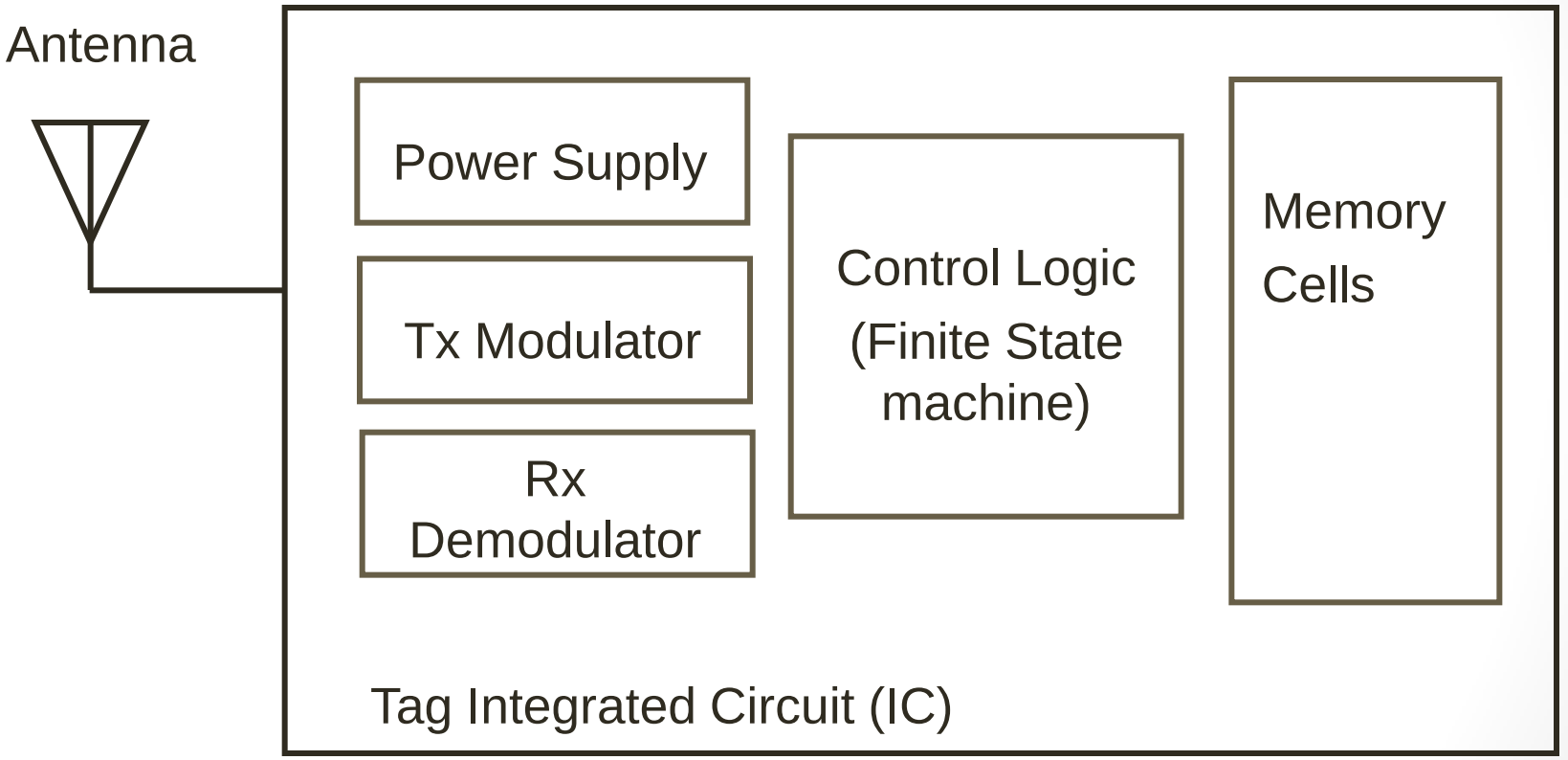




RFID Tags

- 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

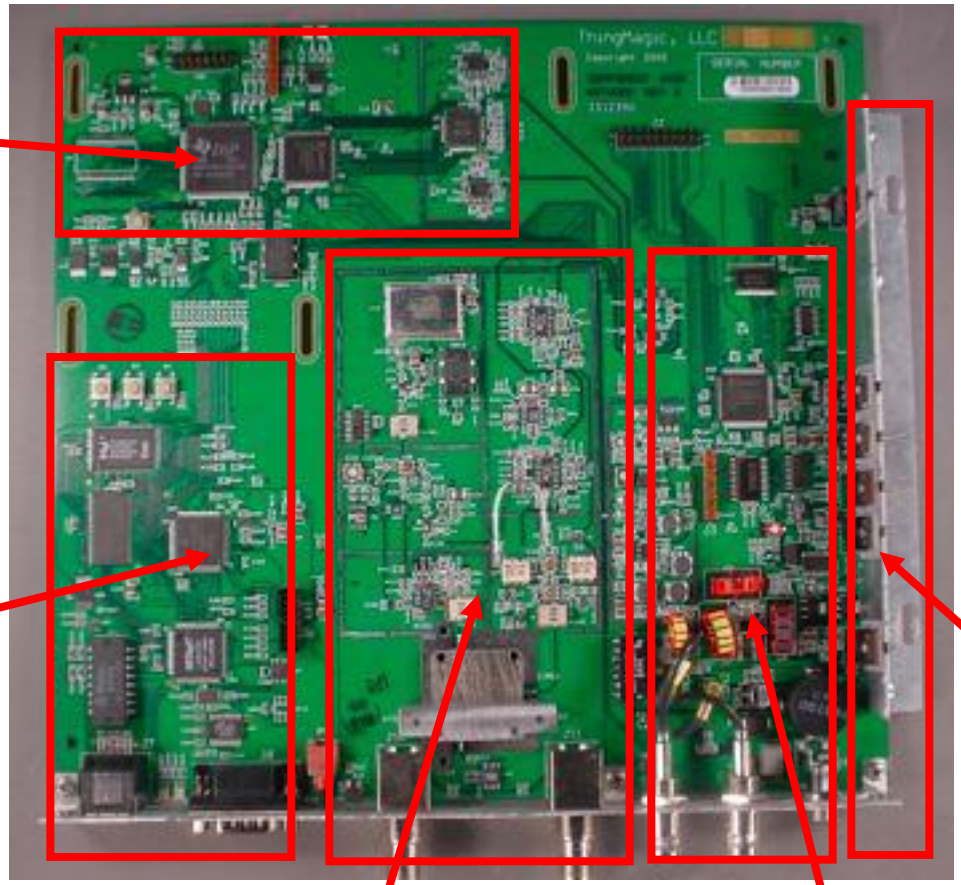
- Read-only tags
  - Tag ID is assigned at the factory during manufacturing
    - Can never be changed
    - No additional data can be assigned to the tag
- Write once, read many (WORM) tags
  - Data written once, e.g., during packing or manufacturing
    - Tag is locked once data is written
    - Similar 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

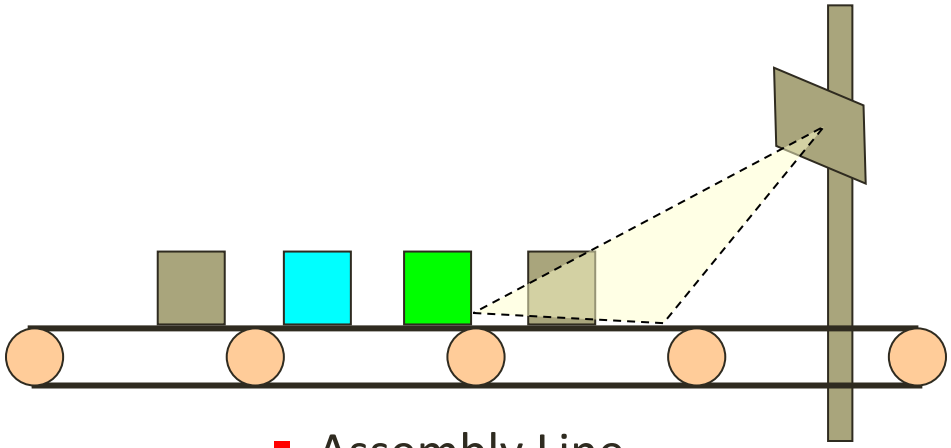
- Reader functions:
  - Remotely power tags
  - Establish a bidirectional data link
  - Inventory tags, filter results
  - Communicate with networked server(s)
  - Can read 100-300 tags per second
- Readers (interrogators) can be at a fixed point such as
  - Entrance/exit
  - Point of sale
- Readers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

Some RFID Readers

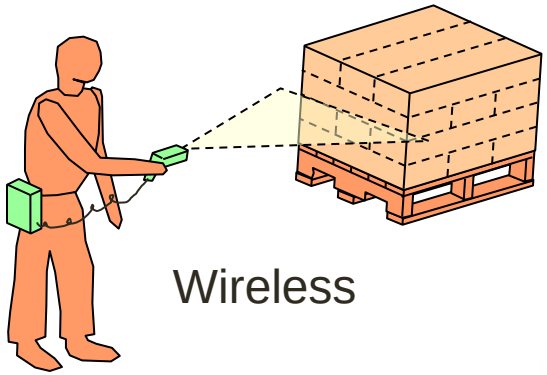
Reader Anatomy



RFID Application Points

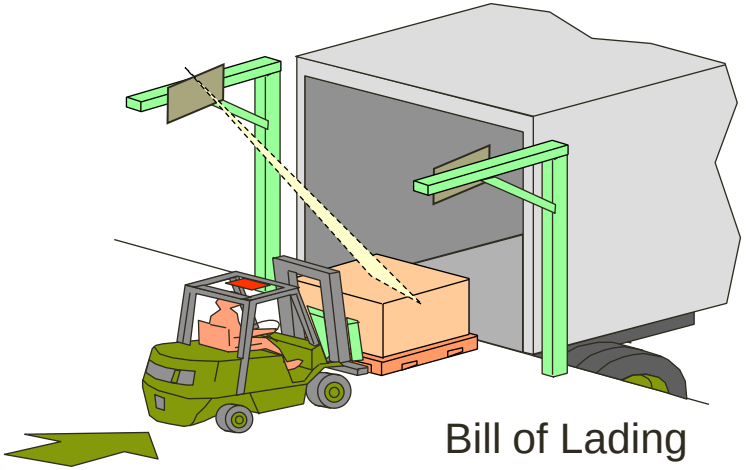


- Assembly Line



Wireless

- Handheld Applications



Bill of Lading
Material Tracking

- Shipping Portals

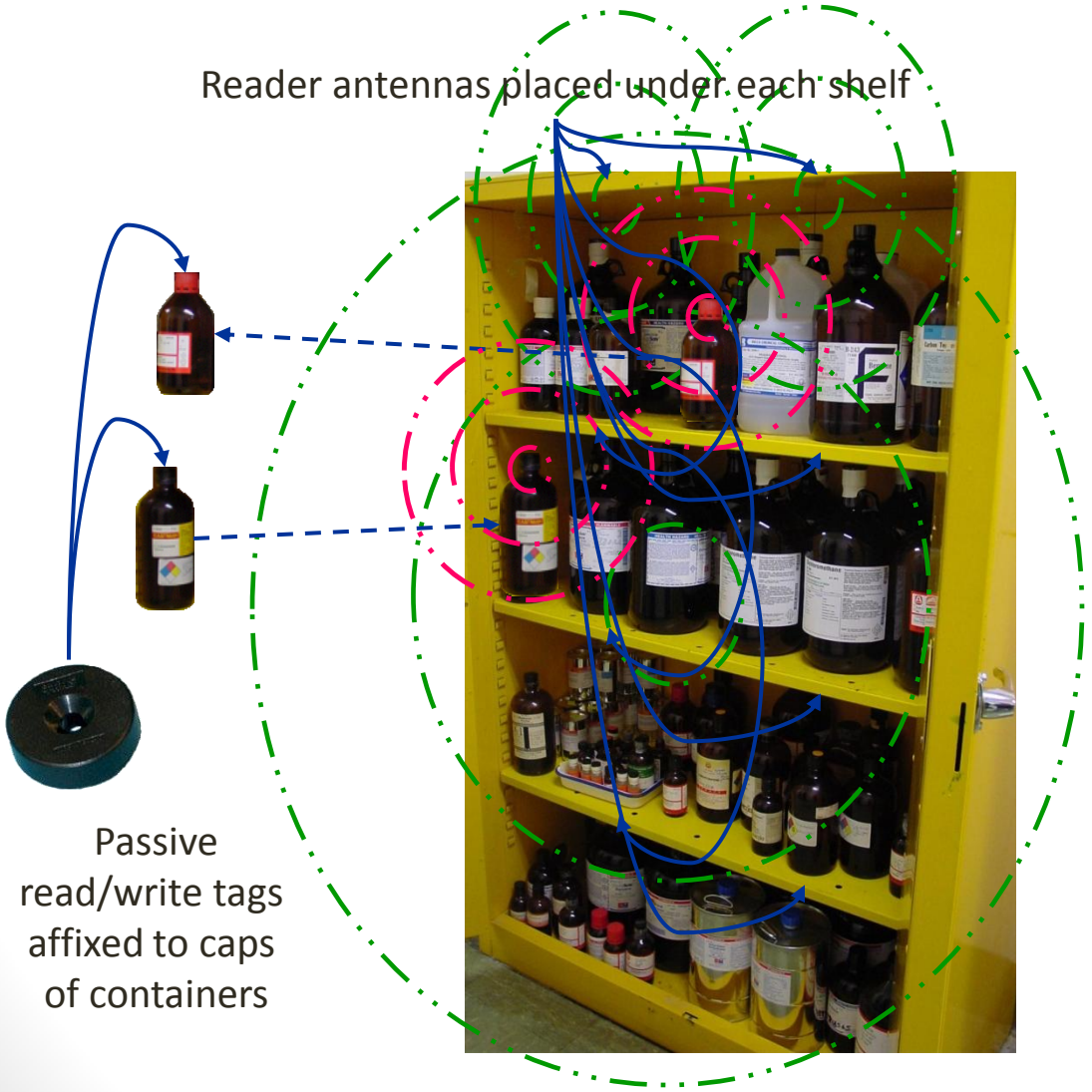
RFID Applications

- 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)

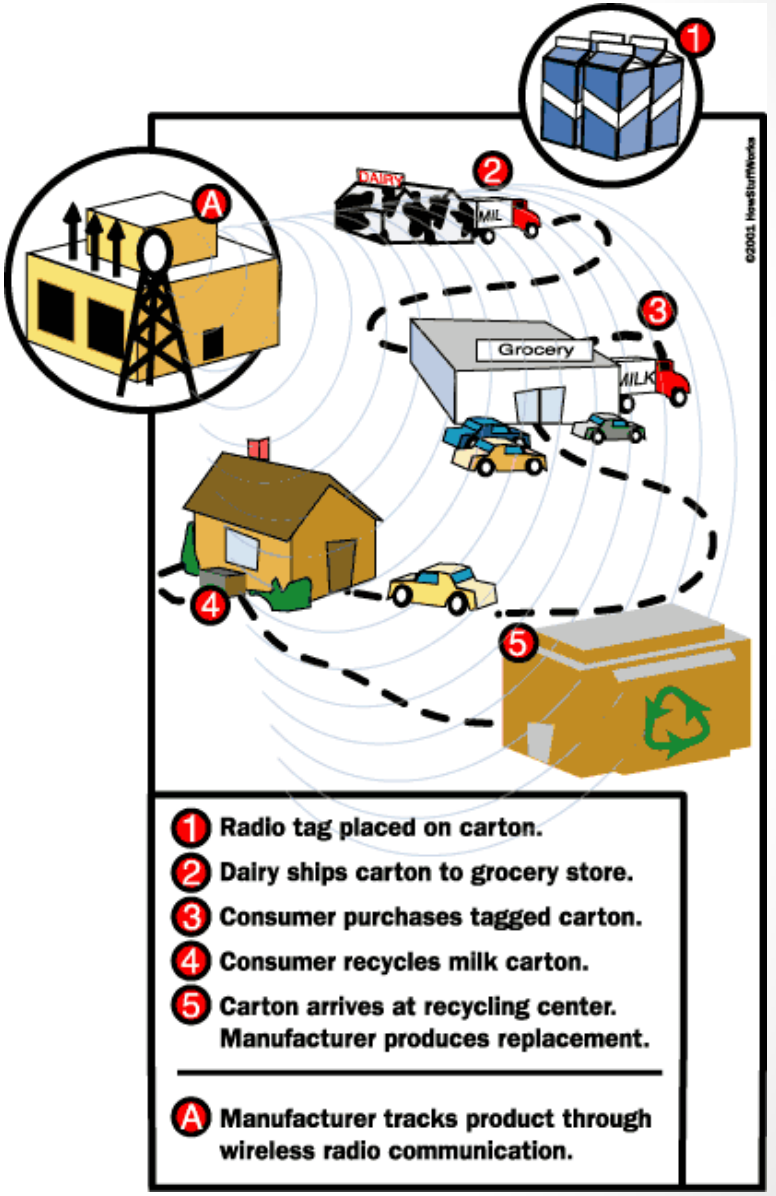
Smart Fridge

- 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



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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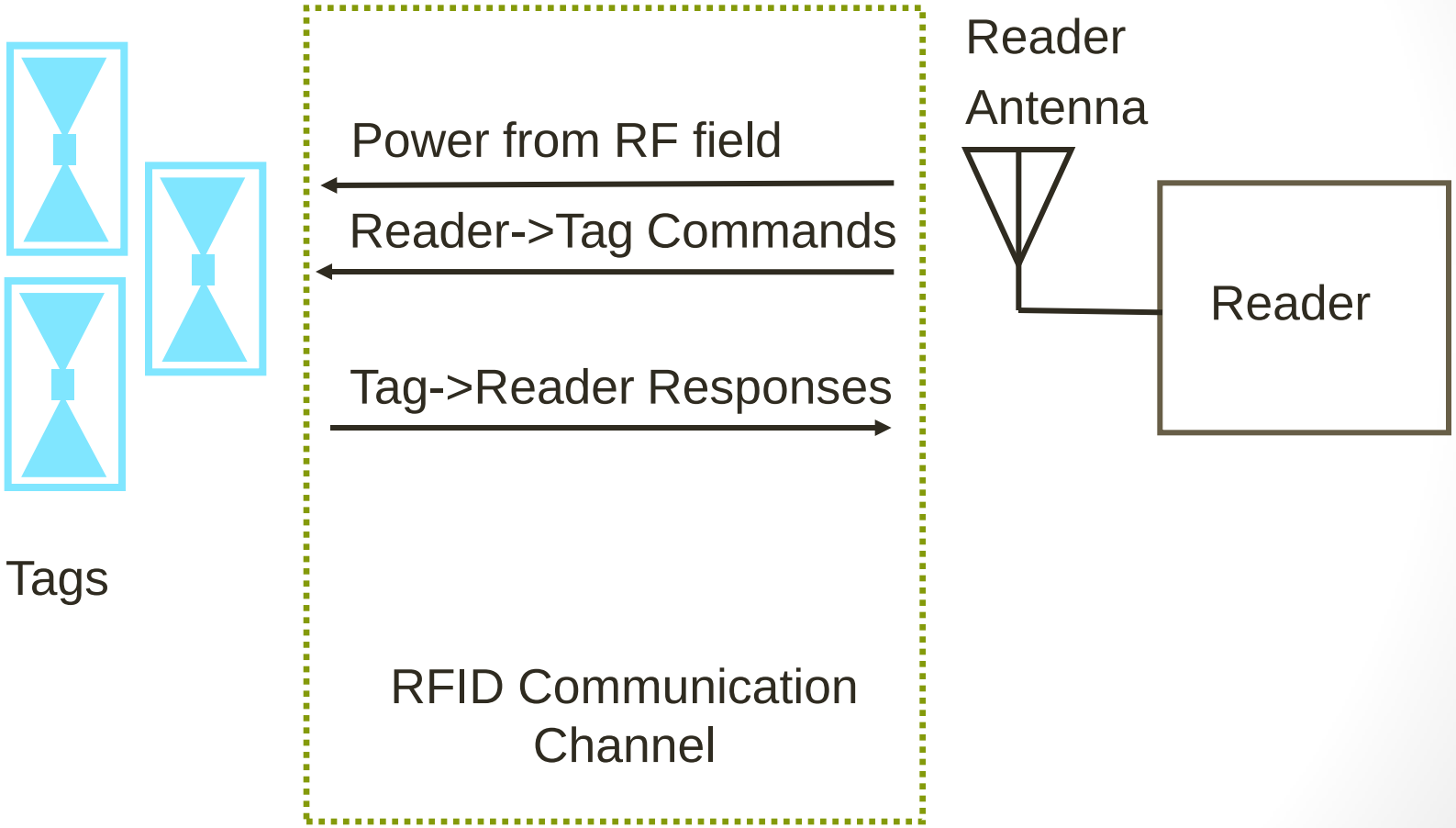
RFID Communications



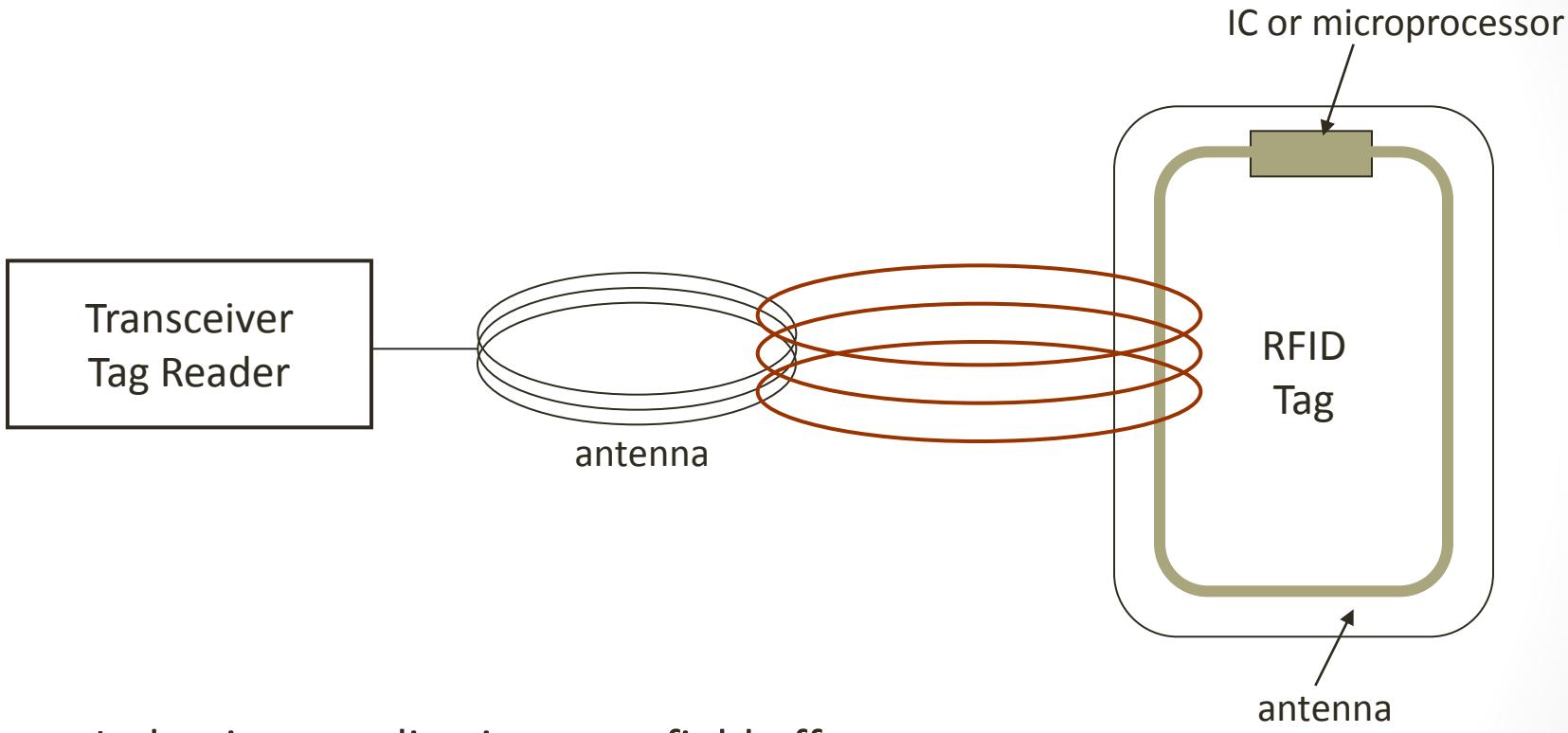
RFID Communication

- 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

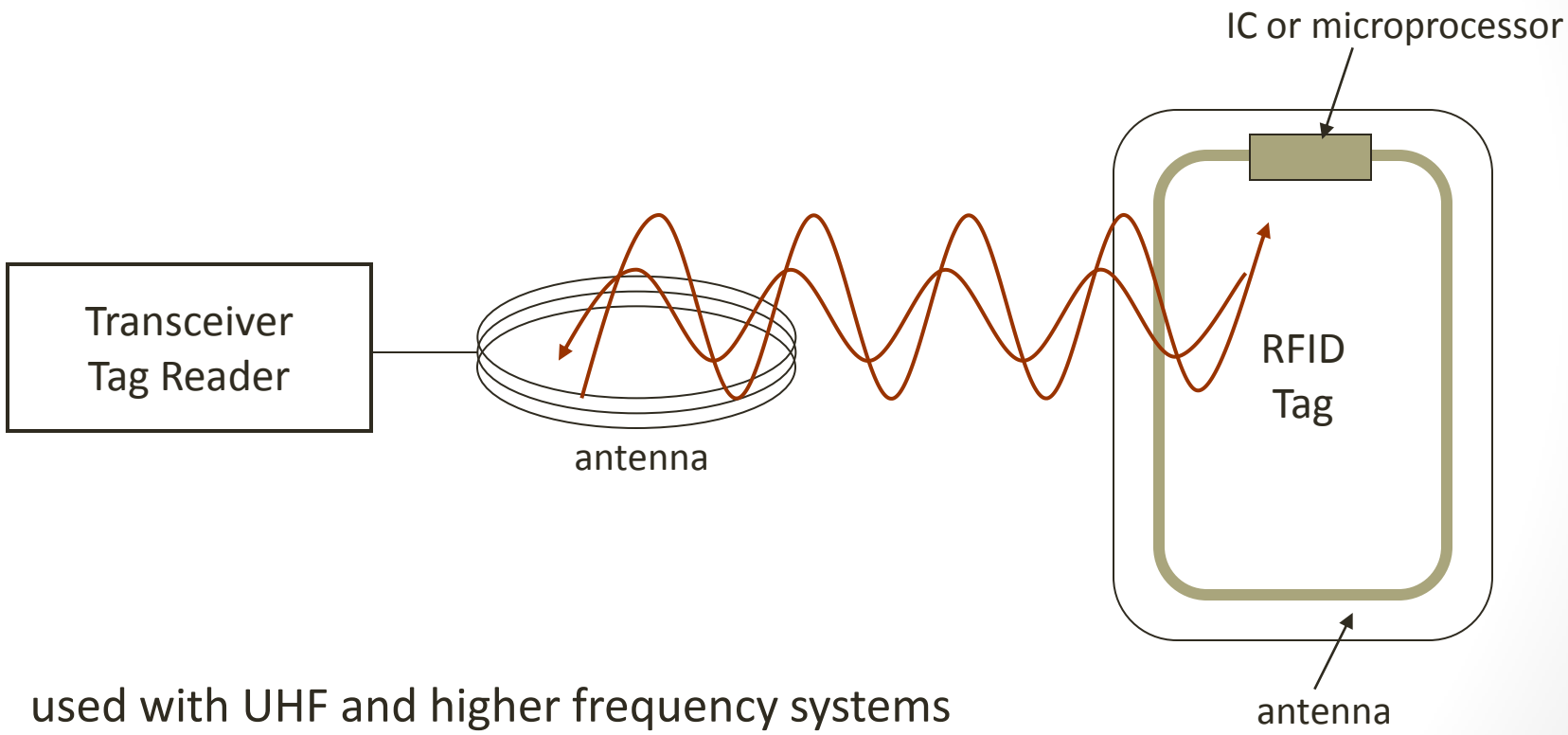
- Reader decodes the data
- Results returned to the host application

Antenna Fields: Inductive Coupling



- Inductive coupling is a near field effect
- Normally used on the lower RFID frequencies - often LF, i.e. below 135 kHz or at 13.56 MHz

Antenna Fields: Propagation Coupling

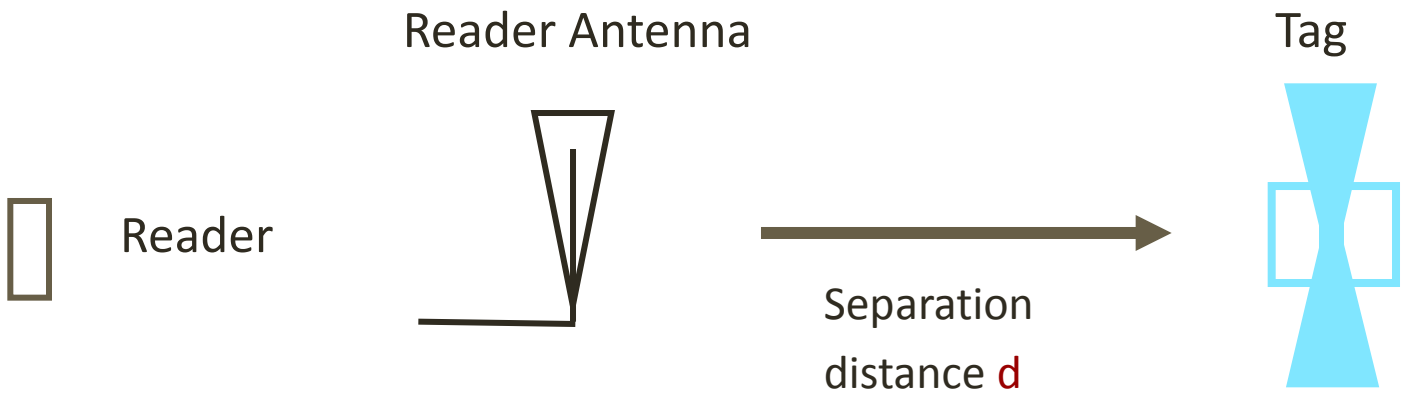


used with UHF and higher frequency systems

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 : $Pt \propto 1/d^6$

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

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.

RF Effects of Common Materials

Material	Effect(s) on RF signal
Cardboard	Absorption (moisture) Detuning (dielectric)
Conductive liquids (shampoo)	Absorption
Plastics	Detuning (dielectric)
Metals	Reflection
Groups of cans	Complex effects (lenses, filters) Reflection
Human body / animals	Absorption, Detuning, Reflection

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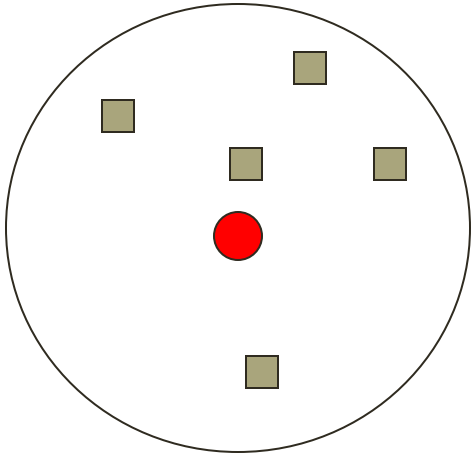
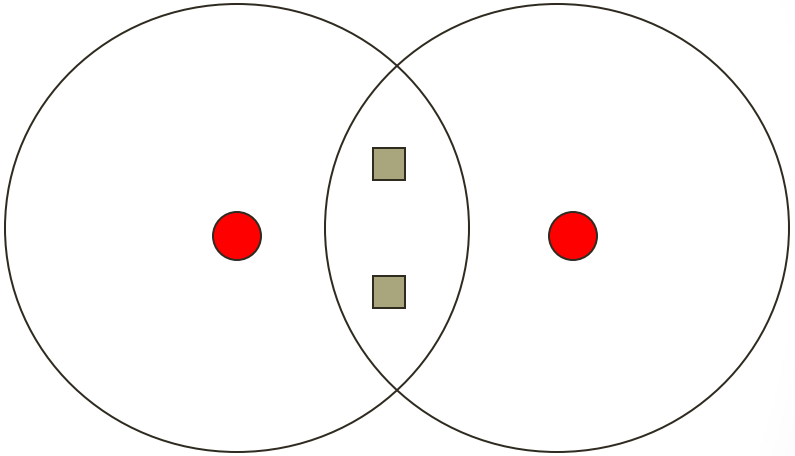
Reader Collision Problem

Tag collision



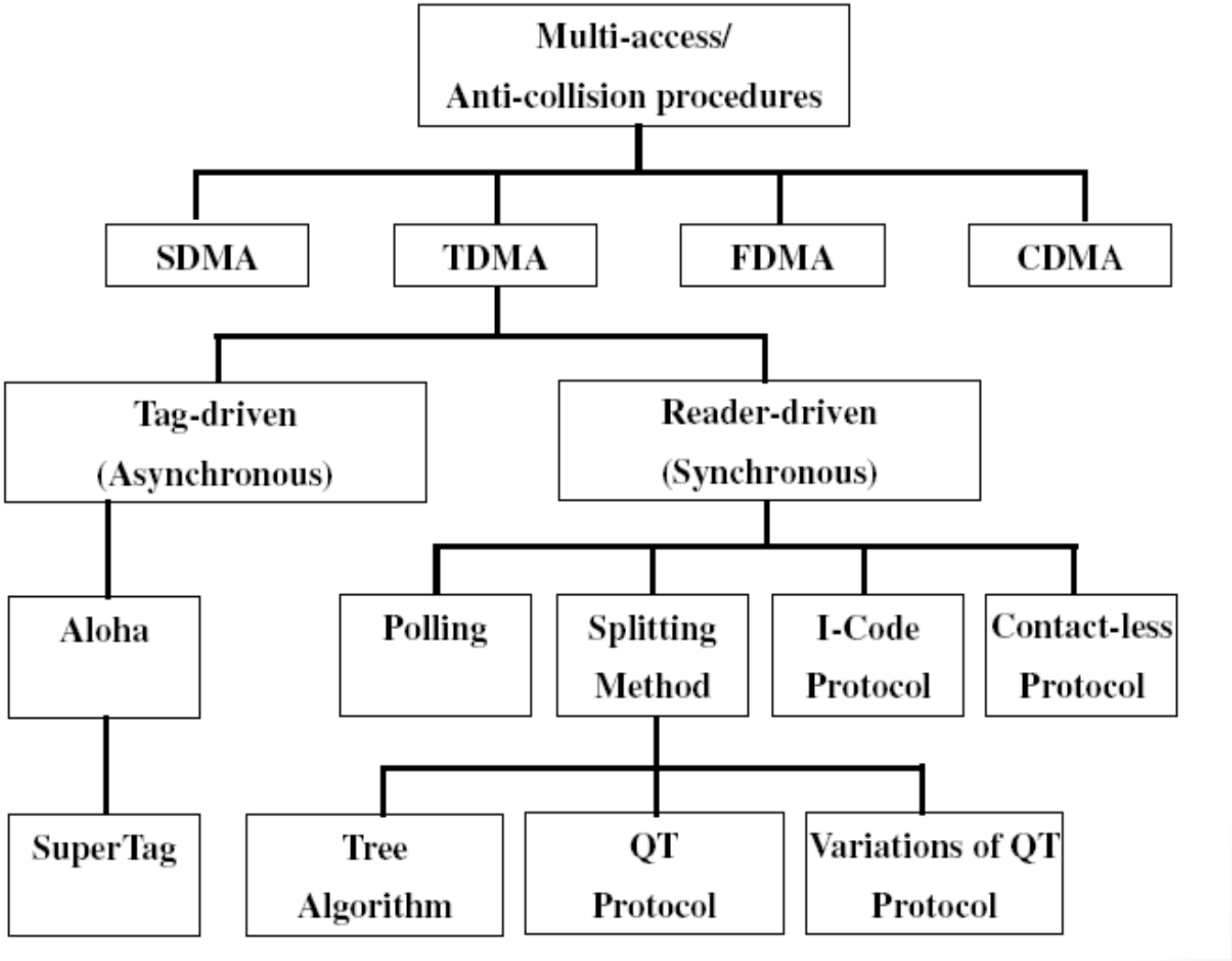
Reader collision



- Probability-based
- Deterministic-based (Prefix-based)

- Centralized
- Distributed

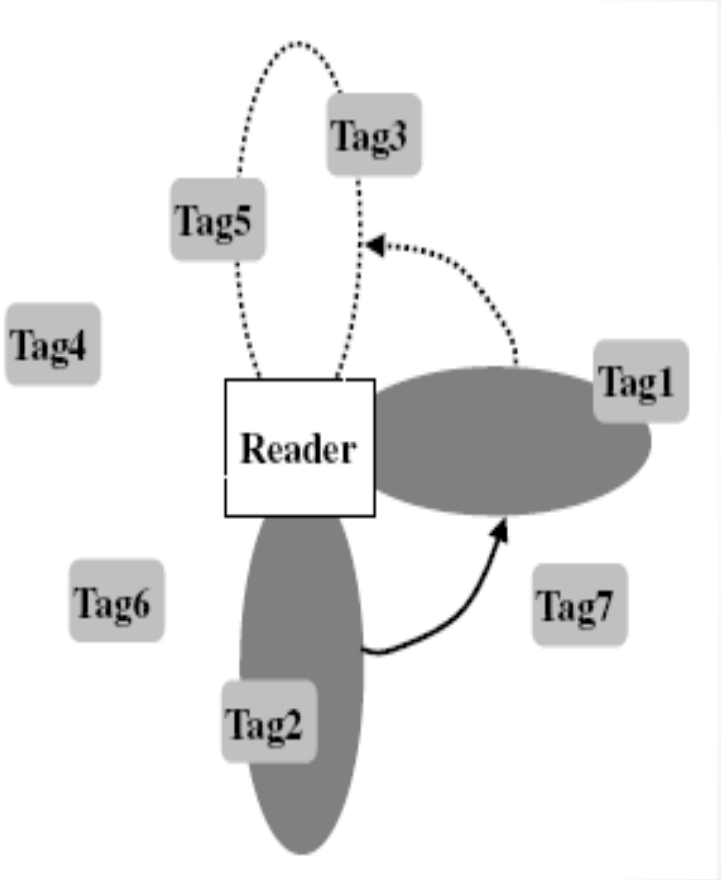
Taxonomy of Tag Anti-Collision Protocols



by Dong-Her Shih et. al., published in Computer Communications, 2006

SDMA

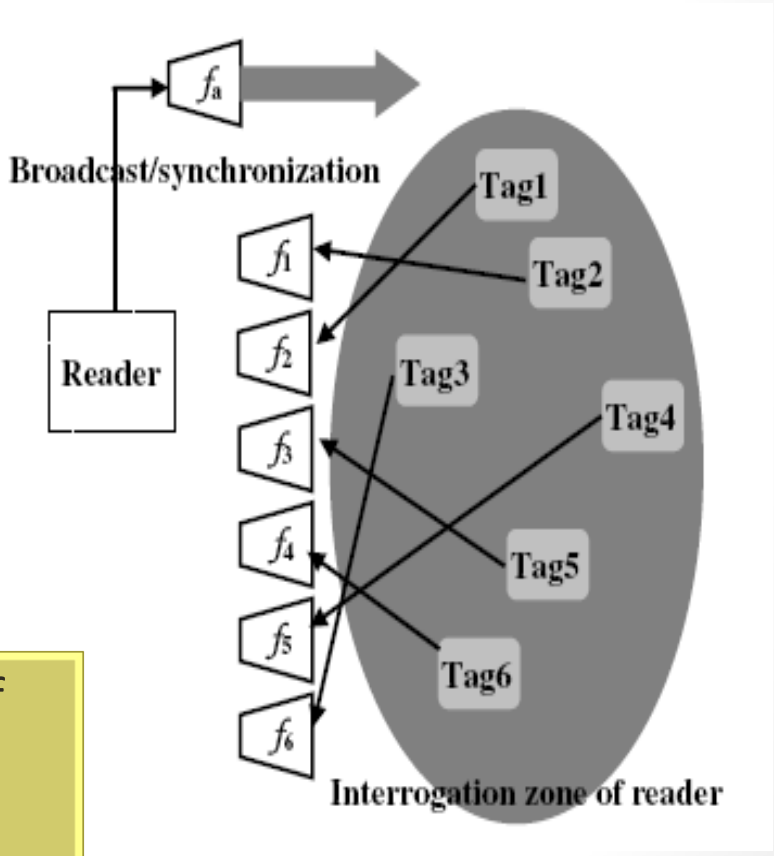
- SDMA (Space Division Multiple Access)
  - Reuse a certain resource, such as channel capacity in spatially separated area
    - Reduce the reading range of readers and forms as an array in space
    - Electronically controlled directional antenna
    - Various tags can be distinguished by their angular positions



Disadvantage: the relatively high implementation cost of the complicated antenna system

FDMA

- FDMA (Frequency Division Multiple Access)
  - Several transmission channels on various carrier frequencies are simultaneously available
  - Tags respond on one of several frequencies



Disadvantage: the relatively high cost of the readers, since a dedicated receiver must be provided for every reception channel

CDMA

- CDMA (Code Division Multiple Access)
  - Too complicate and too computationally intense for RFID tags as well
  - CDMA uses spread spectrum modulation techniques based on pseudo random codes, to spread the data over the entire spectrum

TDMA

- TDMA (Time Division Multiple Access)
  - The largest group of RFID anti-collision protocols
  - Tag driven (tag talk first, TTF)
    - Tag transmits as it is ready
    - Aloha
    - SuperTags
      - Tags keep retransmit ID with random interval until reader acknowledges
    - Tag-driven procedures are naturally very slow and inflexible
  - Reader driven (reader talk first, RTF)
    - Polling, splitting, I-code, contactless

Polling

- Polling
  - Master node invites the slave nodes to transmit data in turn
  - Reader must have the complete knowledge (database) of tags
  - Reader interrogates the RFID tags by polling ‘‘whose serial number starts with a 1 in the first position?’’
  - Those tags meet this test reply “yes” while others remain
  - Similar question about the next digit in their binary serial number continues
  - Slow, inflexible

Splitting

- Splitting or tree-search
  - Nodes transmit packets in time slots, if there is more than one node transmitting in a time slot then a collision occurs at the receiver
  - Collision resolution split the set of colliding nodes into two subsets
    - Nodes in the first subset transmit in the first time slot. Nodes in the other subset wait until the collision between the first subset of nodes is completely resolved
    - If the first subset of nodes encounters another collision, then further splitting takes place
    - This is done recursively till all the collisions have been resolved
    - Once all the collisions in the first subset of nodes are resolved, then a similar procedure is followed for the second subset

Splitting

- Tree algorithm
  - Based on binary search tree algorithm
  - Each collided tag generates a random number by flipping an unbiased B-sided coin (splitting the colliding tags into B disjoint subsets)
    - B = 2, each collided tag would generate a number 0 or 1
  - The reader always sends a feedback informing the tags whether 0 packet, 1 packet, or more than 1 packet is transmitted in the previous slot
  - Each tag needs to keep track of its position in the binary tree according to the reader's feedback

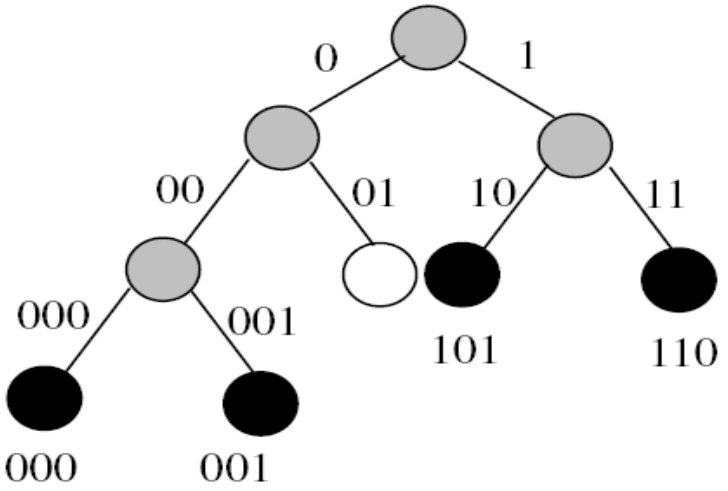
Splitting

L: set generates 1
R: set generates 0
S: single reply
Z: zero reply
C: collision

First Tag Identified: 0, 0, 0
Second Tag Identified: 001
Third Tag Identified: 1

Splitting

- Query Tree (QT)
  - Prefix based
  - Tags match the prefix respond



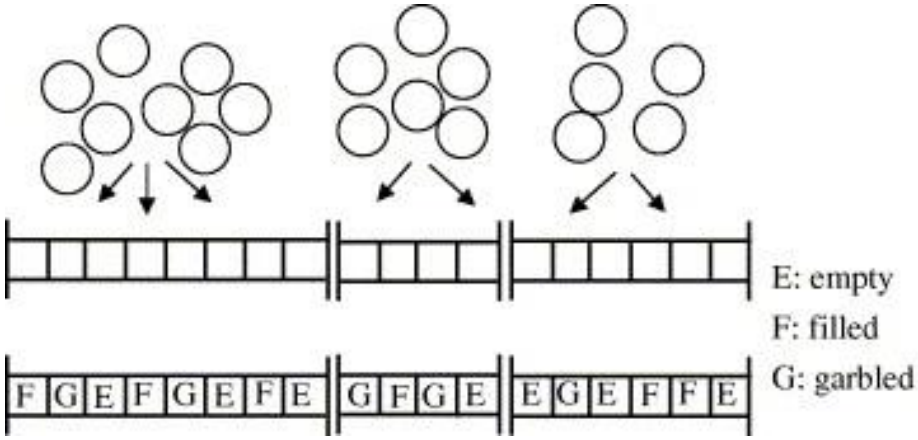
Communication between the reader and the tags with the QT algorithm

ID: {000, 001, 101, 110}									
Step	1	2	3	4	5	6	7	8	9
Query	Empty String	0	1	00	01	10	11	000	001
Response	C	C	C	C	Z	S (101)	S (110)	S (000)	S (001)

To identify 4 tags in this case the reader has to send the prefixes 9 times

I-Code

- I-Code
  - Stochastic passive tag identification protocol based on the framed-slotted Aloha concept
  - Each tag transmits its information in a slot that it chooses randomly based on the seed sent by the reader
  - The reader can vary the frame size N, the actual size of a slot is chosen according to the amount of data requested



I-Code

- Approximation of N
  - The reader detects the number of slots by a triple of numbers c = (c0, c1, ck), where c0 stands for the number of slots in the read cycle in which 0 tags have transmitted, c1 denotes the number of slots in which a single tag transmitted and ck stands for the number of slots in which multiple tags are transmitted
  - Lower bound method
  - Minimum Distance method: distance between read result c and the expected value vector of n

I-Code

Various N values corresponding to specific ranges have been found from experiments and tabulated

Optimality intervals for frame sizes

N slots	1	4	8	16	32	64	128	256
n_low	–	–	–	1	10	17	51	112
n_high	–	–	–	9	27	56	129	∞

```
int adaptFrameSize (N, n_est){
    while (n_est < low(I(N))) {N = N/2}
    while (n_est > high(I(N))){N = 2*N}
}
```

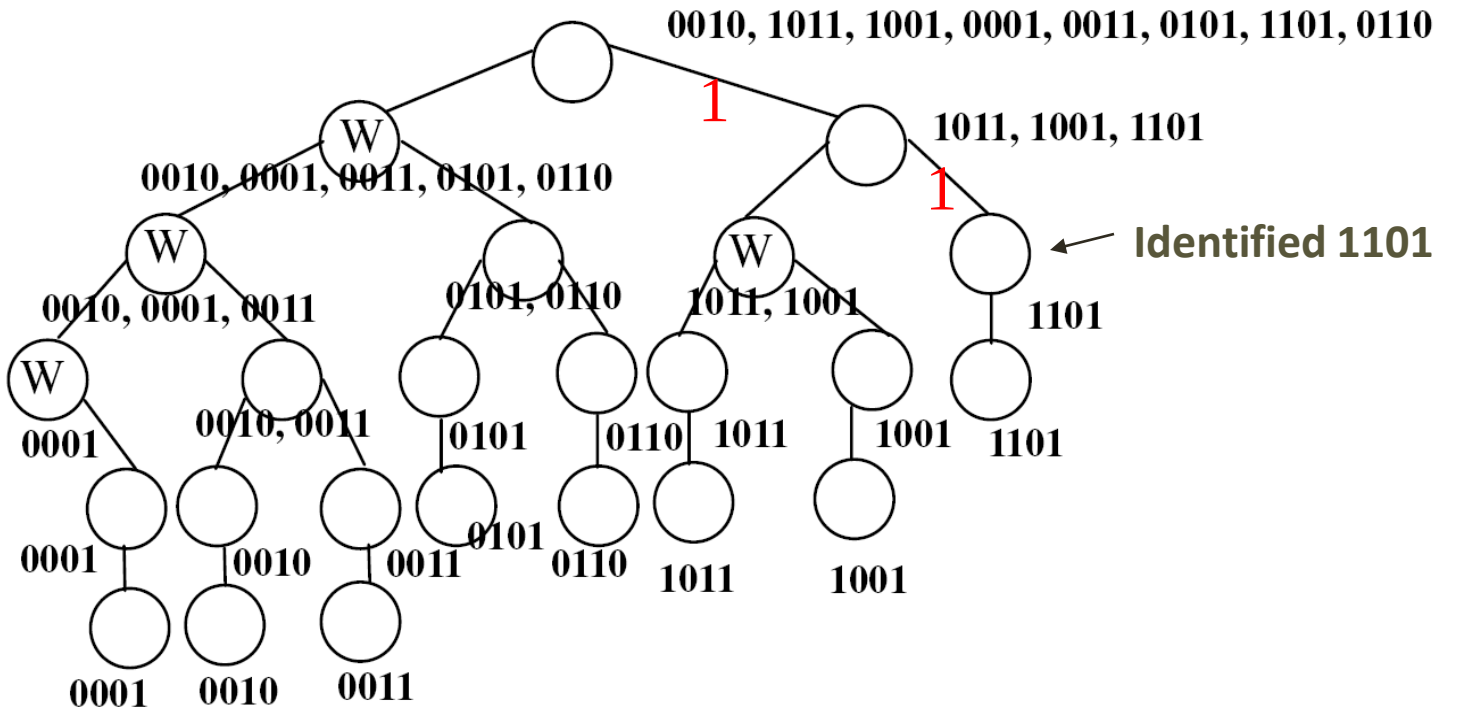
Fig. 10. Choosing a frame size.

If n $\in$ [17, 27], both 32 and 64 are appropriate choices for N

Contact-less

- Contact-less
  - Is based on the tree splitting methodology to identify one bit of the ID in every arbitration step
  - The tag uses the modulation scheme which identifies “0” in the specified bit position with 00ZZ (Z stands for no modulation) and “1” as “ZZ00”
    - In this way, the reader can recognize the responses from all the tags and divide the unidentified tags into 2 groups
      - One had *0*’s in the requested bit position and the other had *1*’s. This is termed as the *BitVal* step

Contact-less



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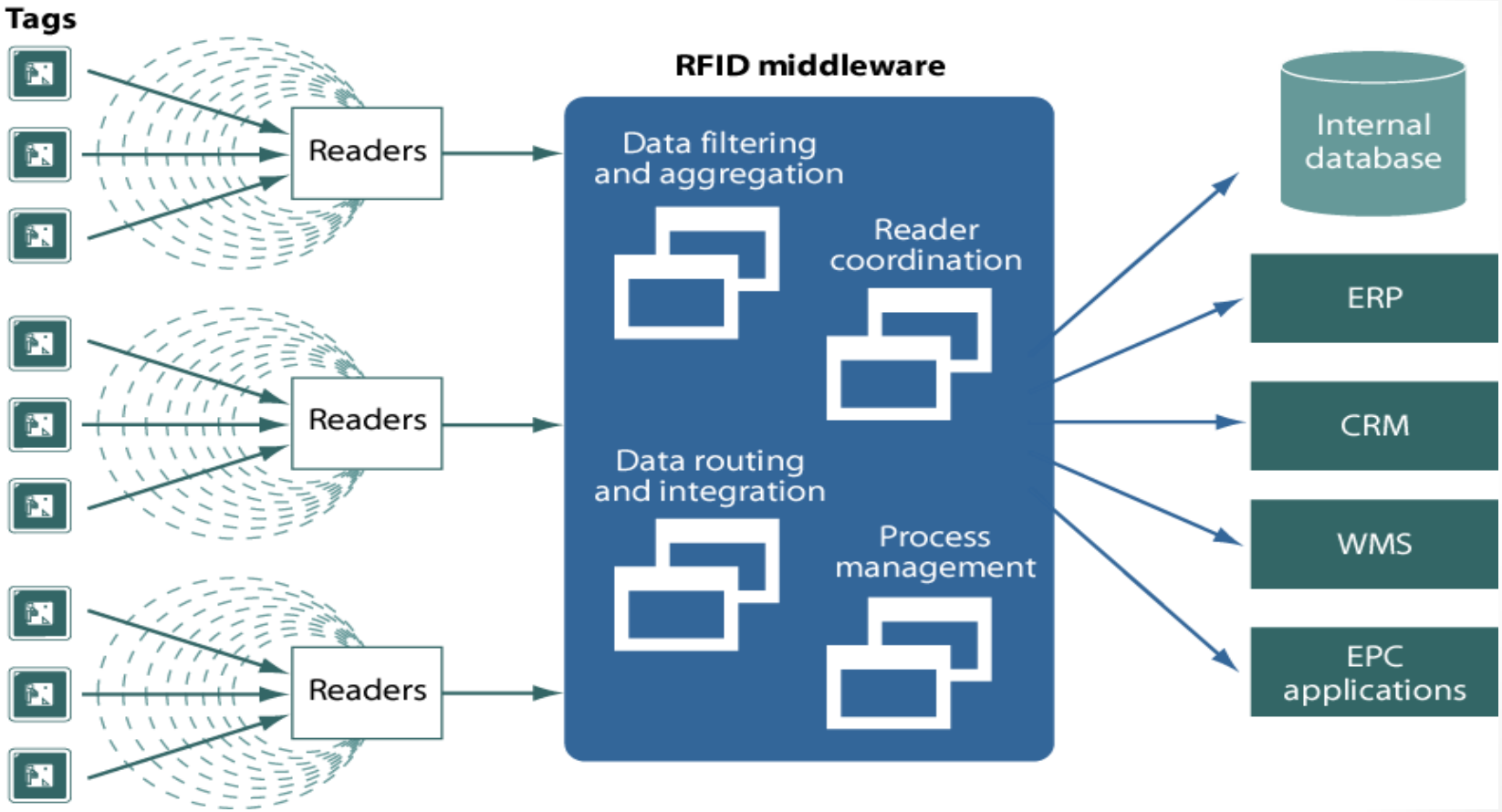
How Much Data?

Consider a supermarket chain implementing RFID:

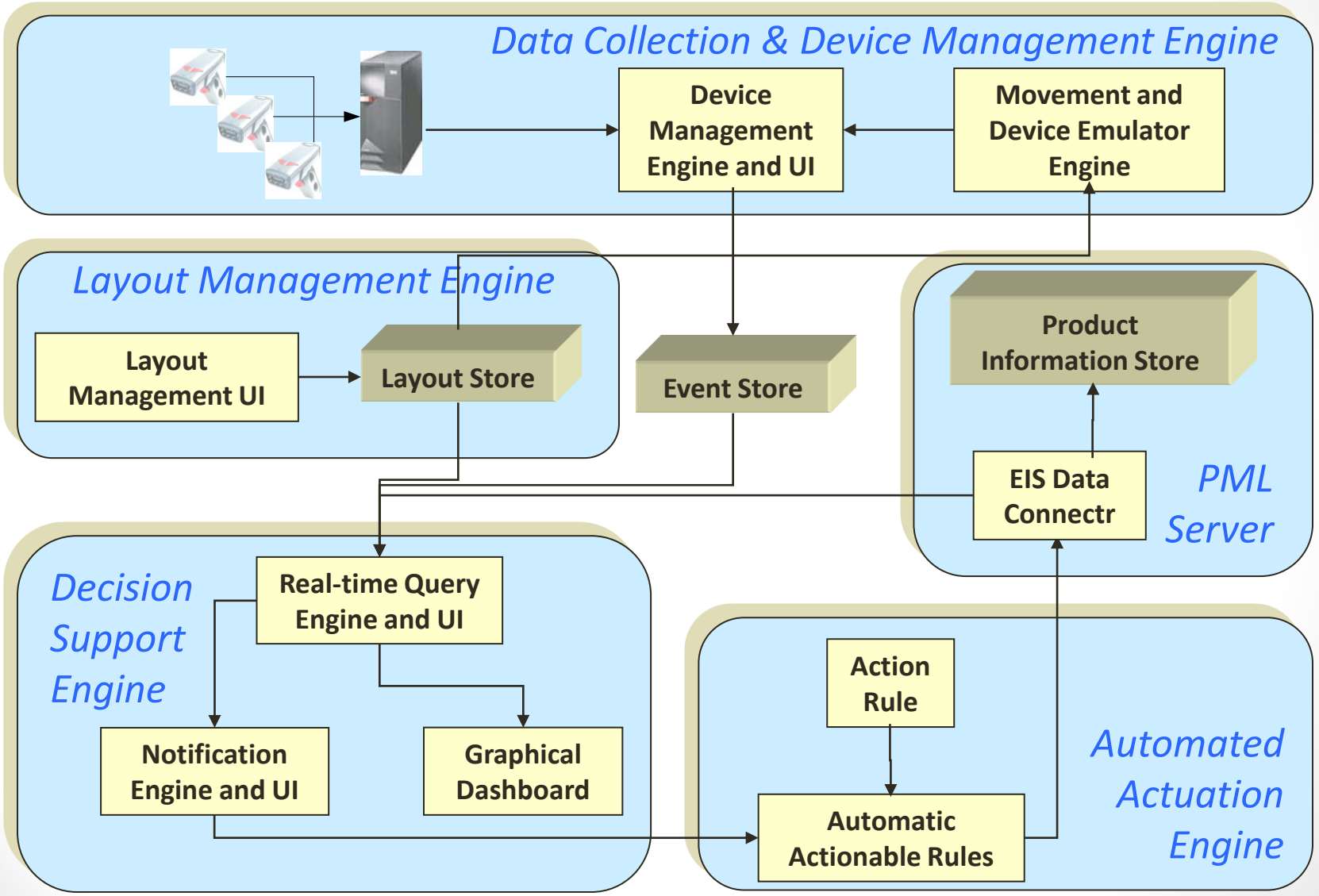
- 12 bytes EPC + Reader ID + Time = 18 bytes per tag
- Average number of tags in a neighborhood store = 700,000
- Data generated per second = 12.6 GB
- Data generated per day = 544 TB
- Assuming 50 stores in the chain,
  - data generated per day = 2720 TB

- Stanford Linear Accelerator Center generates 500 TB

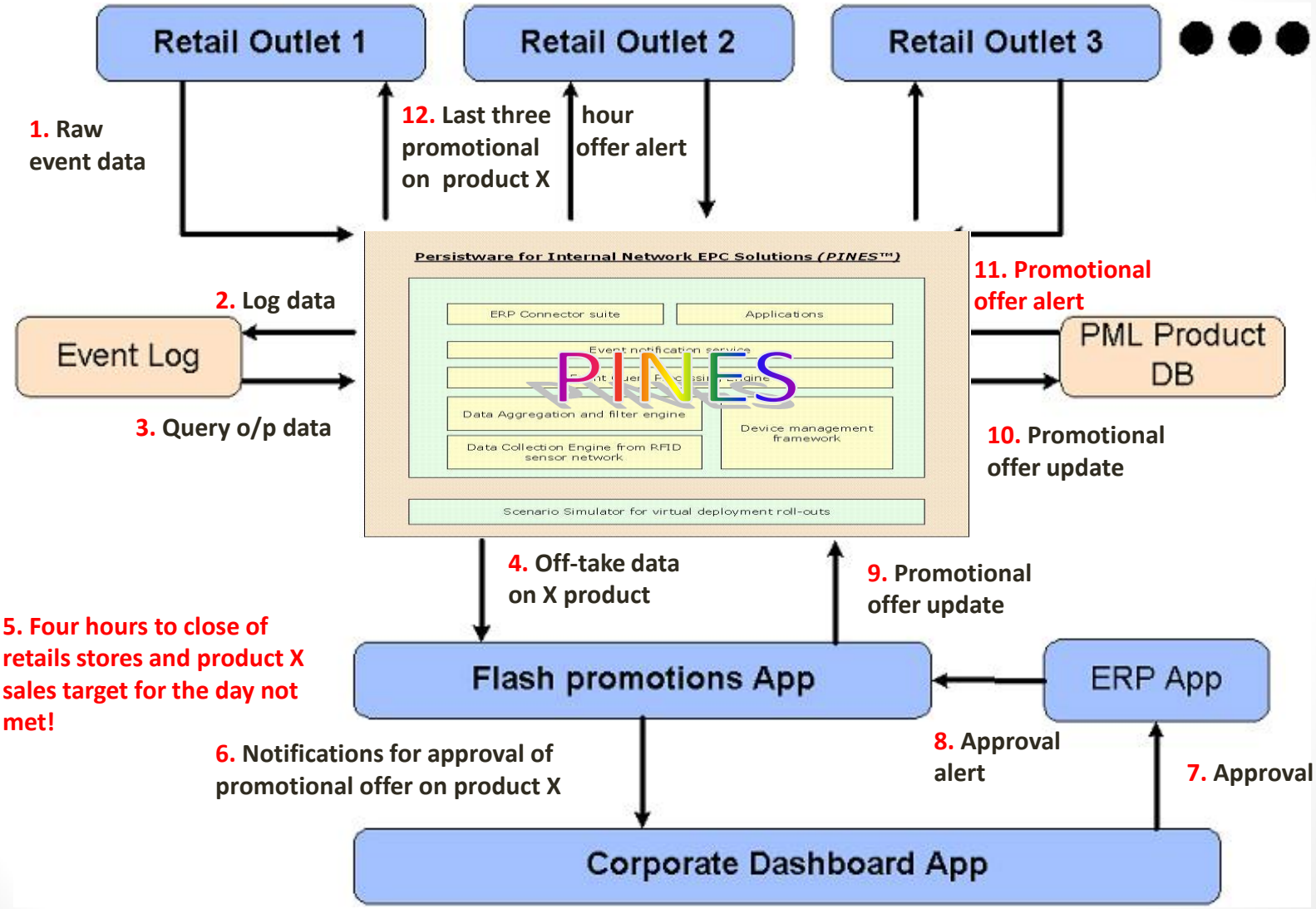
RFID Middleware



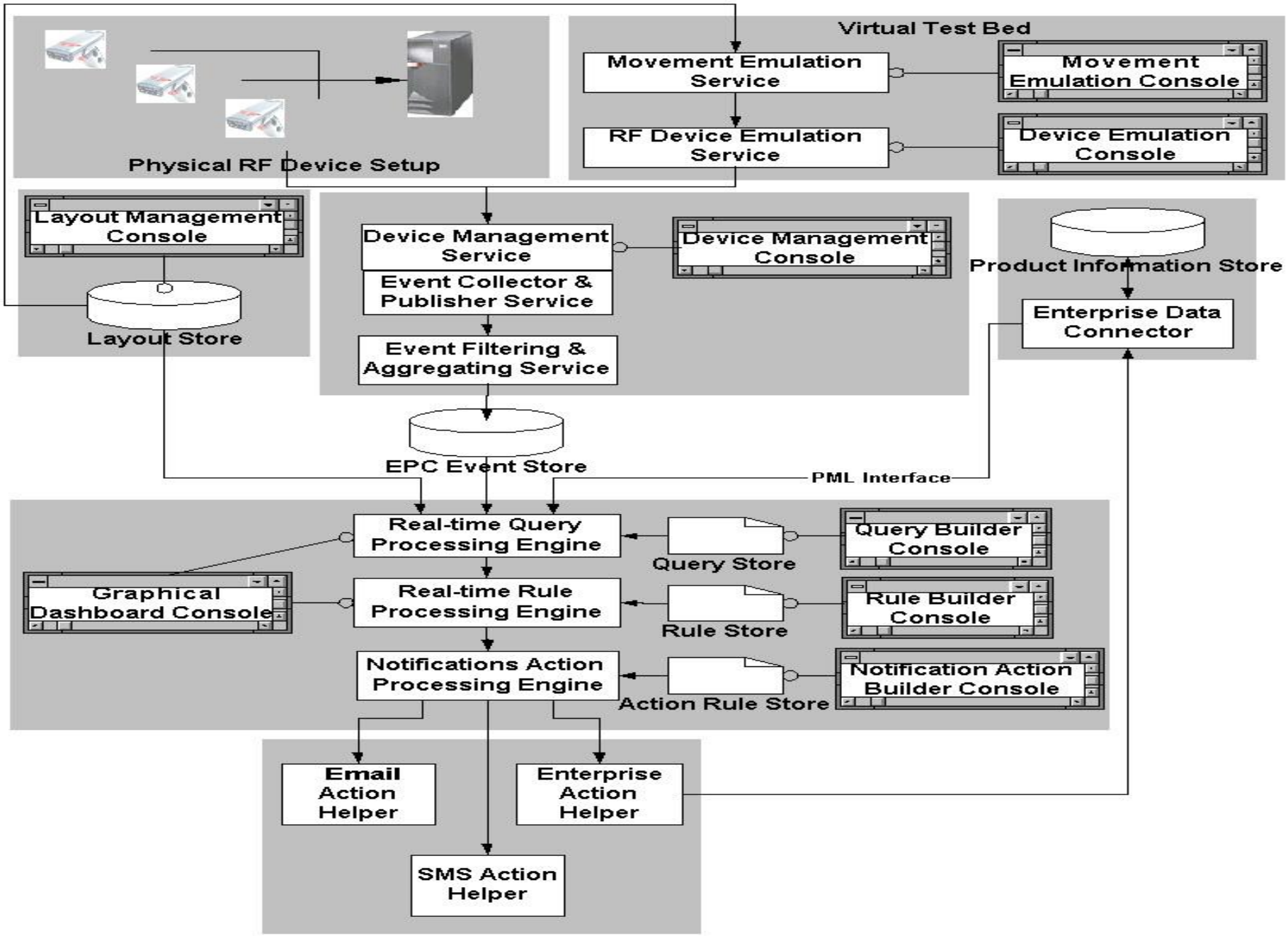
Middleware Framework: PINES™



Retail Case Study: Enabling Real-Time Decisions



PINES™ Architecture Overview



Layout Management Framework

Site Layout Configuration and Location Management

Welcome to PINES - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites Media

Address http://gateway.pspl.co.in:6104/index.html Go Links

PINES
RFID Based Soln

PERSISTENT

Home | Applications | Configuration | Help

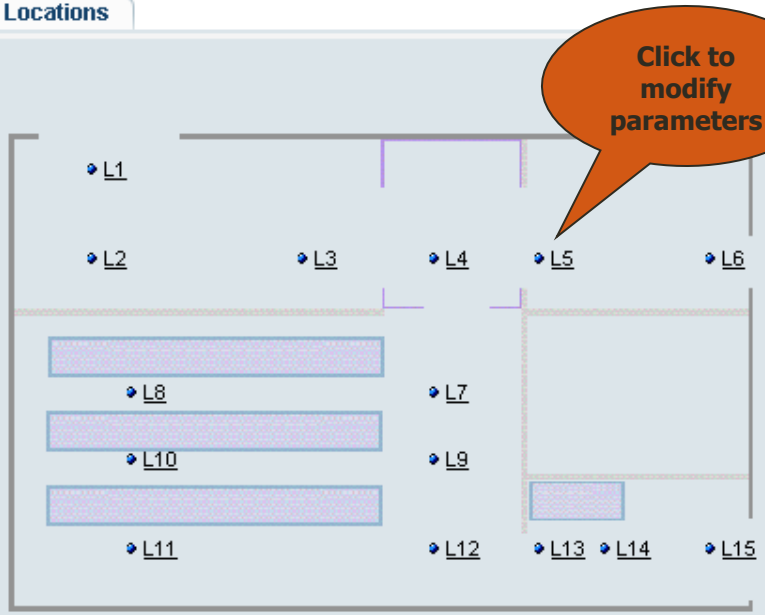
Administration Console
- Layout Management
- Device Management
- Event Store Management

Emulation Console
- Movement Emulation
- Hardware Emulation

Layout Map

Help

Locations



Scale

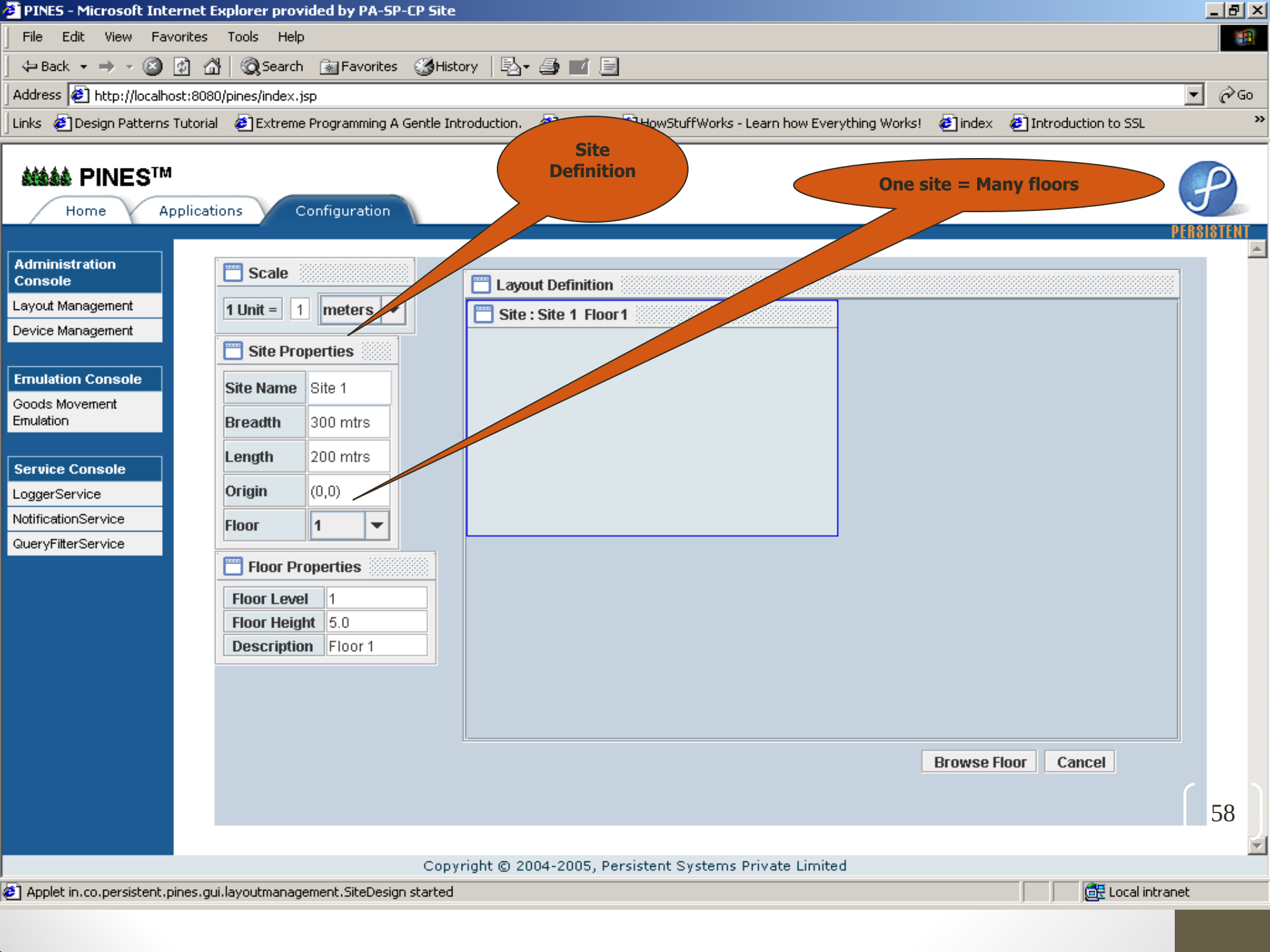
North	(1 Unit = 7px)	East	(1 Unit = 12px)

		Desc	Point	From
Jn	Entry	L1	[20, 6, 0]	main
		L2	[16, 6, 0]	main
Jn		L3	[16, 22, 0]	main
		L4	[16, 32, 0]	main
Jn		L5	[16, 40, 0]	main
Jn	Exit	L6	[16, 53, 0]	main
		L7	[10, 32, 0]	main
Jn		L8	[10, 9, 0]	main
		L9	[7, 32, 0]	main
Jn		L10	[7, 9, 0]	main
		L11	[3, 9, 0]	main
Jn		L12	[3, 32, 0]	main
		L13	[3, 40, 0]	main
		L14	[3, 45, 0]	main
Jn	Exit	L15	[3, 53, 0]	main

Jn	Location "represents Business Prossesing Zone" or "Positions RF Antenna"
Entry	Location that accepts goods within system boundaries
	Location that dispatches goods to outside of

- **Specify the layout for a reader and antenna setup by means of locations and junctions**
- **Ability to continuously modify/update the layout**
- **Provide access to reader and antenna configuration from visual layout**

Done Internet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Address http://localhost:8080/pines/index.jsp
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Links Design Patterns Tutorial Extreme Programming A Gentle Introduction. HowStuffWorks - Learn how Everything Works! index Introduction to SSL
PINES™
Home
Applications
Configuration
PERSISTENT
Site Definition
One site = Many floors
Administration Console
Layout Management
Device Management
Emulation Console
Goods Movement Emulation
Service Console
LoggerService
NotificationService
QueryFilterService
Scale
1 Unit = 1 meters
Site Properties
Site Name Site 1
Breadth 300 mtrs
Length 200 mtrs
Origin (0,0)
Floor 1
Floor Properties
Floor Level 1
Floor Height 5.0
Description Floor 1
Layout Definition
Site : Site 1 Floor1
Browse Floor
Cancel
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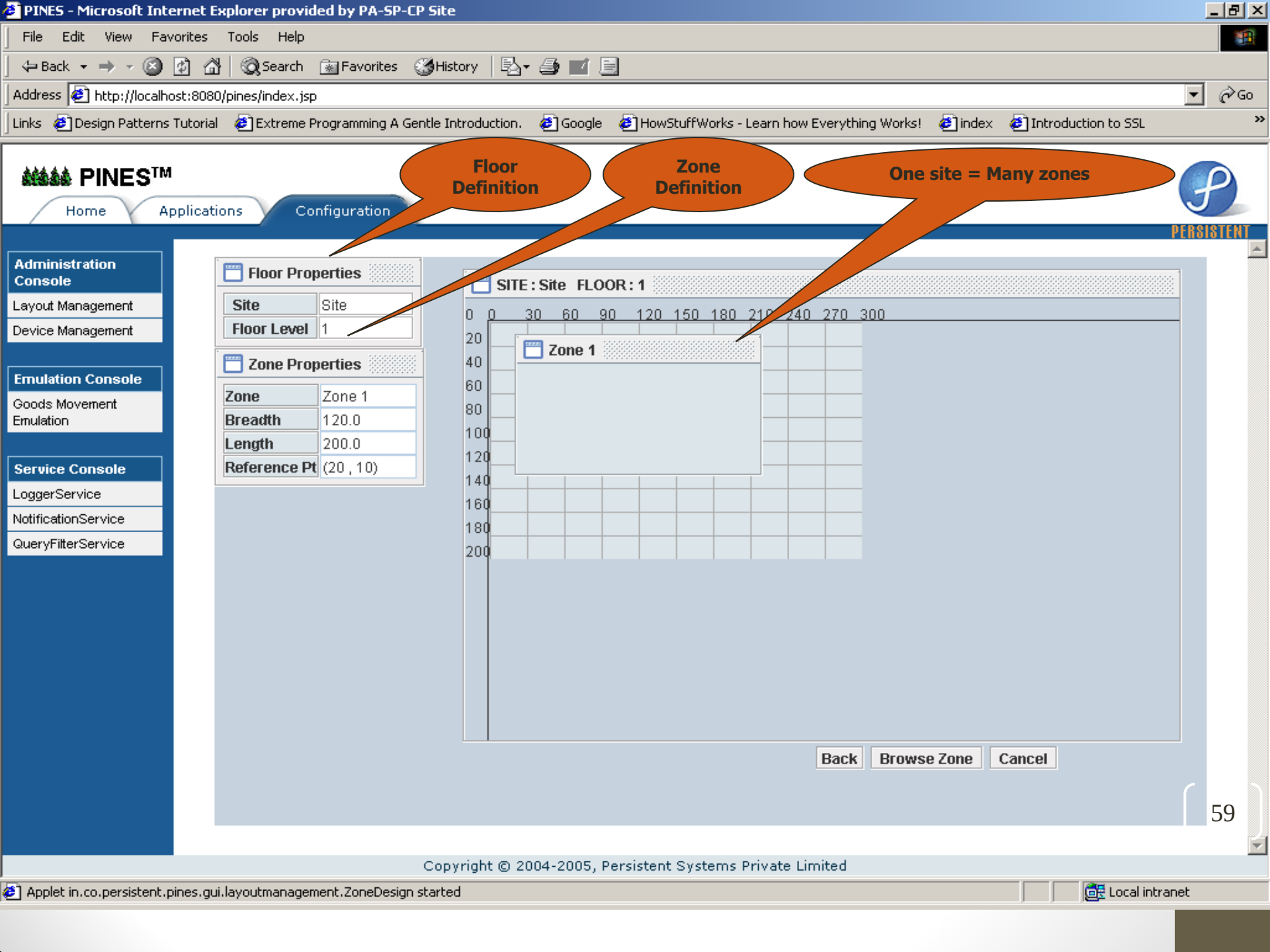
Local intranet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PINES™
Home
Applications
Configuration
PERSISTENT
Floor Definition
Zone Definition
One site = Many zones
Administration Console
Layout Management
Device Management
Emulation Console
Goods Movement Emulation
Service Console
LoggerService
NotificationService
QueryFilterService
Floor Properties
Site Site
Floor Level 1
Zone Properties
Zone Zone 1
Breadth 120.0
Length 200.0
Reference Pt (20 , 10)
SITE : Site FLOOR : 1
Zone 1
Back
Browse Zone
Cancel
59
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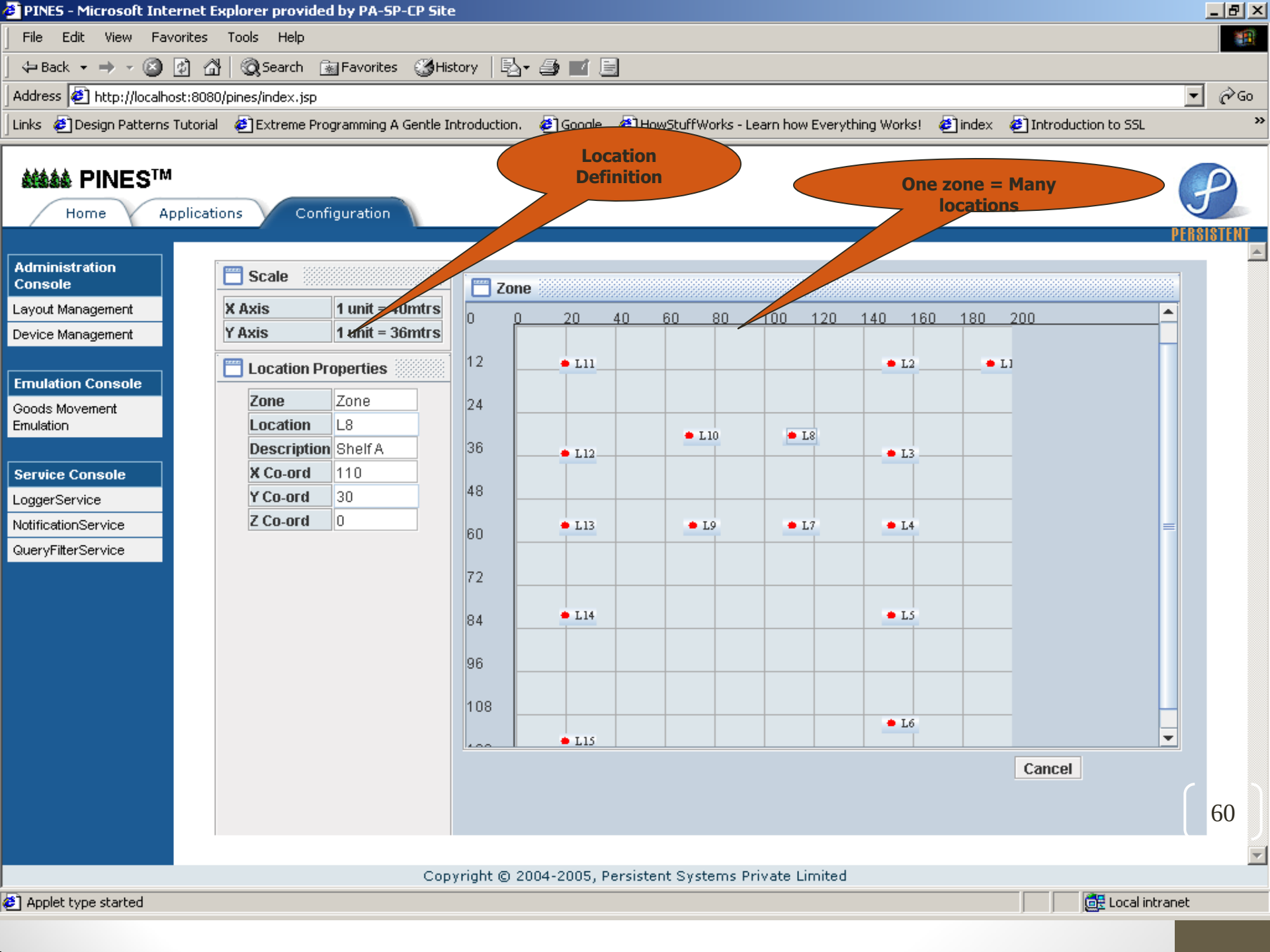
Applet in.co.persistent.pines.gui.layoutmanagement.ZoneDesign started
Local intranet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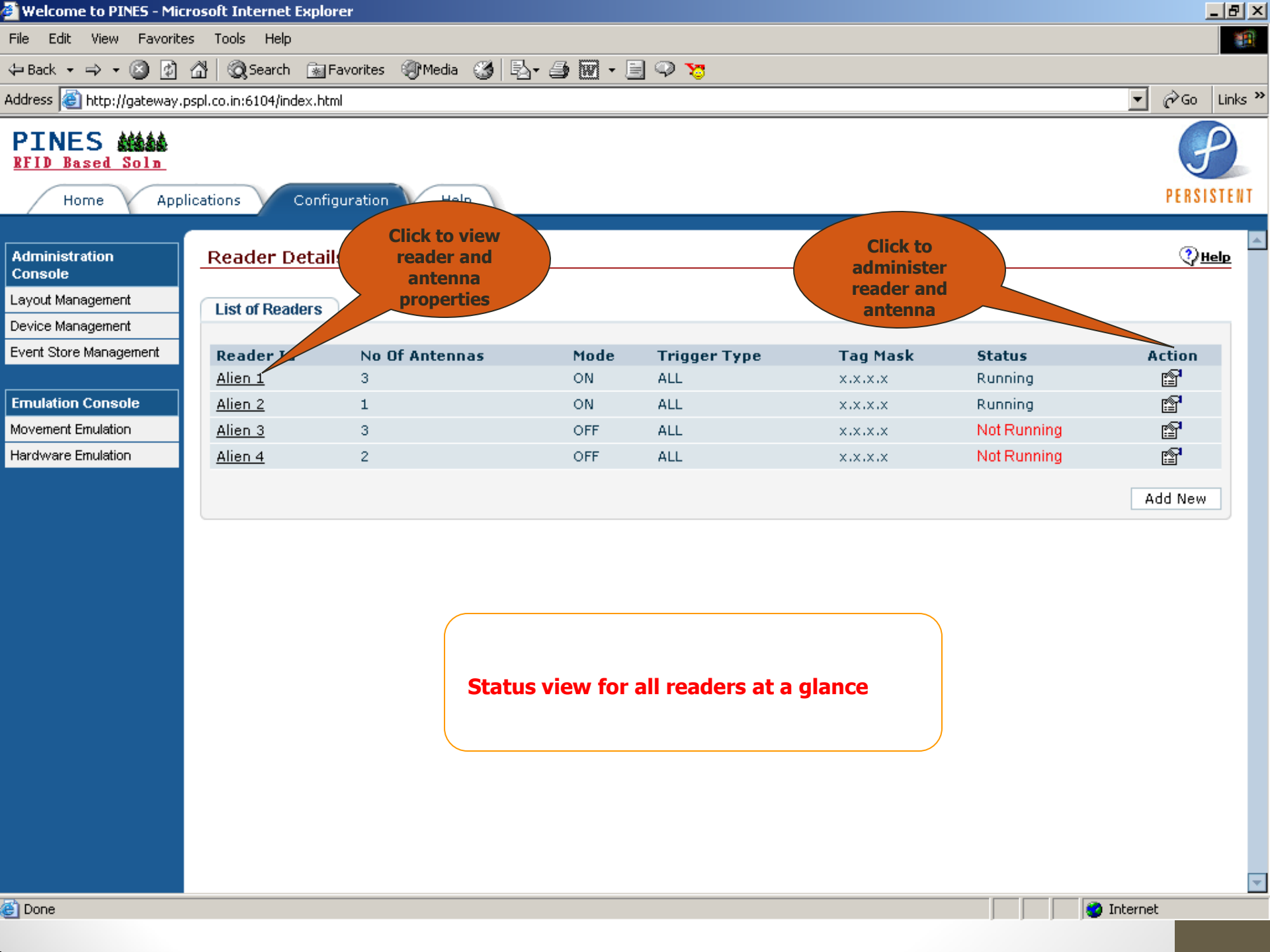
PINES™
Home
Applications
Configuration
PERSISTENT
Location Definition
One zone = Many locations
Administration Console
Layout Management
Device Management
Emulation Console
Goods Movement Emulation
Service Console
LoggerService
NotificationService
QueryFilterService
Scale
X Axis
1 unit = 40mtrs
Y Axis
1 unit = 36mtrs
Location Properties
Zone
Zone
Location
L8
Description
Shelf A
X Co-ord
110
Y Co-ord
30
Z Co-ord
0
Zone
0 20 40 60 80 100 120 140 160 180 200
12 24 36 48 60 72 84 96 108
L11 L2 L1
L10 L8
L12 L3
L13 L9 L7 L4
L14 L5
L15 L6
Cancel
60
Copyright © 2004-2005, Persistent Systems Private Limited
Applet type started
Local intranet

Device Management Framework

Remote Monitoring and Configuration of RF Sensor Network Elements – Readers and Antennas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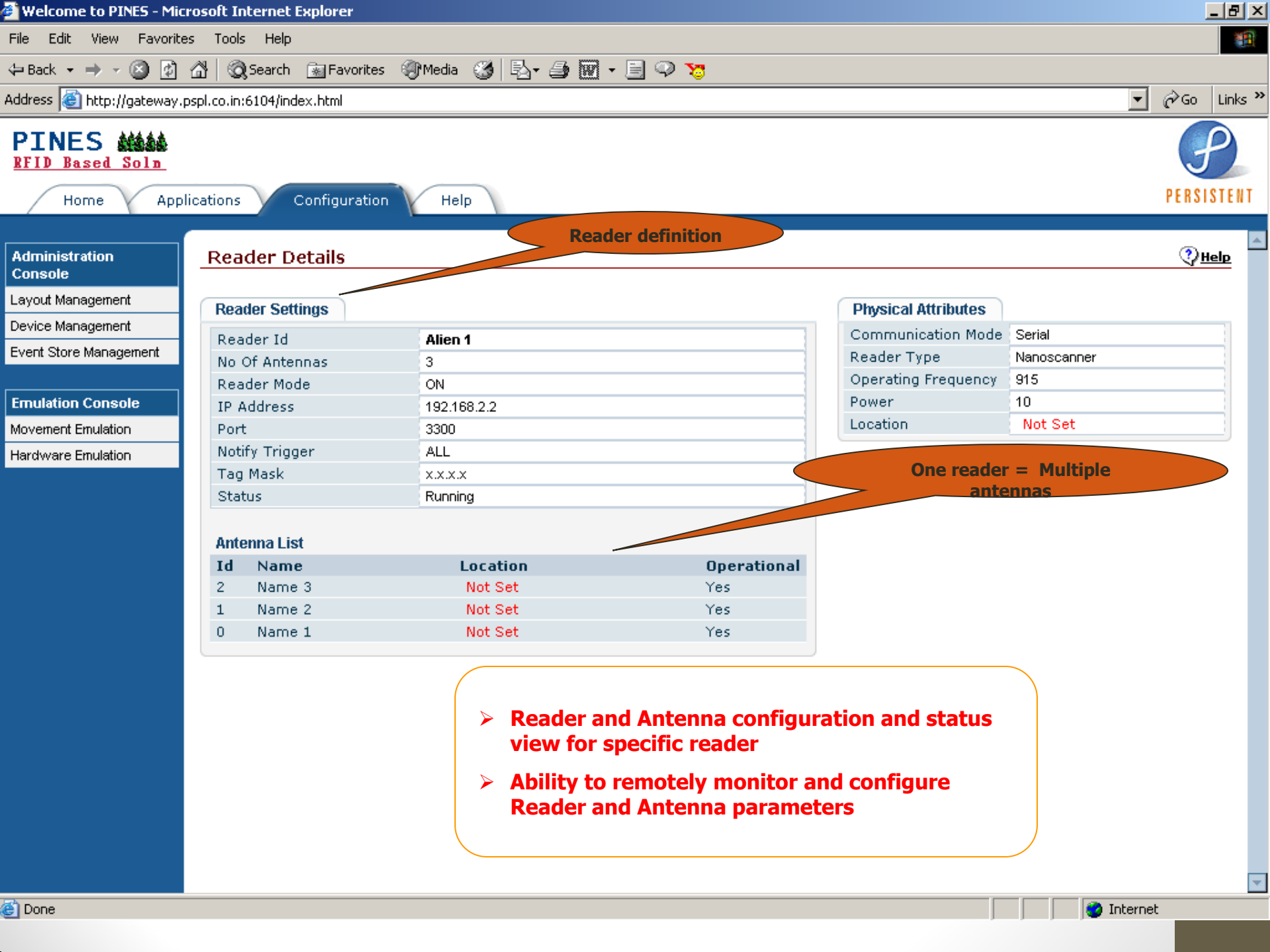
Go Links
PINES
RFID Based Soln
PERSISTENT
Home
Applications
Configuration
Help
Administration Console
Layout Management
Device Management
Event Store Management
Emulation Console
Movement Emulation
Hardware Emulation
Reader Details
Help
List of Readers
Click to view reader and antenna properties
Click to administer reader and antenna
Reader Id
No Of Antennas
Mode
Trigger Type
Tag Mask
Status
Action
Alien 1 3 ON ALL x.x.x.x Running
Alien 2 1 ON ALL x.x.x.x Running
Alien 3 3 OFF ALL x.x.x.x Not Running
Alien 4 2 OFF ALL x.x.x.x Not Running
Add New
Status view for all readers at a glance
Done
Internet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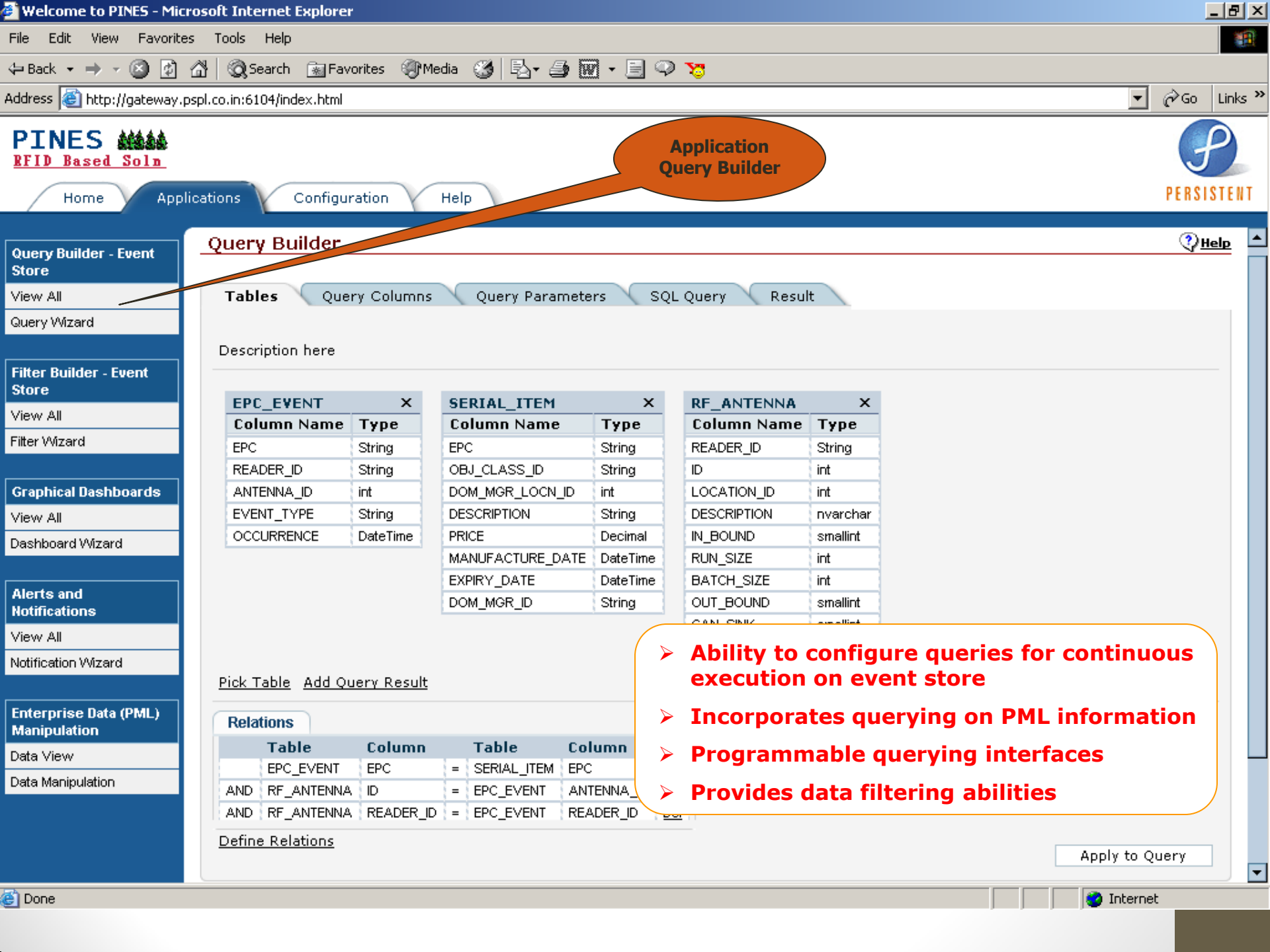
PERSISTENT
Home
Applications
Configuration
Help
Administration Console
Layout Management
Device Management
Event Store Management
Emulation Console
Movement Emulation
Hardware Emulation
Reader definition
Reader Details
Help
Reader Settings
Reader Id Alien 1
No Of Antennas 3
Reader Mode ON
IP Address 192.168.2.2
Port 3300
Notify Trigger ALL
Tag Mask x.x.x.x
Status Running
Physical Attributes
Communication Mode Serial
Reader Type Nanoscanner
Operating Frequency 915
Power 10
Location Not Set
One reader = Multiple antennas
Antenna List
Id Name Location Operational
2 Name 3 Not Set Yes
1 Name 2 Not Set Yes
0 Name 1 Not Set Yes
Reader and Antenna configuration and status view for specific reader
Ability to remotely monitor and configure Reader and Antenna parameters
Done
Internet

Sophisticated Query Processing

Stream based Event Store for Incessant, High Performance Querying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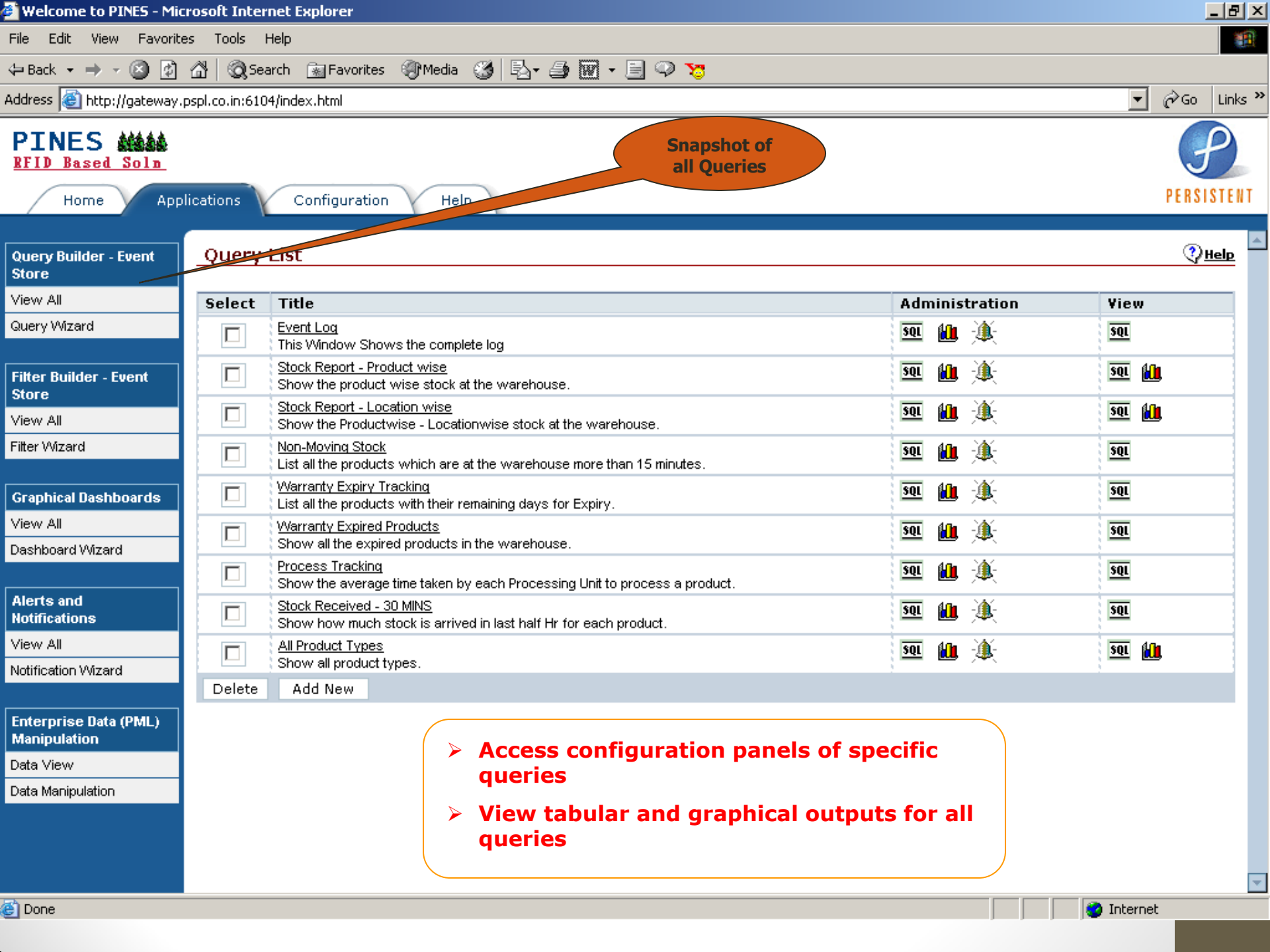
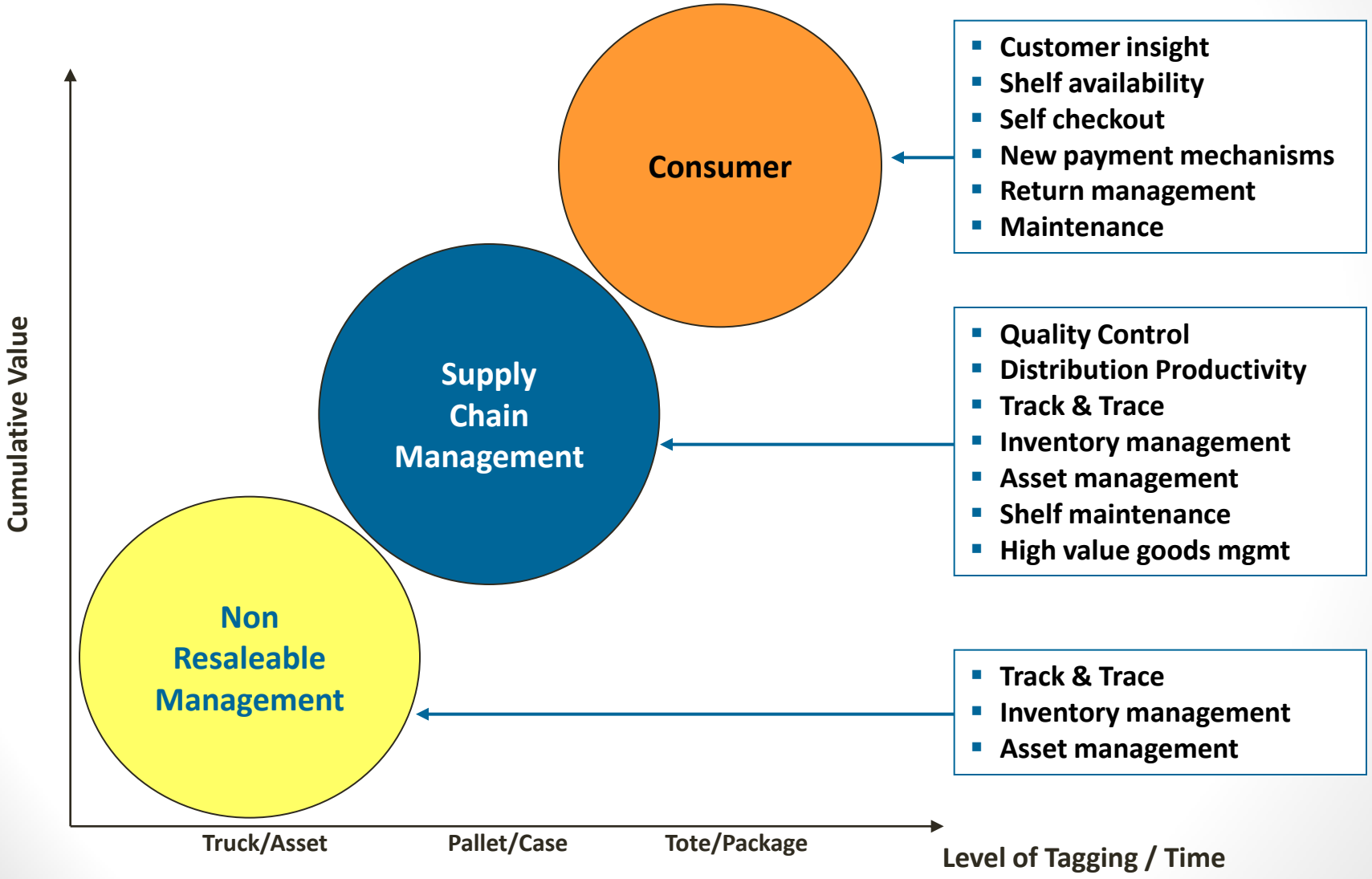
Go Links
PINES
RFID Based Soln
PERSISTENT
Application Query Builder
Home
Applications
Configuration
Help
Query Builder - Event Store
View All
Query Wizard
Filter Builder - Event Store
View All
Filter Wizard
Graphical Dashboards
View All
Dashboard Wizard
Alerts and Notifications
View All
Notification Wizard
Enterprise Data (PML) Manipulation
Data View
Data Manipulation
Query Builder
Help
Tables
Query Columns
Query Parameters
SQL Query
Result
Description here
EPC_EVENT
Column Name Type
EPC String
READER_ID String
ANTENNA_ID int
EVENT_TYPE String
OCCURRENCE DateTime
SERIAL_ITEM
Column Name Type
EPC String
OBJ_CLASS_ID String
DOM_MGR_LOCN_ID int
DESCRIPTION String
PRICE Decimal
MANUFACTURE_DATE DateTime
EXPIRY_DATE DateTime
DOM_MGR_ID String
RF_ANTENNA
Column Name Type
READER_ID String
ID int
LOCATION_ID int
DESCRIPTION nvarchar
IN_BOUND smallint
RUN_SIZE int
BATCH_SIZE int
OUT_BOUND smallint
Pick Table
Add Query Result
Relations
Table Column Table Column
EPC_EVENT EPC = SERIAL_ITEM EPC
AND RF_ANTENNA ID = EPC_EVENT ANTENNA_
AND RF_ANTENNA READER_ID = EPC_EVENT READER_ID
Define Relations
Apply to Query
Ability to configure queries for continuous execution on event store
Incorporates querying on PML information
Programmable querying interfaces
Provides data filtering abilities
Done
Internet


Welcome to PINES - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://gateway.pspl.co.in:6104/index.html
Go Links
PINES
RFID Based Soln
Snapshot of all Queries
PERSISTENT
Home
Applications
Configuration
Help
Query Builder - Event Store
View All
Query Wizard
Filter Builder - Event Store
View All
Filter Wizard
Graphical Dashboards
View All
Dashboard Wizard
Alerts and Notifications
View All
Notification Wizard
Enterprise Data (PML) Manipulation
Data View
Data Manipulation
Query List
Help
Select
Title
Administration
View
Event Log
This Window Shows the complete log
Stock Report - Product wise
Show the product wise stock at the warehouse.
Stock Report - Location wise
Show the Productwise - Locationwise stock at the warehouse.
Non-Moving Stock
List all the products which are at the warehouse more than 15 minutes.
Warranty Expiry Tracking
List all the products with their remaining days for Expiry.
Warranty Expired Products
Show all the expired products in the warehouse.
Process Tracking
Show the average time taken by each Processing Unit to process a product.
Stock Received - 30 MINS
Show how much stock is arrived in last half Hr for each product.
All Product Types
Show all product types.
Delete
Add New
Access configuration panels of specific queries
View tabular and graphical outputs for all queries
Done
Internet

Outline

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

Business Implications of RFID Tagging



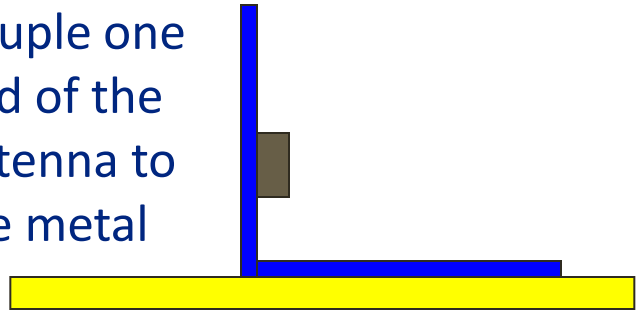
RFID Deployment Challenges

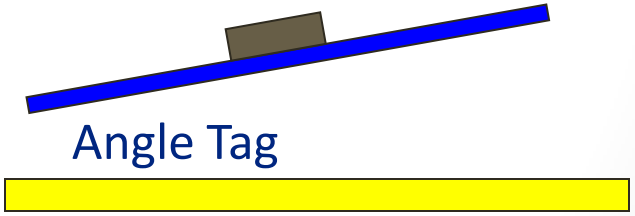
- Manage System costs
  - Choose the right hardware
  - Choose the right integration path
  - Choose the right data infrastructure
- Handle Material matters
  - RF Tagging of produced objects
  - Designing layouts for RF Interrogators
- Tag Identification Scheme Incompatibilities
  - Which standard to 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

Couple one end of the antenna to the metal

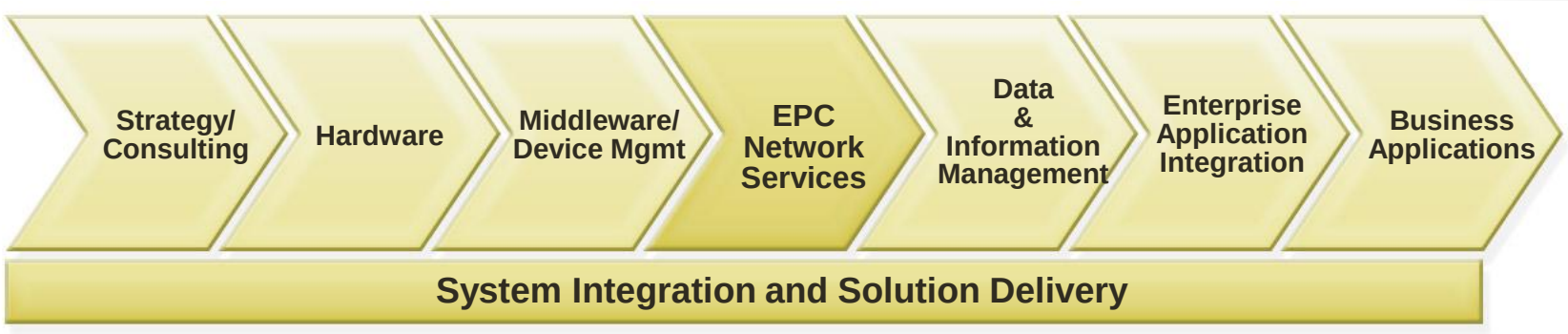




Getting Ready for RFID

- 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

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/ Authentication Framework

- Product Catalog and Attribute Management
- Data Synchro-nization

- ETL Services
- Legacy Application Integration

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

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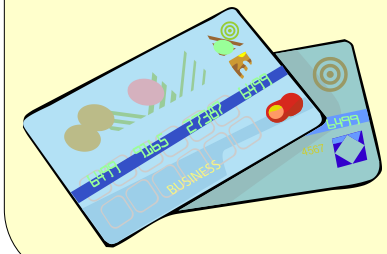
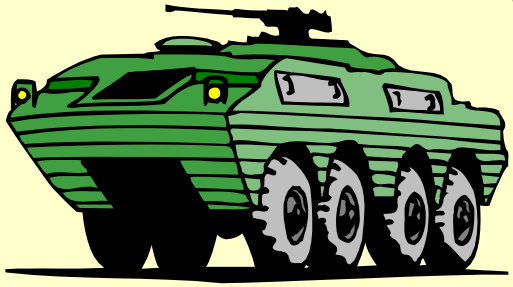
RFID Underpins Essential Infrastructure

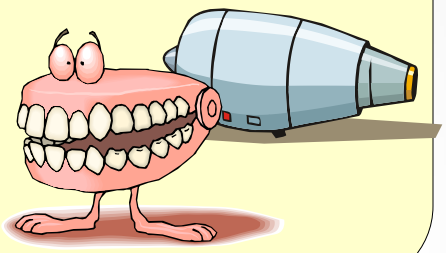
PAYMENT DEVICES



MATERIEL



INDUSTRIAL & MEDICAL PARTS



PHYSICAL SECURITY

BORDER CONTROL

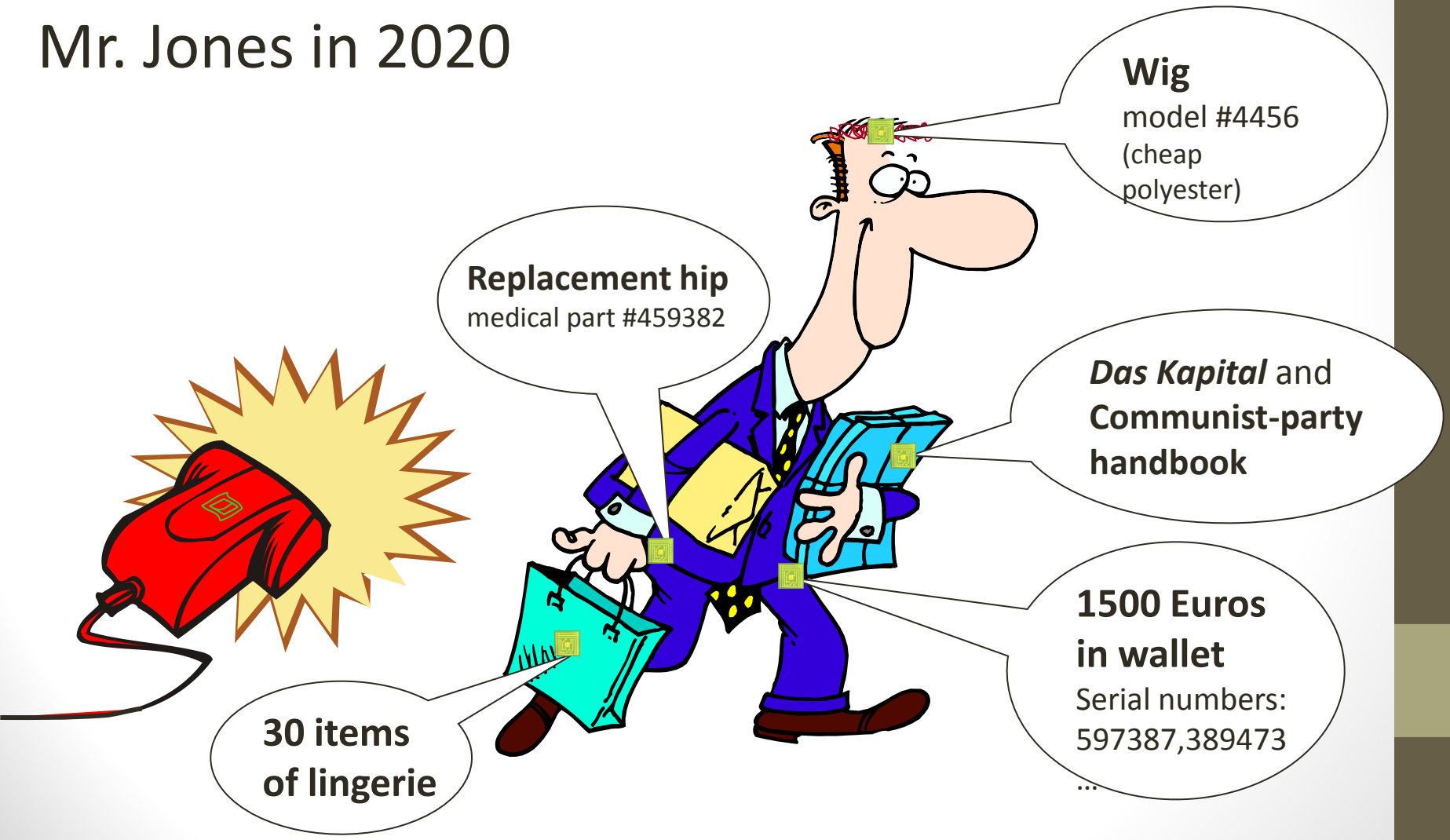
FOOD SUPPLY

CONSUMER GOODS

The Privacy Problem

Bad readers, good tags

Mr. Jones in 2020



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

Content privacy: Protection against unauthorized scanning of data stored on tag

The Capabilities of Basic RFID Tags

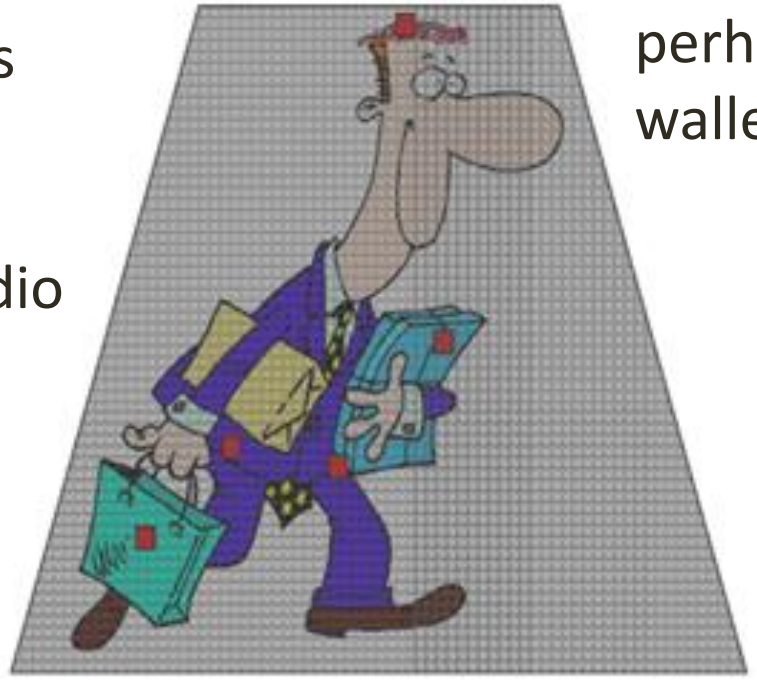
- Little memory
  - Static 64-to-128-bit identifier in current ultra-cheap generation (five cents/unit)
  - Hundreds of bits soon
- Little computational power
  - A few thousand gates
  - ***No* cryptographic functions available**
  - Static keys for read/write permission

Simple Approaches to Consumer Privacy

- Method 1: the Faraday Cage approach

Problem: makes locomotion difficult... perhaps useful for wallets

- Place RFID-tags in protective mesh or foil
- Shield from radio signals



Simple Approaches to Consumer Privacy

- Method 2: the Kill Tag approach

- Kill the tag while leaving the store

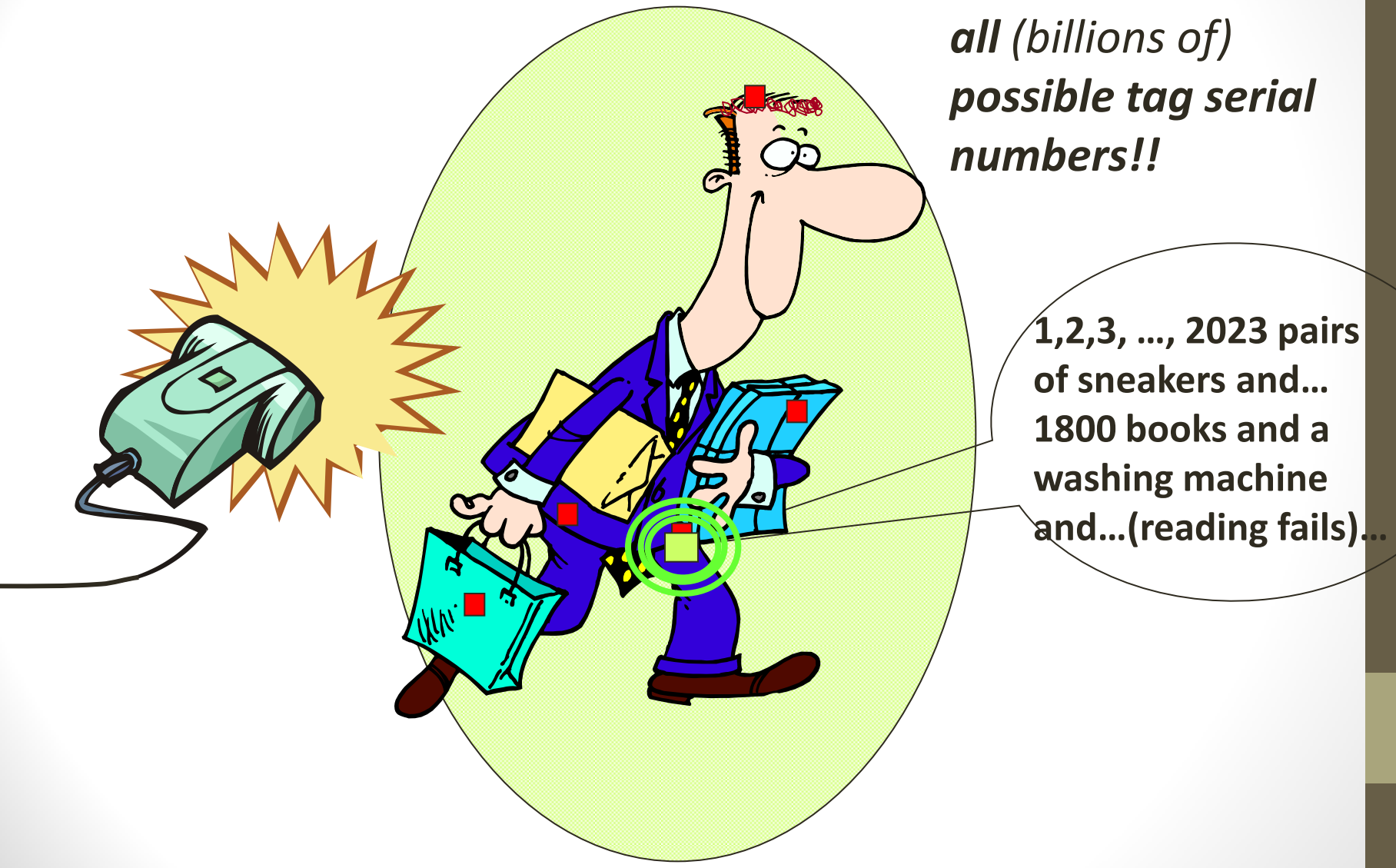
Problem:
RFID tags are much too useful

Content Privacy via “Blocker” Tags

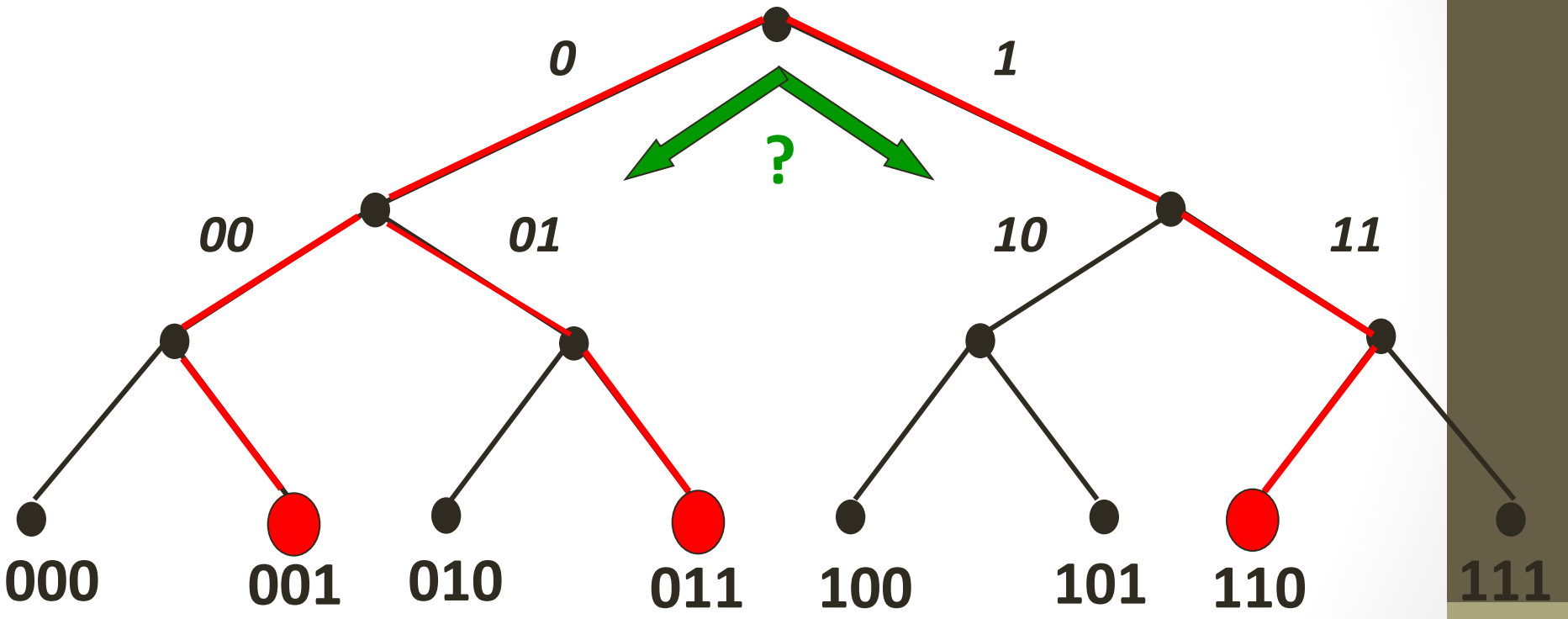
The “Blocker” Tag

“Blocker” Tag

Blocker simulates all** (billions of) **possible tag serial numbers!!



“Tree-walking” Anti-Collision Protocol for RFID Tags



In a Nutshell

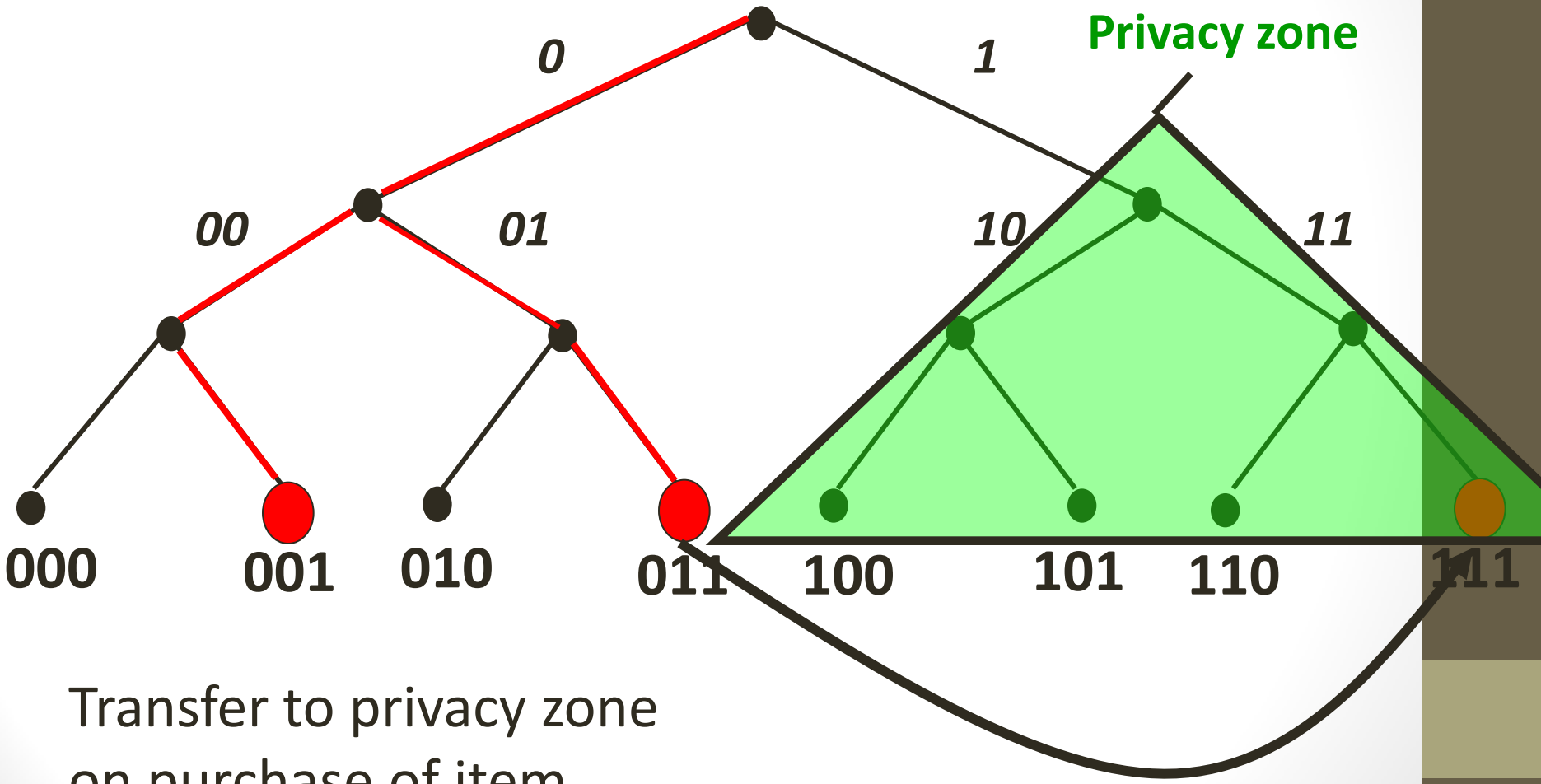
- "Tree-walking" protocol for identifying tags recursively asks question:
  - "What is your next bit?"
- Blocker tag always says ***both '0' and '1'***!
  - Makes it seem like *all* possible tags are present
  - Reader cannot figure out which tags are actually present
  - Number of possible tags is *huge* (at least a billion billion), so reader stalls

Blocker tag system should protect privacy but still avoid blocking un-purchased items

Consumer Privacy + Commercial Security

- Blocker tag can be ***selective:***
  - *Privacy zones:* Only block certain ranges of RFID-tag serial numbers
  - *Zone mobility*: Allow shops to move items into privacy zone upon purchase
- Example:
  - Blocker blocks all identifiers with leading ‘1’ bit
  - Items in supermarket carry leading ‘0’ bit
  - On checkout, leading bit is flipped from ‘0’ to ‘1’
    - PIN required, as for ‘kill’ operation

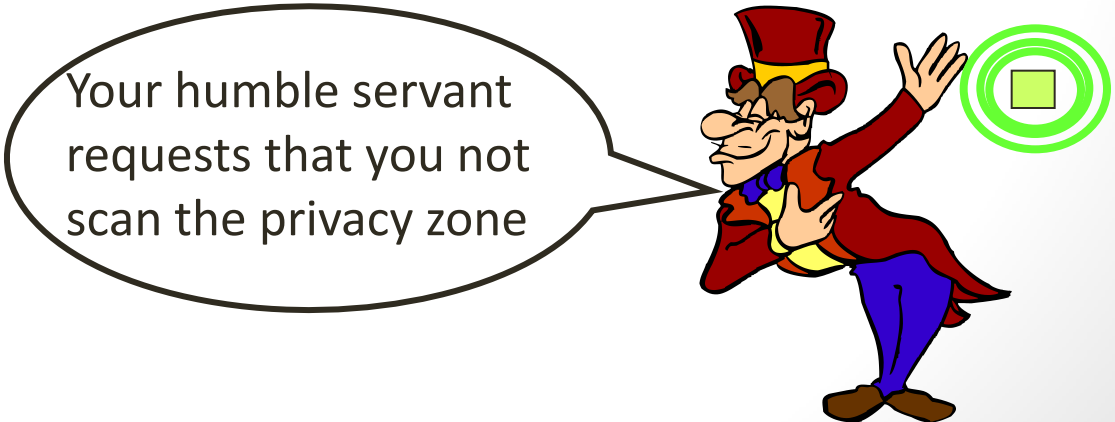
Blocking with Privacy Zones



Transfer to privacy zone
on purchase of item

Polite Blocking

- We want reader to scan privacy zone when blocker is not present
  - Aim of blocker is to keep functionality active – when desired by owner
- But if reader attempts to scan when blocker is present, it will stall!
- Polite blocking: Blocker informs reader of its presence



More about Blocker Tags

- Blocker tag can be cheap
  - Essentially just a ‘yes’ tag and ‘no’ tag with a little extra logic
  - Can be embedded in shopping bags, etc.
- With multiple privacy zones, sophisticated, e.g., graduated policies are possible

An Example: The R_XA Pharmacy

RFID-Tagged Bottle + “Blocker” Bag

RFID-Tagged Bottle + “Blocker” Bag

“Soft” Blocking

- Blocker tags are special-purpose devices enhanced with a non-compliant protocol variant
- **Idea**: Implement polite blocking only – no hardware blocking
  - A little like P3P…
- External audit possible: Can detect if readers scanning privacy zone (enforce reader respect for soft blockers’ preferences)
- **Advantages**:
  - ‘Soft blocker’ tag is an ordinary RFID tag
  - Flexible policy:
    - ‘Opt-in’ now possible
    - e.g., ‘Medical deblocker’ now possible
- Weaker privacy, but can combine with ‘hard’ blocker

Smart Blocking Approach: Personal Simulator or Proxy for RFID

- Nokia mobile-phone RFID kit available in 2004
  - Those phones with NFC could someday get more general-purpose radios…
  - Readers will be compact, available in personal devices
- We might imagine a simulation lifecycle:
  - Mobile phone ‘acquires’ tag when in proximity
  - Mobile phone deactivates tags or imbues with changing pseudonyms
  - Mobile phone simulates tags to readers, enforcing user privacy policy
  - Mobile phone ‘releases’ tags when tags about to exit range

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  - Middleware architecture; EPC standards
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- Security and Privacy
- Conclusion

RFID: The Complete Picture

- Technology which today is still more expensive than barcode
- Lost of efforts made around the price of the tag which is the tip of the iceberg
- What else need to be considered when one want to deploy a RFID system?

- 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

Some Links

- http://www.epcglobalinc.com/
- http://www.rfidjournal.com/
- http://rfidprivacy.com/
- http://www.rfidinc.com/
- http://www.buyrfid.com/