

# Pilot Case for Container Security Device (CSD) Based on Active RFID

Eun Kyu Lee, Young Sik Moon, Joong Jo Shin, Jung Rock Shon, Sung Pill Choi, Chae Soo Kim,  
Jae Joong Kim and Hyung Rim Choi, *Member, KIMICS*

**Abstract**— CSD is Active RFID based Container Security Device which is proposed by the U.S Department of Home Security. It is mounted inside the container to sense opening of the container door. ConTracer is the CSD which is developed in this research whose major features are sensing door opening status as well as history inquiring on internal environment and shock to the container by mounting the temperature/ humidity/ shock sensors. Moreover, its RFID frequency bandwidth uses 433MHz and 2.4GHz to correspond actively to the frequency used by different countries. This paper introduces the development trend of CSD, compares the ConTracer which is developed thru this research and other company's CSD, and introduces CSD System which is designed and established using ConTracer. Finally, the implemented CSD System is verified by applying the demonstration service to container distribution between Korea and China.

**Index Terms**— Container Security Device(CSD), Active RFID

## I. INTRODUCTION

Active RFID(Radio Frequency Identification) has longer recognition distance compare to passive RFID and easy to apply to metal material which makes it easy to utilize in port and inland logistics transportation management system and container security area.

According to the statistic data[1] from Drewry in 2008, total global container port freight volume is 586,930,000 TEU(Twenty Feet Equivalent Unit). North America port freight volume is 49,670,000 TEU, and the U.S reinforced its logistics security system in omnidirectional way to fundamentally block the terror threat against its country by establishing DHS (Department of Homeland Security) which generalizes safety and security jobs, and series of Maritime Security Act, SAFE Port Act, 9.11 Anti-Terrorism Implementing Recommendation Law. Especially, it signed the law which requires security device, which is recognized by US Customs Office and which can confirm that the container door is not opened during transportation, shall be mounted to all the

containers into the country from 2012. In addition to the U.S, EU reinforced logistics security by establishing 'Shipping and Port Facility Security Regulation' which mandates even the International Maritime Organization (IMO) Recommendations of ISPS Code. Also, it continues efforts to reinforce logistics security by legislating the logistics security regulation which is focused to World Customs Organization's (WCO) SAFE Framework, the business security system, and by establishing and operating import freight search system.

This is current trend of advanced countries around the U.S and Europe that they expand investment for related R&D such as developing electronic seal system, smart container technology and standardization as well as market promotion to reinforce security measures while preventing the obstruction in logistics flow.

The representative electronic security devices for freight container are eSeal (Electronic Seal) with Active RFID technology, and CSD (Container Security Device).

eSeal is mounted to the freight container's door. It senses abnormal opening of the container door and inform it to the reader close-by, and maintain its history.

CSD senses freight loss, theft and intrusion into the container when mounted inside the container. There is no standard for CSD as of now, and U.S DHS issued technology spec which is required by Customs & Border Protection (CBP) [2]. According to this spec, foreign companies such as GE centered Commerce Guard and Savi from the U.S and CIMC from China are progressing R&D activities. But there is no product developed to compete with foreign products up to now in severe competition situation by many other foreign companies.

Therefore, this research surveyed electronic security device development direction, and compared the CSD device developed by this research with other company's products which meet DHS CBP requirement spec. [3], [4]. The CSD device developed by this research is named ConTracer. Establish CSD system using the ConTracer, and implemented it to container freight between Korea and China to evaluate the system performance for validating the reliability of this research [5].

This paper is composed as follows. Related Research in Chapter II surveys development trend of electronic security device, compare and analyze container security products. Chapter III explains ConTracer and CSD system using ConTracer. Chapter IV evaluates the performance of demonstration service in domestic/ between Korea and China, and Chapter V gives conclusion.

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Eun Kyu Lee is with the Intelligent Container R&D Center, Dong-A University, Busan, 604-714, Korea (Email: jabanora@dau.ac.kr)

## II. RELATED RESEARCH

This chapter surveys development trend of electronic security device, compare and analyze container security products developed by other companies and ConTracer developed in this research.

Figure 1 shows the development trend of Seal used in containers. One or more traditional bolt barrier "Seal" of plastic or metal "Seal" has been used as door hasp mechanism has been used since the early period of container freight logistics. With development of IT technology and emphasized importance of container security since 2000, eSeal is developed which is mounted to the container door and senses abnormal opening of container door using active RFID technology.

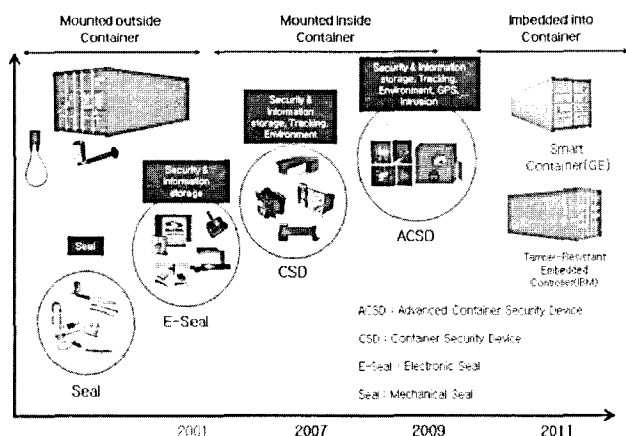


Fig. 1. Trend of Container Security Device

But eSeal is mounted outside container door, has disadvantage that it is fragile and is not reusable.

CSD development became serious according to the CSD requirement document published by US DHS in 2007 which is mounted inside container to detect illegal opening of container door, and can be reused. Currently, ACSD (Advanced Container Security Device) is under developing which is advanced version of CSD, and enables container inside monitoring and illegal immigrants monitoring as well as illegal door opening. Future evolution will be intelligent container with embedded ACSD instead of mounting it to the container.

Device characteristics of ST-675 from Savi and CSD from GE Security which, represents current container security device, are analyzed in Table 1. These two devices can be utilized in container security related area such as CSI and SAFE Port Act, C-TPAT, 10+2 Regulation of U.S DHS. The ST-675 from Savi is a container security tag and developed according to ISO/IEC 18000-7 spec which is RFID standard. It uses

433MHz frequency bandwidth, FSK modulation method, has 0.6mW, and recognition distance from reader is 122m. It is mounted outside of container door edge using auxiliary C-Clamp. It senses door opening with breach and illumination sensor, and is mounted with temperature, humidity and shock sensor to provide history. ST-675 complemented the eSeal's disadvantage of unable to reuse, but it still has disadvantage of fragile since it is mounted outside.

GE's CSD is developed according to ISO10374 which refers to automatic recognition system during container transportation. It uses 2.4GHz frequency bandwidth, and adapts BPSK, DSSS modulation method, has less than 1mW output and less than 30m distance between tag and reader.

TABLE 1.  
FEATURE COMPARISON BETWEEN CONTAINER SECURITY DEVICE COMPANIES

Item	Savi Network (ST-675)	GE Security (CSD)
Standard	ISO/IEC 18000-7	ISO 10374
Frequency Bandwidth	433MHz	2.4GHz
Modulation	FSK	BPSK DSSS
Output	0.6mW	<1mW
Recognition distance	around 122m	around 30m
Container Mounting	C-Clamp	Magnetic Mounting
Door Opening Sense	Breach and Illumination Sensor	Proximity Sensor
Temp/Humidity Sensor Range	-32°C~+70°C	-40°C~+70°C
Shock Sense	○	×
Battery Life	4 Year (Lithium)	6 Year (Lithium)
Application	DHS CSI, C-TPAT, 10+2 Regulation, SAFE Port Act	

It is mounted between container wall and door using magnet, senses door opening using proximity sensor. It is equipped with temperature and humidity sensor and provides its history during transportation. But CSD has disadvantage that it is not equipped with shock sensor and unable to sense impact to the container, and has only 30m of recognition distance between the reader and tag.

### III. CONTRACER INTRODUCTION

ConTracer which is developed by this research is developed to comply with U.S DHS's CSD requirements and ISO/IEC 18000-7 Standards. It uses two frequency bandwidth of 433MHz and 2.4GHz. 433MHz adapts FSK modulation, and 2.4GHz adapts O-QPSK modulation. It has less than 3.6mW output with more than 100m recognition distance between reader and tag. It is mounted between container wall and door using magnet, senses container door opening using micro-switch. It is equipped with temperature, humidity and shock sensor to detect the container status during transportation and provide history. ConTracer is mounted inside the container, has less risk of damage, reusable and has long recognition distance of more than 100m.

#### A. Introduction of ConTracer

Figure 2 shows each part of ConTracer components developed in this research. It is composed of Micro-switch to detect container door, 433MHz RF Module Mounting, Main Board Mounting for temperature, humidity and shock sensor, and 2.4GHz RF Module Mounting. It is designed and manufactured to select 433MHz RF module or 2.4GHz RF module according to the requirement.

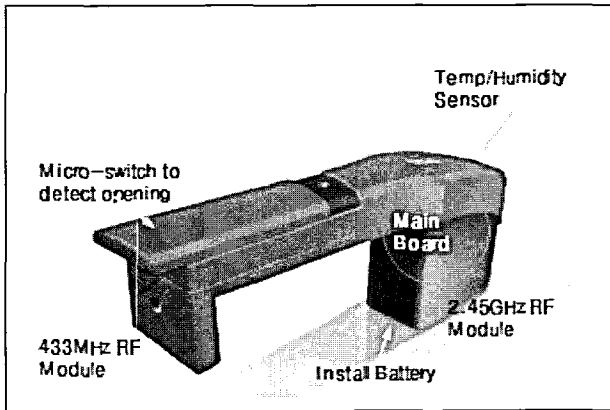


Fig. 2. Description of ConTracer

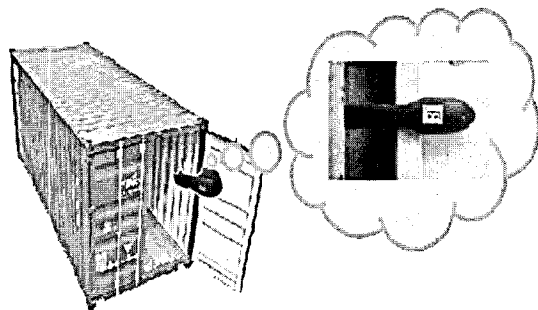


Fig. 3. ConTracer Mounting Location

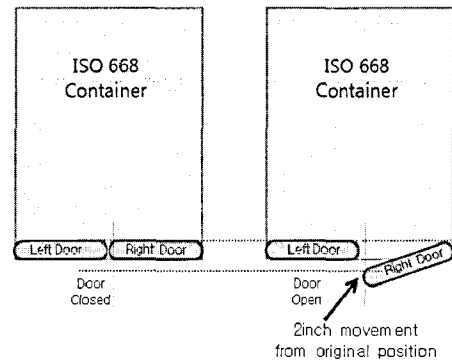


Fig. 4. Door Status Sensing Requirements

ConTracer developed in this research is designed and manufactured to fit to all Dry containers which comply with DHS requirements and ISO 668[6] Standard. As seen in Figure 3, it is mounted in the gap between container wall and door at proper height using fixing magnet. Figure 4 shows door status sensing method based on DHS RFI.

#### B. Container Door Opening Detection by ConTracer

ConTracer is mounted at the gap between container door wall and door, mounted using fixing magnet. It detects container door opening within 2 seconds by pressing micro-switch using the slider attached to wall when the door opened more than 2 inch. The accuracy of door opening detection is above 95%, and it is designed to operate in severe port environments specified in ISO 10374[7] standard.

#### C. Establish CSD System using ConTracer

Figure 5 shows CSD System established using ConTracer which is developed in this research. This CSD System complies with U.S DHS's CBP requirements. And the system is composed of 433MHz, 2.4GHz frequency bandwidth ConTracer, fixed type Reader which performs RF communication with each frequency, Control Program which manages Reader, and DCP (Data Coordination Point) which stores information received from ConTracer.

To drive the ConTracer which is implemented with the system in this research, fixed type Reader is developed by Research Team 2, and Control Program is developed by Research Team 1, and DCP is developed by Research Team 5.

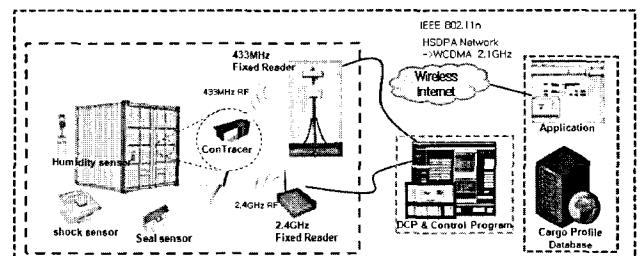


Fig. 5. Indicates door opening detection method.

### IV. CSD SYSTEM IMPLEMENTED DEMONSTRATION SERVICE USING CONTRACER

This chapter introduces domestic and international demonstration service between Korea and China which was made to verify the performance of CSD System established in this research.

#### A. Domestic Demonstration Service

Domestic demonstration service was performed for CSD System performance verification established in this research by mounting ConTracer to empty container which departs from Yangsan ICD (Inland Container Deport) and transported to Gamman CY(Container Yard) through Baekyang Tunnel.

Figure 6 shows general scenario of the domestic demonstration service. Mount 433MHz and 2.4GHz ConTracer inside the container, arming the container to start status detection, and activated the ConTracer. Fixed type Reader monitors the ConTracer status in the container when the vehicle passes through Yangsan ICD Gate. Recognize ConTracer from fixed type Reader installed at Baekyang Tunnel toll gate, the intermediate check point, to inspect the sealing status and container inside status. Recognized the ConTracer mounted in the container from the fixed type Reader installed at Gamman CY Gate and confirm its delivery. Performed inspection for container inside Gamman CY, verified that there was no problem in container transportation, and deactivated the ConTracer and removed it from the container.

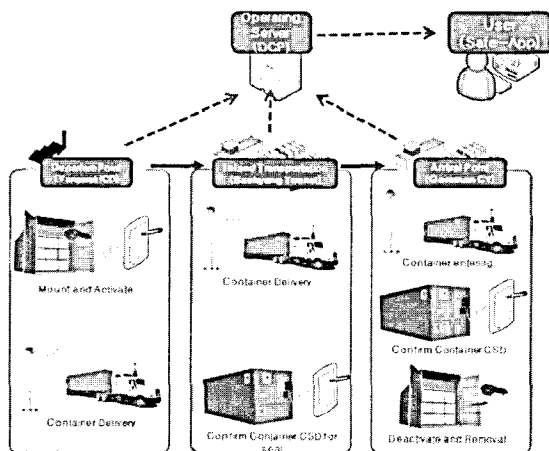


Fig. 6. Domestic Demonstration Service Scenario

According to the result from domestic demonstration service, both ConTracer, each with 433MHz and 2.4GHz mounted to container inside, departed from Yangsan ICD and arrived to Gamman CY via Baekyang Tunnel with normal operation, recorded temperature, humidity and shock to the container, accurately detected sealing status of the container, and confirmed transmitting the information to DCP.

#### B. International Demonstration Service between Korea and China

After the verification of this research developed CSD system's operating performance through domestic demonstration service, international demonstration service between Korea and China was performed using the research developed CSD System which is mounted to the container with full of freight by support from LG Company. The route departs from Namgyung Factory in China and arrives to Gumi Logistics via Pyeongtaek Port.

This demonstration service is to verify the functions of ConTracer according to the sea transportation of containers. Inspection was performed by installing mobile reader at major points, check whether the container is recognized when it passes the points, and check whether the collected information is transferred to the operating server, DCP, without damage.

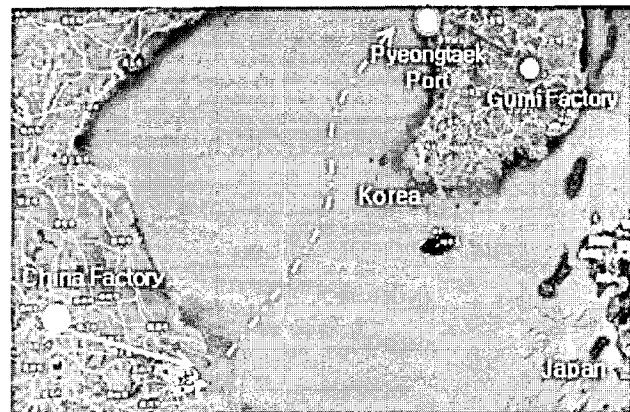


Fig. 7. Korea-China Service Route

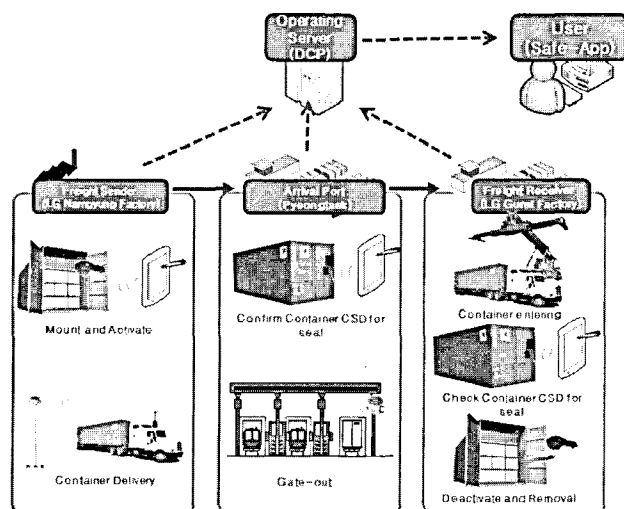


Fig. 8. Demonstration Service between Korea and China

Figure 8 shows general scenario of international demonstration service between Korea and China. After fill the freight to container from departure point of LG company factory in Namgyung, China, then mount each

of 433MHz, 2.4GHz ConTracer to proper height which would not damage the freight, close the door, arming and activate the ConTracer. Performed container mounted ConTracer recognition using fixed type Reader installed at the gate of stopover point, Pyeongtaek Port. Performed container seal inspection and intermediate inspection for container inside status. Recognized container mounted ConTracer from fixed type reader installed at the Gumi Logistics Site Gate to confirm the delivery of container. Performed inspection on the container to verify the status during transportation, confirmed that there had been no problem at the logistics site, then deactivate the ConTracer and removed it.

Figure 9 shows pictures of device installation and container vehicle which passes the reader in International Demonstration Service between Korea and China.

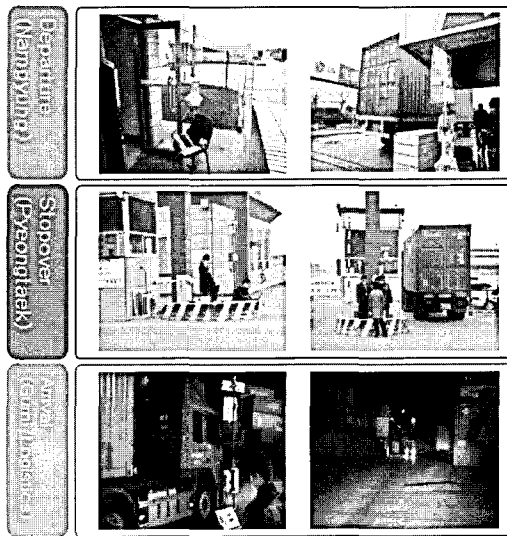


Figure 9. Device Installation for international Demonstration service between Korea and china

TABLE 2  
RESULTS OF CONTRACER RECOGNITION AND INFORMATION TRANSMISSION TO DCP BY EACH MAJOR POINTS

item	433MHz ConTracer		2.4GHz ConTracer	
	Reader Recognition	DCP Transmission	Reader Recognition	DCP Transmission
Arming (Namyung, China)	○	○	○	○
Gate-out (Namyung, China)	○	○	○	○
Gate-out (Pyeongtaek Port)	○	○	×	×

Inspection	○	×	△	○
Gate in (Gumi)	○	×	○	○
Inspection	○	○	△	○
Deactivation	○	○	○	○

Table 2 is the summary of International Demonstration Service between Korea and China results using this research developed CSD system. Both Arming and Activation for 433MHz, 2.4GHz ConTracer were done properly at departure, and its information is well transmitted to DCP through internet. For recognition and inspection on 433MHz ConTracer at stopover Pyeongtaek Port gate, inspection and recognition by the Reader was successful but failed to transmit information to DCP. For 2.4GHz ConTracer, it failed to recognize when pass through Pyeongtaek Port gate, but responded to inspection, which was successful in transmitting part of information to DCP. At the arrival Gumi Logistics Site, ConTracer is recognized at the gate but failed to transmit information to DCP due to network problem for 433MHz ConTracer. For 2.4GHz ConTracer, it was successful for both ConTracer recognition and information transmit to DCP. For Final Inspection at the arrival to check container status during transportation, both 433MHz, 2.4GHz ConTracer are properly recognized, and was successful to transmit the recorded temperature, humidity, shock information and container door opening history to DCP. Finally, both 433MHz, 2.4GHz ConTracer Deactivation were successful to stop ConTracer operation.

## V. CONCLUSIONS

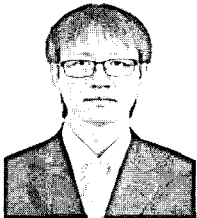
This paper introduced the development stages of container security device, and investigated container security devices whose design and manufacturing are based on Active RFID. It also introduced ConTracer which is developed in this research and complies with CSD requirements published by the U.S Department of Homeland Security (DHS). ConTracer is mounted at the gap between container wall and door using magnet. It detects door opening using micro-switch, equipped with temperature/ humidity/ shock sensors to detect transportation status of container and provide its history. It also introduced CSD system established with ConTracer implementation, and made performance evaluation through domestic and international demonstration service between Korea and China. Future projects would be ConTracer mounting location to solve recognition instability problem when the container is filled with steel freight, DCP interlocking problem for data transmission to server, RF performance environment interference of ConTracer in steel structure which were found from the international demonstration service results.

## ACKNOWLEDGMENT

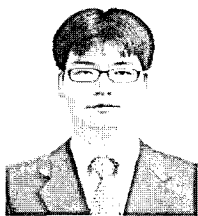
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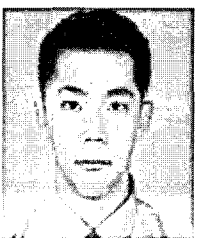
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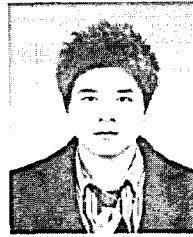
**Eun Kyu Lee** is an Assistant Researcher of Dong-A University. He received the B.S degree in information communication department from Young Dong University, Korea in 1999, and M.S degree in electronic information communication from Kunkok University, Seoul, Korea, in 2001. He is currently Ph.D. candidate in electronic information communication from Kukkuk University. His main research topics are active RFID and container security Device.



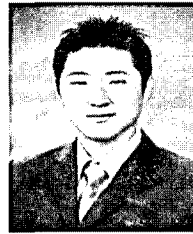
**Young Sik Moon** is an Assistant Researcher of Dong-A University. He received his bachelor degree in Computer Engineering Pusan National University in 2007. And M.S degree in Department of Computer Engineering from Pusan National University, Busan, Korea, in 2009. His main research topics are active RFID and container security Device.



**Joong Jo Shin** is an Assistant Researcher of Dong-A University. He received his Master degree in Management Information Systems from Dong-A University, Busan, Korea, in 2007. He is currently Ph.D. candidate in Management Information Systems from Dong-A University. His main research topics are a RFID/USN application and design & development of Port Logistics Systems.



**Jung Rock Son** is an Assistant Researcher of Dong-A University. He received his bachelor degree in Computer Engineering Dong-Seo University in 2003. And M.S degree in port and logistics system from Dong-A University, Busan, Korea, in 2010. His main research topics are a RFID/USN application, S/W Engineering, Port and Logistics Systems.



**Sung Pill Choi** is an Assistant Researcher of Dong-A University. He received his bachelor degree in Management Information Systems from Dong-myung University, Busan, Korea, in 2005. and M.S degree in port and logistics system from Dong-A University in 2010. His main research topics are a RFID/USN application, S/W Engineering, Port and Logistics Systems.



**Chae Soo Kim** is a professor of Dong-A University. He received his Ph.D. degree in Industrial Engineering from KAIST, Daejeon, Korea, in 1999. His main research topics are a RFID/USN application and design & development of Port Logistics Systems.



**Jae Joong Kim** is a professor of Dong-A University. He received his Ph.D. degree in Civil Engineering from Seoul University, Seoul, Korea, in 1989. His main research topics are a RFID/USN application and Port and Logistics Systems.



**Hyung Rim Choi** is a professor of Dong-A University. He received his Ph.D. degree in Management Science from KAIST, in 1993. His main research topics are a RFID/USN application and Port and Logistics Systems.