Implementation and Application of RFID EPC Information Service for Forward and Reverse Logistics

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ABSTRACT

The fast changing pace of business and its intensely competitive environment force enterprises to seek out innovative methods to reduce inventory and to improve operating efficiency by ways of both continuous internal improvement of efficiency as well as externally through speedy, automated connections, by which companies can quickly access information to satisfy the rigorous demands of their customers. Of late, Radio Frequency Identification (RFID) has become a popular topic among industry insiders, although the technology – involving tags that emit radio signals and reader devices that can pick up the corresponding signals – has existed for decades. In particular, the EPCglobal Network™ is a type of information architecture that can be applied to RFID supply chain applications, and the EPC Information Service (EPCIS) can fulfill the information requests from the corresponding authorized clients. However, experience shows that in several situations calling for RFID utilization, the process has not always run smoothly. Moreover, the cost of RFID implementation is much higher than in traditional automatic identification technology. Therefore, we concentrate on research issues as following. First, this study focuses on exploring the functions of EPCIS and operations model of EPCIS. In so doing, we would like to develop the functions of EPCIS in an organization so that it could communicate with internal systems by using XML (eXensible Markup Language). Secondly, we have constructed prototype system to prove the feasibility of the message exchange procedure concept. Lastly, we illustrate possible scenarios for RFID utilization and show how EPCIS can enhance forward and reverse logistics.

Keywords: Radio Frequency Identification (RFID), EPC Information Service (EPCIS), logistics

INTRODUCTION

Today’s business environment has witnessed an onslaught of rapid change and intense competition, causing forward-looking enterprises to seek out innovative methods to reduce inventory and to improve operating efficiency, by ways of continuous internal efficiency improvement and externally through speedy automated connection, so that the companies can quickly access information to satisfy the rigorous demand of their customers. In this light, logistics has become a quintessential issue in any discussion of supply chains.

The barcode labels that have triggered a revolution in identification systems some considerable time ago are becoming inadequate in an increasing number of cases. In contrast, Radio Frequency Identification (RFID) can contain more information than barcodes and can be detected rapidly without manpower or line-of-sight. In other words, the advantages of RFID can remedy barcode’s shortages.

While RFID – a technology utilizing tags that emit radio signals and reader devices to pick up the corresponding signals – has existed for decades, its popularity as a discussion topic among industry insiders has emerged relatively recently. In terms of architecture utilizing the RFID platform, the EPCglobal Network™ and its EPC Information Services (EPCIS) component holds significant promise. The EPCIS system works much like a Web Server in a network supplies information for authorized parties’ requests. Moreover, enterprises can use an Object Name Service (ONS) to search for the EPCIS to reconcile the items they have in inventory against what is demanded by customers.

That is, the EPCglobal Network™ is the architecture that applies RFID technology in a supply chain, while the EPCIS fulfills information requests from authorized clients. However, most research on RFID and EPCIS discuss system component parts of RFID technology, RFID operation methodology and EPC standards; they fail to address how the respective technologies can be used in tandem to create efficient supply chains.

Specially, the situations of utilizing RFID are not always smooth going. The cost of RFID implementation is much
higher than traditional automatic identification technology. The research institution, ABI Research, reported that only 30% of Wal-Mart’s suppliers possess the capability to execute the RFID project by year 2005 [8]. And the standards of RFID are not yet established entirely. These factors will obstruct the industries adopt RFID. And the information about the execution of RFID in industry is important in such initial stage of RFID. Therefore, we concentrate on research issues as following:

1. This study focuses on the functions of EPCIS and operations model of EPCIS. We discuss the function of EPCIS in an organization to understand how to communicate with internal systems by XML (eXtensible Markup Language). We construct a prototype system to prove the concept of message exchange procedure.

2. RFID is still a new application, and related application cases are rare. There are no established applications in distribution, repair and return process. In this study, we illustrate possible scenarios of utilizing RFID and show what EPCIS information flow can support the forward and reverse logistics.

**RFID AND EPCGLOBAL NETWORK**

**RFID**

RFID tags basically consist of a transponder that is electronically programmed with unique data. Data is read/written on the tag through an antenna or a coil by a transceiver (with a decoder), which is connected to a host computer. RFID functional components are described in the sections below. Furthermore, EPCglobal Network is a set of technologies that enable immediate, automatic identification and sharing of information on identifiable items in the supply chain. In that way, EPCglobal Network will make organizations more effective by enabling true visibility of information about items in the supply chain. EPCglobal Network architecture is shown in Figure 1 [8].

The functional components shown in Figure 1 are described as following:

1. **ID system**: The ID system consists of RFID tags and readers; may also include optical readers and other types of sensors. Readers are devices responsible for detecting when tags enter their read range. They may also be capable of interrogating other sensors coupled to tags or embedded within tags.

2. **Savant**: Savant is the middleware designed to process the streams of tag or sensor data (event data) coming from one or more reader devices. Savant performs filtering, aggregation, and counting of tag data, reducing the volume of data prior to sending to enterprise applications.

3. **EPC Information Service**: An EPCIS enables users to exchange EPC-related data with trading partners through the EPCglobal Network™.

4. **ONS**: The ONS provides a global lookup service to translate an EPC into one or more Internet Uniform Reference Locators (URLs) where further information of the object may be found. These URLs often identify an EPCIS. ONS may also be used to associate EPCs with web sites and other Internet resources relevant to an object.

5. **Electronic Product Code (EPC)**: The EPC is the unique identifier (currently a 96-bit number) for a physical object.

6. **Physical Markup Language (PML)**: The PML is a collection of common, standardized XML vocabularies to represent and distribute information related to EPCglobal Network enabled objects. The PML is a collection of common, standardized XML vocabularies to represent and distribute information related to EPC Network enabled objects. The PML standardizes the content of messages exchanged within the EPC network. It is, therefore, part of the Auto-ID Center’s effort to develop standardized interfaces and protocols for the communication with and within the Auto-ID infrastructure. The core part of the PML Core provides a standardized format for the exchange of the data captured by the sensors in the Auto-ID infrastructure, e.g. RFID readers.

**EPCIS IMPLEMENTATION**

The system implemented refers to the architecture set forth by EPCglobal Network. Several important elements can be summarized below (illustrated figure 4):

1. **Registration component** (illustrated figure 5)

   To allow every supply chain partner to research the information they require, every partner involved in the supply chain must record their activities and register EPC to Global ONS. When the authorized inquirers cannot find the
needed information in the internal systems, they can still get the EPCIS position related to the products through Global ONS by enquiring the EPC related information. The information would come as a XML document and would include information such as EPC, EPCIS position and the company’s name.

(2) Search component of local ONS (illustrated figure 5)

For product information, instead of going directly to Global ONS to inquire external information, EPC registered information can be researched inside the business to see if anything is available. If information inside the business cannot be found then they can inquire for research via Global ONS.

(3) Search component of global ONS (illustrated figure 5)

It is similar with local end search. This inquire the EPCIS position which related to products by EPC to be the key word to inquire all of the EPCIS positions which saved the EPC and inquirers can search the related information about inventory.

(4) Inner and EPCIS exchange component (illustrated figure 6)

When local ONS has found that the EPCIS of the company has the data of the EPC, related information of products form EPC can be found, though it is not required that all items have EPC to be queried.

(5) External EPCIS exchange component (illustrated figure 6)

When authorized inquirers can not find the needed information in the local ONS, they can query Global ONS to search for the position of the external EPCIS. When looking for the position of external EPCIS, the external EPCIS can be entered to inquire the event information of the product but the different event type also needs different content information. During the first inquiry, all events in the EPC will be listed; the event names can then be used to inquire more detailed information.

APPLICATION SCENARIOS OF EPCIS

Forward Logistics has been defined as the part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point-of-origin to the
point-of-consumption so that customers needs can be met. Reverse logistics is the process of planning, implementing, and controlling the efficient, cost effective flow of raw material, in-process inventory, finished goods, and related information from the point of purpose, of recapturing or of proper disposal [9].

Figure 4: The Component of EPCIS System

Figure 5: XML Documents of ONS

Figure 6: XML documents of EPCIS
In this section, we illustrate four EPCIS application scenarios. Scenario 1 and 2 are the query of inner as well as external EPCIS for forward logistics, respectively. Scenario 3 and 4 highlights reverse the logistics process of the service center and the service center querying EPCIS, respectively.

**The Query of Inner EPCIS (Scenario 1)**

Scenario 1 is the operational process when a retailer places an order to a manufacturer (the search of inner EPCIS, illustrated figure 7):

1. **Each sale position has inventory information in the inventory information system**
   - (a) Each sale position detects in a regular manner the products in the sale position. The inventory numbers of each kind of product should be known to prevent items from becoming lost or stolen.
   - (b) Each sale position transmits the inventory information, which was detected by the reader, to the inventory information system located at the headquarters. Correct and timely inventory information can help the business assess inventory numbers to reduce the cost of excess storage and product shortage.

2. **Retailers search the number of inventory to local EPCIS**
   - (a) Retailers check the present inventory numbers before placing orders and connect to the retailer’s EPCIS to inquire the product’s inventory numbers.
   - (b) The retailer’s EPCIS is connected with a business’ inner information system. The EPCIS gets the inventory data form an inventory information system, which undergirds the order strategy.

3. **Retailers place orders for products whose amounts are lower than safe stock**
   - (a) If the inventory is higher than the safe stock, retailers won’t have to purchase the goods to reduce inventory costs; if the inventory is lower than the safe stock, retailers need to purchase the goods to prevent a shortage of the good. If deemed higher than the inventory, the order activity is skipped.
   - (b) Retailers decide on how much should be ordered when the number of goods reaches lower than the safe stock. The orders are then put into a XML document, which is then transferred to the supplier of the goods.

4. **Manufacturers receive the order from the retailer**
   - (a) After the manufacturer receives the retailer’s order, the order’s XML document is checked to see if it fits the information system format of manufacturers, and to see whether any null items are present.
   - (b) The manufacturer transfers the XML order to fit with relational database adopted in the information system.

5. **Manufacturers give the responses of orders transaction to retailers**
   - The manufacturer must respond to the retailer’s order no matter if the order is correctly or incorrectly processed. This would allow both parties to understand the final result of the transaction. If a discrepancy in the transaction is found by the manufacturer, it needs to point out which part is wrong so that both parties in the supply chain can solve the transaction problem.

**The Query of External EPCIS (Scenario 2)**

Scenario 2 is the source of searching goods information after retailers receiving the goods (the search of external EPCIS, illustrated figure 8):

1. **The Event Information of Product Record in Manufacturers’ EPCIS**
   - (a) The supplier will produce the products according to the factory’s order. When the supplier produces the products, they will give each product a set of EPC™ numbers, which starts the record of each event. The record may contain information including the manufacture data, expiration data, position… etc.
   - (b) After the products are produced, the supplier registers the EPC into the Global ONS so that its related information may be found in searches made by the inquirer and so the position of local EPCIS can be located.
   - (c) When the goods are delivered to the retailers, the local EPCIS will record information related to the transportation of the products, which may include the products’ shipping numbers, order numbers and goods content, for future checking.

2. **Retailers’ checking activity after receiving goods**
   - (a) When the goods arrived at the retailer’s position, the retailer’s reader detects the goods’ EPC, which records
the event information received by EPC. The information may include EPC of goods, the data of receiving goods… etc.

(b) After the retailer receives the EPC, it can check the source of the goods. First, the Local ONS may be searched to determine whether any registration information from the EPC exists. If the information can be found in the Local ONS, the retailer can enter the local EPCIS to search for any other relevant order information that corresponds to the EPC. If no such registration information corresponds to the EPC in Local ONS the Global ONS can be searched to find the information in EPCIS which saved EPC

(c) If the registration information of the EPC™ number exists in the Local ONS, the local EPCIS can be entered to find the corresponding EPC™ number information. If the EPCIS can satisfy the needs of goods IQC (incoming quality control), the supplier may send the notice to the retailer before shipping the goods so the retailer can be assured the received goods are indeed those goods that were purchased. If EPCIS can not satisfy the inquiring needs, it probably is the other event information. We still needs to search external, so enter Global ONS to find EPCIS position which saved this EPC.

(3) The Inquiring Activity of Global ONS

(a) Global ONS is the EPC position which all EPCglobal Network members registered. Here, retailers can find the EPCIS position of relative information which saved EPC™ number. Inquirer who is searching has to be the authorized member.

(b) If there is not exist this EPC™ number’s register information in Global ONS, the manufacturer which produces this product is not the member of EPCglobal Network or the product of manufacture is illegal produce. If we can find the EPCIS position in Global ONS, the retailer can connect to opposite side’s EPCIS to search the data.

(4) The Inquiring action in Manufacturers’ EPCIS

(a) Authorized inquirers can enter manufacture’s EPCIS to search for the information. The possible result is that the good is exactly what retailer ordered or the good is a counterfeit.
The Reverse Logistics Process Querying EPC from Retailers (Scenario 3)

We redesign the reverse logistics process of the Company A and add the Service Center in the process. We assume the RFID tag is attached to the LCD TV in this logistics process and the information is recorded from the manufacturer to retailers by way of RFID and EPCglobal network utilization. The service center’s process is shown in Figure 9.

(1) The customer finds the product defective.

(a) The customer finds the product defective bought from the retailer and the customer requests the Service Center to resolve the defective condition of the product.

(b) The Service Center answers the customer’s questions to resolve the breakdown condition of the product. If the Service Center cannot resolve the problem and needs to return the product, the service center will follow the steps according to Scenario 2 to know the product’s characteristics.

(c) If the product is under warranty or the customer is willing to pay the cost of the return and repair process when the product is out of warranty, the Service Center will ask the Service Center to support the RMA (Return Merchandise Authorization) service. When this is the case, the Service Center will receive the defective product from the customer and will follow the steps in Scenario 3 to obtain the necessary information from the manufacturer’s EPCIS.

(2) Confirming the product in the warranty condition. The service center’s process is shown in Figure 7.

(a) The Service Center’s reader reads the defective product’s EPC number and the Service Center’s EPCIS finds the EPC of the retailer that has sold the defective LCD TV by using the EPC Network ONS service. At this stage, the EPCIS takes the first and second role shown in Figure 2.

(b) When the identity of the Service Center’s EPCIS is authorized, it may enter the retailer’s EPCIS.

(c) The Service Center can use the product’s EPC to query the retailer’s EPCIS to reveal the date the defective products were sold. This information would allow the status of the product’s warranty to be inferred – that is, whether the product is still under warranty, out of warranty, or DOA (Defective on Arrival). At this stage, the EPCIS takes the third role shown in Figure 2.

Figure 9: The Reverse Logistics Process Querying EPC from Retailers

Figure 10: The Reverse Logistics Process Querying EPC from Consumers
(d) If the product’s EPC is not contained in the retailer’s internal system, the product may be in a “gray market” condition or may have been stolen or counterfeited. The status can be confirmed by utilizing the manufacturing’s EPCIS, and the retailer EPCIS will propose the Service Center to further commit the product’s condition by utilizing the manufacturer’s EPCIS. At this stage, the EPCIS takes the third role shown in Figure 2.

(e) The Service Center’s EPCIS queries the EPC Network ONS to find the manufacturer’s EPCIS with the defective product’s EPC number. If the product’s EPC is contained in the manufacturer’s internal system, the product may be in the “gray market” condition. If the product’s EPC number is not correctly recorded in the manufacturer’s internal system, the product may have been stolen or counterfeited. In this stage, the EPCIS takes the first role shown in Figure 2.

(f) All the responses from the retailer or manufacturer’s EPCIS will return to the Service Center’s EPCIS.

The Reverse Logistics Process Querying EPC from Consumers (Scenario 4)

First, The Service Center requests EPC from the LCD TV manufacturer (illustrated in Figure 10).

1. By making confirming the product’s warranty condition, the Service Center can take action to carry on the repair process. If the product is out of warranty, the Service Center will ask the customer whether it is acceptable for him to repair the product on his own expense and if customer doesn’t want to spend the repair money, the Service Center will return the product to the customer or recycle the product.

2. If the product is DOA or in warranty condition, the Service Center’s EPCIS will get more information to benefit the repair process from the manufacturer’s EPCIS. The Service Center’s EPCIS queries the EPC Network ONS to find the manufacturer’s EPCIS with the defective product’s EPC number.

3. After confirming the requestor that has the authority, the manufacturer’s EPCIS will respond to the request. The response can support the product in warranty with the detailed information about the product’s manufacturing process details, the details of the product’s components, and using the product’s GTIN to find this kind of product’s common damage (e.g., the control software in the motherboard has some bug, the design of LCD TV’s hardware has some fault, etc.). The system also supports the resolve method (e.g., providing the revision software to download, supporting the way to repair the defective hardware, etc.). At this stage, the EPCIS takes the third and fourth role shown in Figure 2.

4. The system can support the defective product the suitable components by utilizing the EPC number and GTIN of the defective product. The GTIN can provide the common components in this kind of product. The EPC number can provide the unique information of the manufacturing process. And if the damage components are not in repository, the system can suggest the same level component to displace according to the information of EPC number and GTIN and because the GTIN record the all components of this kind of the product, so the substitutive components can be judged to be suitable or not for the other fine components. In this stage, the EPCIS takes all the roles shown in Figure 2, because the EPCIS must support the information about the product’s GTIN and relative information (the fourth role), the unique information of the manufacturing process (the third role), and where the suitable components is storage (the first and second roles).

5. The system supports the DOA product the exchanged inventory information. If there are no the same product to exchange for and system can select the same level substitutive product according to the information of EPC number and GTIN. And the Service Center can use this detailed information to ask customer’s desire. The customer can get more information of the substitution product and the customer satisfied degree will be raised. In this stage the EPCIS takes all the roles shown in Figure 2.

CONCLUSION

Information technology developed very quickly and information system developed like shoots after a spring rain. However, many information systems cannot exchange information effectively. How to integrate information systems is an important issue. Through the development of RFID, this study linked information systems within the business to be
the main axis by EPCIS then by way of a XML standard form to be the medium so that system information could be exchanged heterogeneously. The contributions of the study are as follows:

(1) Barcodes can only be used at the product level so they face significant limitations in providing supply chain assistance. The product information provided by EPCIS can reach to a single product and record the product information in lifecycle. EPCIS can provide better assistant for product sales, product tracing, product service and reverse logistics. We proposed the possible scenarios of utilizing RFID in repair process. We implemented the scenarios of our design, and supply the possible information flow in the EPCIS when utilizing in repairing and returning process.

(2) Through the development of RFID, the study linking information system within the business to be the main axis by EPCIS then use XML standard form to be the media to achieve the goal of heterogeneity system information exchange.

(3) The study provides the application of RFID EPCIS in supply chain. Through information sharing between partners in supply chain, we can promote the operation efficiency and communication ability. The implementation and data structure in this research can be a reference of constructing EPCIS.

There are further issues that need to be researched in the future:

(1) This research has focused on order and delivery processes, taking EPCIS application as an example by highlighting the EPCIS combination application of order and delivery system. However, the implications on information systems of EPCIS can be extended to other information system in the future. Using information provided by other information systems can create better scale integrated systems that can make information in supply chain seamlessly.

(2) The reuses, recycling in reverse logistics are also very important, but we only discuss the repair and return process in the reverse logistics. What are information flows and processes of RFID to be utilized in reusing or recycling could be the future topic to research. The amount of data collected by RFID will be very large. And how to use these data to assist repair processes will be an important issue. The EPCIS application needs data mining technology research to help to utilize the information. The research of data mining will decide how the EPCIS can help the repair process.

REFERENCES


