An Intelligent Middleware Platform and Framework for RFID Reverse Logistics

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Abstract. Radio Frequency Identification (RFID) systems enable serivces such as information exchange among objects, position tracking, and remote processing and mangment by attaching electronic tags to objects, collecting data from the objects, and processing the data. RFID needs interface environment and network structure that make it easy to use microsensor technologies and information communication devices for communication between humans and objects and between objects in addition to existing communication between humans. The application of RFID technology is going beyond forward logistics, which is the delivery of manufactured goods to consumers, and being expanded, though not frequently yet, to reverse logistics, which includes return, recovery, reuse, reproduction and disposal. The present study purposed to propose middleware platform and framework by applying RFID technology to reverse logistics.

Keywords: RFID, Reverse Logistics, middleware

1   Introduction

Radio Frequency Identification (RFID) system is a technology that identifies objects using RF signal without contacting the objects directly. This technology collects accurate information on the characteristics of products moving through logistic activities and on the paths of movement and storage, and based on the information, manages the products accurately and thoroughly during their life cycle, and by doing so, it provides information necessary for processing materials, parts, finished products and inventories and supports decision making.

   The concept of forward logistics, which is logistic management as the process of manufacturing goods and delivering them to end consumers, can be understood as general logistic management, but with the advance of RFID tag technology, a large volume of multiple data can be managed and as a consequence people are taking interest in the application of the technology to reverse logistics. Reverse logistics has not been studied much, but it is a concept comprehending return, recall, recovery, waste landfill, etc. From the position of companies, furthermore, it is utilized strategically for reducing costs through saving resources, coping with environmental regulations, enhancing consumers' satisfaction, etc.

An advantage that product identification technology like RFID technology can bring to reverse logistics is the visibility of logistics information. The present study purposed to review the concept of RFID technology and to propose middleware platform and framework for the application of RFID technology to reverse logistics.

2   RFID Technology

A RFID system is composed of RFID network technology that detects and transmits information on various states of objects efficiently, RFID middleware platform technology that provides services by storing, processing and integrating collected information, and RFID service platform technology that connects infrastructure built in various industrial areas and provides intelligent services through analyzing collected information.

2.1   RFID Network

RFID technology is composed of a reader that reads data stored in tags using radio frequency, middleware that links the data to application services, and server-network interlocking technology for tag identifier management.

Depending on whether power is supplied to tags, RFID is divided into passive RFID and active RFID, and in consideration of the characteristic of radio wave according to application area, low frequency tags use frequency band of 125~134 kHz, high frequency tags 13.56 MHz, UHF tags 868~956 MHz, and microwave tags 2.45 GHz.

The early RFID network model is Savant model by Auto-ID Lab. Using RFID, a tag "communicates" Electronic Product Code(EPC) number of an item to a reader. The reader then passes the number to a local computer, called Savant. The Savant sends the EPC number to the Object Name Service (ONS). ONS tells the savant where to locate information on the network about the object carrying an EPC. Finally, PML (Physical Markup Language) server gives the detailed information.
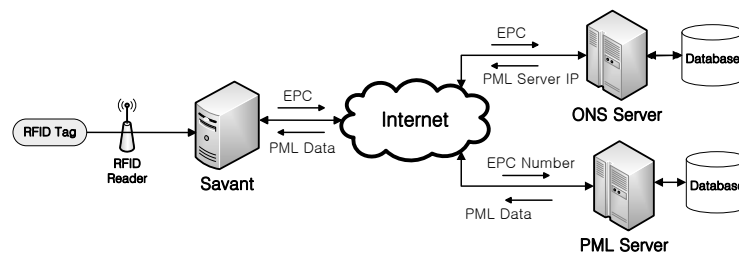

Fig. 1. EPC Global Network

2.2   RFID middleware platform

RFID middleware platform is a technology for collecting ID and data from a RFID network, filtering the data, and producing meaningful information.

RFID middleware platform includes data management technique that collects and processes data in real-time, stores the data in databases, and performs query processing and information analysis, context awareness technology that extracts real-time context information from data, figures out the context intelligently and makes decisions autonomously as an agent, search technology that links collected information and data to object or position information and shares and searches the information and data in global environment, information management and processing technology that provides heterogeneous clients with various types of information generated in RFID environment, and service profile technology that divides RFID information according to service, group, network connection state, and computing resource, and provides specific composition of API and services according to context.
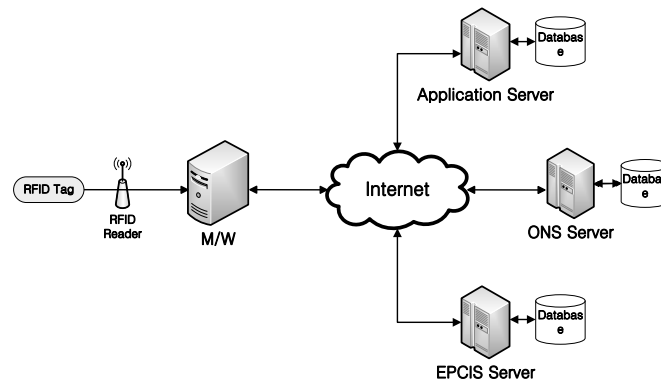
Fig. 2. RFID System Architecture

2.3   RFID service platform

RFID service platform technology interconnects infrastructure built widely throughout various industrial areas, provides intelligent services through high-performance analysis of collected information and context awareness, and supports the development high value-added fusion services through flexible connection among various industrial applications.

As a common platform technology, it is composed of wide-area composite u-infrastructure integration technology, high-performance fusion u-context awareness data processing technology, wide-area fusion data synchronization technology, u-process and service fusion technology, etc.
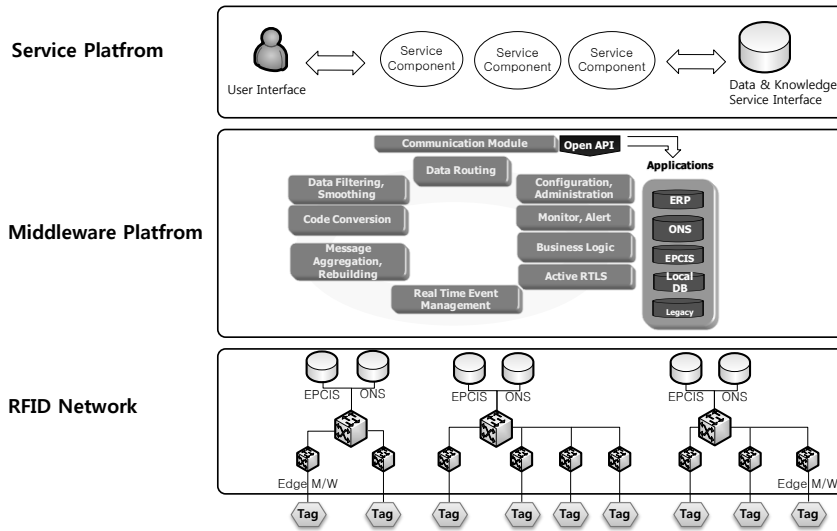
Fig. 3. RFID Technology

3   Reverse Logistics

The development of logistics for the management of supply networks is expanding its scope from forward logistics focused on the production and distribution of new products to reverse logistics focused on the effective processing of a huge volume of returns and wastes occurring after sales for various reasons. Reverse logistics can be defined as logistic activities dealing with return, recovery, repair, resale, recycling, reuse, disposal, etc. occurring during or after the use of products by customers and consumers.

Traditionally, the role of reverse logistics was customer service, namely, dealing with goods that consumers return after they have purchased. Recently, however, the definition and function of reverse logistics are focused on reprocessing, recycling and incineration.
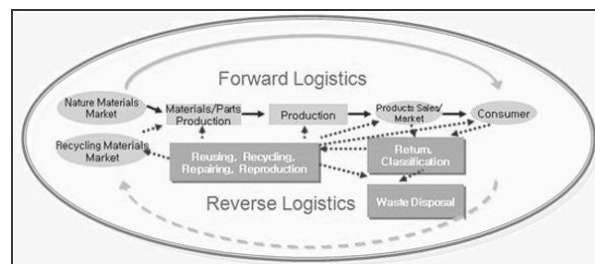

Fig. 4. Forward and Reverse Logistics

4   RFID-based Intelligent Middleware Platform and Framework

In existing logistics, the application of RFID has been focused on forward logistics and it is not easy to find instances applying RFID to reverse logistics that recovers products for reuse or recycling. For the intelligent reuse or recycling of products as much as possible, we need to provide accurate information for companies' decision making at a proper point of time. RFID-based logistics technology can support intelligent decision making by providing accurate and timely information for the reuse and recycling of recovered materials. In case RFID is applied to such an area, the effect is much higher than other technologies and can create new businesses. In this sense, it is urgently required to develop "RFID-based intelligent middleware platform."

RFID-based intelligent middleware platform covers all logistic processes existing in the life cycle of products including design, manufacturing, packing, transportation, storage/unloading, return, recovery, recycling and disposal. In addition, it is an application technology based on real-time information, mobility and ubiquity supported by IT technologies such as RFID and related distribution/logistics solutions.

4.1   Requirements for RFID Middleware

General RFID Middleware is required data management, abstraction, device management, and application integration. Moreover high performance and extensibility are also important.

Data Management
   - Data Filtering
   - Redundant data removing
   - Sending data to right destination

Abstraction
   - Abstraction for diverse devices
   - Various commercial RFID readers

Device Management
   - Dynamic configuration
   - Monitor and control
   - Reader Deployment

Application Integration
   - Support heterogeneous applications
   - Support standard and widely used technology such as JMS, XML, and SOAP
   - Reliable connectivity

High Performance
   - Need to process enormous event data
   - Have to serve a lot of applications

Extensibility
  - Support new RFID Readers
  - Support new event data
  - Support global standard

4.2   Integrated Database Management

At present, data are generally managed in the source system and thus the visibility of the entire sales channel is low and the limited visibility causes problems in the reliability and availability of information.

In response to these problems, we can introduce an integrated database model that resolves inconsistency and redundancy in information, improves the efficiency of information use in terms of time and cost, and realizes the integration, consistency, synchronization and localization of information.

The following figure shows the overall architecture of the network platform that is including the proposed middleware platform and framework for reverse logistics.
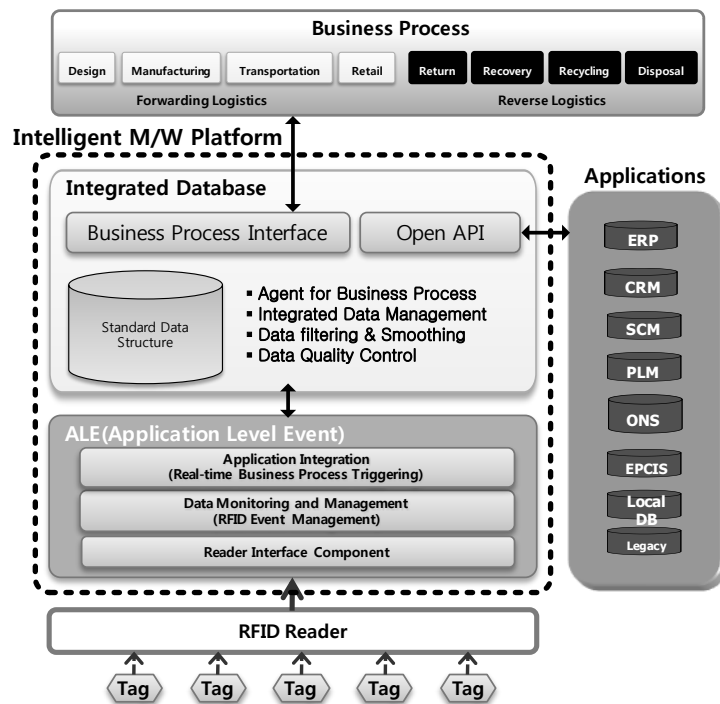
Fig. 5. RFID-based Intelligent Middleware Platform and Framework

5   Conclusion

Most previous RFID applications in the logistics area have focused on Forward Logistics. Reverse logistics deal with methods and technology that supports effective and efficient logistics for reuse and recycling. Trace & track are as important for reverse logistics as for forward logistics. Keeping product pedigree is critical for end-of-lifecycle applications. RFID can play a very important role.

The present study proposed network infrastructure that supports logistic activities for the entire process from the recycling of product materials to the disposal by adding reverse logistics to existing forward logistics.

The proposed database model that integrates information scattered among manufacturers, suppliers and consumers provides consistent visibility to the general state of operation, enhances the reliability of information, and provides information systems necessary for decision making efficiently.

RFID technology is developing to ubiquitous computing based smart network technology as it evolves from the most basic identification of objects to history tracking, state information monitoring, real-time monitoring and control and autonomous services.

References

1. A Ustundag, S Baysan, E Cevikcan : A Conceptual Framework for Economic Analysis of REID Reverse Logistics via Simulation. RFID. Eurasia, 2007 1st Annual, pp 1--5(2007)
2. Chao, C.-C., Yang, J.-M. and Jen, W.-Y. : Determining technology trends and forecasts of RFID by a historical review and bibliometric analysis from 1991 to 2005. Technovation, Vol. 27, pp. 268--279(2007)
3. Karkkainen, M. : Increasing efficiency in the supply chain for short shelf life goods using RFID tagging. International Journal of Retail & Distribution Management, Vol. 31, pp. 529--536(2003)
4. H. -B. Jun, J. -H. Shin, Y. -S. Kim, D. Kiritsis, P. Xirouchakis : A framework for RFID applications in product lifecycle management. International Journal of Computer Integrated Manufacturing (2007)
5. Samar K. Mukhopadhyay, Robert Setoputro : Reverse logistics in e-business. International Journal of Physical Distribution and Logistics Management, Vol.34, No.1, pp.70--88(2004)
6. Jihyun Yoo, Hyunju Lee, Seokyoung Back, Yongjin Park : Service quality management for value chain of wireless communication network. Industrial Electronics Society, 2004. IECON 2004. 30th Annual Conference of IEEE, Vol. 3, pp 2758--2761(2004)
7. Wigand, R.T : Electronic commorce : definition, theory and context. The Information Society, Vol.12 No.1, pp.1--16(1997)