

A Design of Distributed PML Service Architecture for Ubiquitous Logistics

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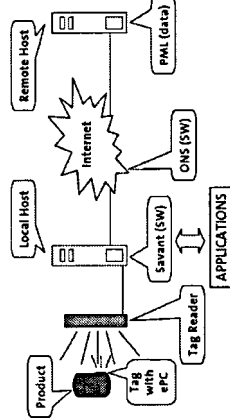
1. Research Background
 - EPC Network Architecture
 - PML
 - Research Problem
2. PML Data Analysis
3. Architecture of Distributed PML Servers
 - Data Middleware
 - Stand Alone PML Server
 - Integrated PML Server

1. Background

- **RFID technology**
 - Key of the ubiquitous computing
 - Means of automatically identifying objects
 - Auto-ID Project
 - uCode Project
 - KOREA: IT838 USN,
- **Vision**
 - Everything and everybody connected to the network
- **Application in SCM: Automate the supply chain**
 - Computers will be able to "see" physical objects, allowing manufacturers to track and trace items automatically throughout the supply chain

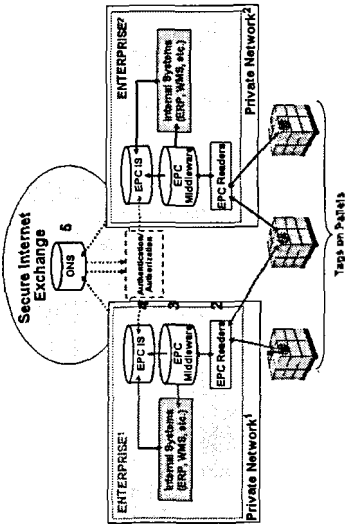
Electronic Product Code (EPC)

- RFID tag stores just the minimal amount of information
- EPC: a unique identification number for the tagged object in the Auto-ID infrastructure
 - Currently represented as just 64 or 96 binary digits
- EPC serves as a lookup key for retrieving additional data about the object



The Auto-ID EPC Network

Standards and services used to support goods flow and inventory management through the supply chain



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Auto-ID EPC Network Components

5	ONS	Connectivity Service Provides a global lookup service to translate an EPC into data or error information. Uniform Reference Location (URL) where further information on the object may be found.
4	EPC Information Services	<p>Data Structure</p> <ul style="list-style-type: none"> Collects and organizes EPC IS data elements and attributes including Static Data Store, Describe common data about physical instances of physical things. Instance Data Store, Describe common data about unique instances of physical things. History Data Store, Describes common data about the top the unique instance data over the supply chain (EPC IS servers) <p>Authentication / Authorization</p> <ul style="list-style-type: none"> Establishes security of users within the EPCglobal network. Above data owner to control access to data. <p>Interface</p> <ul style="list-style-type: none"> Defines protocol for getting data from EPC Middleware to EPC IS
3	EPC Middleware	Designed to process the streams of tag or sensor data (event data) coming from one or more reader devices. Performs filtering, aggregation, and counting of tag data, reducing the volume of data prior to sending to enterprise applications.
2	Reader	Devices responsible for detecting when RFID tags enter their read range. Can be portable or fixed devices. Connects to EPC Middleware or EPCglobal Network.
1	Tag	Chip + Antenna. The capture of physical data within the system. Attached to an item, case, pallet or truck.

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PML

→ PML Service is a networked database interface, through which the additional data about the tagged object can be accessed

- What is PML?
 - PML is the "Physical Markup Language" - a common "language" for describing physical objects, physical processes, and environments
 - PML is based on the widely accepted XML used to share data over the Internet in a format all computers can use.
 - PML will not be an exhaustive specification, but only describe the most basic characteristics shared by physical systems

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Distribution of PML Data

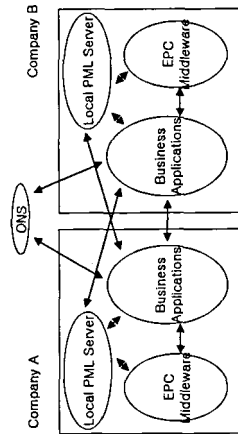
- Distribution inside a company
 - The data in a local PML server may be distributed over multiple sites in the company
- Distribution across a company
 - The business applications may require PML data distributed over multiple PML servers

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Research Problem of PML Service

- Business applications directly communicate with other local PML servers.
- So, the applications have a burden of querying each server and integrating the results



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2. PML Data Analysis

- **Timestamped historical data**
 - Tag readings
 - Symbolic location/container
 - EPC → Transaction ID
- **Static attribute data**
 - **Attributes defined at serial level**
 - Instance-level data: date manufactured, expiration date, ...
 - **Attributes defined at product level**
 - product-level data: size, weight, price, ...

New types of data
(Frequent Data Update)

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Timestamped Historical Data

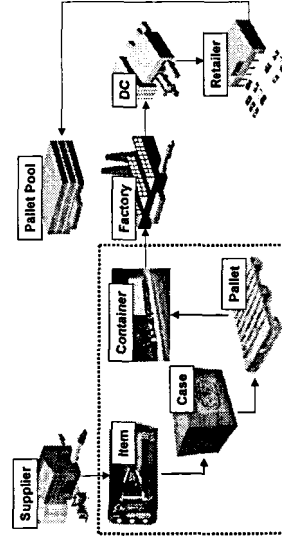
- **Observations**
 - Which object was seen, by which reader, when
- **Transactions**
 - Which objects were associated with a particular transaction
- **Measurements**
 - Historical data from sensors
 - Correlate with observations to deduce temperature etc.
- **Containment/ Symbolic Location**
 - Identifies the enclosing object or the location identity
 - Not represented as spatial co-ordinates e.g. (x,y,z)

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PML data Elements

- **<data>, <node>, <entity>, <measure>, <date>, <location>, <trace>**



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PML Usage Patterns in Supply Chain

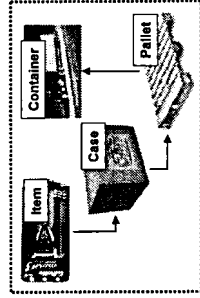
- Shipping Information
- Packaging History
- Product Movement
- Shipment Tracking
- In-Store Movement
- Temperature Tracking

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PML Data Example: <Node>

```
<node label="Container" ePC="01.0016CA2.000104.0000008910">
  <node label="Pallet" ePC="01.000142F.001C0E8.0010296730">
    <node label="Case" ePC="01.000142F.001C0F3.0000319280">
      <node label="Truck3" ePC="01.000A571.003459.000E3FC61E">
        </node>
      </node>
    </node>
  </node>
```



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PML Usage Example: In Store Movement

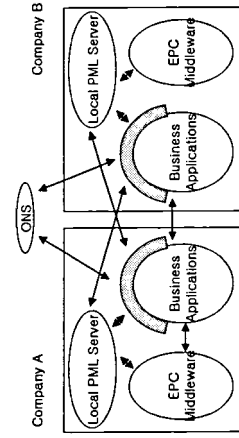
```
<trace>
  <step>
    <owner> <role>"Shipper"</role>
    <entity>"Schneider"</entity>
    <data type="Aq" accuracy="5">5536928000</data>
    <location>
      <measure label="latitude" m1 accuracy="7"> 4058809.5 </measure>
      <measure label="longitude" m1 accuracy="7"> 625111.5</measure>
      <measure label="altitude" m1 accuracy="7"> 9075090.6</measure>
    </location> </step>
    <owner> <role>"Shipper"</role>
    <entity>"Schneider"</entity>
    <data type="Aq" accuracy="5">55389728000</data>
    <location>
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      <measure label="longitude" m1 accuracy="5"> 65896.5</measure>
      <measure label="altitude" m1 accuracy="5"> 9075549.7</measure>
    </location> </step>
    <owner> <role>"Shipper"</role>
    <entity>"Schneider entity"</owner>
    <data type="Aq" accuracy="5"> 55404139000</data>
    <location>
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      <measure label="longitude" m1 accuracy="5"> 917219.2</measure>
      <measure label="altitude" m1 accuracy="5"> 9075695.3</measure>
    </location> </step>
  </trace>
```

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3. Design of PML Service Architecture

- Implement a functionality that is responsible of querying the distribute PML servers hiding the distribution of data
- ➔ distributed database middleware



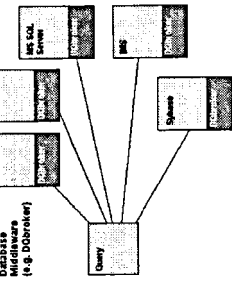
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Distributed DB Middleware

- Middleware is a software interface that functions as an intermediary between clients and servers
- Distributed database middleware provides a common interface between a query and multiple, distributed databases

- It enables data to be consolidated from a variety of disparate data sources

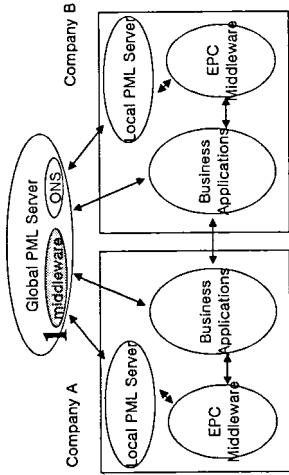


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Design PML Server Using DB Middleware

- Business applications communicate with a global PML server
- The global PML server integrates all the local PML servers using a database middleware



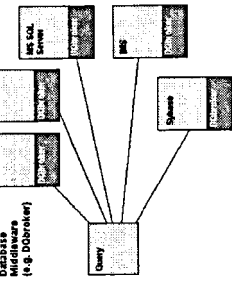
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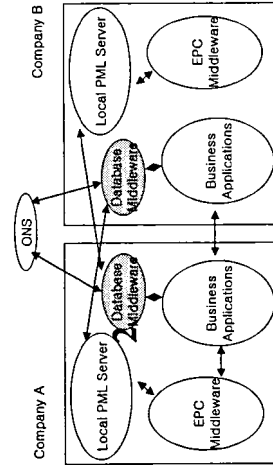


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Secured PML Server

- Each company has an integrated PML



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Security Considered PML Servers

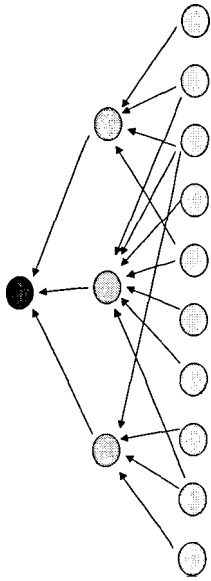
- A company has a different access policy for the different counterpart
 - Controlled by authentication
- It may not be possible to have a global schema in the global server or in the intermediate PML servers
- Given a query from a company, each local PML server checks whether the company has a right to access the data needed to process the query
 - Companies would not reveal their schemas as well as data if it is not inevitable

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Applying PML Servers

- The system has a hierarchy of PML servers
- Leaf PML servers are local PML servers
- Internal PML servers integrate the lower-level PML servers
- Each internal PML server provides an integrated DB
 - E.g., Beverage database, Food database

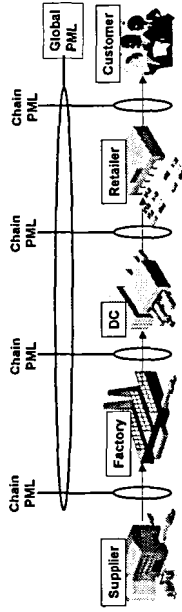


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Models of PML Service Provider

- Internal PML Service Architecture
- Intermediary Using DB Middleware
- PML Service Provider as an ASP
 - Chain Provider
 - Industry Provider



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4. Conclusions

- PML services allow users to track and trace items automatically throughout the supply chain
- Proposed distributed PML servers has a hierarchy of PML servers
- The stand alone PML servers should maintain tables for time-stamped data and static attribute data
- The integrated PML servers provide an integrated view of data for its lower PML servers using DB middleware
 - Business applications can utilize full benefits from the database middleware
 - Not request for each company to reveal unnecessary schemas
 - Traffic is distributed on the server in each company
 - It is an easily understandable framework by those who know the Auto-ID project

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