RFID-based Logistics Information Service with Semantic Web

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Abstract. A logistics information service manages a large amount of products and product transport flow. Many applications request logistics information from a logistics information service. For effective sharing of logistics information and knowledge, the design of a logistics information management system is important. The current web is changing to a semantic web that provides a common framework for data sharing. In this paper, we present a logistics information service architecture that supports a semantic web. Our logistics information service deals with RFID-sensed data and product-related data such as attribute, and containments. Logistics data is represented using the RDF for service to various applications.

1 Introduction

In logistics flow, according to the transportation of materials, a large amount data is transferred and shared. It is important to integrate and control a large amount logistics information according to the standard information management framework.

A warehouse or distribution center will receive the stock of a variety of products from suppliers and store these until receiving orders from customers. Within a wide logistics network, various data is shared and transferred among logistics subjects. Materials are stored in a warehouse or distribution center, and delivered to customers. Logistics automation systems can powerfully complement facilities provided by higher-level computer systems. A complete warehouse automation system can drastically reduce the workforce required to run a facility, with human input required only for a few tasks, such as choosing units of product from a bulk-packed case. Even here, assistance can be provided with equipment such as pick-to-light units. Smaller systems might only be required to handle parts of the process. In the flow of material through a network of transportation links and storage nodes, there is much logistics information generated by the automation system. To improve the efficiency of logistics operations, logistics automation is widely considered.

Recently Radio Frequency Identification (RFID) tags have been widely adapted to logistics, to the automatic identification of materials and to the tracking of containers.

Enterprise applications such as ERP and SCM integrate with logistics information services. An information integration and control system is important to provide overall control of the automation machinery and higher level functionality, such as identification of incoming deliveries, stock and scheduling of orders, and assignment of stock to outgoing trailers. In this paper, we present a logistics information service architecture based on Semantic Web for efficient managing and sharing of logistics information

2 Related Work

2.1 RFID

RFID technology uses wireless radio communications to quickly and easily identify individual products and items. It is one of the most promising and fastest growing automatic data collection technologies, opening new possibilities to improve business processes from manufacturing to supply chain management and beyond. Products can be identified uniquely and they can themselves communicate information for a wide range of business applications and solutions. In addition, RFID is more than just an ID code, since it can be used as a dynamic data carrier with information being written and updated to a label as a product moves along the product value chain [3].

The purpose of an RFID system [12] is to enable data to be transmitted by a portable device, called a tag, which is read by an RFID reader and processed according to the needs of a particular application. The data transmitted by the tag can provide identification or location information, or specifics attributes of the product tagged, such as price, color, date of purchase, and others.

RFID tags are often envisioned as a replacement for UPC or EAN bar-codes, having a number of important advantages over the older bar-code technology [3]. RFID codes are long enough that every RFID tag can have a unique code, whereas UPC codes are limited to a single code for all instances of a particular product. The uniqueness of RFID tags means that a product can be individually tracked as it moves from location to location.

An organization called EPCglobal is working on a proposed international standard for RFID and the Electronic Product Code (EPC) in the identification of any item in the supply chain for companies in any industry, anywhere in the world [3, 4].

2.2 Semantic Web

In the Semantic Web, an extension of the current web, information is given well-defined meaning, better enabling computers and people to work in cooperation [1]. The Semantic Web comprises and requires the following components in order to function: knowledge representation, ontologies, agents.

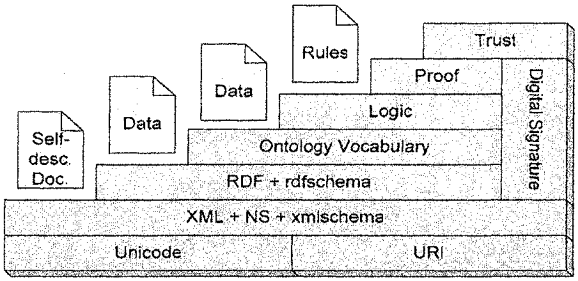

Figure 1. Semantic Web layered architecture [5]

The Semantic Web provides a common framework that allows data to be shared and reused across applications, enterprises, and community boundaries [5]. It is a collaborative effort led by W3C with participation from a large number of researchers and industrial partners. It is based on the Resource Description Framework (RDF), which integrates a variety of applications using XML for syntax and URIs for naming

Recently, there has been much research about the efficient handling information of logistics information. W.S. Lo introduced a framework for the e-SCM multi-agent system, which combines ontology to improve flexibility of access with different terms [6]. There was also research on the ontology concepts for the SCM information infrastructure [7]. An approach to managing knowledge for coordination of e-business processes in the systematic application of semantic web technologies was introduced as semantic e-business [8]. Aabhas V Paliwal *et al.* proposed an OWL-S based approach for the automatic composition of Semantic Web Services [10].

3 Framework of RFID based Logistics Information Service

Logistics systems control the logistics flow that transports products from manufacturers to customers. In the process of product transport, many data related to logistics flows may be produced. RFID-based logistics systems create many more data. RFID-tagged data is some of data to be managed in logistics systems.

In the logistics environment, many applications require and exchange logistics information or knowledge about products. For the effective management of a large amount of logistics information such as product descriptions, transports of goods, and packing of products, logistics information management systems are required. In our research, the logistics information service managed a large amount of logistics information in providing information to related applications.

3.1 Logistics Information

There are many data in the logistics environment. A large amount of data is related to logistics flows. Logistics flow includes the transport steps of products such as manufacture, delivery, and use. It is important to control logistics flows in logistics systems

A logistics information service manages logistics information to control logistics flows and provide information on products. To control logistics flows, there should be sufficient information, and effective management of logistics information is also essential. Especially, RFID-based logistics systems handle much more information. Because RFID technology helps to recognize products automatically, a tremendous amount of RFID-related data is produced in the logistics flows. Also, to manage RFID-related data, much information such as product attributes, shipments, and containers, are required.

To establish the RFID-based logistics environment, the efficient handling of information on logistics is important. To handle logistics information efficiently, it is necessary to understand logistics flow and logistics information flow. RFID-based logistics information service handles four types of data: RFID-sensed data, attribute data, containment data, and transaction data.

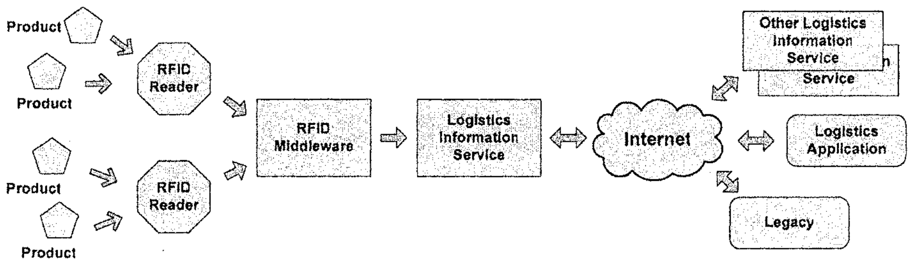

Figure 2. RFID-based logistics information flow

The RFID-sensed data is data that is automatically sensed by RFID technology. An RFID tag with an electronic code is attached to a product, and that product is identified by the electronic code in the RFID tag. When RFID-tagged products are delivered from manufacturers to customers, RFID readers sense the value written into the RFID tag of the product, as shown in *Figure 2.*

RFID-sensed data is collected and filtered by RFID middle-wares. A logistics information service stores RFID-sensed data received from RFID middle-wares. Also, a logistics information service provides this data to applications, legacy, and other logistics information services. RFID-sensed data basically consists of an electronic product code, the time that the RFID tag of products is read by an RFID reader, and the location of products that are detected by an RFID reader. Additional information such as temperature, humidity, the status of e-seals, etcetera, can be included in the RFID-sensed data.

Attribute data is data specifically on products. A company designs a model, makes prototypes of the model, and manufactures the products. Attributes of products are specifications of products and specific information about each product. Specifications of a product describe the common characteristics of all products grouped as one model. For example, model number, length, depth, ingredient, functions, and outward appearance are examples of specifications of products. Another type of attribute data is the attributes of each product. Each product has such attributes as product date, manufacturer name, manufactured factory, a certificate of origin, and others.

Containment data is data about the relationships between products and containing objects, or between contained objects and containing objects. Most products are packed into some containing objects, for instance, boxes, palettes, and containers. Also, packed products are loaded into trucks, trains, ships or airplanes. This data is also containment data. By the containment data, we can track where products are located.

Finally, transaction data is related to business transactions in logistics systems. Most products are transported from manufacturers to customers according to the contracts written between them. Transaction data is data related to contracts. Let us assume that a customer wants to buy some products from a manufacturer. After checking the specifications of a product, a customer orders some amount or number of that product. By this contract, the manufacturer transports the ordered amount or number of the product to the customer. To confirm whether the proper product and the proper amount or number of that product is transported, the relationships between contract documents and contracted products are set. Transaction data consists of contract identification and an electronic product code list.

3.2 Layers of logistics information service system

In the logistics system environment, the information service system plays important roles. The information service manages a large amount of logistics data and provides logistics information to applications. In RFID-based logistics systems, an especially large amount of logistics data has to be managed. For effective provision of logistics information, a logistics information service is designed on the basis of a web service. The logistics information service consists of four layers: the service layer, the data-handling layer, the data-access layer, and the repository layer.

The service layer consists of an interface for applications requesting logistics information and security modules. Authentication and authorization for accessing a logistics information service are in the security modules. Access to logistics information services is permitted only for an authorized user. An authorized user requests logistics information or provides information to the logistics information service. The Request Manager in the service layer controls requests for applications or other logistics information services. To relay messages between the logistics information service and applications, service layer uses SOAP (Simple Object Access Protocol).

The data-handling layer provides methods for managing the logistics information service. In other words, methods to control RFID-sensed data, attribute data, containment data, and transaction data are provided for application service requests. In the data-handling layers, there are four different data-handling modules, a service method manager, and an XML utility. The data-handling modules deal with each data types. For instance, the attribute data-handling module manages the attribute data of products, and the RFID-sensed data-handling module deals with data provided by RFID middleware. The methods of data-handling are controlled and published for applications by the service method manager. Methods are described using WSDL and are published. Legacy systems and applications can be made compatible with the methods of a logistics information service.

The data-access layer provides an accessing repository. In this layer, there is a repository accessing module that is commonly used by the data handling modules. The data-access module provides operations for storing and retrieving of logistics information in the repository.

Finally, the repository layer provides an XML repository. Logistics data is stored in XML format in this repository. XML data in the repository is managed by the data access module in the data access layer.

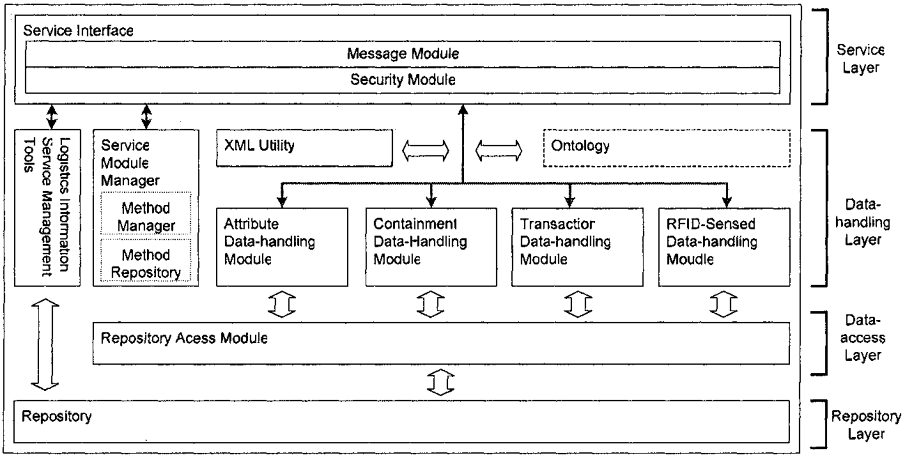

Figure 3. Logistics information service architecture

4 Semantic Web with logistics information service

A logistics information service is not limited to a local logistics system. A logistics information service provides logistics information to legacy systems or various logistics applications on the Internet. Any authorized users on the Internet can require logistics information. The current web is changing to a Semantic Web. A logistics information service should be applied to the Semantic Web.

4.1 Data Representation using RDF

A logistics information service should satisfy the following. First, it should be effectively store logistics data. Various types and large amounts of logistics data are stored for service. A logistics information service should support many requests of various applications such as ERP and SCM. Especially, effective sharing of logistics information with various applications is important. To effectively exchange information, we design logistics information service supporting the Semantic Web. Logistics information in the logistics information service is represented using ontology and RDF.

```
<rdf:RDF
      xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
      xmlns:epc="http://www.pusan.ac.kr/ontology/epc#"
      xmlns:dc="http://purl.org/dc/elements/1.1/">
<epc:RFID_SensedData>
      <epc:ProductID>urn:epc:id:sgtin:15025.31.110</epc:ProductID>
      <epc:ReadDataTime>2005-06-10 11:34:50</epc:ReadDataTime>
      <epc:ReaderID>rd345612</epc:ReaderID>
      <epc:ReaderLocation>Jang-jeon, Busan</epc:ReaderLocation>
      <epc:ReaderType>Normal</epc:ReaderType>
</epc:RFID_SensedData>
</rdf:RDF>
```

Figure 4. An example of RFID-sensed data represented using RDF

4.2 Ontology module

To semantic processing of logistics information service, we set ontology module. Ontology module processes type checking of logistics data and constraint check.

4.2.1 Type conversion

There are various requests of logistics information from a legacy system or of logistics applications such as SCM and ERP. Applications can request information using their own data types, which are different from those of a logistics information service, even though their data types represent the same meaning. For sharing logistics information and knowledge, it is necessary to perform data-type conversion. Data-type conversion is controlled by the ontology of the data type. In this research, we focused on the ontology of time and of the measurement unit. Ontology improves interchangeability between legacy systems and a logistics information service. For example, a product manufactured at Location A is transported to Location B. Location A and B are in different time zones. If they both use local time, they cannot obtain exact time data. However, if they exchange time data that is converted to global time, they can obtain the right data. In logistics systems, there are many data related to data, time and unit of measurement. Ontology of date, time and measurement units can help to share of logistics information between a logistics information service and logistics applications.

4.2.2 Type and constraints check

In a logistics system, various types of products are transported by truck, ship, or train. There are many logistics data for transported products and transport flows in a logistics information service. In the transport processes, it is important to confirm the validity of product information and the validity of logistics flows. Our ontology module confirms the validity of product information such as expiration data, stock conditions, and logistics flow. Using ontology and RDF, this semantic processing is possible. For example, when a product in stock is sensed and the sensed data is inserted into the logistics information service, the ontology modules check whether the expiry date of the product is valid or not. The validity of the product is confirmed by the comparison of the expiry date of the product and the current date.

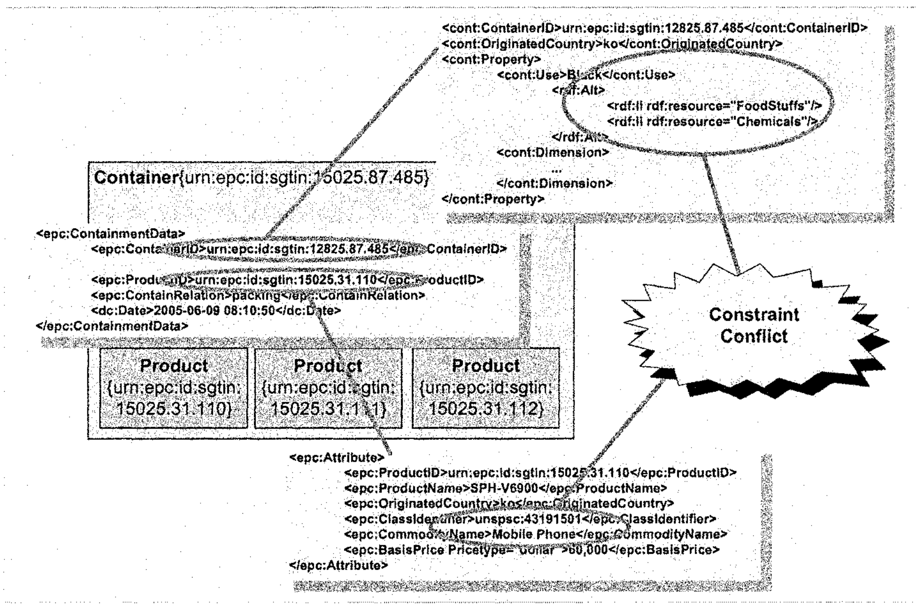

Figure 5. Constraints confirmation of logistics information

Figure 5 shows a constraint conflict of containment data. In the relationship between a container and products, even though the container cannot load the products owing to constraints, the products are loaded into the container. Logistics information service provides notification of constraint conflicts.

5 Conclusions and Future work

In this paper, we present RFID-based logistics information service architecture that manages logistics information: RFID-sensed data, product attributes, containment data, and transaction data. According to data type, we define different data-handling modules, and represented logistics information using RDF. Our logistics information service architecture is based on a web service for providing information to various applications. Also, to extend interoperability with applications, we used semantic web technology for our ontology module which provides flexibility of access and ensures the validity of logistics data.

Also in this paper, we designed the architecture of a logistic information service applying semantic web. In the future, we will implement this logistics information service and research effective semantic web service methods in a logistics system. And we will extend Ontology for the logistics information service.

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