A Study on Data Communication Method for Optimizing Communication Cost of Real-Time Based Global Container Tracking System

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Abstract. As the trade gets animated due to the abolition of the trade barrier worldwide, the number of global containers being moved increases. Along such a trend, each main agent that uses the logistics services requires real-time location information, security information to prevent the theft of cargo and information concerning temperature/humidity/impact to check the internal status of containers in order to check if the cargo is being transported with punctuality by using the ubiquitous technology. The plan of communication & operation of the container tracking system proposed in this research provides functions that can manage the container as the container tracking device transmits and receives data with the data-collecting server. This is done by tracking the container units which are transported worldwide through a real-time mobile communication module and base stations of mobile communication companies unlike the existing method. In addition, minimizes the communication costs generated when operating the system as well as the information required to manage the container by providing the communication method that has a systematic communication standard and data format in case of communication between real-time tracking device and the location information-collecting server.

Keywords: Global container tracking system, Communication cost

1 Introduction

If the international trading volume increases as the tariffs are abolished due to the conclusion of the PTA, it is expected that the quantity of goods transported would increase as well. Though there are various transportation methods such as marine transport, air transport, railway transport and land transport in case of internal trade, the increase of trading volume means the increase of marine quantity of goods transported. This is because of marine transport whose freight charge is cheap for being used in most cases. In order to transport the increased marine quantity of goods, though it may differ according to the trading goods, it is expected that the amount of containers increases as much as the increased trading volume because most cases are supposed to be loaded in the standardized and normalized containers. The logistics companies are adopting the related systems to provide value-added services such as safe transport, location tracking and provision of status information (temperature, humidity, impact & opening/closing door) as well as the simple transporting unit along such as changing environment. But, now that the existing RFID-based container management systems have the limit to provide real-time passing information of points from shipper to consignee, it needs to develop a M2M(Machine to machine)-based real-time mobile communication technologies whose utilization have increased currently by applying them to the container to provide the information the users want.

Now that the system that transmits and receives the information of containers in real time which is transported worldwide, what is proposed in this research can receive the supply of information that the users want and does not require the installation of a RFID reader compared to the existing RFID-based container management system. Also, it costs less to build up the infrastructure. However, it has problems such as high communication costs because the services of mobile communication companies for real-time communication and has to pay for huge data due to worldwide transporting of containers rather than in a specific country, due to the different classes of communication costs for each country such as roaming. The real-time based global container management system to satisfy the requirements of the logistics environment that has changed due to the conclusion of FTA explained as above is proposed. In addition the communication method to minimize the costs of the global container system is also proposed in this research.

2 Literature Review

The advanced researches up to date related with the global container management system and communication methods are as follows. C.Y. Lee[1] developed a message protocol that supports interoperability between application systems by applying the features that the M2M-based sensor system has in an M2M-based environment that transmits and receives the sensor data with real-time communication not in RFID-based system. J.T. Kim[2] studied the communication method and protocol in the equipment that supports real-time communication such as a proposal that provides the safe mutual authentication and key exchange between M2M-based equipment and information system. It performed the study of perspective that improves the performance of communication. However there is a difference from the study of operating plan to reduce communication costs carried out in this research.

3 Real-time based global container tracking system

The real-time container tracking system introduced in this research is attached to the inside of the container carrying the real-time container tracking equipment as described in Fig. 1 and detects the information of the location and state(temperature, humidity, vibration and the opening/shutting of the door) of the container carrying the equipment in real time.

3.1 System configuration

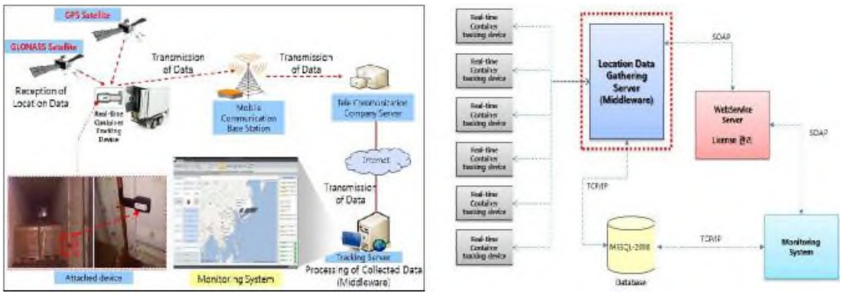

Fig. 1**.** Diagram of the Container Tracking System

The information detected from the real-time container tracking device is transferred to the middleware and monitoring system through communication i8tlnfrastructure such as a mobile communication base station, etc. Also, as users can check the status of containers in real time, they are able to make proper decisions for global SCM. The container tracking device applied to the container tracking system uses WCDMA(Wideband Code Division Multiple Access) and GSM(Global System for Mobile communications) communication systems. The location of the device & temporal information are acquired by using GPS/GLONASS for identification of location. The real-time container tracking device checks the time using RTC(Real Time Clock) and in case temporal information cannot be acquired from GPS or GLONASS, the prior-transmitted time is used. In addition, time synchronization is implemented by using UTC(Universal Time Coordinated), however, it is composed to synchronize the time of RTC using the value of UTC and GNSS acquired from communication with the base station of mobile communication when the electric power of the device is initially operated.

3.2 Applied case

Real-time based global container management system that is explained as above is under operation as the type of pilot by working level and was specifically applied to the areas where marine transport and land transport(TSR : Trans-Siberia Railway) from Korea to Moscow, Russia are linked. In particular, TSR is the longest railway in the world connecting a distance of 9,300km between Moscow and Vladivostok. It has a harsh transportation environment in which the temperature gets below -30℃ in the winter.

Table 1. Application environment of global container tracking system

Section		Definition
Objects		2 LCL cargo containers of 40ft
Operational Period		Dec. 16, 2011 (Fri.) ~ Jan. 10, 2012 (Tue.), for 26 days
Selection of Routes and Equip.		Yangsan ICD in Korea ~ Busan New Port in Korea ~ Vostonych Port in Russia ~ Moscow, Russia(Among 100 devices, 2 devices were selected randomly)
Equip. ID	11110089	Cycle of transmitting information: 1 hr domestically, 10 hrs overseas
	11110227	Cycle of transmitting information: 1 hr domestically,1 hr overseas

4 Communication protocol and method of T/R data 4.1

Communication protocol

The real-time container tracking device transmits information according to the established cycle (basically 1 hour), and at this time, using a TCP/IP socket communication, it transmits information to the server by a payload (40 bytes) as shown in the table below. In case of transmitting information, SEED encryption algorithm is used for the information protection with a payload of 40 bytes, and in case the information cannot be transmitted to the server due to the surroundings (No ship, steel-frame structure and base station for mobile communication), the retransmission of the information is to be attempted once.

Table 2. Payload of Information Transmission in Real-time Container Tracking Device

Section	Index	Protocol ID	Device ID	Date & Time	Location Data	Temp	Humid	Impact	RSSI	Error Status	Door Status	Battery Capacit	On/Off	TR Cycle
Length (byte)	2	1	8	6	11	2	2	2	1	1	1	1	1	1

In the real-time container tracking device, information is periodically transmitted to the server by using a TCP/IP socket communication, and in the server, the packet that is encrypted through SEED encryption is decoded and ACK (ACKnowledge) is identified. At that time, the length of the encrypted packet is 32 bytes, and if it is normally decoded, it is arranged into 19 bytes. A detailed explanation of the received payload is as follows.

Table 3. Payload in case of receiving information from server

Section	Packet Length	Protocol ID	Device ID	Setting Change
Length(byte)	1	1	8	1

4.2 Cause of additional communication costs

In the real-time container tracking system, data is transmitted and received in the TCP/IP method and, at this time, data is transmitted 100% correctly at the level of protocol. But, in case of forwarding data twice when transmitting it from an equipment, there is a need of sorting the message to its original status separately because the end of the server receives the data in a bundled condition. In general the end which receives data in the TCP/IP communication reads it at a socket buffer of server side whenever there is a request of received method. Also the data read, at this time, is decided according to the buffer size allocated by the received method. That is, if buffer size is smaller than the data to read, the problem of not being able to read the data completely would occur and if buffer size is increased limitlessly, the trade-off is that memory at the server end may be wasted.

Other than that, though there is a room for the socket buffer at the end of the server as shown in the figure below, the case which data is not received due to the multiple forms of transmitted message size may happen. In case where the size that the C# server socket processing part based on a .net framework 4.0 receives from the equipment one time is 33 bytes or the data is received in a bundle, it shows that it is not received in multiple forms of the one-time transmitted message size. That is, when the data of 23537bytes arrives at the socket buffer like in the case below, it receives the message that it is going to receive it next time in advance as the number of 0.2424 as 23537/33 = 713.2424.... In this case, the incorrect information is saved in a database due to the occurrence of a problem when processing data at the server.

Fig. 3. Data arrived at socket buffer and Data packets to be lost

In order to solve such a problem, it processes data by collecting the packet as much as its size at the server as it forwards the data size to transmit in case of TCP/IP communication between server and equipment(client) and transmits the actual data.

However, the real-time based container management system proposed in this research transmits and receives data through a mobile communication network such as WCDMA or GSM, etc. When using a mobile communication network such as WCDMA or GSM, etc., the transmission and receipt are implemented by attaching the header and authentication-related packet(PDP Context: the gathering of various kinds of information for connection with Packet Data Network) additionally for maintaining the session between equipment and server whenever transmitting data. That is, a much higher communication cost occurs because more data is transmitted. Nevertheless, if it takes enough buffer capacity for receiving data at the end of server, it is regarded as the normal data receipt being not completed at the server because of a parsing problem that would take place at the data which is going to arrive as shown above Fig. 3. and retransmission is attempted accordingly and the communication cost definitely occurs by that.

4.3 Method of transmit/receive data for optimization of communication cost

The real-time container tracking system proposed in this research enables it to set the buffer size of the server socket that receives data flexibly in the server or external client program to resolve such structural problems of TCP/IP, and the problems that are generated when using mobile communication networks such as WCDMA/GSM.

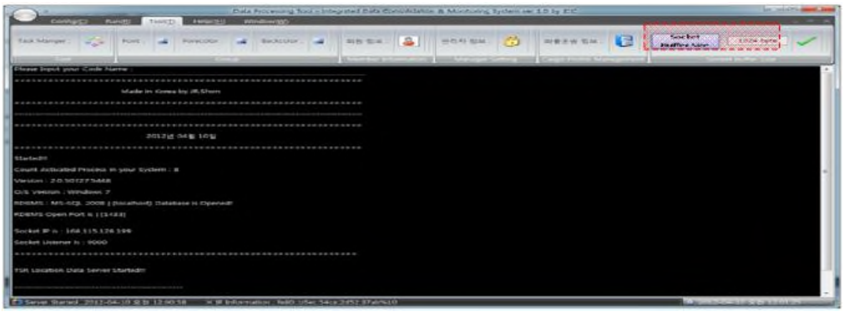

Fig. 4. Setting of socket buffer size at the server

It was composed to set the buffer size of the server socket by setting the socket buffer side at the server as in Fig. 4. Also it was designed to process the socket buffer size to 1:1 after analyzing the form of message received through such method. With that, the equipment can minimize the loss of packet by only transmitting the message size that was set flexibly in the server or an external client program, transmitting the data that exceeds the set value during the next communication. That is, communication costs can be saved because retransmission between equipment and server does not happen as a loss of packet does not take place.

5 Simulation analysis of communication cost

In order to check how much communication costs the plan proposed in this research can save compared to the existing method, an analysis was performed by using the simulation program of measuring communication cost provided by A company(a Global Telecommunication company) as in table 4, Fig. 5.

Table 4. Environmental variables applied in the simulation program

Section	Details
Number of container tracking device	10,000EA
Countries that mobile communication was applied	South Korea, Russia, Belarus & Poland
Ratio of used communication for each country	South Korea(5%), Russia(75%), Poland(10%), Belarus(10%)
Calculating method of communication cost	Apple the amount of used data and rate of tariff for each country

The environmental variables set in the simulation program are as follows. It was presumed that retransfer rate of data increases by 10% when communicating without using socket buffer configuration at the server such as the common TCP/IP communication method. Also, the data communication cost per container tracking equipment was as much as 6.32 € a month at this time. But, when applying settings of the socket buffer configuration at the server proposed in this research as in Fig. 5., it can be presumed that the retransfer rate of data almost never occurs and the data communication cost per container tracking equipment was as much as 5.92 € a month at this time. If compared in respects of operating cost regarding the above results, it came out to 63,200 € in case of using 10,000EA of equipment per month and 59,200 € in case of using the socket buffer at the server per month. It is expected that the plan that uses the socket buffer setting at the server can save as much as 4,000 € per month and as much as 48,000 € can be saved in one year.

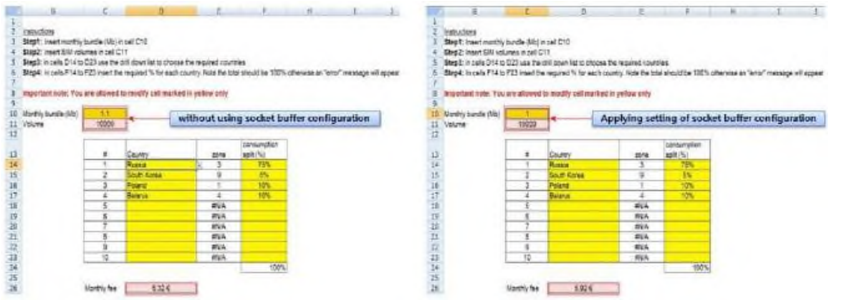

Fig. 5. Analysis of data communication cost according to the socket buffer size configuration

6 Conclusion

This research can provide the configuration of a container tracking system and the optimization of communication costs for global SCM by presenting a communication protocol and data communication methods in case of communication between real-time container tracking device and the server that collects the information. But, in case of data communication method suggested in this research, it has limitations in that the communication costs were measured only by a communication simulator program of a mobile communication company, and we are willing to apply and analyze data communication method suggested in this research to the various transportation routes as well as the container transportation between Korea and Russia in further research. We expect that the results of this research can be used in places that require real-time tracking and status information of cargo using mobile communications such as circulation & cold chain as well as containers.

Acknowledgments. This work was supported by the grant No. B0009720 from the Regional Technology Innovation Program of the Ministry of Knowledge Economy

References

[1] C. Y. Lee.: A Study of the Message Protocols Technologies in M2M Platforms. Journal of Korea Information and Communications Society, vol.35, no.1, pp.53--61 (2010)
[2] J. T. Kim, Analyses of Light-weight Protocol for in RFID System. Journal of the Korea Information and Communication Engineering, vol.15, no.11, pp.2399--2403 (2011)