

RFID: Addressing, Event Management and Network Services

Directory and Information Services

Overview

- The role of networked services
- Directories and Lookup
- Object Naming Service operation
- ONS and DNS
- Tracing further information
- EPC IS Collections and Queries
- EPC IS Profiles

Network RFID

- Tags have to minimize cost:
 - very limited storage, i.e. contain ID only
 - very limited computational power
- IDs by themselves are not useful
- Tradeoff: ID is the key to query the network for information
- Need:
 - directory,
 - lookup service
 - (federated) database to hold info
 - associated protocols
- Employ internet and web standards where possible
- Cost and interoperability

EPCglobal NRFID architecture

Discovery	Object Naming Service (ONS)	Discovery of authoritative object manufacturer information
	EPC Discovery Service	Track-and trace chain information discovery (pointers to)
Storage	EPC Information Service	Store and retrieve item and class level usage information
Authentication	EPC Trusted Services	Authentication, authorization and access control

Directory

- Map IDs to service locations
 - e.g. map product ID to web service that can be queried for its expiration date
 - does NOT include serial number
- It also maps EPC Manager IDs to EAN.UCC Company prefix
- Requirements: global directory on the internet
- Obvious candidate: Domain Name System

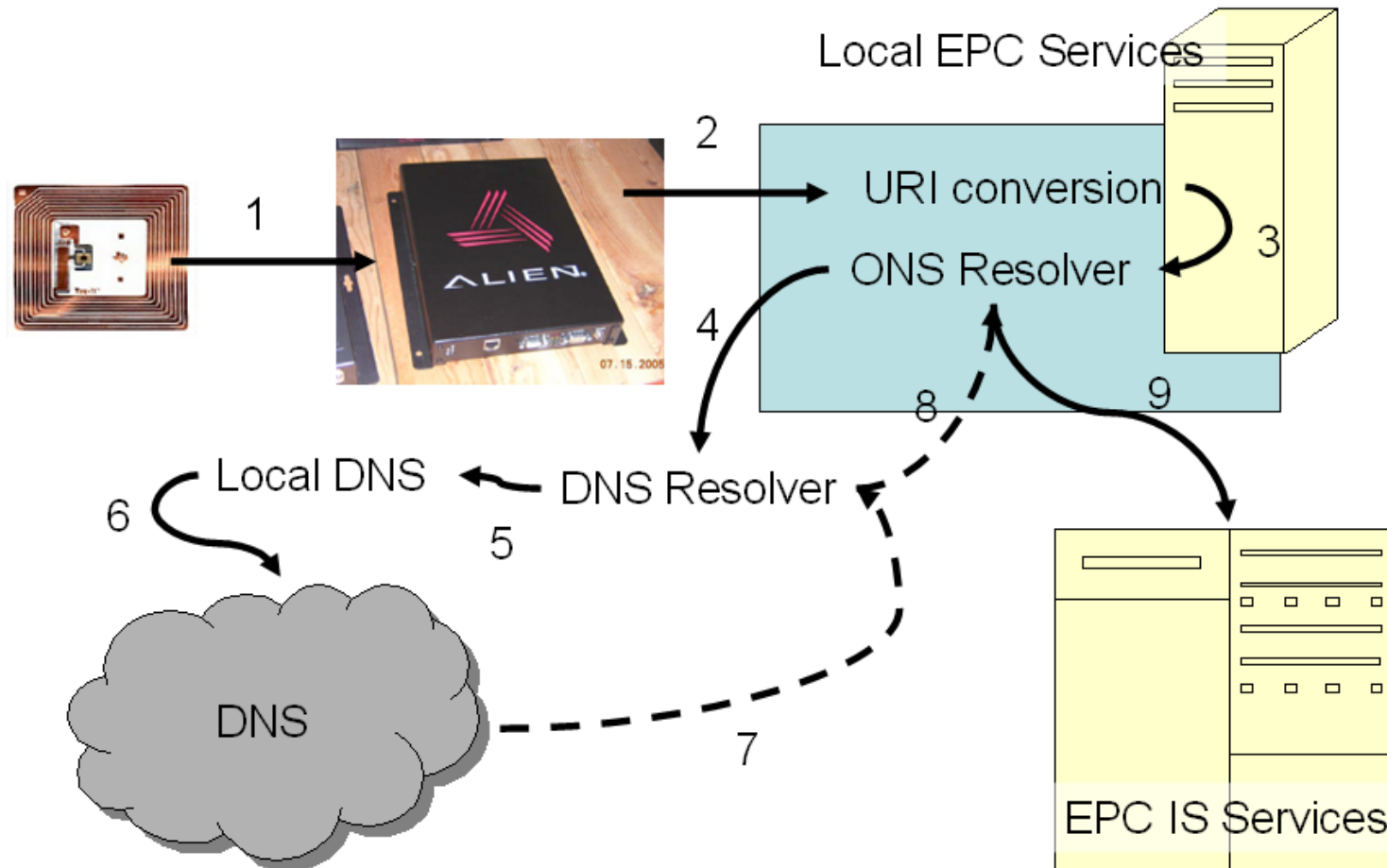
DNS and X.500

- DNS maps IP numbers to names and vice versa
- In fact, it maintains general Resource Records
- Extensible using NAPTR records
- Well established API and tools
- Efficient lookups, global reach
- Decentralized: location, administration (hierarchical)
- X.500 (ITU) free search but less efficient
- White pages, yellow pages
- Update protocol, security

ONS lookups

- Using the usual DNS tools
- Two types of DNS resource records
 - NAPTR for EPC codes
 - TXT for company code tables
- Translating the ID into a DNS query
- Follows path to (local to authoritative) onsepc.com through DNS
- Follows path within onsepc.com from root to ID custodian local server

Query sequence



Translation

EPC 64-bit Format:

[10 000 00000000000000 000000000000000011000 0000000000000000110010000]

Step 1: Reader captures and sends to EPC event manager

10 000 00000000000000 000000000000000011000 0000000000000000110010000

Step 2: EPC EM creates URI following Tag Data Standard:

urn:epc:id:sgtin:0614141.000024.400

Step 3: To local ONS resolver:

urn:epc:id:sgtin:0614141.000024.400

Step 4: ONS resolver converts the URI to the equivalent DNS NAPTR query

000024.0614141.sgtin.id.onsepc.com

Step 5: DNS returns result set (redirect to manager domain)

ONS Resolver

- Remove URI pre-fix

urn:epc:id:sgtin:0614141.000024.400 → 0614141.000024.400

- Remove Serial Number

0614141.000024.400 → 0614141.000024

- Invert

0614141.000024 → 000024.0614141

- Append ONS root

000024.0614141 → 000024.0614141. sgtin.id.onsepc.com

- Issue DNS query e.g.

nslookup 000024.0614141. sgtin.id.onsepc.com (set type=NAPTR)

ictx.getAttributes(epcDomainName, new String[]{"NAPTR"});
(javax.naming)

NAPTR

- Naming Authority Pointer (NAPTR) is a type of DNS Resource Record (RFC 2915)
- Designed for Dynamic Delegation Discovery System (DDDS) applications (RFC 3401, 3401, 3403, 3404)
 - Lazy binding of strings to data
 - Supports dynamically configured delegation
- Uses regular expressions to specify a delegation point within some other namespace
- e.g. used to locate SIP users

\$ORIGIN 3.8.0.0.6.9.2.3.6.1.4.4.e164.arpa.

NAPTR 10 100 "u" "E2U+sip" "!^.*\$!sip:info@example.com!" .

ONS Result Set

- NAPTR fields:
 - **Order** And **Pref** show priority of this result within the set
 - **Flags** when set to “u” means regular expression containing URI
 - **Service** designates different types of services. The format of this field is EPC+service_name where service_name can be pml, html, xmlrpc, and ws
 - **Regexp** specifies a URI for the service being described (for ONS currently it is hostname and additional path information)
 - **Replacement** specifies the replacement portion of the rewrite expression (not used in ONS)

ONS Result Set Example

Orders	Pref	Flags	Service	Regexp	Replacement
0	0	u	EPC+pml	^.*\$!http://www.epc.dcs.bbk.ac.uk/cgi-bin/epcpml.php!	.
0	0	u	EPC+html	^.*\$!http://www.epc.dcs.bbk.ac.uk/epcpml.jsp!	.
0	0	u	EPC+xmlrpc	^.*\$!http://www.epc.dcs.bbk.ac.uk/exist/epc!	.
0	0	u	EPC+epcis	^.*\$!http://www.epc.dcs.bbk.ac.uk/epc!	.
0	0	u	EPC+ws	^.*\$!http://www.epc.dcs.bbk.ac.uk/ws/epc.wsdl!	.

Service codes:

EPC+pml: Product Markup Language document

EPC+html: Web page description

EPC+xmlrpc: XML Remote Procedure Call interface

EPC+ws: Web Service interface (WSDL)

EPC+epcis: Authoritative EPC IS server

Example

Solaris 10
nslookup

Set DNS record
type to NAPTR

ONS reply

```
hermes.dcs.bbk.ac.uk - PuTTY
hermes{113}% /usr/sbin/nslookup
*** Can't find server name for address 193.61.29.197: Non-existent host/domain
Default Server:  loki.dcs.bbk.ac.uk
Address:  193.61.29.134

> set type=NAPTR
> 075861.0434687.sgtin.id.onstest.com
Server:  loki.dcs.bbk.ac.uk
Address:  193.61.29.134

Non-authoritative answer:
075861.0434687.sgtin.id.onstest.com      order = 1, preference = 1
    flags = "u"
    services = "EPC+EPCIS"
    rule = "!^.*$!http://reference.verisignepctest.com!"
    replacement = (root)

> █
```

Simple EPC Query with XML RPC

```
<methodCall>
  <methodName>lookupEPCDS.getCurrentCustodian</methodName>
  <params>
    <param>
      <value>
        <string>urn:epc:id:sgtin:800900.456.9876</string>
      </value>
    </param>
  </params>
</methodCall>
```

- EPC DS interfaces in flux
- Open source implementation of a possible solution with XML RPC
- Based on the eXist native XML engine and query XQuery processor available via **exist**.sourceforge.net

Delegation

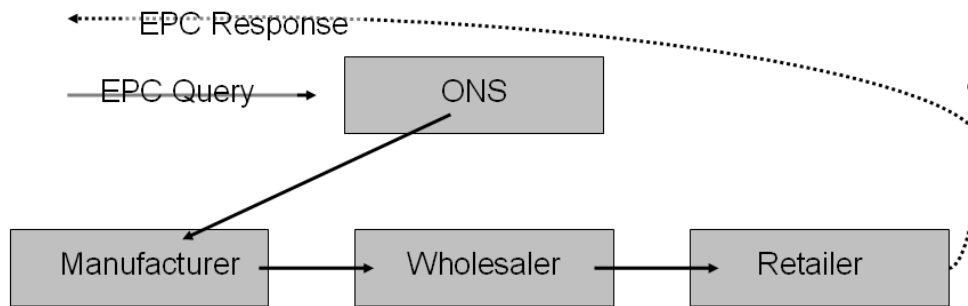
- Domain sgtin.id.onsepc.com controlled by EPCglobal
- Delegation at the EPC Manager layer
 - e.g. domain 0614141. sgtin.id.onsepc.com is delegated to EPC Manager 0614141
- List of EPC managers' EAN.UCC codes (used in bar codes) maintained on ONS
- `wget http://www.onsepc.com/ManagerTranslation.xml`

```
<GEPC64Table date="2006-06-20T08:51:55-05:00">
  <entry index="1" companyPrefix="0037000"/>
  <entry index="2" companyPrefix="0047400"/>
  <entry index="3" companyPrefix="0080878"/>
  <entry index="4" companyPrefix="038004"/>
  <entry index="5" companyPrefix="0036000"/>
  <entry index="6" companyPrefix="0681131"/>
  ....
</GEPC64Table>
```

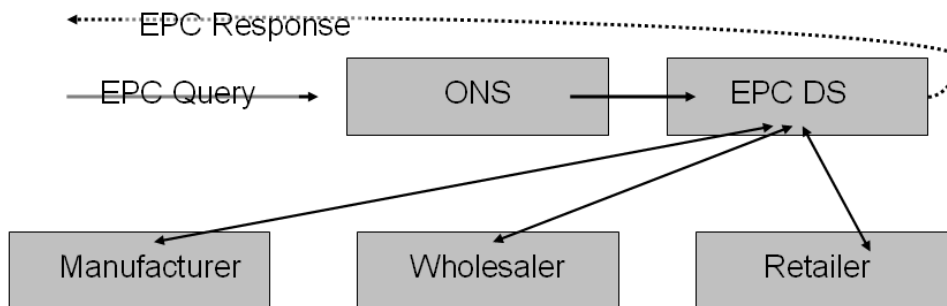

EPC Discovery Service

- ONS is authoritative at production
 - i.e. ONS points to the originator/manufacture of the object but not subsequent custodians of the EPC (serial) code
 - even more complex if objects are transferred from consumer to consumer
- EPC observation responsibility moves from one custodian to next
 - e.g. from manufacturer, to wholesaler, to retailer
- ONS queries cannot follow through (cf. next slide)
- EPC DS allows track-and-trace applications

ONS and EPC DS



Track-and-trace with ONS



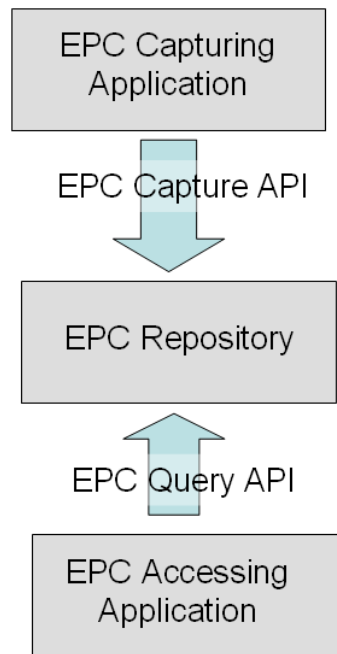
Track-and-trace with EPC DS

- One approach for tractability is to daisy-chain at the ONS from custodian to custodian
- One broken link destroys the sequence
- Solution: keep pointers to each link in the sequence at the EPC DS

EPC DS records

- change of custodian (arrival / departure)
- change of EPC to track
 - upon aggregation into a container
 - upon re-tagging / re-packaging
- whether the particular EPC is marked for recall
- track forwards to the current custodian
 - to get current information about location/status
 - to determine who to contact about a product recall
- trace backwards to find all custodians which
 - have handled the object and may hold some data on it

EPC Information Service



- EPC IS: Standard Interface for capture and publication of EPC data (still draft)
- In essence, a distributed database
- Some degree of “semantic” level information
- Provides a common model for location data

EPC IS records

- Instance level data:
 - Time-stamped observations
- Class level data
 - Classification schemes
- Queries:
 - Which readers saw tag A?
 - Which tags did reader R see?
 - What happened from time t1 to time t2?

Full SOAP example

```
<?xml version="1.0" encoding="UTF-8"?>
<soapenv:Envelope xmlns:soapenv="http://schemas.xmlsoap.org/soap/envelope/"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
  <soapenv:Header>
    <AuthInfo>
      <UserToken>
        <UserName>epcisuser</UserName>
        <Password>password</Password>
      </UserToken>
    </AuthInfo>
  </soapenv:Header>
  <soapenv:Body>
    <getCapabilityNSList xmlns="urn:epc:specification:interchange:EPCIS:BaseProfile:xml:wSDL:1"/>
  </soapenv:Body>
</soapenv:Envelope>
```

- EPC IS Authentication profile
- Full SOAP envelope shown
- Any WS framework can be used as client
- HTTP GET is also supported for backward compatibility

Observation Profile: Log data

- Clients log observations in batch to the EPC-IS
- Same or different locations allowed
- Same or different observations allowed

```
<logEvents>
  <logEvent>
    <location> urn:epc:id:gln:900100.7296</location>
    <observation>
      <DateTime>2005-12-17T09:30:47-05:00</DateTime>
      <Tag>
        <ID> urn:epc:id:sgtin:900100.456.989</ID>
      </Tag>
    </observation>
  </logEvent>
  <logEvent>
    <location>MarinaDelRay</location>
    <observation>
      <DateTime>2005-12-17T09:30:47-05:00</DateTime>
      <Tag>
        <ID> urn:epc:id:sgtin:900100.456.990</ID>
      </Tag>
    </observation>
  </logEvent>
</logEvents>
```

Operation returns status:

e.g.

<status>true</status>

Observation Profile: Query

- Query EPC-IS for observations recorded at a specific location

```
<getEventsByLocation>  
  <location>urn:epc:id:gln:900100.7296</location>  
</getEventsByLocation>
```

Operation returns the full list of observation i.e. exactly the XML on the previous slide

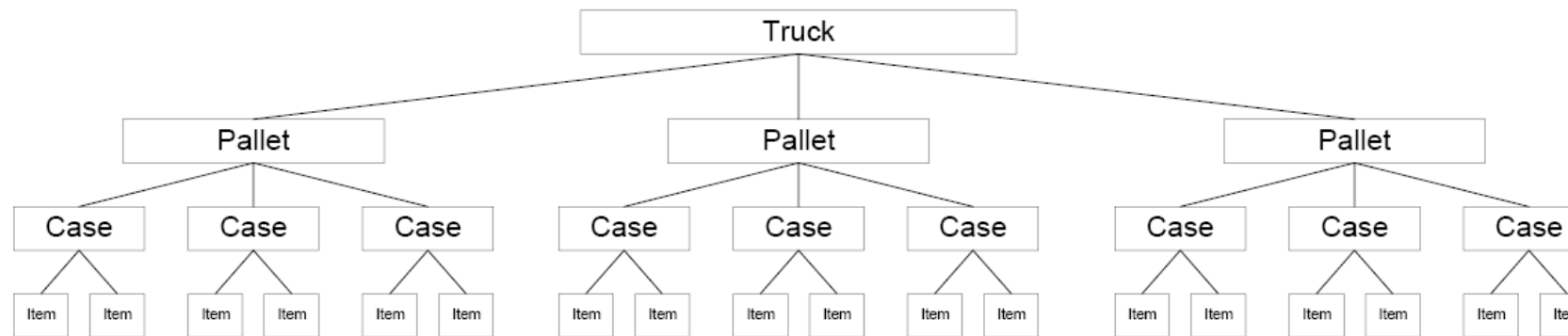
```
<logEvents>  
  <logEvent>  
    <location> urn:epc:id:gln:900100.7296</location>  
    <observation>  
      <DateTime>2005-12-17T09:30:47-05:00</DateTime>  
      <Tag>  
        <ID> urn:epc:id:sgtin:900100.456.989</ID>  
      </Tag>  
    </observation>  
  </logEvent>  
</logEvents>
```


Observation Profile: Other Queries

- logEvent(logEvents)
 - Logs multiple observations
- getEventsByLocation(location)
 - Retrieves all observations logged at the specified location
- getEventsByLocationByTimeRange(location, fromTime, toTime)
 - Retrieves all observations logged at the specified location between two times
- getEventsByTimeRange(fromTime, toTime)
 - Retrieves all observations logged between two times
- getEventsByEPC(epc)
 - Retrieves all observations of the specified EPC
- getEventsByEPCByTimeRange(epc, fromTime, toTime)
 - Retrieves all observations of the specified EPC between two times
- deleteEventsByLocationByTimeRange(location,fromTime, toTime)
 - Deletes all observations made at a location between two times
- deleteEventsByEPCByTimeRange(epc,fromTime,toTime)
 - Deletes all observations of an EPC made between two times

Containment Profile

- Aggregation into larger units



- The aggregation hierarchy is defined implicitly by specifying the items included in a container
- Both container and contents are specified using their respective EPC codes

Containment Profile: Example

- Containment relationships are time sensitive i.e. they start at a specific time and have a specific end
- Relationships do not exist outside their defined time frames
- Thus, each method in the profile requires a time parameter

```
<setContents>
  <epc>urn:epc:id:sgtin:900100.456.870</epc>
  <time>2001-12-17T09:30:47</time>
  <epcList>
    <epc>urn:epc:id:sgtin:900100.456.871</epc>
    <epc>urn:epc:id:sgtin:900100.456.872</epc>
    <epc>urn:epc:id:sgtin:900100.456.873</epc>
  </epcList>
</setContents>
```

returns

```
<result>
  <status>true</status>
</result>
```

Containment Profile: Example

- How to find the container of a particular object

```
<getContainer>
  <epc>urn:epc:id:sgtin:800100.432.987</epc>
  <time>2005-12-17T15:32:39</time>
</getContainer>
```

- If there is such a container, then

```
<epcList>
  <epc>urn:epc:id:sgtin:000200.100.900</epc>
</epcList>
```

- If there is not, then an error message

```
<result>
  <status>false</status>
</result>
```

EPC IS Static Attribute Profile

- Ask for specific attributes of an object

A schema must be defined

```
<getAttributeData>
  <epc>urn:epc:sgtin:800900.321.123</epc>
  <schema>prodDetails</schema>
  <xpath>/NVP/Name[@id='color']/text()</xpath>
</getAttributeData>
```

XPath query

- Returns the requested data

```
<attribute>Black</attribute>
```

- And then change it

```
<setAttributeData>
  <epc>urn:epc:sgtin:800900.321.123</epc>
  <schema>prodDetails</schema>
  <xpath>/NVP/Name[@id='color']/text()</xpath>
  <value>Red</value>
</setAttributeData>
```

Summary

- From RFID to NRFID
- Directories and Lookup
- Object Naming Service operation
- ONS and DNS
- Tracing further information
- EPC Information Services
- EPC IS Profiles