2003 International Symposium on Advanced Intelligent Systems
September 25-28, 2003, Jeju, Korea

Designing Smart-tag based Logistics System with Intelligent Track and Trace Service

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Abstract – **All over the value chain, a logistics information system must satisfy several requirements about gathering and sharing related information. For example, distributors or forwarders need up-to-date information for scheduling and managing their logistics resources. Meanwhile, consignors or consignees want to know the dynamic information about current states or location of their goods. Such information is dependent upon the quality of data sets collected throughout the logistics processes. Thus, gathering accurate data promptly is the essential factor for the success of a logistics information system. However, there are limits in reducing both time-gap and man-power for data sourcing, since this process is done manually or by using bar codes and scanning devices. Smart-tag can be the alternative to such a time-consuming and inefficient operation, especially for handling piles of goods. The tag includes a micro-chip containing data which is remotely readable by readers with antenna. Logistics system with Smart tag can provide all the information anywhere and anytime, and it will increase the efficiency of logistics and satisfaction of users. In this paper, we propose a conceptual architecture for smart-tag based logistics system and describe its functions.**

I. INTRODUCTION

The drastic effect of Internet has changed the traditional business methods as well as daily life in South Korea since the late 1990s. Nowadays many citizens start their own day by checking up e-mail and Internet news from web sites rather than from either TV or newspaper. Similar changes have already come to the area of commerce. Commerce environment has moved from the real market to 'Cyber Space'. People are looking for goods, and then buying the selected ones in web sites, usually called electronic shopping mall(s), without visiting off-line stores on the streets. Despite almost everything seems to be done on the electronic space, however, there are still essential areas which must be remained and executed in the physical space. One of them would be 'Logistics'. Whatever may be possible on cyber space for electronic commerce, logistics still is heavily related with the real world problems.

The concept of logistics can be explained as the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from point of origin to point of consumption for the purpose of conforming to customer requirements. South Korea is the country that shows the most rapid growth of Internet in the world. But the inefficiency of logistics prevents South Korea from establishing the reliable and profitable environment for e-Commerce. For example, the portion of logistics cost is more than 10% among the total amount of retail sales in Korea.

In general, logistics information system is to satisfy distributors as well as consumers. Distributors need a system which supports to make an effective plan and provides up-to-date information. In the other hand, consumers want to know either 1) the current states of their goods ordered, such as, location, quantities, and temperature, or 2) the advanced notices including information of when to come. These information could be readily obtained from a reliable logistics information system which handles large amount of real-time data throughout the whole logistics processes. Particularly, data sourcing, data consistency, and data continuity would be the three critical keys to construct this information system. But many cases in real world show that data sourcing is still done by hands, sometimes relying upon scanner and bar codes. And very a few logistics information systems have consistent and continuous logistics data.

In our study, logistics system based on smart-tag(s) is suggested to enhance the efficiency of logistics. Smart-tag is the alternative to such a time consuming, inefficient operations for the logistics data. Smart-tag has the chip with information, which is readable or writable by readers with antenna. So it has computing power everywhere it exists. Our logistics system consists of several structural functions for 1) assigning a unique identification to a tag, 2) storing product and logistics data, 3) searching data location with a unique identification, 4) internet-based networking and messaging, and 5) user interfaces available to use anywhere and anytime. This system's objective is to make both distributors and consumers get their relevant logistics information which they wanted.

Furthermore, this system is hoped to increase both logistics efficiency and customer satisfaction.

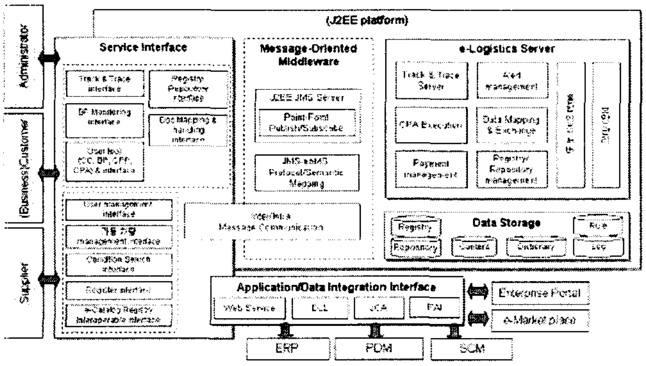
II. RELATED STUDY

A. VIOLA Platform for Electronic Logistics

The research project for developing an electronic logistics platform, named VIOLA(Visibility and Integration and Optimization for Logistics Application), has been under way by e-Logistics Research Team at ETRI. The goal of VIOLA is to reduce logistics costs and improve both efficiency and flexibility, by providing functions for integrating logistics information and real-time services among multi parties over the Internet. To do so, VIOLA has been designed with several components, such as, XML document handling component, message transportation component, repository and registry, business process management component, and track-and-trace component.

VIOLA Platform is expected to integrate all the offline process to the electronic technologies, so stakeholders are able to handle their logistics business process; information searching, partner matching, transportation service ordering or contract, tracking of tracing for either vehicles or goods. It is noted that we assume the stakeholders include consigners, consignees, carriers, and information providers.

Following figure illustrates the outline of VIOLA structure and several functional components.



<Figure 1> VIOLA e-Logistics Platform Structure

B. Smart-tag and Logistics

A smart-tag is a tag which uses RFID(radio frequency for identification) technology, and generally consists of micro-chip and antenna. A common method of identifying objects using RFID is to store a serial number that identifies a product, and perhaps other information, on a microchip that is attached to an antenna (the chip and the antenna together are called an RFID transponder or an RFID tag). The antenna enables the chip to transmit the identification information to a responder, or sometimes called 'reader'. The responder converts the radio waves returned from the tag into a form that can then be passed on to computers that can handle it.

RFID is a proven technology that's been around since the Second World War, and its features show that a smart-tag can contain much more information than a barcode, as well as it can be re-usable. So it has been expected to use widely and to substitute barcode or paper tags. Up to now, however, relatively higher prices and building costs for complex computing system have been big obstacle to the real-world applications.

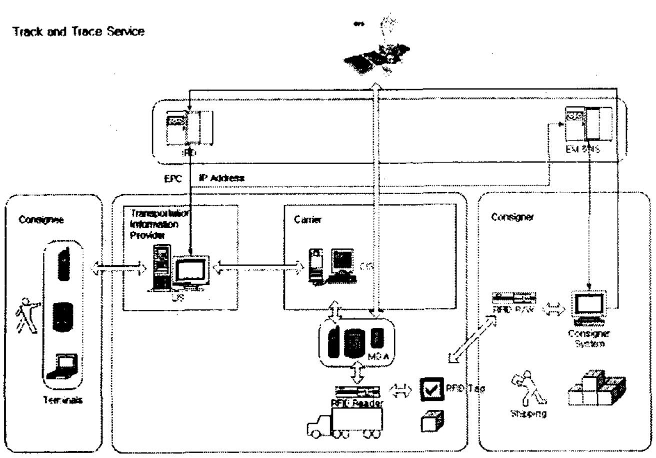
In recent years, RFID technology gets to attract public attention. A certain number of companies and organizations try to adopt RFID technology to information systems in domain of pharmaceutical, health care, amusement park, manufacturing, logistics, cashless payment, security, and warehousing. There are a few research projects using RFID technologies such as ParcelCall of EU, TRON of Japan, and Auto-ID of U.S. Among those related researches, the two major projects made us interested: ParcelCall and Auto-ID.

Since the development phase for VIOLA platform has been started, we were looking for the more improved way of data sourcing for the track and trace component. Then we got to know smart-tag would a promising solution, because the tags can be read as long as they are within range of a reader and can be used to identify a unique item. Thus, if tags can be made cheaply enough, they can solve many of the problems associated with data sourcing depending upon bar codes.

As distributed system, ParcelCall is designed to support real-time track-trace function over companies or borders among separated parties. This situation is similar with that of VIOLA platform. VIOLA is designed to support all kinds of parties of logistics. It could be separate consigner, information provider or a certain company who can provide the service as consigner, carrier as well as information provider. In that case, VIOLA platform needs the unified identification system that must be consistently identified by any parties of platform. So we came to re-design the track and trace component with considering idea obtained from Auto-ID's identification system.

III. PROPOSED SYSTEM ARCHITECTURE

We propose a track and trace system which makes use of smart-tags. In this paper, we simplified the logistics stakeholders as the four parties including consignee(s), transportation information provider(s), carrier(s), and consigner(s). As shown in the figure below, this system is composed of 8 sub-components: LIS, IIS, EM, IRD, CIS, MDA, user terminals, and RFID responder. Each role is described as follows:



<Figure 2> Smart-tag based Track and Trace System

A. LIS(Logistics Information Server)

LIS is located in Logistics Information Provider, and its main function is to matching and providing information contents. Because user terminals used by consignees are various, it might be desktop PC, PDA, or cellular phone with LCD display. But each device capability is much different, so LIS must convert the contents into proper formats for service device types. When consignee requests the information about a unique item, it will provide related information including the item's position and states, by asking CIS(s).

In a way, LIS is similar with relay station. When user requests the item's information on transportation, LIS sends that request to all CIS(s), and LIS delivers the information with the answer from related CIS.

B. IIS(Item Information Server)

IIS provides the information of all Items that is registered by shippers. It stores item information using XML database, which enables extensible and scalable information sharing among the parties of VIOLA platform.

C. EM(EPC Manager)

After Item information registered in IIS, EM generates specific identification code, EPC (Electronic Product Code), which will be used for identification of each Item. A unique EPC must be stored in a unique tag.

D. IRD(Information Resolution Database)

In this track and trace system, the dynamic transportation information of an item is managed by CIS, while static information is separated and stored in IIS for information sharing. Therefore, when consignee wants to know transportation states or location of any item, these two parts of information must be merged for final service.

LIS is responsible for this merge. It receives transportation information from CIS, and item information from IIS, but LIS doesn't know where IIS is located. To find IIS, LIS communicates with IRD using EPC given by consignee. IRD plays a role of mapping EPC with IIS address.

E. CIS(Carrier Information Server)

CIS is operated by carrier, for example, a truck company. Carrier's Information Server manages all the information during transportation as like position, item loading and unloading, motion, speed, temperature, and etc. Those information comes from MDA periodically. Then, CIS stores all the information from MDA, and provides to LIS when requested.

F. MDA(Mobile Digital Assistant)

MDA is a set of devices equipped on carrier vehicle like truck. Cellular phone, PDA, and GPS receiver cooperates to gather transportation information and to send it to CIS. PDA is connected with RFID reader and gathers information read by reader when items loaded and unloaded. GPS receives position value from GPS satellites to calculate present position and speed. And cellular phone is to send all this information to CIS by mobile internet communication.

G. User Terminals

Users, mostly consignees, use their terminals to request and receive the transportation information of items. Those terminal devices may be desktop PC, notebook, PDA, or cellular phone, and each of them has different computing and displaying capabilities. So each user application must be developed specifically for the features of devices, and information formats and contents also have to be modified like that.

H. RFID Tag and Responder

There are two types of RFID tags, passive tag and active tag. Passive tag doesn't have internal power, but active tag has battery. So passive tag is more simple and cheaper, but its memory size is usually very small. To the contrary, active tag has computing power and larger memory, but it's more expensive so its use is limited till now. In this simplified system we considers only passive tag is considered. And there are two kinds of responders. One is connected to consigner system. The other is equipped in the transportation vehicle.

It is noted that there are some assumptions as following:

1) The system should allow lots of independent parties. Parties include consigner, consignee, carrier, and logistics service provider
2) Due to the network connection and management, a CIS handles limited number of MDA in one carrier company

3) MDA sends the information periodically to CIS by wireless internet using cellular phone
4) CIS stores all information from MDA and delivers to LIS when requested.
5) LIS is not responsible for the storage of logistics information.
6) Though we suggests the component-based system architectures with 4 groups as shown in figure 2, these components may either be located in one server or belong to one company in the implementation level.

Track and trace function begins after a transportation contract settles among the given logistics stakeholders. For the first, consigner inputs item information using its terminal to IIS, and request the identification code. Then EM issues EPC to item after validation of input information of IIS.

Consigner records EPC to a smart-tag attached to an item using responder and load the item to the carrier's vehicle. When an item is loaded on car where both MDA and reader are equipped, the reader reads EPC in the smart-tag and transmits related information to MDA. During transportation, MDA checks item states and code during loading and unloading, and delivery. Such dynamic information is transmitted periodically towards CIS. The period and condition of information transmission can be modified by implementation condition or policy.

CIS receives the information from MDA and delivers to LIS when requested. If consignee wants to know the transportation information about the item, consignee should request to LIS with EPC. Then LIS has to three operations to provide a response to the user's request.

For first, with EPC given from user, LIS ask IRD the location (that is, IP address) of IIS, where stores the item's information. If IRD returns the address of IIS, then LIS requests related information to IIS. Though LIS doesn't have to store such information, it may temporarily store the information once served for future service request(s) from same user or about same item. Secondly, LIS asks CIS any dynamic information about the given item.

Finally, LIS has to create the geographical information and convert web contents. LIS must manage geographical information and creation map with GPS values sent from MDA since MDA has little computing power. And LIS has to convert this map and other contents to show properly to user's terminal device, since users can use several kinds of terminal devices like desktop, notebook, PDA, or cellular phone.

IV. CONCLUSION

VIOLA project has been designed and implemented to support various logistics businesses and services through the electronic ways. And the platform tries to make uses of XML, message transportation mechanisms, repository and registry, and track-trace system so that all parties including consigners, consignees, carriers, and information providers may share logistics-related data, and may use standard business processes.

In logistics information system, the key feature is visibility. But the former developed track and trace system of VIOLA was not enough to satisfy requirement of parties. Data collection was handled by hand. It is slow and not precise. Even the data types and size were limited. So we should find effective the alternative, 'smart-tag', and it has several merits for data collection and checking data change easily. Then, data consistency and data continuity are guaranteed by the proposed architecture which consists of several specific servers such as IIS, LIS, and CIS. These servers also may support VIOLA platform where every party can share the information. This track and trace system is under implementation now, and it will be tested on the field in 2004.

At present, passive tag is used but for the future of smart-tag spread, active tag and several issues must be considered.

- ✓ Explosive increase of data communication
- ✓ Standardization of identification code
- ✓ Frequency band allocation and interference
- ✓ Business process change management
- ✓ Privacy

Especially, the privacy issue has to be cautiously managed, several smart-tag test plan were cancelled due to privacy invasion. And it is also considered as one of the biggest obstacle of commercializing smart-tag applications.

REFERENCE

[1] Spinardi, G.; Williams, R; Jakobs, K.; Pils, C.(eds): System requirements and initial system concept, ParcelCall IST-1999-10700, Deliverable D01, 2000.
[2] Jakobs, K.; Pils, C.; Wallbaum, M: Using the Internet in Transport Logistics - The Example of a Track & Trace System. ICN (1): 194-203, 2001.
[3] Caesar, T.; Walischewski, H.: ParcelCall - A Network of Cooperating Track & Trace Systems 1st IFAC Conference on Telematics Applications in Automation and Robotics, July 2001.
[4] Finkenzeller, K.: RFID Handbook : Fundamentals and Applications in Contactless Smart Card Identification, John Wiley & Sons., 2003.
[5] Tron Project: http://www.tron.org/
[6] McFarlane, D.: Auto-ID based Control, www.autoidcenter.org, 2002.
[7] Cole, H.; Engels, D.: Auto ID – 21st century supply chain technology, AEEMA National Conference, 2002.