RFID Tag Data Standards

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Outline for Today

• 11:30: RFID Visibility Data for Business Applications
  – What’s the important data, and how do you use it?

• 12:15: RFID Data Capture Software
  – How do you collect the important data?

• Lunch

• 1:45: Putting It Together: Architecture, Product Selection and IT Governance
  – How do you build a complete system for the enterprise?

• 2:30 (now): RFID Tag Data Standards
• 3:30: RFID Data-Capture Standards: LLRP and ALE
What’s In a Tag?

- More data (up to kilobytes)
- Random access
- Writeable as well as readable
- Fancy features (passwords, access control, crypto, “files”, sensors, …)
- Info about the tag’s chip itself

⇒ RFID Tag Data more complex than bar code!
# Types of Tag Data

| Identification          |  |  |
|-------------------------|  |  |
| What’s the tag attached to? |  |  |

| Supplementary data       |  |  |
|--------------------------|  |  |
| Info about the thing the tag’s attached to (height, weight, expiration…) |  |  |

| Control Data             |  |  |
|--------------------------|  |  |
| To operate various tag functions (passwords, filter values, …) |  |  |

| Tag Manufacture Data     |  |  |
|--------------------------|  |  |
| Make, model, mfr serial, … |  |  |
Gen 2 RFID Memory Map

Bank 00 (Reserved)
- 00h: Kill Passwd
- 10h: Access Passwd

Bank 01 (EPC)
- 00h: CRC
- 10h: PC Bits
- 20h: EPC
- 210h: XPC Bits

Bank 10 (TID)
- 00h: TID
- 10h: XTID

Bank 11 (User)
- 00h: DFSID
- 08h: Encoded Data Elements

Legend:
- Green = Business Data
- Pink = Control Information
- Yellow = Tag Manufacture Information

Attribute bits
Filter value
EPC Tag Data Standard

- EPC “pure identity” URI
- Correspondence specified in TDS
- GS1 keys (specified in Gen Specs)
- GS1 Alas (specified in Gen Specs)

Independent of RFID

RFID-Specific

- Attribute Values
- Filter Values
- EPC “tag URI”
- EPC binary encoding

Key
- = Business Data
- = Control Info
- = Tag Manufacture Info

Reserved Bank contents (specified in Gen2 Spec)
EPC Bank contents
TID Bank contents
User Memory Bank contents

Gen 2 RFID Tag (specified in Gen2 Spec)
EPC Tag Data Standard

- EPC "pure identity" URI
- GS1 keys (specified in Gen Specs)
- GS1 AIs (specified in Gen Specs)
- Correspondence specified in TDS
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- Gen 2 RFID Tag (specified in Gen2 Spec)

- Independent of RFID
- RFID-Specific

Key:
- 
- = Business Data
- = Control Info
- = Tag Manufacture Info

Other Data
## EPC Identification Schemes

<table>
<thead>
<tr>
<th>EPC Scheme</th>
<th>Related GS1 Identification Key</th>
<th>Use</th>
<th>Tag Encodings</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGTIN</td>
<td>GTIN (with added serial #)</td>
<td>Trade items</td>
<td>SGTIN-96, SGTIN-198</td>
</tr>
<tr>
<td>SSCC</td>
<td>SSCC</td>
<td>Pallet or other unitized loads</td>
<td>SSCC-96</td>
</tr>
<tr>
<td>SGLN</td>
<td>GLN (with optional extension #)</td>
<td>Locations</td>
<td>SGLN-96, SGLN-195</td>
</tr>
<tr>
<td>GRAI</td>
<td>GRAI (serial number mandatory)</td>
<td>Returnable/reusable assets</td>
<td>GRAI-96, GRAI-170</td>
</tr>
<tr>
<td>GIAI</td>
<td>GIAI</td>
<td>Fixed assets</td>
<td>GIAI-96, GIAI-202</td>
</tr>
<tr>
<td>GDTI</td>
<td>GDTI (serial number mandatory)</td>
<td>Documents</td>
<td>GDTI-96, GDTI-113</td>
</tr>
<tr>
<td>GSRN</td>
<td>GSRN</td>
<td>Service relations (e.g., loyalty card)</td>
<td>GSRN-96</td>
</tr>
<tr>
<td>GID</td>
<td></td>
<td>Auto-ID Center legacy</td>
<td>GID-96</td>
</tr>
<tr>
<td>DoD</td>
<td></td>
<td>US Dept of Defense</td>
<td>DoD-96</td>
</tr>
</tbody>
</table>
Different EPC Forms

- **GS1 Element String** – as used in bar code
  
  (01) 1 0614141 00743 8  (21) 401
  
  --------- GTIN  --------- Serial

- **Pure Identity URI** – just the EPC – as used in EPCIS
  
  urn:epc:id:sgtin:0614141.100743.401

- **Tag URI** – in software when all tag info needs to be represented – as used in RFID middleware
  
  urn:epc:tag:sgtin-96:3.0614141.100743.401

- **Binary** – on-tag representation
  
  001100000111010000100101011110111100001100010010111110000000000000000000000001100100

  3074257bf46261c00000191 (Hexadecimal equivalent)
Bar Code to EPC URI

(01) 1 0614141 12345 2 (21) 401

urn:epc:id:sgtin:0614141.112345.401

Check digit not included in EPC
URI to RFID Tag

- In information systems, an EPC is a URI:
  \[ \text{urn:epc:id:sgtin:0614141.112345.401} \]
- Too big to encode directly into a 96-bit tag
- So, an equivalent binary form is used:
  \[ \text{urn:epc:id:sgtin:0614141.112345.401} \]

<table>
<thead>
<tr>
<th>Header</th>
<th>Filter Value</th>
<th>Partition</th>
<th>Company Prefix</th>
<th>Item Reference</th>
<th>Serial Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 bits</td>
<td>3 bits</td>
<td>3 bits</td>
<td>20-40 bits</td>
<td>24-4 bits</td>
<td>38 bits</td>
</tr>
</tbody>
</table>

x30 for SGTIN-96  Additional control info to help isolate tag populations
Same EPC, different binary forms

- An SGTIN serial number may be up to 20 alphanumeric characters (from GS1 standard)
- Too large for 96-bit tag
- So, two binary variants:
  - SGTIN-96 handles all-numeric serial number whose value is $< 2^{38}$
  - SGTIN-198 handles any serial number, 1–20 alphanumeric characters
- Latter becoming less rare, as tags with that capacity have now become available
Where Different Forms are Used

- Moral: Business apps should never use the binary format!
EPC Translation – Resources

• Free interactive translators

• Usually included in commercial “RFID Middleware” software
  – Always present in an ALE implementation

• Translator-only software libraries
  – FossTrak TDT (free)
  – [www.kentraub.com/tools.html](http://www.kentraub.com/tools.html) (see the FAQ)
EPC Tag Data Standard

- EPC “pure identity” URI
  - Correspondence specified in TDS
- GS1 keys (specified in Gen Specs)
- GS1 Alns (specified in Gen Specs)

Independent of RFID

RFID-Specific

- Attribute Values
- Filter Values
- EPC binary encoding

- Reserved Bank contents (specified in Gen2 Spec)
- EPC Bank contents
- TID Bank contents
- User Memory Bank contents

Key
- □ = Business Data
- □ = Control Info
- □ = Tag Manufacture Info

Gen 2 RFID Tag (specified in Gen2 Spec)
Supplementary Data – GS1 AIs

<table>
<thead>
<tr>
<th>AI</th>
<th>Description</th>
<th>Format</th>
<th>Label</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Batch or Lot Number</td>
<td>an..20</td>
<td>BATCH/LOT</td>
</tr>
<tr>
<td>11</td>
<td>Production Date (YYMMDD)</td>
<td>n6</td>
<td>PROD DATE</td>
</tr>
<tr>
<td>12</td>
<td>Due Date (YYMMDD)</td>
<td>n6</td>
<td>DUE DATE</td>
</tr>
<tr>
<td>13</td>
<td>Packaging Date (YYMMDD)</td>
<td>n6</td>
<td>PACK DATE</td>
</tr>
<tr>
<td>15</td>
<td>Best Before Date (YYMMDD)</td>
<td>n6</td>
<td>BEST BEFORE or SELL BY</td>
</tr>
<tr>
<td>17</td>
<td>Expiration Date (YYMMDD)</td>
<td>n6</td>
<td>USE BY OR EXPIRY</td>
</tr>
</tbody>
</table>

• Plus dozens more…
User Memory Outline

• Conceptually, the contents of user memory is a collection of many data elements (name/value pairs)

• Challenges:
  – Efficient data compression / limited memory
  – Random access
  – Selection based on tag contents
  – Adding/updating/deleting data elements
  – Selective locking
User Memory Encoding

- All encoding schemes share a common format for the first eight bits of user memory, called the “Data Storage Format Identifier (DSFID)”:

<table>
<thead>
<tr>
<th>Access Method</th>
<th>Data Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifies the encoding scheme used</td>
<td>Identifies which data system predominates (all encoding schemes allow escape to other data systems)</td>
</tr>
<tr>
<td>00 = no-directory</td>
<td>00000 = uninitialized tag</td>
</tr>
<tr>
<td>01 = directory</td>
<td>01001 = GS1 AIs</td>
</tr>
<tr>
<td>10 = packed objects</td>
<td></td>
</tr>
</tbody>
</table>
Example

Gen 2 RFID Tag

Bank 00 (Reserved)

Bank 01 (EPC)

Bank 10 (TID)

Bank 11 (User)

GTIN

Serial

Best-by Date

Batch

urn:epc:tag:sgtin-96:0.3123451.023456.1234

DSFID AI 15 = 991224; AI 10 = LV111
User Memory Encoding/Decoding

• Quite complex:
  – Efficient compaction for numeric, alpha data
  – Gen 2 “select” command support
  – Random vs sequential access, “directories”
  – Incremental add/update/delete
  – Selective locking
  – Multiple data systems

• Don’t try this at home! Use a commercial software package:
EPC Tag Data Standard
TID Memory Bank

• TID includes three things:
  – 12-bit numbers identifying the make and model of the tag (not the product to which the tag is attached)
  – (Optional) a serial number assigned at tag manufacture time, unique within the tag make/model
  – (Optional) flags that indicate which optional features the tag supports
  – Latter two are called the “Extended TID” (XTID)

• The TID serial number is *not* the same as the SGTIN
  – Not useful *as* the serialized identifier of the product:
    • Too RFID specific
    • Doesn’t identify product SKU
    • Different than existing product identification
  – Has applications for anti-counterfeiting
Other Data Systems – Identification

• Bit 17h of EPC memory is the “toggle”
  – If zero, remainder of EPC memory follows EPC standards (as previously discussed)
  – If one, remainder of EPC memory contains:
    • An “Application Family Identifier” (AFI) allocated by ISO for a specific purpose; e.g.:
      – C1 = IATA Baggage Identifier
      – C2 = Library loan item
      – Etc…
    • An application-specific identifier defined by some standard as indicated by the AFI
Other Data Systems – Supplementary Data

• Several different supplementary data systems exist:
  – GS1 Application Identifiers (AIs)
  – ANSI MH-10 Data Identifiers (DIs)
  – ATA Text Element Identifiers (TEIs)

• Each originated in a separate bar code world
• Rather similar in content
• In user memory,
  – The DSFID indicates which system predominates
  – All compaction schemes permit inclusion of elements from system other than what DSFID indicates
Summary

- Four types of Tag Data:
  - Identification
  - Supplementary data
  - RFID Control data (RFID-specific)
  - Tag Manufacture data (RFID-specific)
- Identification and Supplementary Data are defined by carrier-independent standards
  - Carrier-independent forms should be used in business applications,
  - …not the RFID-specific binary/hexadecimal forms
- Tag Data Standards give encoding/decoding rules for use in RFID
- Multiple standards exist, but tag data indicates which is used
About the Speaker

• Independent Consultant
• Specializing in EPC/RFID Standards adoption
  – Software architecture for enterprises and solution providers
  – Educational programs on standards tailored to clients’ needs
• Actively involved in EPCglobal standards development
  – Member, Architecture Review Committee
  – Editor, EPCIS specification
  – Co-chair, Filtering & Collection (ALE) Working Group
  – Editor, EPC Tag Data Standard
  – Contributor to five other software specifications
  – Member, Joint Strategy and Planning Committee

• Consulting Instructor for Academia RFID
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