IMPINJ™

DIGITAL LIFE FOR EVERYDAY ITEMS

Speed Reading in a Crowd

Chris Diorio, CEO

RAIN Alliance Meeting

February 5, 2020

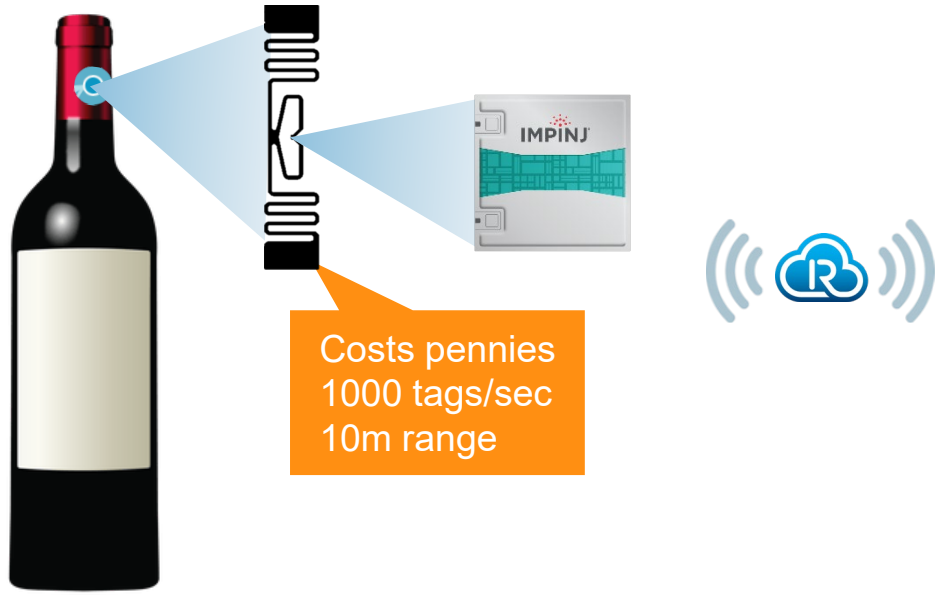
Imagine a Truly Connected World

IMPINJ™

Internet Connectivity for Trillions of Items Every Year

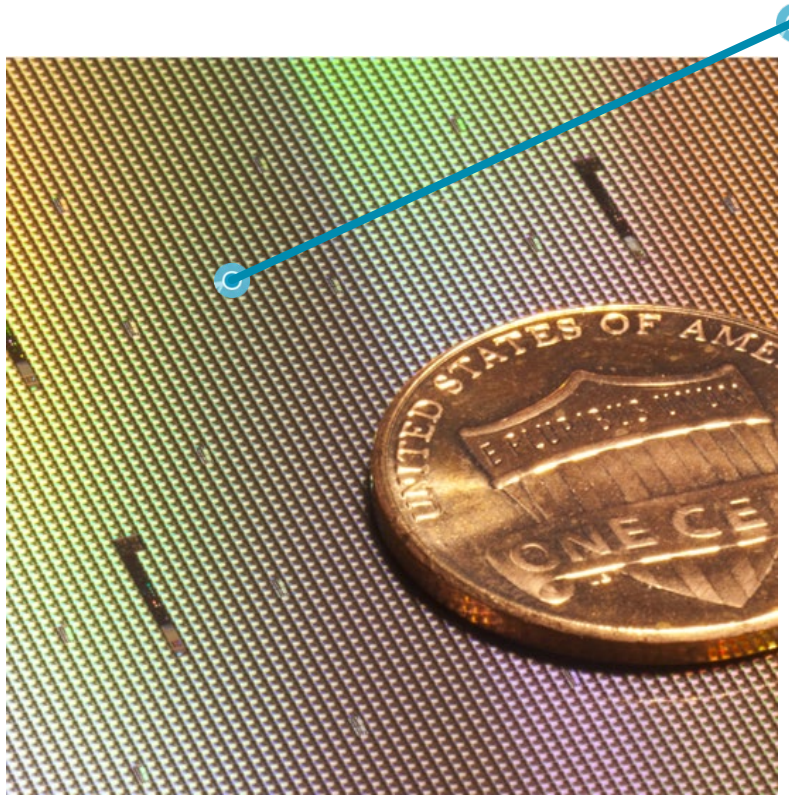
We Have the Technology

- Small & low cost
- Unique identifier per item
- Uses **RA**dio **I**dentificatio**N**
- No batteries
- Lasts forever
- Fast & long range



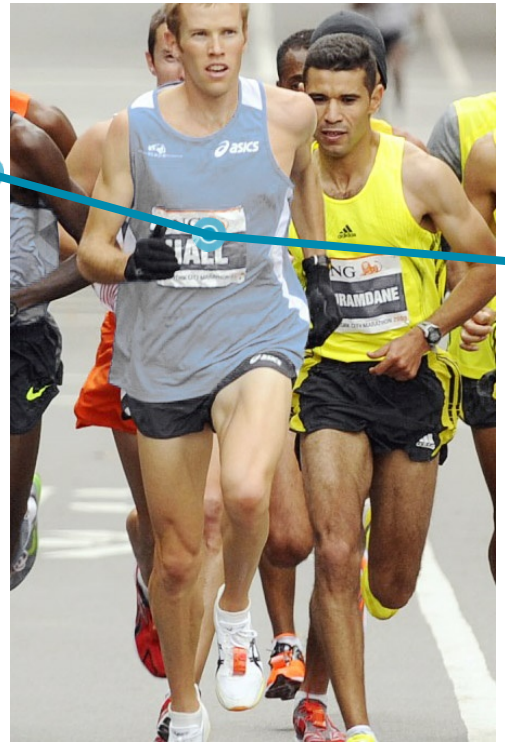
It Can Connect Everything

Little RAIN IC

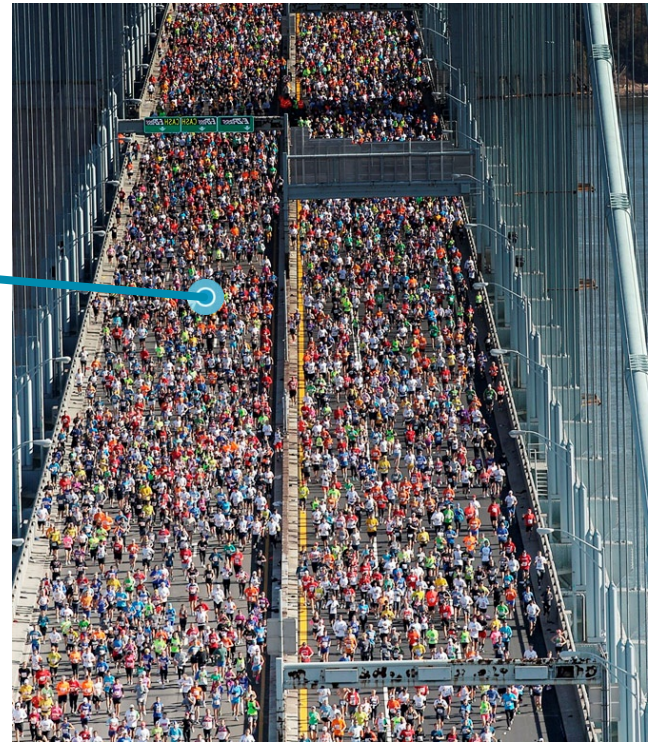


RAIN ICs on a silicon wafer

Big Opportunity



RAIN-enabled race tag



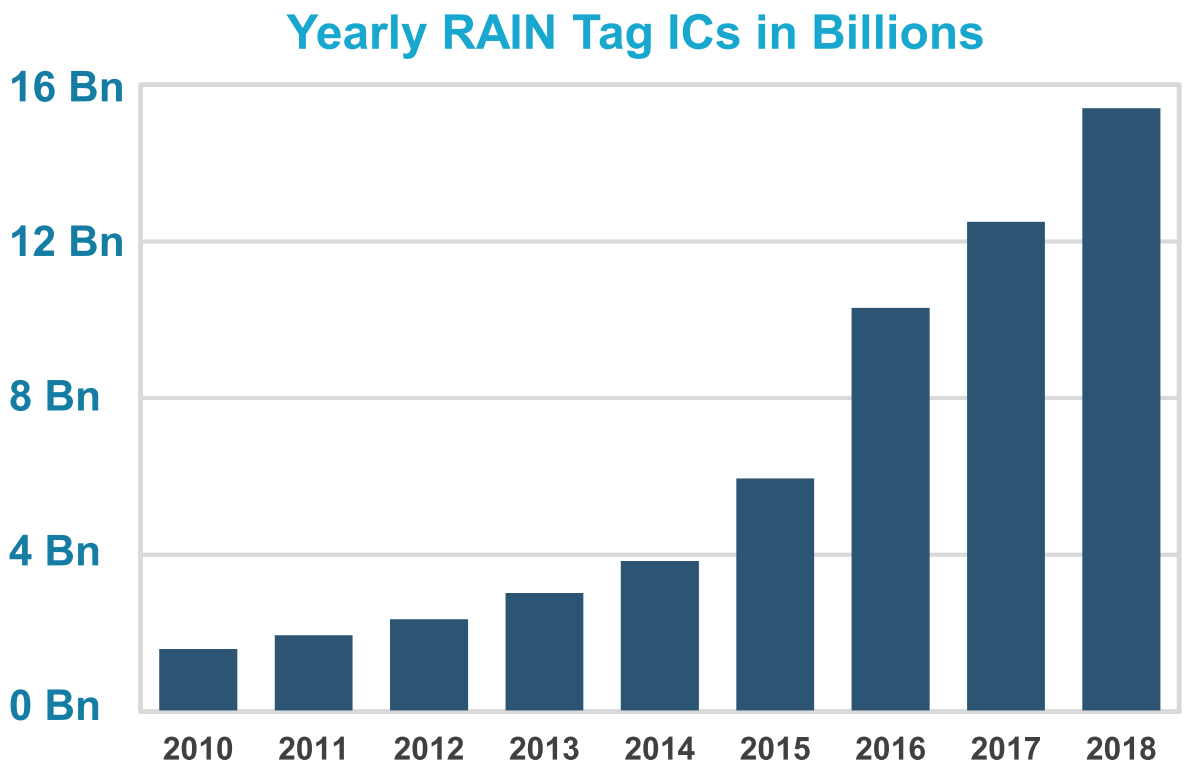
NYC marathon

Volumes are Growing Rapidly

RAIN is Established

- Worldwide Spectrum
- RAIN Industry Alliance
- GS1/ISO Numbering/Standards
- Established Tagging Ecosystem

Industry Unit-Volume Growth[1]

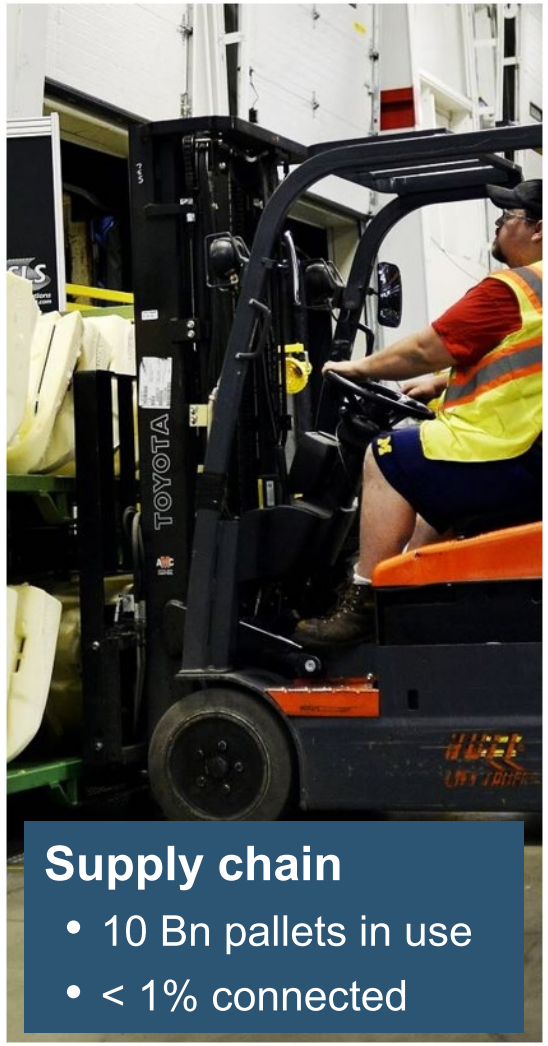


1. Industry-wide volumes (a) for 2010 & 2011 are based on VDC Research: “Strategic Insights 2013: RFID, Contactless & RTLS Technology," for 2012 is based on IDTechEx: "RFID Forecasts, Players and Opportunities 2014—2024,” 2013, (c) for 2013 and 2014 are based on IDTechEx: "RFID Forecasts, Players and Opportunities 2016—2026,” 2015, (d) for 2015-2018 are based on data compiled by the RAIN RFID Alliance.

Adoption is Broad-Based

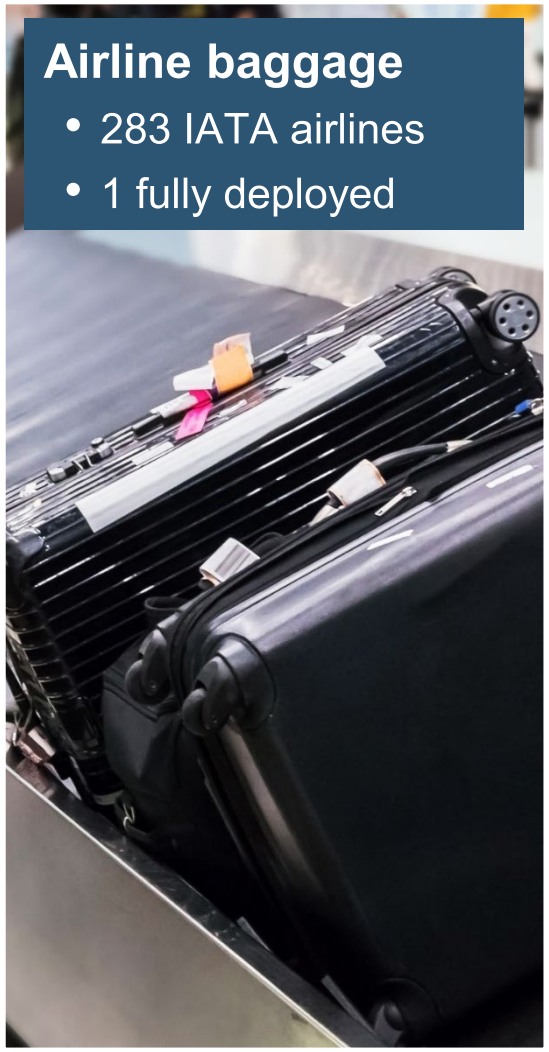
Retail apparel

- 80 Bn/yr opportunity
- ~10% connected



Supply chain

- 10 Bn pallets in use
- < 1% connected



Airline baggage

- 283 IATA airlines
- 1 fully deployed

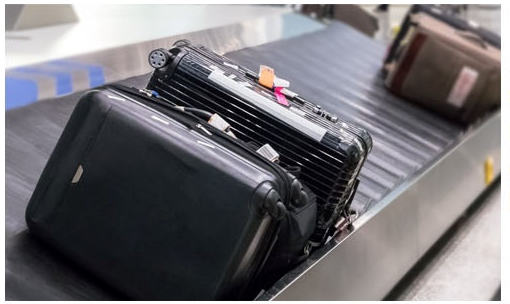
Convenience stores

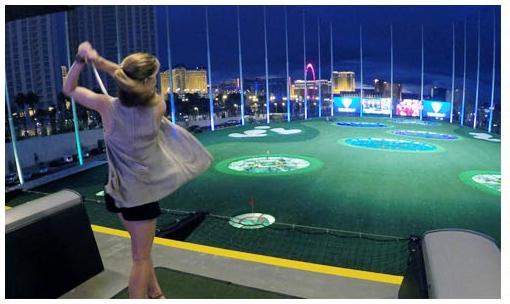
- 100 Bn/yr (Japan)
- 2025 METI plan

Success Brings Its Challenges

- **Success:** With tag volumes growing worldwide, unwanted tags appear ever-more-frequently alongside the tags an application wants to read
- **Challenge:** How can a deployment maintain inventory speed when unwanted tags clutter the read zone

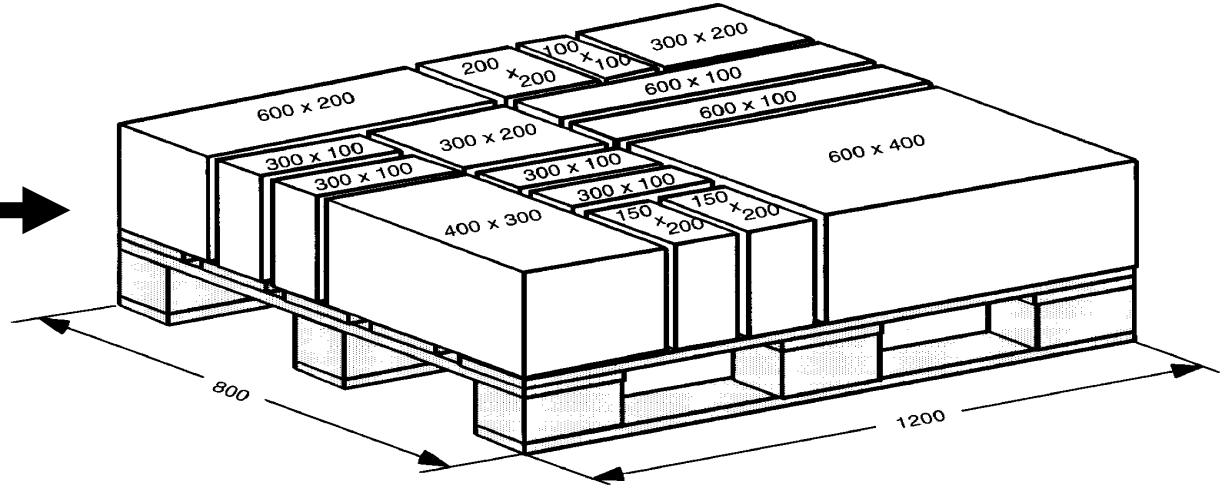





Some History

- **End users provided the original Gen2 requirements back in 2004**
- **Read-speed requirements**
  - Read up to 500 case tags with this representative stacking
  - Pallet moving 13 km/h thru a dock door
- **Bit-mask filtering requirements**
  - Flexibly filter on any part of the EPC
  - Provide “include” and “exclude” filtering



A Difficult Decision

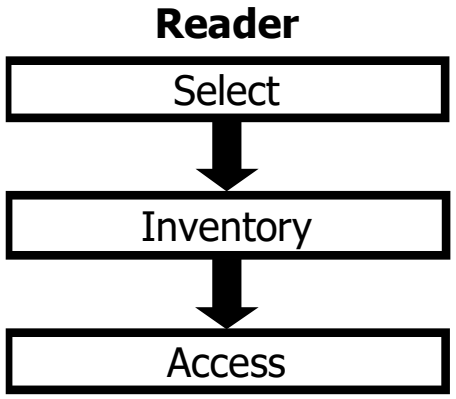
- **The working group considered two options…**

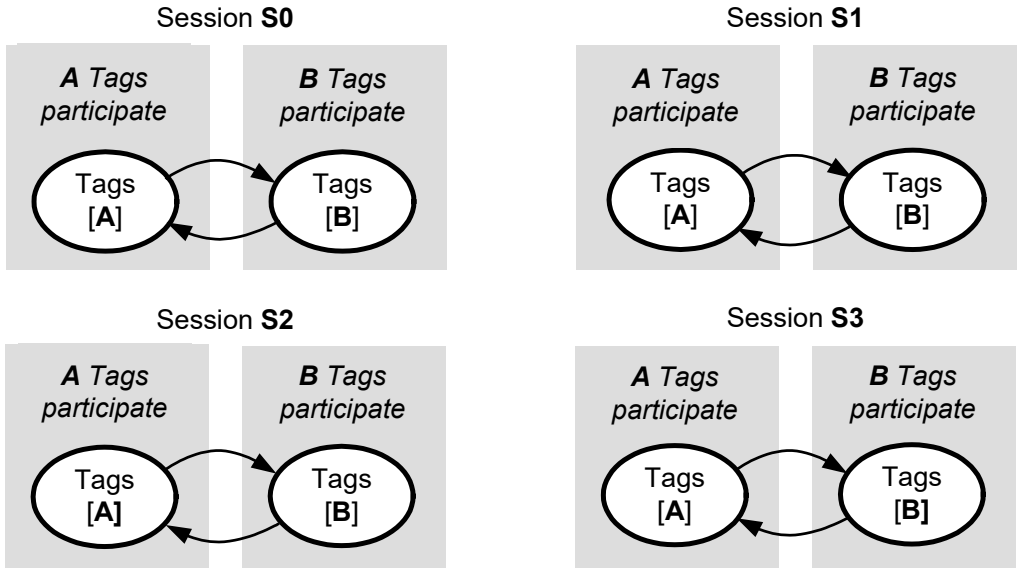
Option	Pro	Con
Bit-mask filtering in the inventory command	• Only “wanted” tags get inventoried • 5 – 10% faster inventory when filtering	• 2 – 4% slower inventory when not filtering • Increased tag IC complexity & cost
Bit-mask filtering in a pre-inventory command	• 2 – 4% faster inventory when not filtering • Decreased tag IC complexity & cost	• 5 – 10% slower inventory when filtering • Some “unwanted” tags get inventoried

- **… and chose to place bit-mask filtering in a separate *Select* command**

How It Works

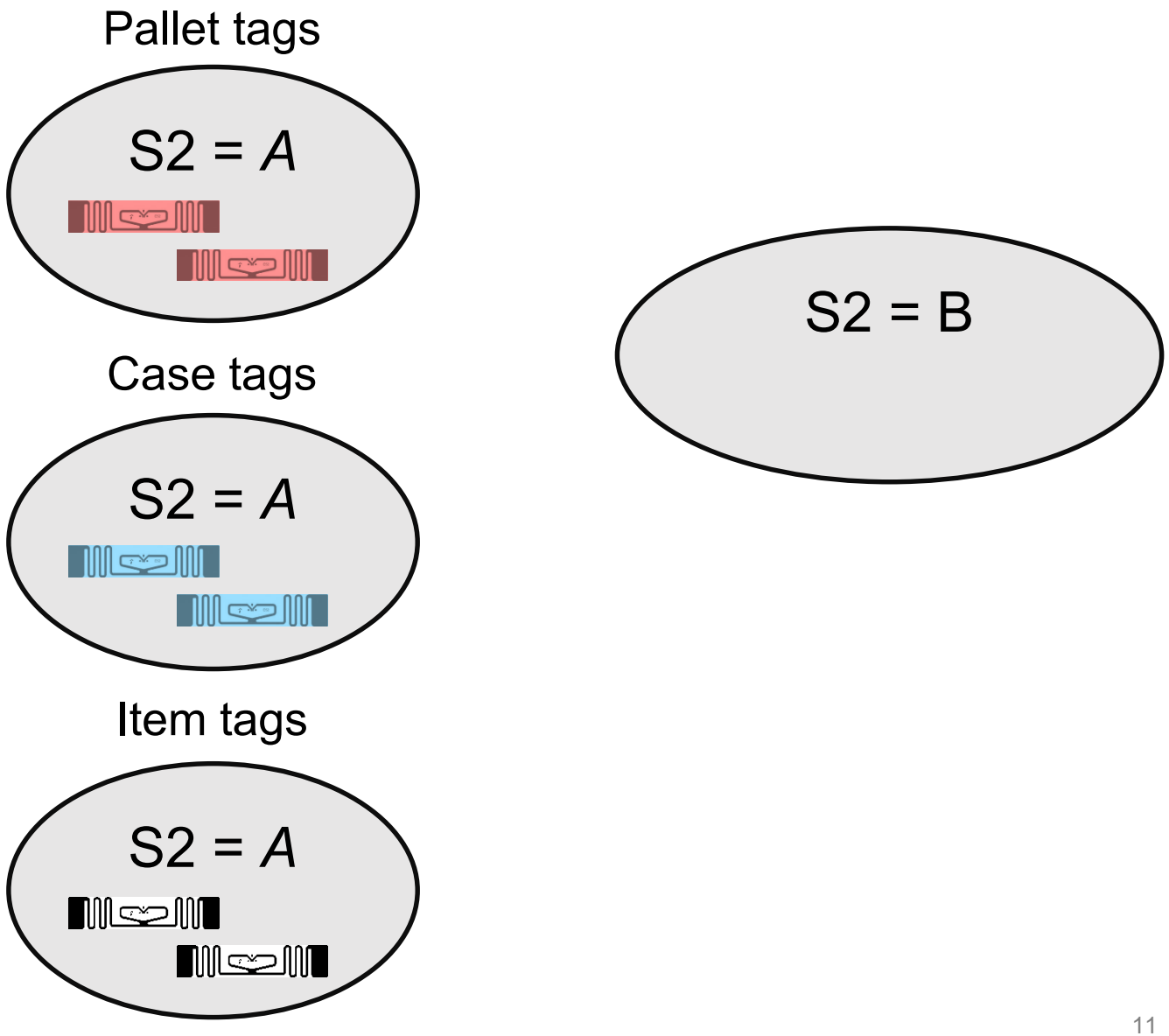
- **Select: A reader selects tags for inventory**
  - *Select* command includes a bit mask each tag compares against a specified memory location
  - *Select* sets one tag flag to *A* or *B*
    - SL flag, or
    - A session flag
  - Readers perform complex tag selection (union and intersection) using successive *Selects*
- **Inventory: Uses the flags to specify which tags participate in an inventory round**
  - SL = *A*, *B* or don't care
  - Session (S0, S1, S2 or S3) = *A* or *B*





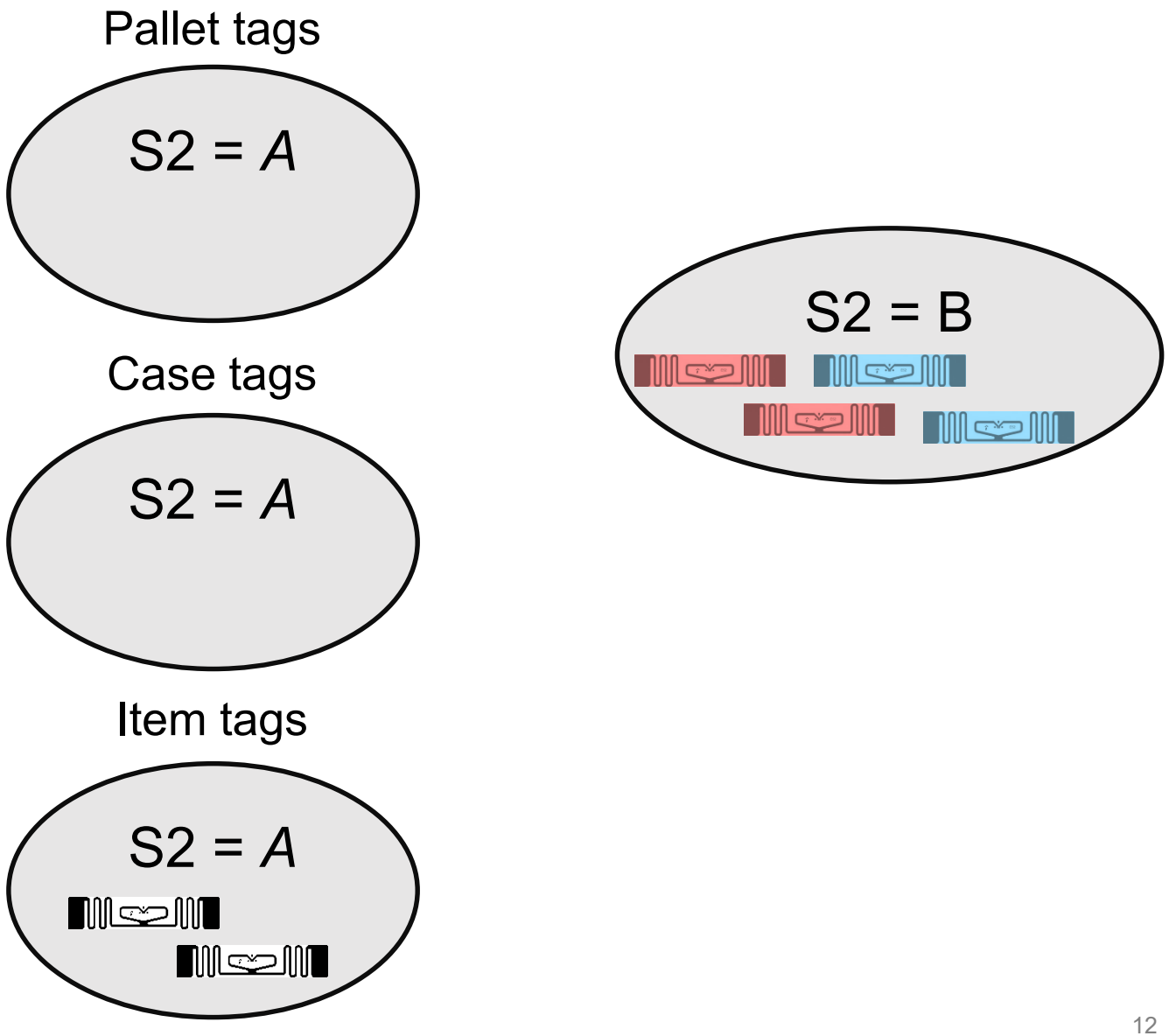
Example

- ***Select*** **(pallet, S2, A➔B)**
- ***Select*** **(case, S2, A➔B)**



Example

- ***Select*** **(pallet, S2, A➔B)**
- ***Select*** **(case, S2, A➔B)**
- ***Query*** **(S2, B➔A)**

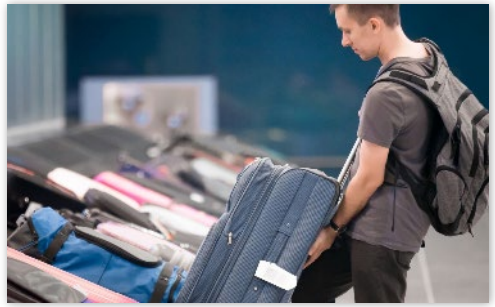


So What's the Issue?

- **Issue 1: Tags use different encodings**
- **Issue 2: Tags may enter field with flag = B**
- **Issue 3: Some tags don't hear the *Select* command**
- **Issue 4: Some applications don't have time to send a *Select* command**

Issue 1: Different Encodings

- **Situation: Three encodings**
  - GS1 EPC; ISO UII; proprietary
  - Complicates bit-mask filtering



- **Tools: T (toggle) and AFI**
  - If you want EPCs
    - *Select* (T=0)
    - *Select* (EPC bit mask)
  - If you want UIIs
    - *Select* (T=1 | AFI)
  - If you want proprietary
    - *Select* (T=1 | ??)

StoredPC Bit Assignments

Application	MSB															LSB
	10_h	11_h	12_h	13_h	14_h	15_h	16_h	17_h	18_h	19_h	$1A_h$	$1B_h$	$1C_h$	$1D_h$	$1E_h$	$1F_h$
GS1 EPCglobal	**L4**	**L3**	**L2**	**L1**	**L0**	**UMI**	**XI**	**T**=0	RFU							
Non-GS1 EPCglobal	**L4**	**L3**	**L2**	**L1**	**L0**	**UMI**	**XI**	**T**=1	AFI as defined in ISO/IEC 15961							

The RAIN Alliance is investigating an AFI for proprietary applications

Issue 2: Flag Already Set to B

- **Situation: Tag may have S2=B or S3=B**
  - S2 / S3 flags hold B state while powered
  - Some ICs hold B for hours when unpowered

- **Tools: *Select* command**
  - *Select* (Flag, all, B➔A) before inventory

Issue 3: Don't Hear the *Select* Command

- **Situation: Tags may miss a *Select***
  - Tags don't always hear commands
    - Insufficient power or interference / noise
  - Tag may enter read zone after the *Select*

- **Tools: Move unwanted tags to B**
  - *Select* (unwanted, A➔B)
  - *Inventory* (flag = A)

Issue 4: Don't Have Time

- **Situation: *Select* + *Query* reduces inventory speed by 5 – 10%**
  - Multiple *Selects* take more time

- **Tools: Maximize protocol speed**
  - Optimize modes, UII length, etc. for speed
  - Move unwanted tags to B before read zone

Time is Making Things Harder

- **Tag volumes continue growing**
  - Proprietary number systems are also growing
- **Use-case overlap is proliferating**
  - Example: License-plate tags and in-car tags
  - Example: Baggage tags and personal item tags in baggage
  - Example: Asset, consumable, pharmaceutical and patient tags in hospitals
- **Use cases are becoming more demanding**
  - Vehicle tolling
  - Foot-race timing
  - Store loss prevention
- **Gen2 tools are an exercise in compromises**
  - Vendor solutions help but can’t fully solve the issue

Suggestion

- **RAIN working group**
  - Numbering do's / don'ts
  - Best practices & usage guidelines
  - We as a community working together to address the issue
- **Maybe we won't solve the problem, but we owe it to ourselves to try**
  - At least we may find ways to make the situation better
  - The longer we wait, the harder it will be
- **Please see Steve Halliday at break if you'd like to help with this issue**