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Design of the management system of port in China based on the internet of things technology

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Research on the application of the internet of things technology in port management

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

Signature: .....

Date: ..... May 30, 2013 .....

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ABSTRACT

Title of research paper: **Research on the application of the internet of things technology in port management**

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The Internet of Things (IoT) refers to uniquely identifiable objects and their virtual representations in an Internet-like structure. With the relevant policy approved, IoT technology gets rapidly developing. IoT is more widely applied to the port construction, and it will have a huge impact on the construction of the port management system.

The dissertation focuses on how IoT be used in the application of the port management. From the view of port authorities, this dissertation states the definition, key technology and working principle of IoT and connects it with port development. Utilizing the IoT perception and interconnection technical feature, port management system connects the port facilities, cargo information, port logistics, to realize port intelligentization in the respect of recognition, location, tracking, monitoring and management. The author will put forward the concept of intelligent port and research on the application layer with feasibility analysis and data model.

To achieve this purpose, this dissertation will first introduce the internet of things technology, especially its architecture, which includes sensing layer, network layer, and application layer. Second, present the concept of the IoT port, and analysis the advantages, disadvantages, user demand and function demand of new port management system. Third, design the management system in the way of using IoT technology. Finally, illustrate real case to prove importance and necessity of developing IoT in port management.

The developing of ports in China now, has a huge influence around the world. The developing trend is accelerating information system construction to help major ports transform from the fourth generation to fifth generation based on IOT technology. In this dissertation, through describing the usage of IoT in container terminal management, the author will expound the concept of intelligent port management system for upgrading ports functions.

KEYWORDS: Internet of Things, Intelligent port, Port management, RFID

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List of Abbreviations

IoT	Internet of Things
RFID	Radio Frequency Identification
GPS	Global Positioning System
GIS	Geography Information System
EDI	Electronic Data Interchange
AIS	Automatic Identification System
VTS	Vessel Traffic Service

Chapter One: Introduction

1.1 Research background and significance

Port is a transportation junction for safe accessing and mooring equipped with facilities and conditions of water-land transshipment and is also an assembly place and pivot of water-land transportation. With the development of globalization, informatization and networking of economy, port which is the key step of international and domestic logistics supply chain and a pivot in logistics channel has been playing a more and more important role of improving the regional and local economic development as a joint of international logistical multimodal transport. Combined with the vigorous expansion of logistics industry, modern port has transformed its function from transiting and transporting to comprehensive logistics service center of more connotative and higher of level. The continually expanding of function makes it develop towards the direction of providing comprehensive value-added service. In order to adapt to development of modern logistics industry along with expanding and improving the function of value-added service, many countries of the world make much account of construction on port logistics system. After the construction within several years, our main ports have been preliminary formed into the port container transport system of rational layout, various types, perfect supporting facilities and higher-level modernization. There were seven Chinese ports raking on world Top10 of cargo and container throughput in 2012. The software and hardware facilities of

Chinese port have been currently stepped into world-class level with the specialized and upsizing development constantly of infrastructure construction. A number of ports have been transformed into the fourth generation port with its aspects of advanced port handling technology and efficiency. However, it also brings the crisis awareness to these ports with the difficulty of how to further upgrade the competitiveness of port for each port manager.

IoT (Internet of things), as the hot spot issue currently, has been showed great attention to all of the society. Established with the immanent network technology, IoT has become a completely new techno-sphere and a wave of IT industry after the appearances of computer, Internet and mobile communication network. IoT is a developing goal of next generation to achieve the “interconnection among objects” for the reason of making them delivery like information. So, IoT can make our world more intelligent. IoT can be applied into many aspects in our life like the industry sector of port, public safety, manufacturing, supply chain management, traffic guidance, military affairs, smart home, environment monitoring, health monitoring and so on.

This paper mainly studies the appliance and development of IoT which is based on RFID, GPS GIS and sensor technology in field of port to build the sensor network on aspects of container, wharf, waterway and logistics distribution, then to reach to the efficacy of reducing logistics costs, improving the transportation efficiency and security. Due to the supporting of these advanced technologies, can the information management system of port be improved along with the promptness in operation orderly and the diversity in service considerately of the fourth generation to ensure better to get to a qualitative leap. That is exactly what the idea of the fifth generation port --intelligent port.

Intelligent port here means the port based on IoT. It takes advantage of technological characteristics of the awareness of IoT and Internet to make a wider interconnection among various resources and participants of port equipment, cargo information and port logistics to realize the intelligent recognition, locating, tracing, monitoring and managing in port or wharf logistics, then to sensor more quickly and intensively and to informationize more promptly and deeply. The port based on IoT (IoP) is not only a new information technology and solution, but a new idea and developing pattern. The construction of it can bring into the integration of this industry catering for the transformation from 4PL in logistics field to e-business through the update of port information system to create the core of new generation international trading transportation, thus, to achieve the developing goal of shipping economy informatization, globalization and standardization.

This paper will fractionize the detailed appliances of technology on the foundation of giving the concept of the port based on IoT via researching the IoT technology and comprehensively analyzing its development on port management to propose a set of design concepts of management system.

1.2 Research status

1.2.1 Domestic research status

In the world field of IoT, one of the predominant countries is China has enacted the international standard with Germany, America and Korea. Nowadays, the standards system of Chinese IoT has been formed the preliminary frameworks which amounts

of proposals are adopted by international organization for standardization. Limited by development of IoT, this kind of technology is widely applied into port field. The comparative famous researches on port information platform in China have:

He Mingkan who teaches in business school at Beijing Technology and Business University in *Logistics System Theory,* pointed out that the excellent logistics information platforms interiorly achieved well on integration of logistics transportation and international trading, thus, to implement the functions of online trading, online electronic data transmission, online clearance, cargos tracing, online cargo operations on base of integration of the industrial services of international trading, shipping logistics, port, customs and so on. These logistics information platforms provided a new type of international trading method, reduced the operation links of logistics service, saved the costs and improved the core competitiveness of ports.

Xu Yongjun from the institute of computing technology, Chinese Academy of Sciences in his book *Appliances of IoT in Field of Port Logistics* pointed out that the objective of development scheme of IoT in intelligent port was to upgrade the working performance, improve the port environment, enhance the information construction, strengthen its integration, innovation, practicability and advance with the openness of its system. The IoT in intelligent port should require the informational demand of global port logistics chain, lie on each of the domestic ports to provide the safe, reliable, efficient and convenient managerial plans of port logistics.

Bao Qifan, the vice president of Shanghai Port, said that the container logistics in modern port needed the RFID system to record timely quantity, types, moves and safety information in container transport by using of the global network environment to achieve the full real-time online monitoring and improve its transparency, safety

and efficiency, and overall level of service of container logistics. Not only modern ports require the function of cargo handling, but integrate the function of logistics and services. The informational, smart and automatic technologies will play an important role on expansion of modern port logistics service industry.

There are about 80 existing members in Chinese Sensor Network Standardization working group led by the Ministry of Chinese electronic Standardization Institute, affiliated with Institute of micro-systems as their secretariat. Recently, the working groups is divided into 8 groups, that is PG1 (international standards), PG2 (standard system and architecture), PG3 (communication and information interconnection), PG4 (cooperative information processing), PG5 (mark), PG6 (security), PG7 (interface), PG8 (industrial application investigation).

1.2.2 International research status

The research on IoT technology abroad is earlier than that of China. The famous relatively researches are Professor Ken Sakamura from Japan, *EU Seventh Plan* and American theory of smart planet.

The professor Ken Sakamura, from Tokyo University, aiming at “realizing calculating to any object at any time and place ” by embedding TRON chip to make them “talk automatically”, thus, to reach to the interconnection among things and humans.

EU has been carried out its study in *EU Seventh Plan* from the following aspects of: correlated international standard and programs including the application and homogeneous criterion; the problem of supervision management and global coding system on some related standards; ubiquitous computing and network; the

development and related criterion of RED and sensor; current and future application area and its criterion; the social and economic factors and problems of security and privacy in applications.

The core of “Smart Planet” which is carried out by IBM, is that to change governments, corporations and human beings’ interconnection method which will be smarter than that before by using new-generation information technology to improve the definitude, effectiveness and flexibility and response speed of interconnection. The perfect combination between information architecture and highly integrated infrastructure makes governments, corporations and human beings smarter decisions. “Smart method” has the following three features of: more intensive sensor, wider interconnection and more embedded intelligence.

The platforms of TRADENT and PORTNET in Singapore, as the effective and paperless communication channel among the government, shipping agencies, firms and ship-owners have three main acts of: satisfying the customers logistics demands in port operation; providing the project management services to users; assisting the users implementing the port circulation control system to complete its logistics services.

The KTNET platform in Korea has moved its all trading on the Internet by setting them at the tasks to achieve complete electronics. What they provide is mainly contained of: giving the applications of credit attorney, letter of guarantee, cargo insurance request, notice of payment, arrival notice, raw materials purchasing documents and customs applications.

Other famous logistics information platforms of practical experiences are the

automatic system conducted by United States Customs mainly including automatic business system, enhanced system and management system; of which in Japan has been achieved the electronic customs clearance of import and export which having a cargo examination based on risk assessment through computer technology to upgrade the customs clearance efficiency.

1.3 Research purpose and procedure

This paper will carry out the innovation and escalation based on initial harbor facilities and information networks via the analyzing of IoT technologies to melt into a large amount of new IoT technologies to improve the efficiency, expand the amount of information, accelerating the information transmission and ensure its security aiming at studying and analyzing the application and development prospect of IoT technologies in port management.

The main procedures of this paper are arranged as follows:

Chapter One: introduction. Briefly to dissert the background and significance of this paper and give a description of domestic and aboard research status in this academic field to hide the foreshadowing for unfolding of this whole paper.

Chapter Two: the description of IoT technology. Combined with port logistics from the start of its architecture to analyze and introduce the IoT technology to carry out the conception of intelligent port, then, collecting this information to describe the development of IoT and its application in port.

Chapter Three: discussions of the problems faced in IoT technology when applied in port construction. Having the feasibility analysis on port construction according to SWOT model along with the analysis of its strength, weakness, opportunity and

threaten, and then to set out a certain solution. More combination with the strengths of IoT technologies will be discussed and the demand analysis will be necessary from the perspective of port managers.

Chapter Four: to carry out the overall plan of intelligent port and construct the system overall framework from the perspective of container integrated management and shipping management to analyze the developing application of IoT technology in port management. Then, the author will express the effectiveness of IoT digitized by intelligent gate system through using the model.

Chapter Five: conclusion and outlook. The author will draw a conclusion and put out the future developing directions of IoT in port management.

Due to the fresh conception of intelligent port, this paper is aimed at giving proposals and suggestions on improving IoT in the port management and contributing my idea on research of IoT applied on port construction.

Chapter Two: Port construction based on the internet of things

2.1 Internet of Things

Internet of Things (IoT) is the expanding application and network stretch of communication and internet. It uses the sensation technology and intelligent equipment to perceptual recognition in physical world through the online transmission and interconnection to compute, handle and knowledge excavation to achieve the mutual connection and attachment of information among human beings and objectives, reaching to the goals of constant controlling, exact managing and scientific decision in this physical world. IoT, which is the global basic network, relates actual objects with dummy ones via development of data obtaining and communication ability. Supported with the technologies of existing internet, specific object recognition, sensor, RFID EPC global and wireless sensor networks, is has formed into the super network of achieving constant information sharing and covering all of the objects. Thus, IoT has the functions of highly autonomous data acquisition, information exchange, internet connection and synergetic working.

IoT has become a completely new techno-sphere and a wave of IT industry after the appearances of computer, Internet and mobile communication network. As the information development technology of new generation, IoT mainly has three basic

characters as follows:

- Overall Perceptions

Make using of the various sensor facilities such as RFID, sensor and two-dimension code to collect a variety of dynamic information at any time in any place to fully perceive the world.

- Reliable delivering

The information perceived needs to be constantly delivered by Ethernet, wireless-net and mobile network. The transmission of perceptive information becomes very realistic under the circumstance of the omnipresent wireless network which has been covered around the entire world.

- Intelligent processing

Achieve the intelligent control and management to reach to the real communication between human and objects via the constantly handling with huge information with the technology of cloud computing.

2.2 The technological architecture of IoT

The technological architecture of IoT is mainly divided into three layers: the bottom is the sensor one used for sensing and accepting the data; the second is the network one for data transmission; the highest is the application one which can be able to apply into real life (seen from the figure 1).

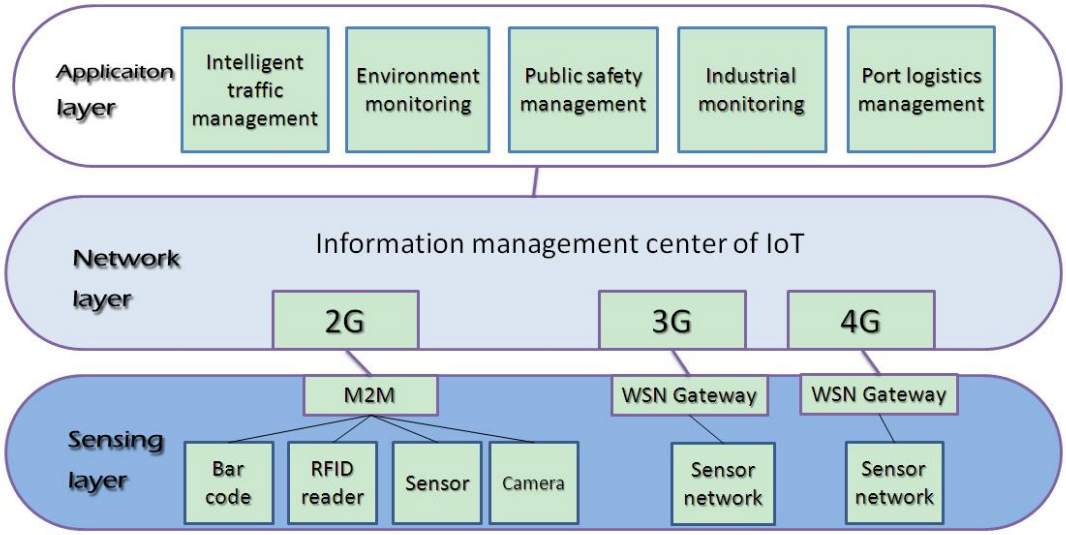

Fig.1 Stratification system structure of Internet of Things

2.2.1 Sensing layer technology

The layer of sensing means that to recognize and mark objects by using of RFID tags, reader-writer, camera, GPS, GIS, sensor and terminal facilities on container, shipping cargoes and relevant equipment to collect data which helps the statistic, planning, organization and management of cargoes. What key technologies related to this layer is RFID, GPS and so on.

2.2.1.1 RFID

RFID (Radio Frequency Identification) technology, which is a newly recognition automatically technology started in the 1990 of the 20th century, is also a non-contact one integrated with the automatically recognition technology and radio frequency communication technology. It has brought the important revolution on aspects of Internet, life, economics, culture, law and military and finally, will melt with Internet (IPV6), mobile communication network, wireless sensor network, biometrics

and GPS technology. Radio Frequency can be divided into 9 types according to its radiation into space (see Table 1).

Tab.1 The scope of the RFID

The Scope of Frequency	**Name**
Below 3kHz	Extremely Low Frequency (ELF)
3kHz~30kHz	Very Low Frequency (VLF)
30kHz~300kHz	Low Frequency (LF)
300kHz~3000kHz	Middle Frequency (MF)
3MHz~30MHz	High Frequency (HF)
30MHz~300MHz	Very High Frequency (VHF)
300MHz~3000MHz	Ultra High Frequency (UHF)
3GHz~30GHz	Super High Frequency (SHF)
30GHz~300GHz	Extremely High Frequency(EHF)

RFID is an applied technology of conducting easily, simply practice and especially suitable for automatically control which can automatically recognize the object via radio-frequency signal to obtain the related information. The best advantage lies on the recognition process completed automatically without touching. The work of recognition both can support the read-only, but read-write working model without manual intervention.

The working process of RFID system is that: the reader emits energy forming into the electromagnetic field around a certain region through which RFID tag emits the data stored in tags after receiving the signal transmitted by the reader; then the reader receives the signal transmitted by RFID tag to decode and test the accuracy of data to get to the goal of recognition.

According to the method of getting electricity, RFID tags can be divided into passive tag and active tag. Passive tag is handy but without power sources. Active tag has strong performance to carry further induction, but the power source should be paid attention to replacing.

RFID can achieve the non-contact recognition automatically of multipurpose with moving objects based on the interconnection between object and information emphasized by IoT of RFID. Applying RFID into data collection and logistics tracing can largely improve the logistics industrial service level which mainly manifests as three aspects of: achieving the automation of data collecting and information processing; realizing the automation of operating stages in object sorting, carrying, handling and discharging, storing; achieving the automation and intelligence of management and decision-making such as inventory management, generating orders automatically, optimizing distribution route and so on. RFID technology which applied into the logistics information management system can approach to the highest logistics managerial efficiency of supply chain with the lowest costs.

RFID applied more in intelligent management of port. The managerial system mainly consists of passive transponder with frequency band of UHF, RFID reader with its antenna, communication system, public data managerial platform and vehicle-mounted sensors. The passive transponder can be written into the information of container, inside cargo and supply chain. Communication system is established with much wireless base station by means of combining of wired and wireless arranging separately on lighthouse of port to access into the LAN in harbor area by using of High Speed Optical Fiber, and it can basically complete the wireless network signal over the port. The system can handle with the automatically

recognition and paperless recording of database and yard information. Based upon the powerful inquire, statistical and analytic, tasks real-time disposal and reporting functions in information system on container port, it also can be applicable to integrated management of distributed multi-yard. It can nicely achieve the whole process of data collecting, interconnecting and analysis from discharge to yard delivering. The manager there can timely master the information of container in logistics processing on the foundation of RFID information system and can be timely find out the exceptional condition in each running status.

2.2.1.2 GPS

Global Positioning System (GPS) is an advanced navigating technology which can carry on the real-time supervision to orient the moving objects combined with GIS. The wider application of it includes the terrestrial, oceanic and aerospace ones. The terrestrial one involves the vehicle navigation, atmospheric physics observation, project measuring and emergency reaction. The oceanic one contains the optimal flight and route measuring of trans-ocean vessel, real-time dispatching and navigation, maritime SAR, measurement of hydrologic geology and work-platform positioning. The last includes air-navigation, attitude controlling of airborne remote sensing, determination of low-earth-orbiters, missile guidance, air-rescue and so on.

Logistics GPS monitoring system conducts real-time locating and tracking of logistics vehicles, vessels and cargoes to integration fully of the information in each link of transportation industry which makes owners obtain the running conditions timely of vessels and positioning of cargoes, thus can effectively remote control. Recently, the application of GPS is widely used in logistics field, especially in distribution area. Given that the process of distribution is the transmitting of space location, so, considering the related handling links of transportation, storage, handling and

discharging, delivering, the problems like choice of route and warehouse location, capacity setting of warehouse, the strategy of reasonable handling and discharging, the vehicle dispatching and choice of post route, all of this can be managed and analyzed by the GPS functions of tracking and inquiring which helps distribution firms using existing resources to reduce the wasting and upgrade the efficiency. So, GPS technology is regarded as the indispensable key part in whole process of logistics management. GPS exchanges the information via Internet while logistics GPS monitoring can achieve the third-party application of vehicle users, transportation companies and receivers to make them timely obtain the position and running conditions of vehicles and cargoes. It helps the three coordinate the commercial relationships to make out the perfect logistics plans and gain the maximum economical effectiveness.

GPS technology has a comparatively impact on whole supply chain not just in logistics field. On terms of port, it will be applied not only into the information recognition of vessels, the plan of shipping route but the handling and discharging of facilities, supervision of cargoes to make them more exact and safer.

2.2.1.3 GIS

Geography Information System (GIS) which is a comprehensive technology related to subjects of geography, topography, computer science and technology, environmental science, urban science and management science is the key content of global space information science. Its conception and foundation result from the geography and topography by technological support of computer science. As spatial information sciences, GIS is related with data of surface (including atmospheric layer) of the earth and space and geography by data collecting, storing, managing, analyzing and description. It is widely used in many fields of urban management,

logistics management, regional planning, environmental renovation and military emulation.

GIS is consisted of five parts: computer hardware and software system, geo-spatial database, spatial analysis model and related personnel. Among them, the computer hardware and software systems are the core of GIS while the database is the object for operation. Spatial analysis model can provide the resolution of various space problems. The last part includes systemic managers, developer and data processing analyst.

Spatial analysis is the main function different from other computer systems like MIS, image analyzing and processing system, CAD system. To solve the specialized issues in application, it needs to construct the special application analysis model like location model, mathematic flooding model, population diffusion model, land use suitability model, forest growing model, water and soil erosion model and optimizing model.

It can be showed constantly the factual position of vehicles by using of the GPS and GIS technologies and magnified, narrowed, restored and exchanged them discretionarily; keeping the objects on screen by which it can traceable transport to key vehicles and cargoes. Using the real-time positioning, tracing, alarming and communicating technologies can meet the vehicle basic information and the need of tele-management, while can know about the details in transportation for customers via Internet technology. It can improve the vehicle work efficiency and reduce the logistics costs to avoid the risks via the navigation tracing of transportation equipment. Combined with the wireless communication, GIS/GPS makes transportation devices more transparent and controllable in various areas while also

can monitor drivers efficiently.

GIS has been applied into the management of port construction, planning and its pipeline to promote effectively its scientification of decision-making and managerial modernization, thus to bring out the largest economical effectiveness for port infrastructure. Traditional infrastructure management adopting manual or CAD mapping with memory management and manual statistical analyzing, is low-efficiency and hard to suitable for the fast growing managerial requirement of massive data which will cause the huge waste of resources and prevent the further improvement of maintaining and managing level. It is necessary to change the behind-hand managerial conditions by using these technologies to make it step into the pathway of automation and standardization. The integration of GIS, information technology and port managerial standard helps: port departments fast inquiring related construct information and obtaining the files needed; the share of basic materials and facility resources to avoid the wasting caused by repeat working; the maintain and construction of port infrastructure to upgrade the troubleshooting efficiency; to assist the managerial department on macro decision-making to step forward to the intelligent digital port.

2.2.1.4 Sensor

The main features of sensor if to percept and test certain form of information and to exchange the information into another form. So, sensor means that having these functions of certain definite information of the measured and to make them change into the corresponding components and equipment of useful output signal on a regular basis. Sensor often consists of sensitive element which refers to part of interface element of directly inducting and test out the object information to be measured, also refers to part of that to exchange into electric signal of suitable for

transmitting and measuring and interface element. People define the sensor as the generic term of corresponding components on electric signal, parts of an apparatus or devices.

In term of the function, sensor referring to replace or even surpass the human's "five sense organs" means that the components and devices with the functions of sight, auditory, tactility, olfaction and gustation. The reason why to say "surpassing", is not only for applying into the intolerable severe environment of high-heat, high-pressure and radiation, but can test out various information like slender magnetic, electrical, ionic and rayed information which cannot be perceived by humans with those which high-energy information is over the human sensory functions.

Sensor technology, recently, including the research, designing, trial-producing, producing, testing and applying of sensor has gradually generated into a comparatively independent specialized subject which has the following characters compared to the others: discrete content with high degree of knowledge-intensiveness and colors of interdisciplinary subjects. In development process, the conflicts are outstanding between type and quantity, high personal action, complex technique and craftwork, various types, extraordinary functions and performance, wide application. As a commodity, its user has lots of varietal requirements without the sufficient demand of each type.

2.2.2 Network layer technology

Network layer contains the converged network, network management center, information center and intelligent processing center of connecting and communicating networks. The information obtained in this layer will be transmitting

and handled intensively from sensor layer.

The key technologies in this layer are EDI, middleware technology and data exchange technology.

2.2.2.1 EDI

Electronic Data Interchange (EDI) commonly consisting of software and hardware, communication network and data normalization refers that according to the universal standard format on a unified stipulation, transmitting the standard logistics information via communicating network to have the data exchange and processing automatically among the computer systems of cooperative partners. One firm achieving the EDI must have a set of computer data processing system and also need adopt the EDI standard to easily change the internal data to its normal format. Expect for its own conditions, the quality of communicating environment is also the key factor to realize the EDI.

2.2.2.2 Middle-ware

Middle-ware belonging to the network layer is a software located between that and sensor layer. When using it, the integration of middle-ware which needs a communicating one, forms into a system, that limits the range of using into the distributed system and distinguishes from supporting and practical software.

2.2.2.3 Data exchange

Data exchange means that a process of data exchange with transmitting corresponding information to the other side or receiving from them and giving data to recognize and use according to the regular information and its data format via the transmission medium of internet and related software. Aimed at defining a set of form

standard of data exchange, the system can exchange according to the need of business among heterogeneous systems with freedom. The standard of data form defines the expression of it to exchange data based on message mechanism. Port information platform of IoT should target the butted object information between what they needed and external data lying on the standard of XML with defining the corresponding data interface. The data interface contains exchange data packet, data packet unit and data files. Exchange data packet refers to the information resource integration of complete business used in data exchange which consisted by the basic unit -- data packet unit. These resources, finally, are to be provided outside by means of data files.

2.2.3 Application layer technology

Application layer is the depth of integration of IoT and industrial specialized technologies combined with its demand to achieve the widely intelligent, and are also the social division of IoT.

It can be widely applied into such fields of : public security management (containing food security, medicine and health, hazmat management and ID authentication); manufacturing industry (containing production process control, production manufacturing and assets management); modern logistics and supply chain management (including warehousing management, logistics distribution and retail management); traffic management (including transportation ticket, electronic toll collection, vehicle management and related facilities management); military, smart grid, smart housing, environment monitoring and health monitoring.

Application layer of port construction feedbacks its various functions through each

factual application system related with the main applications in port field which contains Smart Gate-out Automation System, logistics Transportation Management System, Container Video Identify System, Smart Warehouse System, Safety Monitoring System and Shipping automatically recognition system. In Chapter Four, the author will analyze the use of IoT application layer technologies in port management in detail.

2.3 Developing situation of the internet of things

The conception of IoT was first carried out in 1999 which was called the name of sensor network. Chinese Academy of Sciences has lunched the research in 1999 and obtained some achievement with establishing some idoneous sensor networks.

In the 1990s, Japan and Korea has started planning the relevant IT development strategies with applying the ideas of sensor network technology of u-Japan and u-Korea.

The international conference holding in USA in 1999 on Mobile Computing and Internet Technology carried out that the sensor network would be another opportunity to develop faced by human in next century.

In 2003, the journal of technical review raised an issue that sensor network technology would be on the top of “top 10 technologies” to change humans’ life in the future.

The official conception of IoT was carried out on the World Summit on the Information

Society held in Tunis by ITU (International Telecommunication Union) in their ITU Internet Report 2005: IoT. The report pointed out that the age of communications of omnipresent IoT was coming which all of the things could exchange actively by internet from tire to toothbrush, house to paper-towel. RFID, sensor technology, nanotechnology and intelligent embedded technology will become more popular. Based on the description by ITU, human will reach to a new dimension of communication in world of information and communication by embedded a short-distant mobile transceiver during the age of IoT, thus to expand the communication links among human to a wider range of human and objects at anytime and anyplace. The rising of its conception, largely profits from the annual report in 2005 on topic of IoT by ITU.

Before these, many American universities held plenty of works on wireless sensor network, such as: the lab of embedded network sensor center and the wireless integrated network sensor lab with the experiment of network embedded system in University of California at Los Angeles; the research on extreme low-consumption of wireless sensor network in MIT; the research on self-organizing sensor network in Auburn University which has been completed a series of development and production of experimental systems; the deep-seated research on mobile computing lab of wireless sensor network technology in State University at Binghamton and Cleveland State University. These famous enterprises abroad were lunched this research and established the partnership with the pioneer Crossbow Corporation, software maker Microsoft, computer hardware maker Intel, sensor device tycoon Honeywell, network equipment maker Cisco and the University of California at Berkeley.

After Obama took his oath as President of the United States, he held a “round table

meeting” with American leaders of industry and commerce on Jan.1, 2009. Peng Mingsheng, the CEO of IBM, firstly pointed out the conception of smart earth, giving advices to government to invest new-generation smart infrastructure. Given that conception, it was highly focused in America even with the analyses that this imaginary of IBM would upgrade to the national strategy and create a sensation over the world. IBM considered that the next task of IT industry was to fully use the IT into each industry. Particularly, to embed and equip this into various things like electric network, railway, bridge, tunnel, highway, building, water-supply system, dam and oil and gas pipeline, then to be linked commonly to form into the IoT.

In the same year, EU Committee submitted the Action Plan of EU IoT to European Parliament. European Council, European Economic and Social Committee and local committee to ensure Europe the leading role in construction of IoT. Their political suggestion mainly contained that to strength the management of IoT, improve the privacy and personal data protection and upgrade the reliability, acceptance and security of IoT.

Targeting with the Chinese economic situation, Premier Wen Jiabao said “in development of sensor network, we should plan the future early and make a breakthrough the core technology” when he was inspecting the technology research and development center of IoT in Chinese Academy of Sciences in Wuxi. In 2009, Li Yi, the minister of industrial information department, issued a signed article named the Situation and Outlook of Chinese Industry and Informatization Development on journal of Technology Daily, first publicly referred to the sensor network and then upgraded to the level of Strategic emerging industries, pointed out the widely permeate and highly application of IT which would generate new growth pole. In November of the same year, Wen addressed a lecture on Let Science Lead the

Sustainable Development at Beijing Great Hall, and pointed out that key content of melting IoT into information network development which also emphasized to be the important traction of global economic recovery to scientific and technological circle in Beijing. Sensor network was listed into Outline of the National Program for Mid-Long Term Scientific and Technological Development (2006-2020) and key special subjects of Next Generation Broadband Mobile Wireless Communications as a priority research areas and also listed into the National High Technology Research and Development Program of China (863 Plan).

IBM wished that the smart earth strategy could lift another scientific revolution after the wave of Internet. Guo Shina, the former CEO in IBM carried out a key point that the revolution of computing pattern would be occurred every 15 years. The judgment was exact like Moore's Law and called as “15-Year Mendeleeff's law”. The revolution happened around 1965 took mainframe as symbol, and the population of PC become the symbol was around 1980 and the internet revolution was in 1995. Each of the technological change caused the great unrest and changes of competition situation among enterprises, industries even countries. However, the Internet revolution, to some extent, was accelerated by American strategy of information Highway which announced by Clinton Administration in 1990’s with the investment of 2000~4000 billion dollars to build the National Information Infrastructure (Nil)within 20 years and finally create the huge economic effectiveness and social benefits.

And now, the strategy of smart earth is regarded as the key strategy of revitalizing the economy and setting up the competitive advantages with the similarity of Nil. Whether could start a wave of technology and economics, is focused not only by America, but the whole world. There having an institution predicts that a large scale of population of IoT will be achieved during 10 years which will develop into an

advanced technological market with a trillion scale and its industry will be 30 times bigger than that of Internet.

2.4 The conception of intelligent port

With the development of IoT technology in port field, its development tends to be more automation and informatization and thus causes the conception of intelligent port. It has been not defined accurately and also can be named of the port based on IoT and the 5th generation port which is the fifth stage with the rising and explosion of IoT after experiencing the stage of traditional logistics, distribution logistics, comprehensive logistics and port supply chain. It usually refers to completely perceive, widely connect and deep compute each key information of logistics running core systems by fully using of the technology of IoT, cloud computing and decision analysis and optimization to make objects and human, port logistics resources and participants a better interconnection and to form into the modern and informatization port of technological integration and comprehensive application. There also existing some experts, who points out that the IoT is of using the technological features of IoT sensor, interconnection and wisdom to make the port facilities, shipping information and the resources of port logistics and participants a wider interconnection, thus to complete the logistics smart recognition, positioning, tracing, monitoring, management, quicker sensor, more nimble and deeper intelligent port. It is not only a new IT and resolution, but a new idea and a develop pattern.

The advent of intelligent port has significance to world port development which mainly reflects on three aspects. Firstly, on terms of its development course, it marks the new IoT stage of its develop. Secondly, its construction needs the technology

based on IoT. Finally, the advent of IoT port will bring out the whole great changes of strategic planning and design running.

Intelligent port collects logistics information by means of RFID, sensor technology, GPS positioning and video monitoring and integrates the port logistics system of transportation, port terminal service, yard storage activities and logistics equipment to provide management department and relevant enterprises with various monitoring and product information.

There exist the following obvious features of intelligent port:

- Informatization

Intelligent port has the feature of highly-informatization. Its level of informatization can be improved via widely and deeply applying the technologies into port constructions.

- Networking

Intelligent port improves its port productivity, collects basic data and transmits the messages and data via net and thus to increase the service functions of society in port.

- Intelligence

Intelligence is the ultimate goal of intelligent port construction. Only through using plenty of technologies of RFID and sensor to collect the huge object information which to be transmitted to backstage for handling with from internet and returned the timely feedback, and then actively pass them to staff who needs to obtain the useful information to achieve the intelligence. That means only achieve the intelligence of port logistics, can it realize the port of IoT.

- Modernization

Intelligent port is of the modern features which mainly reflect on technologies applied

such as RFID, GPS, EDI, XML (Extensible Markup Language), ESB (Enterprise Service Bus), BPM (Business Process Modeling), Portal technology, Web Services technology, middle-ware technology, Data Exchange technology and so on.

2.5 The Significance of constructing the intelligent port

The advent of intelligent port points out the direction of its further development and has the important actual significances:

(1) It helps to improve the service level and efficiency of port. Creating the port regional logistics center, constructing the logistics service networks which take port as important node to expand the functions of storage and cargo trading services. Spreading the functional service chain, setting up the multimodal transport service of information tracking and traceability, promoting the visualization and intelligence management of multimodal transport and strengthening the supporting and leading effects of harbor industry and development of hinder-land economy help the integration of logistics and manufacturing.

(2) It helps to promote the port structural adjustment and provide the R&D of IoT with a reliable public application platform. Combining with the IoT application to construct the specialized port and integrate the harbor operation can not only help to improve the technological level and production ability of existing facilities, adjust reasonably the harbor functions, but improve effectively the level of specialization and scale and the construction of scale harbor as well as provide functional government departments the assistant decision basis on planning, organization, management and controlling of logistics industries and ports.

(3) It helps the construction of collecting and dispatching system which can strength the linkage between main container port and dredging port highway, impel the

large-scale multipurpose port establishing the collecting and dispatching system of cargo-passenger separately and thus enhance the construction and running efficiency of port railway, water transshipment, river-sea coordinated transportation, inner-land waterless port, collecting and dispatching channels and their stations.

(4) It helps the development of advanced shipping services which promotes the shipping finance, insurance, maritime arbitration, information and shipping trading to expand the shipping service industrial chain and improve the shipping trading functions at information platform. It can further improve the traditional shipping service industrial of shipping agency, non-vessel shipping and management to support the establishment of international comprehensive testing zone of shipping development.

(5) It helps to reduce the transportation risks. Achieving the recognition and tracing of cargo via the application of IoT with the technologies of RFID and Internet. For example, the application of EPS, can obtain the data automatically to sort the cargoes, reduce the costs of fetching and delivering with fewer transportation risks to guarantee the efficiency and security.

(6) It helps to provide the personal service and means of remote management and information exchange to improve the managerial level, promote the logistics supply chain management, reduce the managerial operation costs and provide the comprehensive technological supporting of enterprises scale and intensification development thus to support functionally of regional logistics development.

(7) It helps to expand the market share and additional businesses. Especially, the international transshipment, improves the expand of free-trade business on distribution and export processing which effectively promotes the functional construction and resource integration of port logistics public information platform and e-business platform.

(8) It helps to upgrade the market comprehensive monitoring ability. Establishing the

operating qualification warming and dynamic supervision, the terminal of dangerous cargo and passenger dynamic supervision, and the implementing management of ships and dangerous-cargo ships, contributes to the united, openness, competitive and orderly industrial marketing systems.

(9) It helps the green construction in harbor and waterway engineering. Accelerating the technical reform with port facilities is propitious to the utilization of regenerated energy and the improvement of port comprehensive utilization of resources with high efficiency of resource circular using, aiming at reducing the effectiveness in ecological and humanistic environment.

Chapter Three: Feasibility analysis of port construction

The update intellectually of port shows on its managerial system in terms of port departments and related enterprises. To connect each link in supply chain based on IoT technology can reduce logistics costs and improve the transportation efficiency and safety, thus taking this as an advantage to set to informatization port. Port construction based on IoT which has strong epochal and competitive character will be the developing direction of port. But from the existing technology and development situation, there still exist weaknesses and disadvantages. Moreover, how to make use of the IoT technology scientifically on port management is worth meditative.

3.1 The benefit analysis of informatization upgrading

The application of IoT is the constructive propulsion on port informatization. To integrate social logistics resources with form of intelligent port information platform can provide the fundamental conditions on developing intensive and three-dimensional logistics to achieve the multimodal transportation. Standing on height of supply chain management to completely integrate these resources help port companies to realize green logistics and dedicated logistics, thus to create the logistics industrial features and provide basic conditions for cultivating the port

logistics brand.

By intelligent construction of port both can fully integrate port logistics resources and generate the third party industry, then to cultivate the fourth logistics industry and effectively optimize port logistics industrial pattern and construction by providing constant potential on bringing into the thought of modern supply chain, and finally to provide unlimited possibilities to approach to the goal of leading commercial model innovation by supply chain innovation to upgrade enterprise effectiveness. The related should construct cooperation and communications with internal and external logistics industries even foreign ones via platforms to stand in front of modern logistics of developing attitude and develop continuously.

From the point of shipping departments, the complex tasks of port require strictly on its handling and discharging, warehousing pileup, shipping management and multimodal transportation which all linked with one another. The intervention of IoT technology can deepen the automation degree of port operation and promote effectively the informatization management to increase the conducting efficiency of containers and bills of documents with reasonable resource allocation, low-costs and high security of object transportation, thus to increase the harbor care competitiveness and obtain more benefits.

3.2 The advantages embodied in the IoT technology

IoT makes each makeable, controllable and information-changeable objects embedded into an electronic tag which transmits among each links with cargoes as well as the distribution on data platform with which recorded by electronic tags. It

implements existing both in realize but to map as an entity on Internet for a certain object. Along with the longitudinal extension of supply chain, the port enterprise should set up the cooperative relationship with shipping companies, shipping and cargo agencies, logistics companies, import and export corporations and road-transport companies to increase correspondingly the port management information subsystem to exchange and transmit the data, and finally achieve the seamless joint in information delivery.

Tagged information of objects can ensure the accuracy, validity and creditability in data inputting of port MIS. Perfect information collection mechanism provides the precise and timely data. The analyses and resolutions based on these data can make computers deep-seated functional application like predicting and controlling come true. Through analyzing a huge universe of historical data, port managers can predict the key statistical data macroscopically; by analyzing the constant information from related enterprises, they can microcosmically allocate the cargoes including booking and dispatching, operation/staff reservation, voyage reservation; by applying the IoT technology can achieve the excavation and handling of data from macroeconomic and microcosmic perspectives.

The port information technologies recently mainly have EDI, MIS, wireless terminal technology, e-business, GPS and GIS. IoT technology along with GPS, GIS and wireless transportation technology ensures the situation monitored momentarily on transportation. Information managers should commit themselves to maximally exert the new technologies' advantages and use these functions via practices on testing and constantly improving based on achieving the compatible between IoT and original technology infrastructures, thus to realize the mutual coordination from the point of MIS between the new and original technologies.

Before developing the IoT technology, one of the obstacles which is unsuccessful to achieve the interconnection among port systems is unable to have a united and precise description to objects. As the transmission medium among ports, shipping companies collect cargo information passively from shipping port to destination port separately. The problem of the information obviously is un-complete and hysteretic is settled by IoT technology which the objects can be both makeable and timely monitored anywhere and anytime. The systemic interconnection established by port based on the interactive information exchanging on data platform via internet. Delivering the information quickly, perfectly and certainly to MIS of port and then get through the computer data processing function can dispatch the related resources.

3.3 Problems in port information construction

3.3.1 The normative construction

Due to the differences in developing level of port information degree, there is no widely-functionary, complete and reasonable normal which makes it exist information differential problems among ports, related companies and ports at different countries. Applying IoT technology into port management system can not only serve itself, but undertake the responsibility of connecting other business organizations in port industrial cluster which will be tighter requirement on information and standardization of port MIS.

The normative construction of information results from the three aspects in IPO process of: the standardization of data inputting; the standardization of data

processing; the standardization of data outputting. Particularly, the first lies on the objects which will be inputted in IoT with unified forms according to specific mark loaded. The second is that can be normatively approached with the certain pattern according to its different characters when the data is transmitted to database and processed to achieve the computer functions of predicting, controlling and allocating. The last means to set up a series of information delivering method to output efficiently.

The normative construction of port information system includes four parts which are: to normalize the data in port data platform to achieve the coordination between port MIS and up-stream & down-stream firms MIS, then to solve the data isolate problems in different departments and finally to achieve the business and operating utilization in whole supply chain; to normalize the entry work process which means the marked objects will be under the supervision after entry into the port without the disorderly activities of customs declaration, commodity inspection, insurance and warehouse entry which will increase the difficulty of data processing and the accuracy and timeliness of systemic prediction and controlling; to establish the unified language cades among international port MIS to settle with the language barriers in delivering of different countries.

3.3.2 The accuracy of information

The advent of IoT technology makes each objects mapped into the entity which transmitted in IoT systems along with cargoes and delivered to each enterprise subsystem on internet. The convenient and standard weakens the effects on bills of documents in outside trading and information exchanging gradually becomes the main method of trading while the buyer and seller can monitor the conditions of

production, transporting and manufacturing with the data in IoT. Simultaneously, due to the weakness of data itself, the buyer is hard to judge the accuracy of information provided by the seller. The transactions lying on information only, must ensure the highly coherence of information and cargoes.

Via the development of computer technologies, establishing the effect restriction mechanism makes the specific information only loaded on qualified cargoes which means to ensure the highly coherence between objects and tagged information, that will make IoT become the key technology applied in port MIS

3.3.3 The demand of comprehensive talents

Highly-efficient MIS needs managers and maintainer with high level. Especially, each stakeholder related has specialized operation and managerial pattern based on complex of port running, that requires a wider field of confines of knowledge. Lacking of the cultivating on port MIS specialized talents and the aspects of related laws and regulations on port, practice and logistics transportation with the comprehensive talents who are skilled on computer programming and management systemic operation, it can cause the great waste of technology, prevent the further information development and thus effect the that of trading without the talents to communicate the demands of port MIS and the relevant achievements.

China should learn from the advanced managerial experiences outside on cultivating the comprehensive talents who both can be versed in port management working processing and can be engaged in computer achievements.

3.3.4 The budget of fund cost

Due to the differences of information level, it will be tough on the budget of fund cost on port construction. Fund problem is also the efficient one. For example, the precondition of installing the RFID tag on one fork-truck is to install the same tag on each working fork-trucks over the yard. The goal of tracing the fork-truck is to be convenient and quick on internal transportation which needs the supporting of over-yard transportation information systems among each links. The IoT devices should transmit data into the same format uploading to the data platform which brings the plan of information system a great challenge. It appears easily the variances of hardware depreciation and the model or other problem of hard to update. Especially, the highly-efficiency of updating with high-tech products and its expensive costs bring the big challenge of port upgrading.

So, starting from the design and planning of port construction, taking the time nodes as the coordinate, considering the possibility of future development and updating and designing the utilization and maintains of IoT products can save the unnecessary expenditures and prodigality.

As an intelligent program, all nations attach importance to it. Fully excavating the applications of IoT on logistics management supply chain can be a better solution on reducing logistics costs and upgrading the transportation efficiency and security. It can both improve the port working efficiency, bring down the running costs, give play to the roles of predicting and controlling to upgrade its own competitiveness, but also attract more related ones to entry into the data platform with cluster competitive advantages by taking up the share of supply chain, and finally obtain higher benefits and interests in fierce marketing competition.

Chapter Four: Design of port management system based on IoT

4.1 The total framework design

The port management system includes port information database, terminal management system, shipping management system, freight forwarder system, credit monitoring system, container management system, custom and inspection. Figure 2 shows the framework diagram of the port management system based on internet of things.

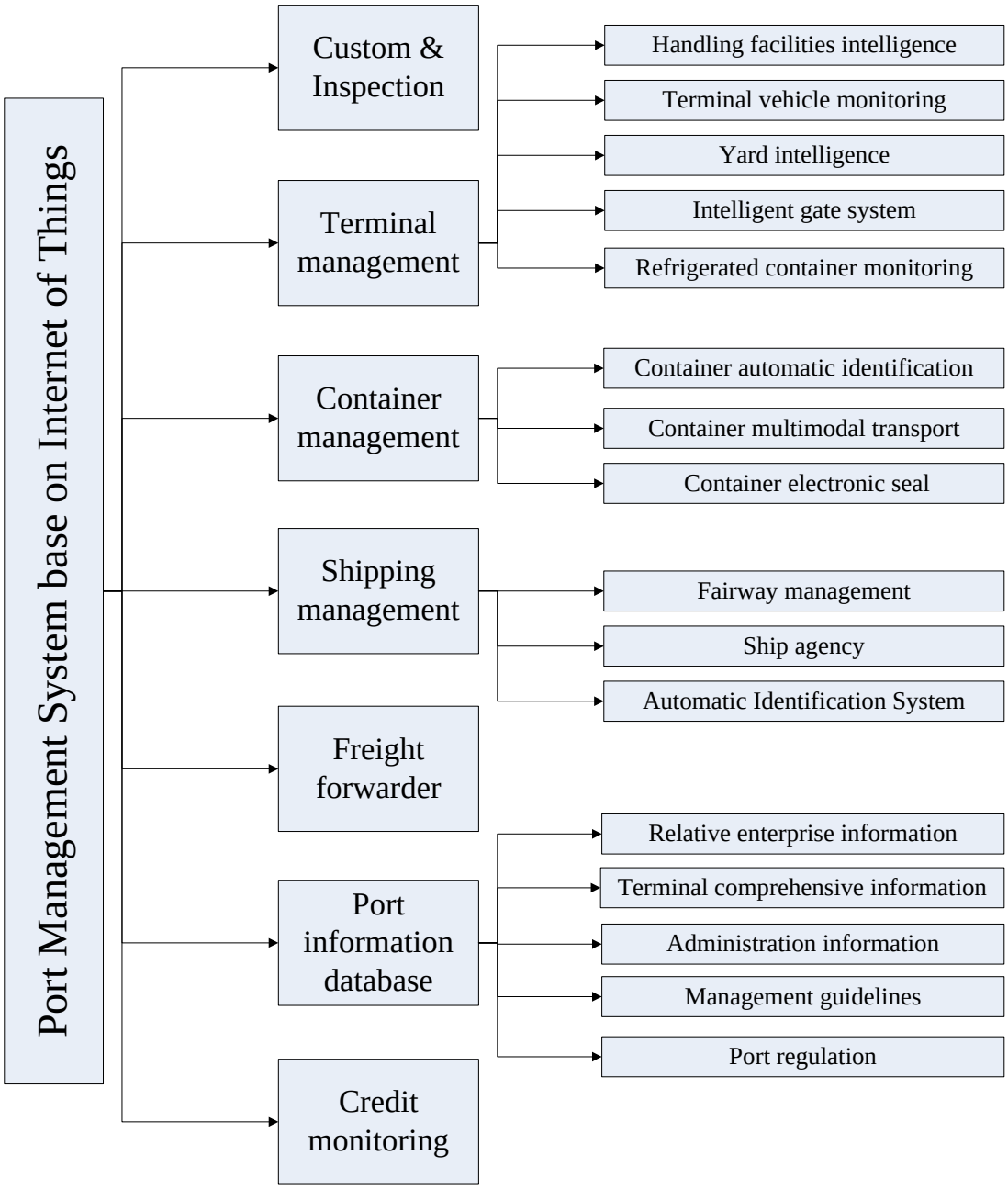

Fig.2 Framework diagram of the port management system based on internet of things

Therein, IoT technology is widely applied in terminal management and container management. This article chooses the container terminal management to describe the application of IoT technology, especially RFID, GPS technology, and then set up mathematic model to show the efficiency improving with RFID.

4.2 Container terminal integrated management

Container terminal is the most representative terminal type on international trade. Compared with the terminals which mainly handle bulk cargo, container terminal has a larger scale and developing space. Container terminal management includes container loading and discharging, yard management, facility management and etc. The facilities which used in cargo handling contain bridge crane, RTG, truck, forklift and other machine. Most of these facilities can utilize IoT to increase the accuracy and efficiency of cargo handling, locating, monitoring and managing. Figure 3 shows the brief function and layout of container terminals

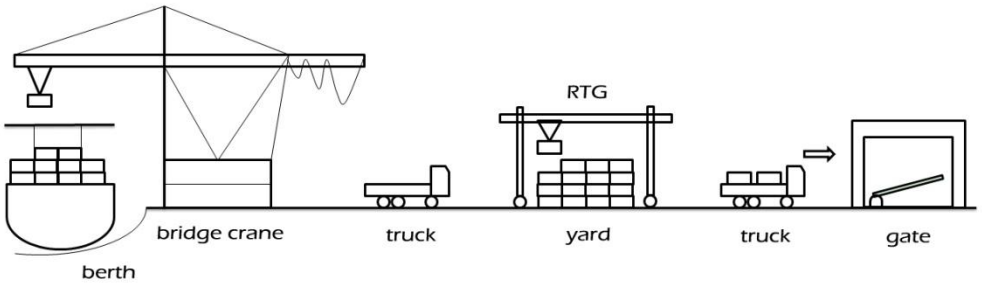

Fig.3 the brief function and layout of container terminals

4.2.1 Handling facilities intelligence

With the development of the international trade and rapid growth of the container quantity, the demand of the container handling facilities is also growing, especially on the demand of different kinds of cranes. Various of large machineries are used in loading and discharging in modern ports now, such as the shore mechanical bridge, mechanical tyre crane, rail-mounted gantry cranes，ship unloaders and portal cranes which used in bulk cargo terminal and etc. The managers can adopt RFID, GIS, GPS and other IoT technique to get the automatic identification of port fixed assets and manage the whole process of all cargos in the terminal.

4.2.1.1 Application of RFID technique in Crane

Bridge crane is the core facility which used in container loading and discharging. The working capacity of the bridge crane determines the cargo throughput of one terminal. The 4^{th} generation bridge carne can trice 70 tonnage cargos with 42 meters high and 70 meters far away. Due to the risk in operating procedure, bridge crane must be approve to use by statutory inspection institution which authorized by state safety supervision department.

With the booming developing of ports in China, the quantity of cranes grows quickly. Also the workload of inspection staff has increased. How to improve the terminal operating efficiency? This question becomes a big challenge for stevedore and their manager to think about. For example, usually, the staff cannot easily find the position of the bridge carne which should be inspected in the periodical survey, because the enterprise related principle often has no idea about the specific location of the due carne with the justification like the change of personnel, the large quantity of the cranes and the change of cranes location. So, it will take the staff some time to check from the historical data and other pathway. The time wasted extends the total inspection time. Managers should think about the solution for how to shorten the

wasted time and how to combine the database management system with the inspection. Using RFID is applicable way to solve the problem.

Staff can stick the tag on the related cranes with the detailed information of the crane. When accessing the dock with the RFID reader, inspection personnel can quickly check the ID（users, location registration code and etc.）and attribute(type specification, inspection deadline, the past inspection conclusion and etc.) through the data transition with the reader. Meanwhile, RFID reader can communicate with background computer management system through wireless network. It raises the efficiency of data transmission and conversion.

RFID can also be used in Dock management system. Terminal can install wireless RFID reader to read the container information on the related RFID tag to judge the container arriving or leaving. Through the wireless network, the container information sends to the port information center, in order to taking notes of the handling amount and the basic information of cargos imported and exported. Due to no uniform international standards of RFID used in container and low operability and safety of installing RFID on the traditional container, fixing RFID on the crane may become a better choice for management. Figure 4 shows the process of RFID information transmission in the container terminal.

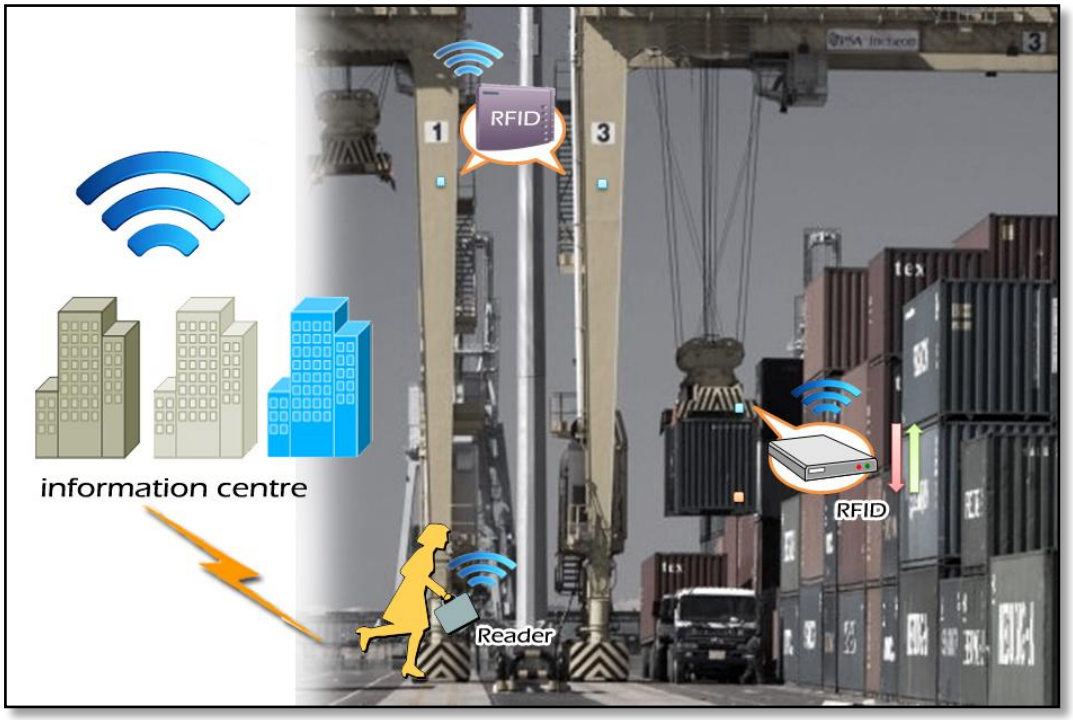

Fig.4 the process of RFID information transmission in the container terminal

4.2.1.2 Application of GPS technique in RTG

RTG plays a significant role in the terminal yard management. Many crane manufacturers now research the application of GPS technique into RTG operation. The positional accuracy of ordinary GPS can reach meter level. If combined with other instrument, GPS accuracy can get centimeter level. Such as the linedrive GPS used in terminal district which combined with RTK technique, the accuracy can reach ±1.5cm.

With the technical parameter of RTG improving, the automation requirement becomes higher and higher. But the problem that RTG has no fixed transportation rail is also a big challenge for managers. RTG cannot use traditional encoder to test the location and it influents the container automated management. Furthermore, due to its own structural limit, driver must continually rectify the route when driving the crane.

It drains of the energy and let the driver feel tired. Especially working in the night, drivers feel more and more difficult to see the runway datum line clearly.

Usually, for the location supervisory defect, operators set up code sensing device on the crane and set up the readers every other 3 or 4 meters on the runway. Through different codes on each sensor, stevedores can identify the RTG location on the yard, and test or control the container information with the encoder. But this method has the gross defects which include high cost, large workload and poor reliability. The installed sensors cannot easily be replaced when damaged. On the side of automatic rectification, managers often draw two datum lines on the runway and judge the wheel rectification through detected datum lines by camera. On this method, operators should pay attention to the lines protection. So, it is not a scientific way on RTG positioning.

GPS technique can help RTG solve above-mentioned issues. Combined with RTG encoder performance, GPS achieves the RTG positioning on X/Y direction in the yard. GPS can also achieve the location verification from the encoders' feedback. This combination not only increase the refresh rate of framing signal, cover the shortage of low turnover rate of GPS, but eliminate the accumulative error from long operating time of the RTG encoder, and ensure the positioning accuracy.

On the side of container automatic management, many terminals have adopted wireless transmission technology at present. Operators in controlling center only need input the container position into computer. Drivers could achieve the containers position and code through the touch screen in the cab. After finishing the task, the information will transmit to controlling center. Here, the communication of RTG and center control room is based on wireless transmission. Some advanced container

terminal, like Yangshan port, has done the synchronization between information center and driver cab. But the basis of wireless transmission are the huge database and strong camera network, it takes terminal much higher cost and complicated structure. Compared with wireless transmission, GPS not only ensure the RTG information transmitting accurately, but also reduce the cost and registration time from the operators. It's better to choose GPS used in RTG to let the aim of automatic and informatization management.

On the side of RTG rectification, managers can combine GPS position signal and PLC software programming to build one fictitious rail for RTG straight operating. This combination can avoid the driver fatigued operations, and also remove the peril of vehicle collision.

4.2.2 Terminal vehicle monitoring

In the port logistics, motorcades is an important management objects. All container trucks are monitored in the terminal. GPS and RFID technique can help managers monitor vehicles position and status in real-time, ensure the vehicles driving on the established path and ensure customs controlling the cargo information. Terminal vehicles are mainly divided into forklifts, container trucks, and other engineering vehicles. In the container terminal management, container information delivering is mainly based on trucks transmission. Due to the technique for signing RFID on container is not mature enough, it is better to temporarily set up the tags on container trucks. Vehicle sensors recognize and record transportation vehicles information like the type, plate and etc. Vehicle tracking with GPS is convenient for department supervision and owners inquiry. By the application of vehicle identification sense and pressure speed sense technology in CFS, managers can enforce the information

acquisition, storage, dispose, inquiry and statistic analysis, then offer the container trucks the function of position report, real-time monitoring, dispatching management, task distribution and container monitoring.

IoT technology has been widely applied in container transportation. Automatic guided vehicle (AGV) is one kind of modern container handling technique systems in the world. As the high level automatic transportation facilities in container terminals, AGV could easily ensure the vehicles position, through vehicle sensor delivering the information to controlling center. The position accuracy can get up to 50 mm, and max to 20 mm. The main techniques in AGV position and navigation system are electromagnetic induction embedded wire technique, laser diagnostic technique, image recognizing technique, inertial navigation technique, coordinate recognition technique and etc.

AGV position and navigation system is mainly consisted of the GPS positioning system, inertial navigation system, laser accuracy position device. GPS positioning system provide the accurate position data which vehicle autonomous navigation needs. While the system working, GPS antenna on the base station sets up in the known point location to receive the GPS signal. The GPS receiver uses time division duplex to send the signal to subscriber station through digital radio link. According to the received data, the subscriber stations make the real-time differential positioning data calculation, and output the calculated positioning information to the AGV independent decision-making system.

On the basis of the gyroscope detective azimuth, the inertial navigation device measures the vehicle position and aided navigation when the GPS positioning system overlapped. The integrated positioning of the GPS technique and the inertial

navigation device resolves the requirement of real-time position.

Laser accurate positioning system can provide the key point accurate position and checking when vehicles driving. Because the cover of cranes and yard containers, the signal of GPS may be influenced while AGV driving through. The requirement of accuracy of position sometimes may be very high, and on this angle, laser accurate positioning system is better than GPS and the inertial navigation device.

4.2.3 Intelligent gate system

As the throat of the container terminal, gates directly impact the terminal operating capacity. With the growth of cargo handling capacity, the limited traffic capacity of gates becomes a bottleneck for further development. The size of gates and the amount of channels is fixed in the beginning of designing. When gates come into use, it is hard to expand by infrastructure. Therefore, it's an inexorable trend for gates promotion to set up an efficient, safe and reliable intelligent gate system.

As the traditional way, when containers transmit in or out of crossing bridge, operators need inspect the container type, code, lead sealing and etc. Also, operators need input each container's information to the background computer according to the document from the driver in container trunk. This complicated process extends the time needed to clear customs and increase the risk of mistakes.

If install the RFID reader and antenna on the crossing bridge, it can largely decrease the passing time and the risk. It is an application of container automatic identification system based on RFID technology. While the container which equipped passive tag passing through the terminal gate, the wagon balance or the antenna senses the

moving container. The wagon balance or the antenna sends the signal to RFID readers, and activates the operating condition. Readers can automatically obtain the container information from RFID and input it to terminal information system. The truck can pass through the gate after the information checking from controlling center. Meanwhile, the passing moment is input into controlling center and database. Because of unmanned operation in this process, the passing time is economized. The working process of RFID used in container terminal gate system can be seen from Figure 5.

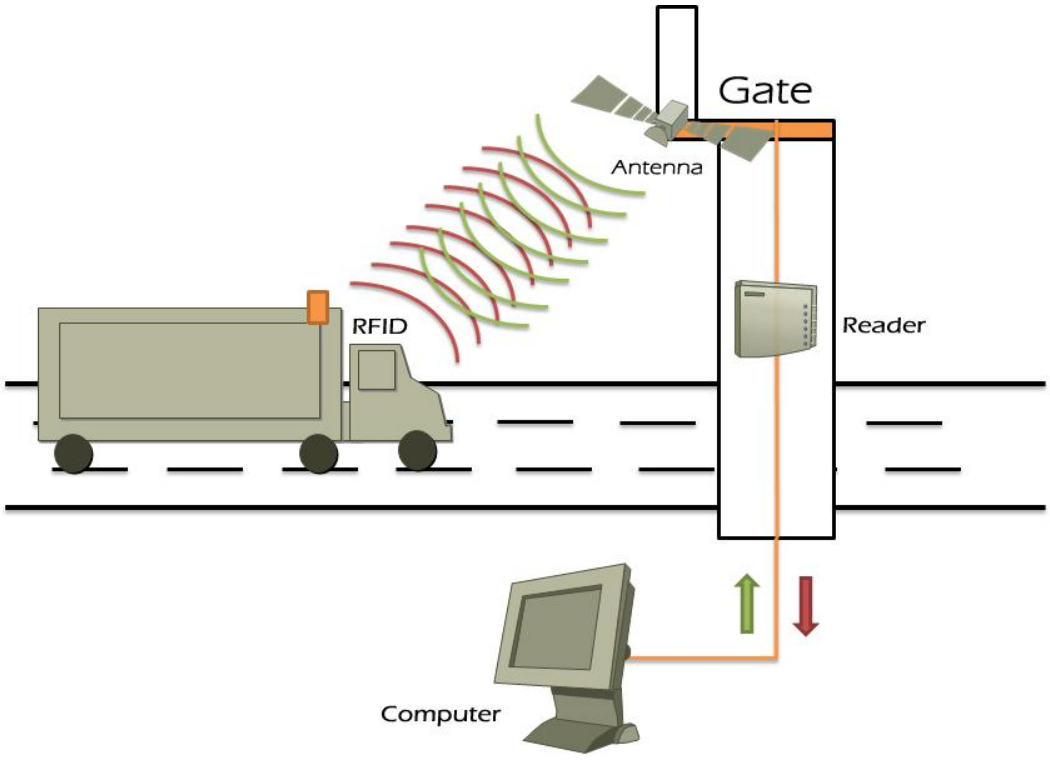

Fig.5 Working process of RFID used in container terminal gate system

4.2.4 Automatic identification system

To the side of port managements, shipping management can be divided into several modules, such as berth management, channel management and etc. Figure 6 shows

the function module of ship transportation service management system.

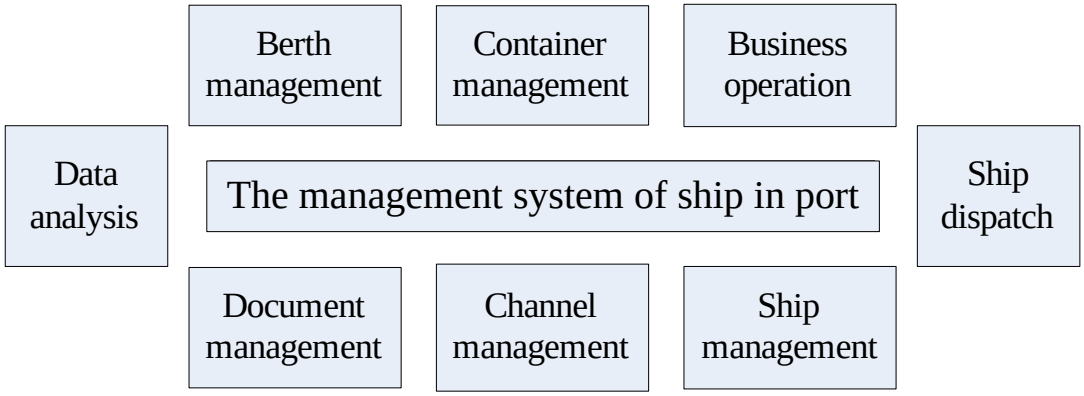

Fig. 6 Function module of ship transportation service management system

Therein, ship dispatch includes storage budget, demand of berths, demand of tugs, cargo stowage and so on. Ship management includes chartering record, vessel movement, ship basic information input, ship credential management and seamen register. The core of channel management is pilotage, which includes pilot schedule, channel monitoring, tide measurement and etc. The channel, berth and anchorage are the key nodes for ship management.

IoT technology is also widely used in shipping management. Automatic identification system (AIS) is the typical ship monitoring technique based on GPS.

AIS, which is one kind of new ship collision avoidance systems, is used in auto-answer and identification between ships and shore. AIS is consisted of AIS slipway and AIS shore station. Through the improvement of ship identification and collection of ship dynamic information, AIS realizes the information transmission and interchange between ships and store. This function brings fundamental improvement on navigation safety, traffic controlling and maritime management. AIS has been installed in all ships so far. With AIS, the ocean navigation accidents is substantially

reduced, and the data transmission becomes faster and more convenient. AIS could automatically launch, receive and deal with ship data, without manual work. Also, AIS could continuously provide ship information to vessel traffic service system (VTS), receive the aid-to-navigation service information from VTS, and greatly simplify the information alternating quantity and communication frequency.

AIS makes the position report more accuracy and quick while broadcast AIS can submit shipping information and insert the ship and voyage information on checking requirements automatically and continuously which can be transmitted into computer center from wireless to cable communication networks. The computer center will set up the database according to systemic demand of information with schedule time, circle and information needed, then to combine with the ship static data, marine e-chart and meteorological data to analyze and handle for providing the shipping information and rescue decision-making service information with the service of transmitting to marine search and rescue department. AIS of ships was integrated into “BLM-Shipping System” with e-map by receiving AIS data to provide the directly ship allocation and the services of checking automatically and historical tracing. So there is wider applying outlook on marine management and helps a lot on aspects of the monitoring ability of shipping traffic management, the managerial ability of controlling and running on transport ships, the navigating ability of entry and exit ports for ships, the rescue ability when into risks and of navigation warming and meteorological information on trips.

The pharos remote monitoring and control system in AIS consists of automatic lighthouse equipment and AIS responder. Compared with existing telemetering and remote control system of lighthouse, there are the following advantages of: directly using the AIS international specialized channel (like CH87B or CH88B) to transmit

the data without applying for the telemetering and remote control channel; saving the construction of specialized communication networks and just needing to set the devices and AIS responder; the interconnection working model of AIS open system which makes it convenient to access into the Internet with the devices monitored, managed by master department; lighthouse information can also achieve the “ship to ship” working pattern; AIS is also to be a virtual application of lighthouse. A virtual lighthouse can be both a certain virtualization of specific one and a virtual navigation mark system. AIS lighthouse telemetering and remote control system has the characters of few devices, low costs, short construction circles, powerful functions and convenient for operation. With the constant development of IoT technology, there exists a certain kind of practical value on shipping monitoring except for AIS, laser berthing technology, MEMS sensor and so on.

AIS improves VTS working efficiency, and helps VTS upgrade the accuracy and database. There are the following advantages about application of AIS in VTS:

- Strengthening the recognition ability of ships

What the radar gained is the average of historical track while the AIS is the transient data of shipping position, direction and speed. So the precision of AIS is higher than radar which may lead to the conditions of marks exchanged or tracing loss when crossing or in region of high density for the reason that it can only obtain the dynamic information of ships. However, the information transmitted by AIS not only includes the dynamic one, but the static without the data loss.

- Improving the dynamic tracing ability and expanding the ranges

AIS has high accuracy of tracking on the large receiving ranges of VHF wireless communication frequency to accept the shipping information and also can be received by other AIS stations and repeater stations. The accuracy of shipping data provided by GPS/DGPS is less than 5m makes the high tracking resolving capability

and accuracy and short stabilization time on tracing vectors. The delay data handled by radar is around 20 scanning cycle (approximately, 1.5 minutes) as well as the directly obtaining the dynamic data to be marked by AIS with un-stabilization time and high reliability of tracking. Unaffected by meteorology and sea-condition, transmitting data can be obviously upgraded on reliability of tracking via the data exchange of international private channel and SOTMA technology.

- Melting and replenishing the VTS functions

The limitation of the information provided by marine aids radar or ARPA, failed to cognize the operating intention especially under the circumstances of narrow-way, corners, the back of islands, the water-region with high density or counting with the terrible weather or sea-conditions, the existing the error tracing and losing objects by automatic tracing function or even failed to explore the objects or the increase of the observing distance can lower the measure accuracy and resolving capability. For the good connection linked by communication chain-road of AIS can make up the disadvantages on bad weather. The ships equipped with the AIS of which position obtains the adjustments of GPS connected with shore-based AIS via the timely exchange of AIS data with near ships, thus to upgrade the high position precision and easily recognition on shipments dynamically.

- The VTS based on AIS has perfect performance price ratio

Due to the fine remote control functions, one controller can control many base stations in a wider range of regions covered by few controllers and many base stations as well as the less costs of investments than that of radar. AIS reduce the workload of operators in low-density port, and upgrade their working efficiency on transportation management, information services and other tasks.

4.2.5 Container e-seal

The traditional container seal is manual lead seal. Sealing is the protective measure for the cargo in containers. Manual seal can be divided into indicative seal and impedient seal. The difference depends on the lead stable level. Impedient seal is harder to destroy. The staff should use specified tool to open it. In contrast, indicative seal can be wiped out by common tools. In custom, container seal need be inspected several times. Any alterations should be recorded on the documents. To some extent, manual lead seal can protect the container and record some basic information, but it cannot provide specific changing second, location and other accurate information.

E-seal can easily achieve the information that traditional seal cannot get. E-seal is the mixed from common seal and RFID components. Most of the container e-seal also divide into passive and active. Passive e-seal has no power source, it cannot detect and record the damage time. Only in the node of supply chain can read the information to check whether it is hurt or not. The initial cost of passive e-seal is high. So it isn't a good choice to use passive e-seal. With its own power source, active e-seal can support wider range and larger function. Active e-seal do the real-time detection and event log. Combined with GPS technology, e-seal system can transmit the container information about the accurate time, position and surrounding environment to the manager when the condition changed. Some special active e-seal can provide immediate distress signal when the seal damaged.

4.2.6 Others

4.2.6.1 Intelligent warehousing system

Research and development of intelligent warehousing system is based on RFID technology. Through RFID reader, this system automatically identifies cargo

information data, and updates the data to data server by the internet. This system can provide the brand new solution of accurate information collection and real-time processing. Furthermore, it seamlessly integrated with MIS, ERP system, while promoting enterprise informatization standard. Intelligent warehousing system could realize agile manufacture, improve the production efficiency, reduce production cost and shorten production phase.

4.2.6.2 Cold chain logistics

Refrigerated cabinet is a special form in numerous kinds of container. No matter on board, yard or land carriage, temperature monitoring is very important. With power line carrier technology, service cable gathers the temperature automatically. On the side of land carriage, operators can set up RFID which carries with temperature controlling function on the truck. Combined with RFID, the tag can continuously record temperature data. Each data has the accurate time information, and it can help managers define the responsibilities of each operator. If the temperature of refrigerated cabinet became abnormal, RFID can trigger the alarm. Managers can take action as soon as possible, and also they can find the reason of each mistake from the database.

4.3 Case analysis: The efficiency improving based on RFID

The biggest three advantages of RFID on container terminal are high management security, high data accuracy, and high operating efficiency. The security and accuracy are very abstract to count into the real number. Efficiency can be expressed by the comparison of the total time of one container which has RFID tad delivering from the

bridge crane to the terminal gate.

Suppose the RFID technology developed perfectly, and each container embeds passive RFID tag. Mostly, the RFID technique can reduce the staff operating risk and time. Suppose no mistake in this data model. Calculation for the total time (T) needs the data of time cost in dock, delivering on trucks and forklifts, yard and the terminal gate. As an example of Yangshan container port, the bridge crane handling efficiency is 40TEU per hour, the forklifts handling efficiency is 45TEU per hour. The distance from the dock to the nearest gate is about 800 meters. Suppose the average driving rate of trucks is 4m/s. The time that RFID optimized cranes operation is very small compared with T. So, in this data model, it could be ignored.

The vital data here is the time passing through terminal gates. Due to the defect that gates cannot easily extend when the terminal developing, gates may have the risk of truck waiting. According to the real operation time in Shanghai Yangshan container terminal, analysis technical index with RFID and without RFID. Table 2 shows the collected data.

Tab.2 Average passing time when trucks passing through gates (s)

Type of container truck	*Braking*	*Checkout*	*Restart*	*Total time*
Without RFID	4	64	7	75
With RFID	4	14	7	25

Suppose open 3 gates and μ_1=1152TEU (without RFID) per day and μ_2=3456TEU (with RFID) per day. Generally speaking, the service in gates and trucks passing distribution can be regarded as the application of queuing theory. Refer to the

container trucks passing distribution situation, the author choose M/Ek/S model to describe the service situation of the gates. Container trucks passing distribution fits Poisson distribution, which means:

$$P_n = P(n) = \frac{\lambda^n}{n!} e^{-\lambda}, n = 1,2,3 \ldots$$

Therein, ***n*** means the number of passing container trucks in someday, ***λ*** means the arrival rate of passing container trucks, $P(n)$ means the probability of occurrence of n trucks passing through the gates. After the container trucks arriving at the gates, the operating time in gates accords with k-Erlang distribution, which means:

$$f_k(t) = \frac{\mu \mathrm{k} (\mu \mathrm{kt})^{k-1}}{(k-1)!} e^{-\mu \mathrm{kt}}, t > 0$$

Therein, ***μ*** means the service rate for truck passing through one gate for a whole day. ***S*** is the number of gates. According to feature of M/Ek/S model，there has:

$$\rho = \frac{\lambda}{S\mu}$$

$$P_0 = \left\{ \sum_{n=0}^{S-1} \frac{1}{n!} \left(\frac{\lambda}{\mu}\right)^n + \frac{1}{S!} \frac{1}{1-\rho} \left(\frac{\lambda}{\mu}\right)^S \right\}^{-1}$$

$$P_n = \mathrm{P}(n) = \begin{cases} \dfrac{1}{n!} \left(\dfrac{\lambda}{\mu}\right)^n P_0, & (n < S); \\ \dfrac{1}{S!\, S^{n-S}} \left(\dfrac{\lambda}{\mu}\right)^n P_0, & (n \geq S). \end{cases}$$

Therein, $\boldsymbol{P_0}$ means the probability of no container passing in the whole day. The evaluation indicator in this system is:

Average amount of trucks waiting in the gate:

$$L_q = \sum_{n=S+1}^{\infty} (n-S) P_n = \frac{(S \times \rho)^S \times \rho}{S!\,(1-\rho)^2} P_0$$

Average amount of passing container trucks:

$$L_S = \sum_{n=0}^{\infty} n P_n = L_q + \mathrm{S} \times \rho$$

Average waiting time of container trucks:

$$W_q = L_q/\lambda$$

Average detention time of container trucks:

$$W_S = L_S/\lambda$$

Tab.3 Actual data when trucks passing through gates without RFID

CTN.NO.	t_w	t_p	t	*CTN.NO.*	t_w	t_p	t
INKU6102043	89	72	161	BMOU4393312	75	50	125
YMLU5035001	124	46	170	GLDU0879225	54	56	110
DFSH6777291	144	57	201	KMTU7326329	94	68	162
YMLU4956169	90	40	130	UACU3371524	102	58	160
SPNU2812837	78	72	150	OOLU8858380	121	75	196
CCLU9292212	87	67	154	TGHU9799940	197	87	284
YMLU8172095	123	69	192	GLDU7213092	262	79	341
HJCU4140362	131	71	202	HUCU1072852	184	92	276
GLDU7464421	56	68	124	HUCU3205546	88	68	156
CBHU8273688	88	63	151	*Average E(t)*	*113.70*	*65.35*	*179.05*
GCSU6008320	87	49	136	*Variance D(t)*	*2472.31*	*167.63*	*3346.75*

Using the data of Yangshan container terminal which from the journal of “Data report of container transportation in Yangshan port in May 2011”. The author choose the data of one terminal in May 15th, and the gates system opened 3 gates for import (S=3). And there are 2304 containers passing through terminal gates on this day. Combined with the situation of truck passing, the author select 20 container trucks as examples to calculate the evaluate indicator in this system. Suppose t_p is the time for manual inspection operation, and t_w is the waiting time for container trucks. $t = t_w + t_p$. Table 3 shows part of data when trucks passing through gates without

RFID. Here, λ=2304TEU/day. Without RFID technology, the result is $P_0 = 11.1\%$, L_q=0.89, L_s =2.89, W_q=33.33s, W_S=108.33s. With RFID technology, the result is $P_0 = 51.2\%$ L_q=0.009, L_s=0.68, W_q=0.35s, W_S=25.35s.

In conclusion, if managers use RFID technology into gate system, the efficiency will improve a lot. It can reduce the time around gates to 23.4%. To the view of total time consumed, compared with 558s, the total time reduces to 475s. RFID help the terminal reduce 15% operating time in container transportation.

Chapter Five: Conclusion

Informatization and intelligentization are the trend of port developing. The internet of things technology is the core technology on port upgrade. IoT brings the integrated database, accurate data transmission, reliable safety monitoring, reduction of labor cost and high operating efficiency to the port management. The application of IoT in port management will improve the port competitiveness. And the intelligent port based on IoT must be the next generation port with the sign of informatization. From the application analysis the case analysis above, the RFID and GPS apply in various aspects of port management. These applications in port facilities can reduce the production time and the manual risk. The competitive advantages of IoT are obvious compared with traditional technology. But, there is normative regulation for RFID, and the relative technique should be improved to suit for the port developing.

The concept of IoT is given attention in last five years. It may need much more time, to doing research and developing for IoT application in different fields. There will be various IoT productions produced for port upgrade and the whole IoT port management system will be completed build when the port develops to a certain informatization extent.

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