A Distributed Architecture of ONS-Discovery Service for the tracing of products in the EPCglobal Network

Mahbubur Rahman  
Dept. of Logistics  
Information Technology  
Pusan National University  
Busan 609-735,  
Republic of Korea  
mahbubcsedu@pusan.ac.kr

Md. Kafil Uddin  
College of Computer Sci. & Information Systems  
Najran University, Najran-1988 Kingdom of Saudi Arabia(KSA)  
mdkaful@gmail.com

Gihong Kim  
Department of Computer Engineering  
Pusan National University  
Busan 609-735,  
Republic of Korea  
buglist@pusan.ac.kr

BongHee Hong  
Department of Computer Engineering  
Pusan National University  
Busan 609-735,  
Republic of Korea  
bhhong@pusan.ac.kr

Abstract—The EPCglobal has defined the standard for sharing the tagged product information among the enterprises, which are mainly the product level information rather than event level information. Now the EPCglobal aims at provide visibility in supply chains by enabling interested parties to query item-level data. Item level data are distributed to several EPCISs (EPC Information Service) in the supply chain. The ONS (Object Name Service) and EPCDS (EPC Discovery Service) are used to trace the product movement through the supply chain. The ONS lookup service can only provide the manufacturer level information. So EPCDS is introduced to the EPCglobal Network. But there is no standard to trace the product using EPCDS. In the supply chain a lots of products need to handle. So there need a huge processing of data for tracing the products. That’s why any kind of centralized server cannot afford to give a good performance in tracing the billions of products in the supply chain. In this paper we have designed different distributed architecture and proposed an appropriate one to enable tracing of huge amount of products in the EPCglobal network.

Keywords—Distributed; EPCglobal Network; ONS; Discovery Service; Product Tracing; EPCDS

I. INTRODUCTION

With the aim to identify, locate and trace the assets, Radio Frequency Identification (RFID) technology was developed. The RFID developed by the EPCglobal is the universal unique identification of individual item. This unique number is called the EPC (Electronic Product Code) and this is stored in tag which are then identified and read by the EPC Network [4]. Several Emerging technologies have been developed to trace this tagged product. The parties that are interested to share their products information to create business value need the proper technology [2]. To know the products genuineness there needs to trace [7] the product at any time. And in the perspective of business, lots of products are handled at the same time. So, in addition to business purposes, the company or parties can use the technology to share the data among themselves to trace the products, the application, like the EPCglobal network architecture should be secure, easy to use, scalable and time effective.

The EPCglobal architecture framework was defined to handle huge amount of EPC tag data effectively. The EPC network captures and stores the tag data [5] in the EPCISs (Electronic Product Code Information Service). The data about an EPC can be distributed to several EPCIS servers in the supply chain. So, if the user wants to trace the product then it needs to query to all the EPCISs [7]. And for this the user needs to know the addresses of all the necessary EPCISs where the information of the relevant EPC data is stored. For finding out the address of the relevant EPCIS’s, the EPC global has defined the standard [5] of ONS (Object Naming Service). But the ONS is not suitable to trace the product as it only gives the manufacturer EPCIS address. That is, the ONS can only give the product level or class level information about the product [5]. But for tracing the product the item level or event level information is needed. That’s why the EPCglobal has introduced the EPCDS (EPCIS Discovery Service) but until now there is no standard for EPCDS and also there is no well-known architecture of this service.

As millions of product are handled by any company, and each product have to visit through a long supply chain, so for tracing of product massive amount of EPC related data have to process keeping the valid enterprise relationship between the parties. For example, in Korea, the govt. has planned to trace all the pharmaceutical products to verify the drugs validity all over the country and for this, billions of RFID tag will be used. This huge amount of tags should be monitored or traced using the EPCDS. This may increase, if other products are required to trace in the near future. So Proper architecture of discovery service can only provide this type of services.

II. EPCGLOBAL NETWORK

The EPCglobal Architecture Framework is a collection of interrelated standards for hardware, software, and data interfaces, together with core services that are operated by EPCglobal and its delegates, all in service of a common goal of enhancing the supply chain through the use of Electronic Product Code (EPCs)[3]. The following figure 1 shows the role and interface of different parts of the EPCglobal Standards.

The EPCglobal Architecture framework consists of different standards and interfaces. At the lower part, the reader
reads [3] the EPC tag and the tag are collected, processed, grouped, and filtered by the ALE (Application Level Events) interface [14]. The result data are formed as physical events. Then the EPC data are captured by the capturing application. The capturing application converts the EPC data together with other business related information, to the events which are called business events. In order to access to the EPC data, the location information of the reader has to store. The capturing application sends the business events to the EPCIS which is the storehouse or true repository of storing the EPC business events [4]. In the upper layer, there exists query interface which are used to process and respond to the user query to the EPCIS. At the top part, there is ONS, EPCDS and management services. ONS and DS are used to lookup the URI of the EPCIS. At the top part, there is ONS, EPCDS and management services. ONS and DS are used to lookup the URI of the EPCIS to access the information from the EPCIS by the remote user.

The standard’s current status specified by the EPCglobal is shown in the following figure.1. The standards are divided into three types: Identity, Capture, Exchange.

The function of the identity portion is to identify the tag and translate the tag data. The capture portion’s function is to collect and filter the tag data and the function of the exchange portion is to store and share the collected and filtered data. The exchange portion comprises of the main core services of the EPCglobal Network: ONS, EPCDS and EPCIS.

Figure 1. EPCglobal Standards overview

A. EPCIS(Electronic Product Code Information Service)

The EPC Information Service is the repository in the EPCglobal Network. This is used for historical data processing in the network. The event data and master data are stored in the EPCIS repository. It has the capturing application interface by which the EPCIS gets the event data from the capturing application. And it also has the EPCIS query interface. The query interface is used to communicate with the user application [4].

B. ONS(Object Naming Service)

The role of the ONS server in the EPCglobal Network is to provide a lookup service [5] of the EPCIS by EPC tag data. This service is similar to the DNS (Domain Name Service) of the internet address mapping service. Actually ONS works as a subdomain in DNS service. The EPC code is first converted to a URL using dot to make the code like an IP address and at the end epcons.com is added by the ONS. Then this is send to the DNS server, which then can find out the appropriate location of the EPCIS.

C. EPCDS(EPC Discovery Service)

The EPCDS provides the location data for all EPCIS where a certain EPC code’s information is stored. The standard operations and functions have not standardized by the EPCglobal yet. But some criteria and requirements are defined by the EPCglobal. Discovery service facilitates visibility by providing a lookup mechanism to help finding multiple source of serial-level information, particularly when that information is commercially sensitive and or not published in the public domain. Serial –level information is considered to be commercially sensitive because it can be analyzed to determine volume of good, flow patterns and trading partner arrangements [7]. That’s why, though the function of the discovery service is much similar to public search engine, it cannot be used as a search engine.

III. RELATED WORKS

The need for tracing the product life cycle in the supply chain is becoming mandatory and that’s why researching one the discovery service is going on. A notable amount of research on the discovery service has already been done by several researchers. The EPCglobal also formed group of researcher to find a standard of the discovery service.

The DNS (Domain Name Server) is an essential component for the internet [9]. It provides global discovery by mapping names to addresses. Based on this service the Auto-ID lab has developed the ONS which can works to search the EPCIS address for the tag information [13]. But the ONS service can only give the manufacturing level information [5]. In contrast to the internet where domain addresses are freely available, EPC related information need to be protected and only selectively shared. The domain name service is therefore not a good choice to build discovery service [2].

A discovery service was developed by the IBM research group [3] which is almost close to the properties of discovery service in context of supply chain. The IBM’s designed discovery showed a great sign of fulfilling the criteria of the discovery service by using distributed server and used proxy server which has the feasibility and usefulness of Discovery service. But they introduce a name server which is much like the centralized server. So performance should hamper in this type of architecture. Another Discovery Service was designed by the Affilias [8] which can works fine to fulfill the requirements of the Discovery Service but this architecture is not also possible to handle a huge number of tags. Though it followed the requirements of the EPCglobal discovery service, but when applies in global supply chain, its performance will go down.
Another Discovery Service was designed by the LIT [1]. This idea is good to follow the EPCglobal criteria to trace the products. But its architecture is done together with ONS and in the same system. So when thousands of products are tracing concurrently it become idle. So this is not feasible for using in the global supply chain.

A project is currently running in Europe known as BRIDGE [10], which is mainly researching on the implementation of EPCDS. The researcher of the BRIDGE project proposed two architecture [10, 11, 12]. The first architecture is based on the requirement of the EPCglobal Standard which provides URL of the EPCISs to the user and the user query to all relevant EPCISs for the information. Another model is the query relay model where the EPCDS sends query to the EPCISs and the return results are merged at the user side to tracing the products.

So from all the research work, it is clear that, all works are done taking EPCDS as a centralized server. But tracing products needs massive amount of data to process and trace. So, one centralized server cannot afford to serve this type of services. The centralize system works in the way that, if any product is observed for the first time to any EPCIS, then the EPCIS directly send to EPCDS server. So every EPCIS send the information directly to the centralized EPCDS when a user wants to trace the product then this also call the EPCDS and EPCDS response to the query. But in any country, millions of products need to trace every day. So if this type of service is given, then the server become very busy almost can’t work. So this type of architecture is not practical for discovery services.

In this paper, we have described different distributed architecture of the EPCDSs and compare the performance of different kind of situations and finally proposed a hybrid architecture for implementing Discovery Service.

IV. DISTRIBUTED DISCOVERY SERVICE

The EPCglobal Network provides the functionalities to capture and share the RFID information to the business partner in a complex trading network [3]. The Network consists of three main components: EPCIS (EPC information Service), ONS (Object Naming Service) and EPCDS (EPCIS Discovery Service). EPCIS is the store house of both tag manufacturing information and event level information with unique items of the supply chain. ONS is the server which finds out the manufacturing location of the querying EPC from the network and EPCDS find out the locations of all EPCIS where the information of a specific EPC is stored. So EPCDS is essentially a chain-of-custody registration service that enabled companies to find detail about a product. So in the next we will describe about the distributed design of EPCIS together with the EPCIS and ONS and finally describe the proposed hybrid distributed architecture of ONS-discovery service.

A. Distributed DS based on Region/Country

This type of distributed Discovery service works based on the location of the EPC observed. The location can be a single country or small region or a big region. This system works as a regional modular basis.

This type of Discovery Service works that if any product is observed by any EPCIS for the first time then the EPCIS call the local ONS to find out the appropriate EPCDS from the network. The local ONS find out the DS which is more near than any other DS geographically. Then the EPCIS is registered to the DS with the EPC code. In the same way the other EPCIS works. If any user wants to trace a product then the user sends query using the EPC of the product. The user application call to the local ONS and the local ONS search the DS to find out all the EPCIS’s addresses where the information about the current EPC is stored. Then from that addresses the tracing information is retrieved.
only one EPCDS or whole Europe can keep a single EPCDS. But the main problem of this type of distributed architecture is that when tracing the product, the application need to search all the EPCDS though information can be found only from one or two EPCDS servers. So this causes performance degradation when the number of Server increases.

B. Distributed DS based on Company/Products

Another possible distributed Discovery Service is based on Company or the Product of the Company. If the DS service is based on the Company, there exists an EPCDS for each company. That is, the local ONS server final subdomain is the company code. And if the EPCDS distributed architecture is based on product of a company like LG has several products such as LGTV, LGLCD, LGMobile etc. So for each product, the company keeps an EPCDS.

This approach works based on the company/product observed by the EPCIS. When a EPC of tagged product is observed by an EPCIS for the first time then the EPCIS immediately call to the local ONS and local ONS finds the best EPCDS to register this EPCIS and this is find out by the ONS based on the company/item field of the EPC tag. For all other EPCISs, registration is done in the same way. So when a user wants to trace the product, then the user sends query with the product’s EPC. The application sends this to the local ONS server to find out the EPCDS where it can find the information of this product. The EPCDS gives the addresses of the EPCIS where the information about the queried EPC is stored.

![EPCDS distributed architecture based on Company](image1)

This architecture is compliance with the ONS standard as the ONS works based on the field of the EPC tag and find out the managerial code of the EPC. So if item level EPCDS is used then the ONS have to design to find out the item level local ONS and DS server. And if company level EPCDS is used then the current version of ONS is enough to find out the DS server. The main advantage of this approach is that all the information about a product is stored only one EPCDS and need to search only one EPCIS to trace the product and thus it can achieve a great performance improvement. But there exists a big problem in this approach that each company should have to maintain at least one EPCDS to trace the product. So without their own EPCDS they can’t trace the products in the EPCglobal Network.

V. HYBRIDE DISTRIBUTED ONS-DS ARCHITECTURE

According to the previous description we found that centralized architecture are liable to performance problem and the distributed architecture base on region or country are liable to performance problem and the company based architecture suffer from the lacking of appropriate discovery server. The architecture given by the IBM research team which is based on the Naming Server does not meet the EPCglobal requirements. So we have proposed a hybrid algorithm which consumes the company based architecture and for exception case, add Naming Server. The previous company based EPCIS architecture has the problem that each company should keep their own EPCDS; this can be removed by using some specialized EPCDS and Name Server. So in this approach, if any company does not have their own EPCDS then the company can keep the tracing information to one of several specialized EPCDS server and this can be managed by the Name Server. So this approach can fully work both cases and can improve the performance of tracing product in the supply chain. The hybrid architecture is shown in the following figure.

In this approach, if any tagged product is observed by any EPCIS for the first time, the EPCIS call to the local ONS server and then the ONS server finds the appropriate EPCDS and stored the tracing information same as the previous approach. And the user also searches for the tracing information at the same way. But the main difference is that, if any EPC code is observed by an EPCIS for the first time, its sends it to the local ONS server, local ONS server process this according to the ONS rules and if it does not find out any EPCDS in this way, then the root ONS call the Name Server.

![ONS-EPCDS hybrid Architecture](image2)
The Name Server has some rules to maintain the product which does not have the EPCDS of their own. The Name Server will find out the appropriate EPCDS server of the products which does not have their own EPCDS. If any user wants to trace this product then that user application sends the query with the tag ID to the local ONS and local ONS process this according to standard specification. If the root ONS does not find any EPCDS for that product, it again calls the Name Server. The Name Server knows which EPCDS contains the information about this product and sends the address. Thus the tracing information is received by the user application in this approach.

In this approach, a new protocol other than ONS is included name as Name Server which was developed by the IBM research group. So this approach solves the problem of the bindings of the company to keep their own EPCDS. That is, if any company does not have any EPCDS of their own then they can share the specialized EPCDS which is maintained by the name server. That is the name server works as ONS server for those companies. So, the ONS can work following the standard format and also tracing will be much easier than the other approach. But one problem is that, it needs to manage extra servers both Naming Server and some other EPCDS. But it can solve the problem arise by the centralized system to trace huge number of tag in the supply chain.

So if the architecture is distributed then the Discover Service engine are designed to process the EPC related events from the EPCIS and can send back the tracing information to the users. There are several architectures [2] for the discovery service engine: query-relay method and direct look-up method are the most important. So discovery service server together with the hybrid distributed server meet the all requirements of EPCglobal discover service together with ONS without any performance problem.

VI. CONCLUSION AND FEATURE WORK

Discovery Service is to discover all type of information of the products through the supply chain. So any kind of centralized server is not feasible to do this type of services. In this paper, we have given architecture of distributed ONS-EPC Discovery Service. In this distributed approach, the information of the same company’s products will remain in the same EPCDS and when querying by the user, the processing time will be much faster than before as it can get all EPCIS’s addresses from only on EPCDS. In this approach, the ONS standard need not be changed but the standard is included in this architecture. There is no architecture of the DS engine in this paper. So the architecture only gives the service of more modular information than the centralized server but other services which should have to be provide by the discovery service is not discussed here. In the query processing, we can use relay type or lookup type process or we can use the normal process. So in our future work our target will be to design the whole architecture of the distributed discovery service compliance with EPCglobal requirements, so that distributed server together with proper designed DS engine will be able to trace huge amounts of tag data in the supply chain.

ACKNOWLEDGMENT

This work was supported by the Grant of the Korean Ministry of Education, Science and Technology (The Regional Core Research Program/Institute of Logistics Information Technology).

REFERENCES