A Future EPC-RFID Supply Chain: A Proposed Grid-Based Solution

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Abstract

The development of high-resolution supply chains based on RFID tags is proving to be a major challenge because the industry has never dealt with such a massive amount of data in this area before. In this paper we review the overall problem, the enabling EPC technology and propose utilisation of Grid services as a practical solution to this problem.

1 Introduction

The advances in supply-chain related technologies such as EDI (Electronic Data Interchange), ERP (Enterprise Resource Planning), WMS (Warehouse Management Systems), CRM (Customer Relationship Management) to name just a few, have produced many benefits to the early adopters in the retail industry who are now better able to select store sites, source products, manage inventory and share up-to-date information between vendors, industries, warehouses and store managers. Despite all the innovations the effectiveness of these solutions are limited by factors such as manual bar code scanning which is inefficient and error prone, pallet-level tracking (instead of cases or individual items contained in the pallet) and product identification based on the SKU (Stock Keeping Unit) which means that it is currently impossible to track single products through the supply chain. These problems lead to a poor resolution in the supply chain and losses due to discrepancies in goods between shipment and receipt which in turn inevitably generate either stock-outs or inventory excess [2].

The adoption of EPC/RFID(Electronic Product Code/Radio Frequency IDentification) technologies will potentially enable automatic identification and tracing of goods at item level producing a high-resolution view of product movement in a large supply chain which could then produce real gains such as reduced chargebacks, counterfeiting elimination, avoidance of stock-out, precise recall of defective products and so on. Besides all the iminent benefits of EPC-based solution for the retail industry, the implementation of high-resolution supply chains will have to overcome challenges of dealing with an enormous amount of data. For instance, the EPC Gen2 standard specifies data rates of 1,800 EPC tags a second [1], which means that the local database will have to handle SQL requests at this rate. In this paper we present a review of EPC technology followed by a discussion of the data flooding consequence in supply-chain solutions and propose a Grid service for handling high-resolution supply chain queries.

2 EPC-RFID: Linking Physical and Logical Worlds

EPC technology was developed at the MIT Auto-ID Center [7] with a vision of environments in which all the electronic devices are networked and every physical object can be sensed by the network. EPC is intrinsically a worldwide unique number embedded on RFID tags which can be used to identify and track objects such as an EPC-tagged bottle of beer as it moves across a supply chain. The network environment is a collection of connected EPC-RFID readers which are located in specific areas of the supply chain, such as the production plant, the distribution warehouse and a supermarket store. The basic EPC code format is a 96-bit number divided into four partitions: version (8 bits), manufacturer (28 bits), product (24 bits), and serial number (36 bits). The difference between the UPC/EAN (universal product code/international article number) system used in bar coding is that UPC/EAN identifies types of object whilst the EPC uniquely identifies each individual object. With this scheme is possible to identify 268 million manufacturers (using 28 bits) and 16 million product code assignments (using 24 bits). The final data partition represents the product serial number, allowing each tagged item to be uniquely identified. A 36-bit serial number allows over 68 billion uniquely identified objects for each of the 16 million products.

The EPC reference architecture is based on the relevant internet standards. Once the EPC code is read it can be resolved into a name via a hierachical name resolver known as ONS (Object Name Service) in similar fashion to DNS (Domain Name Service). The information about the objects is specified using PML (Physical Markup Language) which is based on the meta-data language XML and on XQL (eXtensible Query Language) format. The syntax and semantics of PML is administered by the EPCglobal organisation [1] in conjunction with the user community.

The ECP-IS (EPC Information Service) location of the manufacturer can be found by querying the ONS. The application can then request information on the product it seeks by connecting to the appropriate product information server as illustrated in Figure 1, which also shows the ALE (Application Level Events) layer which is responsible for producing filtered information on products. As products make their way across multiple points throughout the supply chain, this process of products being scanned and the knowledge of their data within EPC Information Services repeats itself. The registration of this product knowledge by each EPC Information Service into the EPC Discovery Service enables full supply chain visibility. By viewing the presence of knowledge for the product, any member of the supply chain can get an immediate view of where a product has been. The result is complete visibility of the supply chain in real-time [8].

3 High Resolution Supply Chain: Data Flooding

Future supply chain solutions based on EPC/RFID will be able to track and maintain information at item level. A single EPC tag reading will include the EPC number, the location of the reader and a timestamp. Using this information to create a logging database provides a mechanism to track and trace goods everywhere in the supply chain. In this way, regardless of what product it is or its location, a data record of all movements will be available. This feature is the foundation for a high-resolution supply chain because it is possible to produce an audit trail associated with every item in the system (in contrast to existing supply chain implementations where tracking is done only at SKU/pallet level), which means that the life-time events of a product will be available for determining its origins, age, components and so on.

High-resolution supply chain implementations can produce many benefits such as a reducion in charge backs due to discrepancies in goods between shipment and receipt, avoidance of stock-outs or over-

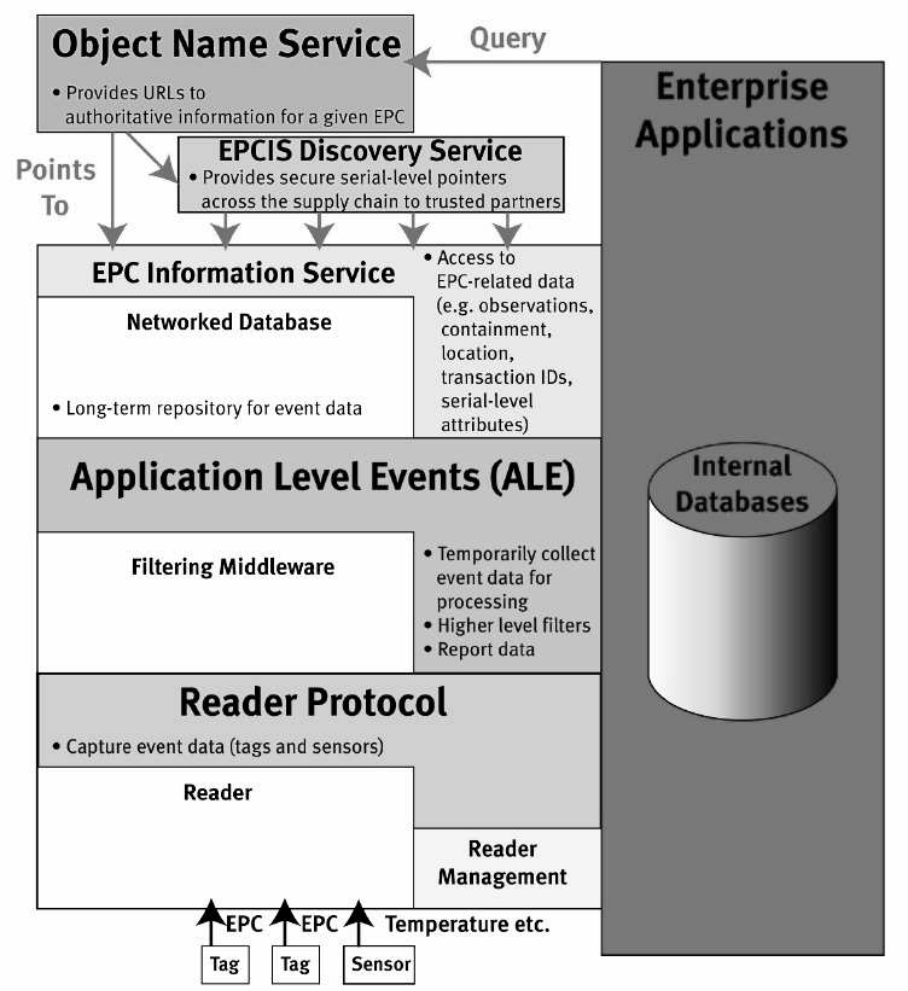

FIGURE 1: The EPC Supply Chain Reference Architecture [5]

stock by better inventory control, improvements in reverse logistics by precise recall of defective products, counterfeit elimination and in addition improved detection of product loss or theft. The combination of these benefits has the potential to generate significant costs savings and improve the overall supply-chain efficiency, but in addition it will create entirely new opportunities for business and lifestyle improvements. Although the benefits are clear (for instance it will be possible to discover that a particular jar of tomato sauce did not use any transgenic product just by reading its EPC tag), if we consider that every tag transaction will be logged in a database and that every individual item will have its entire life history recorded there are significant difficulties and challenges when managing such a massive amount of data.

4 Grid Enabled Global Supply Chain

In order to support the enormous number of items traversing multiple supply chains at any given moment the industry will need a large-scale infrastructure different from any other previously deployed in the supply chain. While the DNS represents one of the largest directories currently in use, which at present handles over 10 billion queries every day, there will be a need for an even larger infrastructure to deal with the activity on the EPC Network. Estimates predict that the EPC system will need to support hundreds of billions of lookups per day. To be worthy of global commerce, the infrastructure

will need to handle this load while delivering carrier-grade reliability (99.999%) [8].

Foster et al. [4] described a view of the Grid as an extensible set of Grid services which later evolved into OGSA (Open Grid Services Architecture). We propose the utilisation of the Semantic Grid [3] technologies for researching into ECP-RFID supply chain solutions based on the reference architecture depicted in Figure 1. A future inplementation could provide ways to simply issue queries such as:

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SELECT * FROM 'Grid-Products' WHERE (ePC.id BETWEEN ePC1 AND ePC2)
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(for example, to recall defective products already on the supply chain).

5 Conclusions

While writing this position paper EPCglobal [1] have decided to stop work on PML and transfer development effort into an alternative scheme based on RDF (Semantic Web Resource Description Framework) [6]. Moreover, ALE (as seen in Figure 1) is under development using WSDL (Web Services Description Language) and XML Schema which is consistent with our view that a future supply chain infrastructure will require Grid technology to provide a global solution.

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