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CONTAINER TRACKING AND TRACING SYSTEM TO ENHANCE GLOBAL VISIBILITY

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Abstract: The objective of a container tracking service is to achieve more information during a supply chain process including shipments in connection with mobile business. At multi-modes, a consignor wants to know the exact situation and position of goods transported or in storage. As an innovative business model, this paper presents CTS (Container Tracking Service) scheme using LEO (Low Earth Orbital) satellite to enhance global visibility of containers. The LEO collects the data periodically and sends to the web server, and eventually customers' PC or PDA. This provides shipping companies or freight forwarders with more robust information such as door status, container-inside condition, etc.

Key Words: Container Tracking, LEO, GPS, Web-GIS

1. INTRODUCTION

It is evident that mobile business leads to more physical goods flows with smaller and more frequent shipments of goods and commodities. This globalization of markets has resulted in the growing need for even more efficient and effective information flows. Internet is user-friendly, inexpensive and both customer and supplier driven. Customers are driving the implementation of systems to ensure timely, thorough and accurate information, often with immediate access, in response tracking and tracing systems are proliferating with the Internet. Value-added service is the key to successful intermediary activities.

The role of the freight forwarder as a transportation intermediary is changing and clients want connectivity with the freight forwarder system. Gebresenbet and Ljungberg (2001) applied information technology to optimize agricultural goods. Logistics management is an integrative process that seeks to optimize the flow of materials and supplies through the organization to the customer. The benefits of better communication, improved tracking, shared information to improve freight efficiency is already in service in various areas.

Most researches for container management include their space and utilization. Holguin-Veras and Jara-Diaz (1998) worked on yard space allocation problems, and Legato et al. (2001) simulated container terminals. The study of Gendron and Crainic (1995) is classified as container fleet management. Rare works have been found about global container tracking, and this paper shows my investigations over the past four years. In tracking equipment such as containers and chassis, RF-Tags with DSRC, etc. are widely used for Electronic Seal, which can be used at special nodes such as ports and airports. In this regard, this paper introduces how I developed the concept of global tracking services of containers using LEO and GPS. The paper also covers advantages and limitations of these services.

2. TRACKING AND TRACING SERVICES

The concept of Intelligent Transportation Systems (ITS), which deals with the application of advanced technologies to transportation, became popular in the 1990s. Commercial Vehicle Operations (CVO) were introduced as a subsystem of ITS in the United States with the application of ITS technologies to the movement of freight. ITS/CVO has been the prominent services in logistics and freight transportation. They include electronic screening, credentials administration, weigh-in-motion, border-crossing and automatic equipment identification. Recently, global SCM (Supply Chain Management) expands ITS/CVO services to intermodal transportation and logistics information systems in diverse areas: warehousing, ports, airports, rail stations, etc.

In Taiwan, the GSM-USSD (Unstructured Supplemented Service Data) was launched in August 2001 by Telecommunication Enterprise. GSM-USSD sends information of a vehicle such as gas mileage, speed, payload status and a route to the center. In freight and fleet management, applications to hazardous materials are distinctive for containers (Chen, 2002). In the U.S., Tranzit Xpress, Operation Respond, Truckdesk are adopted for hazardous-materials management systems. Tranzit Xpress I was developed by State of Pennsylvania and Tranzit Xpress II was developed by State of California. Tranzit Xpress monitors vehicle location, status of hazardous materials to respond emergencies and incidents. Tranzit Xpress system is composed of the Information Dispatching/Operations Center, the On-Vehicle Electronics systems, and a battery of off vehicle devices (UN, 2001).

RF-Tag is popular for electronic seals and also is used for tracking services. International Standard Organization (ISO) has several technical committees regarding packing, transport unit and unit load issues in logistics. Tracking and tracing issues in intermodal transportation are dealt with in ISO/TC204 WG7 and Figure 1 shows related documents in ISO.

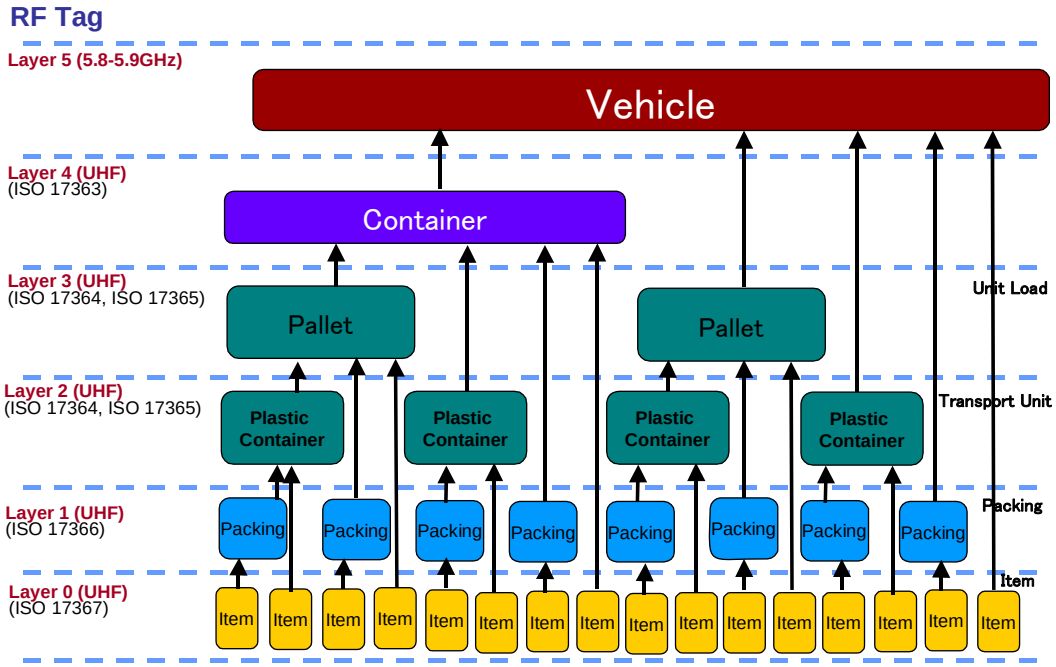

Figure 1. Layer Structure of Supply Chain and ISO Documents

Tracking and tracing of trucks and dispatching services are very popular in the private field and the EDI services are most distinctive in logistics. CVO now has a broader meaning, including intermodal terminal operation and coordination among modes. Global visibility that is, tracking and tracing of freights and commodities emerged as a necessity in various logistics fields, especially for services provided by the integrators such as DHL, UPS, and Fed-Ex.

In Korea, tracking services are provided by several types of companies such as telecommunication, system integration, trucking companies, which are the followings: KTlogis, Zimtruck, Samsung SDS, OK-Net by Daesin, SK Netruck. In 2003, about 15,000 truck drivers use tracking and dispatching services, which is about 1% of the total trucks in Korea. In recent years, it is expected that the market will grow up very fast in Korea: CVO services include border-crossing, credentials administration, logistics e-Marketplace, electronic screening services including dispatching, tracking and tracing services.

In Korea, tracking services depended on GPS and MDT transponders in the beginning; however, most companies provide services using cell-tracking because of high costs currently. Still, GPS and MDT transponders are applied to parcel services and high-value products. Although beacon and DSRC (Dedicated Short Range Communication) are not currently applied to CVO, they offer traffic information and ETCS (Electronic Toll Collection System) services, which can extend their service areas to CVO market. GPS satellites give the information of an exact spot and automatic vehicle location (AVL) services can be provided, but this method cannot be self-satisfied. Wireless telecommunications such as cellular, GSM, DSRC need to send the data from GPS satellites to the operation center. DSRC has limitations in wide-area communications as it is oriented for short-range and it requires devices along the roads. Cell tracking services have wide range of errors, approximately one kilometer. To acquire exact information, GPS sensors are needed and connected to cellular and GSM phones. Beacon and Infra-Red can also be applied to tracking services of trucks (Ahn, 2002).

3. CONTAINER TRACKING SERVICE (CTS)

I have worked on implementation of CTS (Container Tracking Service) for several years with many core technology providers, such as Korea Orbcomm, GeoNSpace, Unicon Communications, etc. in Korea. This location-based system has several key elements. Figure 2 shows the image of container tracking service using GPS. The procedure is as follows. Containers installed with GPS antenna and receivers are carried by ship through ocean. They are unloaded at terminal of container yards and they are headed to final inland destination. Simultaneously all activities and status of containers are reported by LEO, and ISP (Internet Service Provider) notifies the information to shipping company or consignors. Communications like DSRC and Cellular can only provide services in land; moreover, roaming services are necessary to cover many countries. In this manner, satellites can offer global services, covering many countries and ocean without efforts on international standards. Although Orbcomm satellites cannot provide voice-oriented services, it does not matter in tracking and tracing services of containers

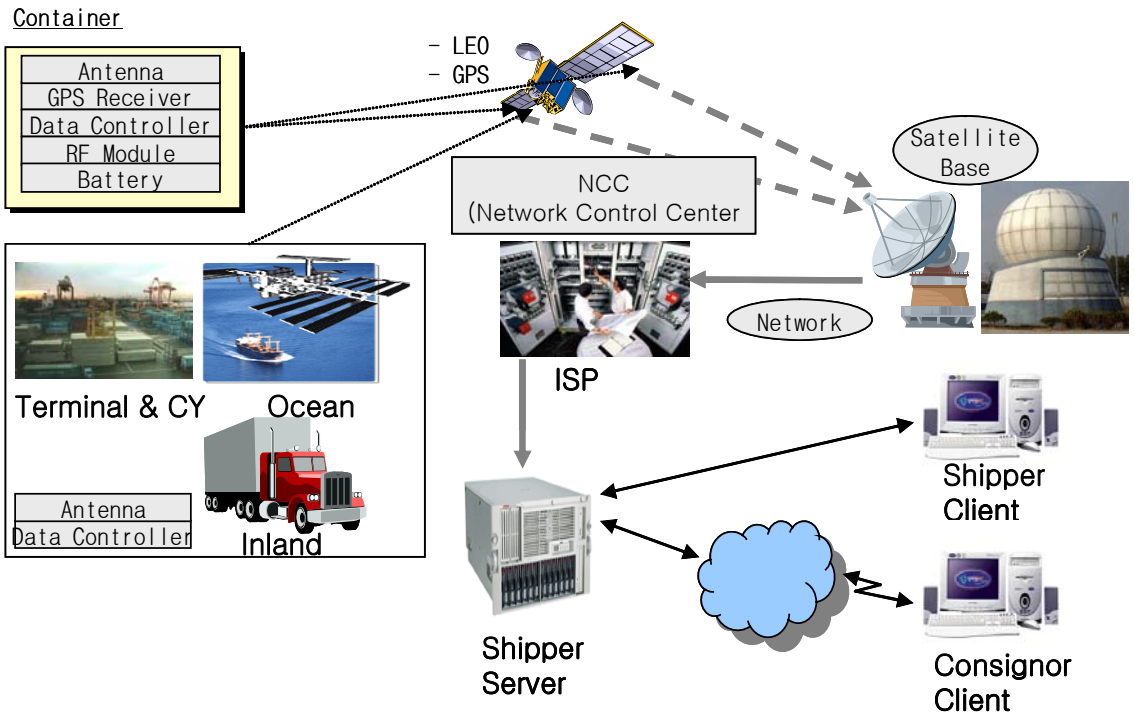

Figure 2. Scheme of Container Tracking Service

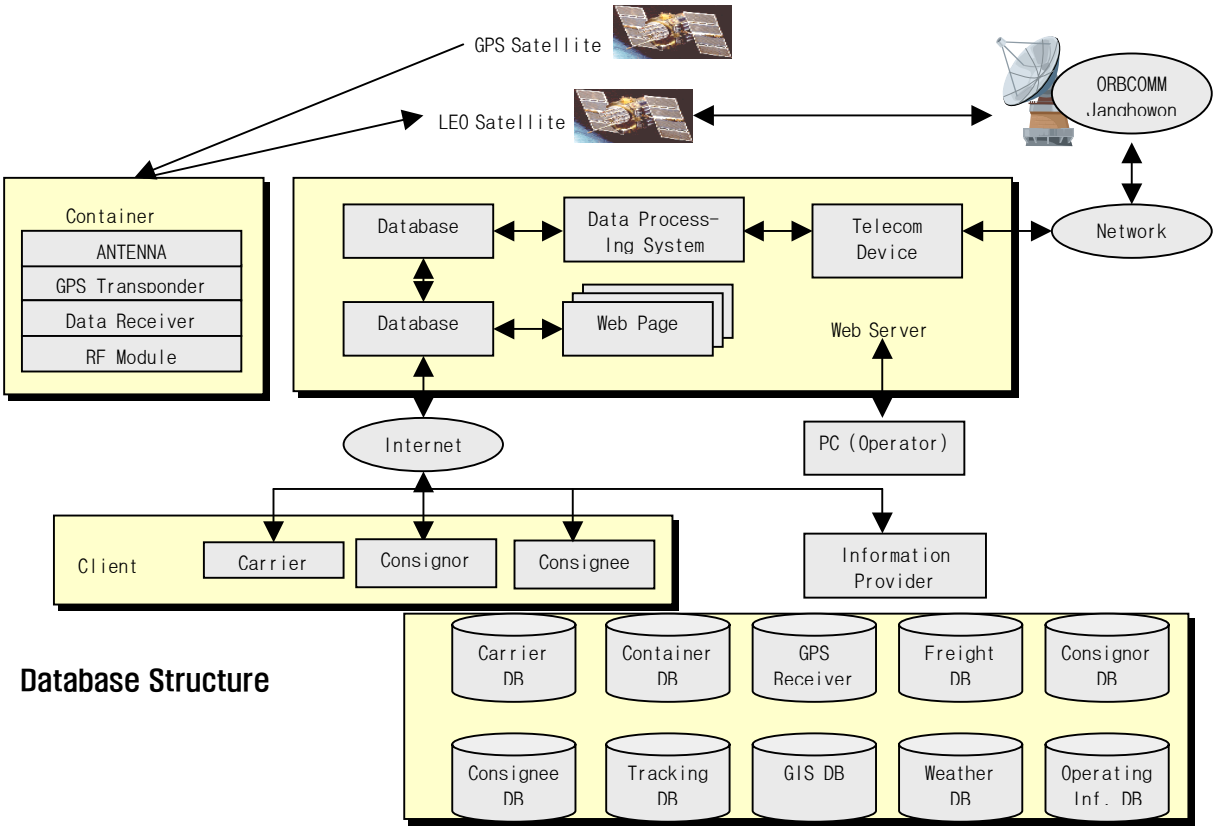

Figure 3. Database Structure of CTS

4. KEY COMPONENTS OF CTS

The CTS consists of four main elements such as antenna, receiver, RF module and battery. The structure of each element is described in each section.

4.1 Antenna

Since GPS is broadcasting system, the container should be well detected and located by satellites. The main constraint is that the antenna should be always exposed to outside, the receiving error can be expected into shade regions. Containers also can be stacked with multi layers, and it takes risk of breakage. Among these restrictions, we selected LEO (Low Earth Orbit) as Korea ORBCOMM. The system represents a new era in remote messaging and data communication. Using a constellation of LEO satellites, ORBCOMM provides cost-effective monitoring, tracking and messaging capabilities. The system increases the productivity and efficiency of remote operations by making location coordinates and other critical information readily available-often from areas that are beyond the geographic and economic reach of traditional systems.

The satellite relays these messages to an ORBCOMM Gateway Earth Station (GES). The message is sent through a Gateway Control Center (GCC) to its destination, through the Internet or other terrestrial networks, to a personal computer, or to a subscriber communicator pager. Messages and data sent to a remote Subscriber Communicator (SC) can be initiated from any computer using common e-mail systems, including the Internet mail and X.400. The NCC or GCC then transmits the information using ORBCOMM's global telecommunications network. The system uses 137~138 MHz and 400 MHz frequencies for transmissions down to mobile or fixed data communications devices and 148~150MHz frequencies for transmissions up to the satellites.

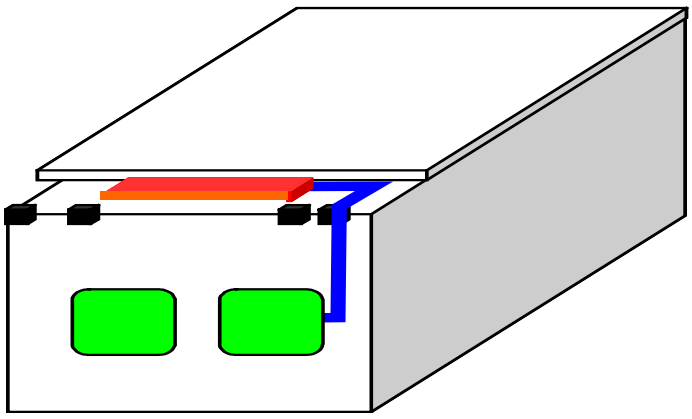

Figure 4. Installation of Antenna

4.2 Receiver Module

The system receives the signal from GPS via satellite, and it can monitor the status of container. We set the power below the 10mW and the channel up to 21 differences. Possible interference can be occurred but, the antenna was manufactured according to the minimum allowance. Figure 5 displays the assembly of antenna and the module.

Figure 5. Configuration of Receiver Module

4.3 RFM

RF Module monitors status and position of refrigerated containers. Servers in remote areas and Wireless Data Collector (WCD) use satellite communications; but controllers of containers use short-range RF modules. Therefore, Wireless Monitoring System (WMS) is required for transportation-system managers. RFM is composed of three systems; Data Reading System, Data Collecting System, and Monitoring Systems.

4.4 Battery

As one of main problems, we had to solve the battery functions. Since it takes more than 3 months for the container to be reclaimed, the life of battery should be more than the same period without recharging. Solar battery could be a solution, but weather does not allow the container to be exposed to Sun at all times. Therefore, we designed the battery minimizing the necessary power such as total of 20Ah. We also assumed 4,320 as the average number of message transmission for 3 months.

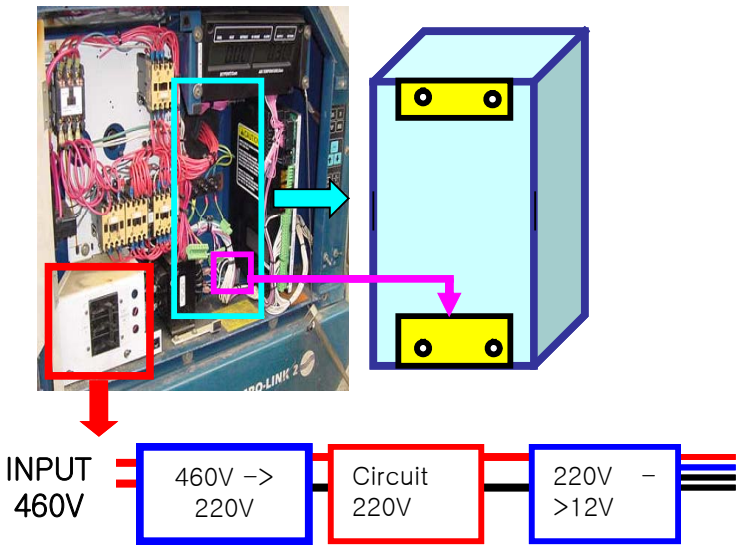

Figure 6. Outline of Battery Installation

$$\text{Total Transmission} = 4{,}320/3 \times 0.003Ah = 13Ah$$
$$\text{StandbyPower} = 0.025\text{Ah} \times 90days = 2025Ah$$

The initial input is AC 460Volts, and transformer works for 220Volts. The final system output is set to 12Volts. Figure 6 shows an outline of battery installation.

4.5 Web GIS

As an application of CTS, the system can track and trace the container and it provides web GIS. With simple globular map, the system can visualize the exact location of the container. User can easily select the container and search data. More information also can be withdrawn including exact altitude and latitude.

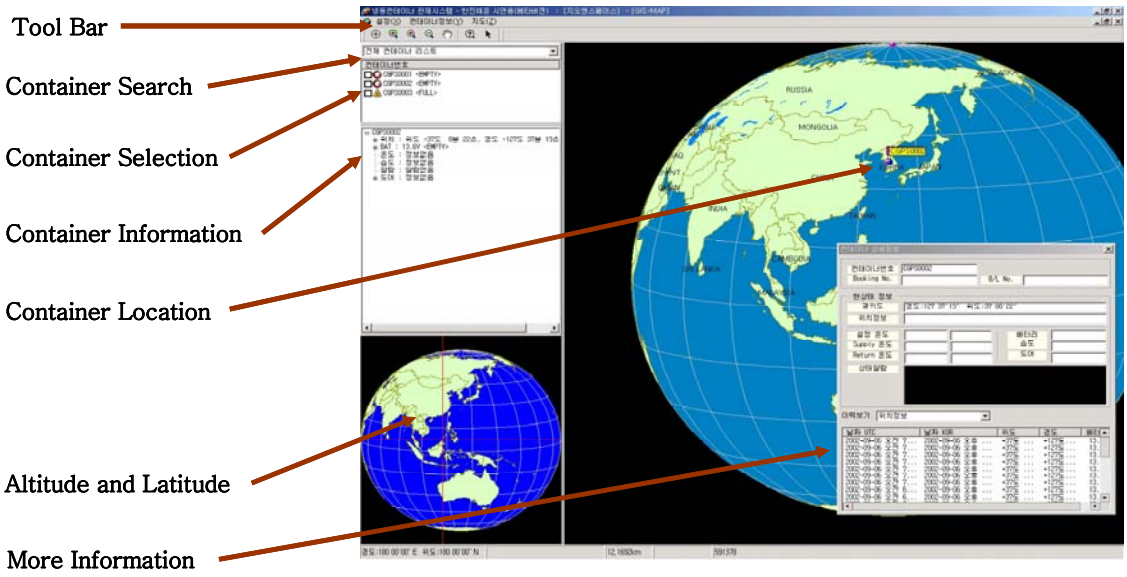

Figure 7. Example of Web GIS

A deployment test was done through 2003 and 2004. The system was applied to two refrigerated containers owned by Hanjin Shipping Co., which is in Figure 8. One was tested in south of the Korean peninsular and the other was tested along the west coast of North America. The test was successful in the ships: Orbcomm provides commercial services for vessels and trucks in Korea and the services are regarded as stable. As only two containers were tested and I could not follow the whole process such as ports and land transportation, the testing experiments cannot show its feasibility, including validation.

Figure 8. Deployment Test (Hanjin Shipping Co.)

5. CONCLUSIONS

In a deployment test of CTS, there was no problem in technologies. Limitations exist in handling containers: for example, many shipping companies, forwarders, and manufacturers use containers as a pool system. Regulations for equipment and devices are different in countries. Shipping companies provide services for manufacturers, wholesalers and forwarders; additional services raise the shipping costs. Therefore, a business model needs to be thoroughly investigated.

The proposed CTS can cover many areas for mobile business. Tracking and tracing containers is one of main issues among shipping companies and freight forwarders. In terms of managing containers, we can not only enhance global visibility, but also save costs against losses or damages. This work shows a new paradigm of location-based systems and possibility of global tracking system over worldwide. Since the system is limited to special containers with power supply, the way to apply for regular containers should be investigated.

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