

Intelligent Ports Based on Internet of Things

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Abstract—In this article, the informatization developments of main international ports are summarized. Then, the detail requirements of next generation Intelligent Ports are collected and analyzed. Later, the corresponding key technologies of Internet of Things are summarized. And, a kind of Intelligent Ports solution is proposed, and its main functions are designed in detail. Finally, the future development trend of Intelligent Ports is predicted.

Keywords—Intelligent Ports; Internet of Things; Wireless Sensor Network; Radio Frequency Identification

I. INTRODUCTION

Major ports in the world have gone through three development stages: informationalized ports, digital ports, and intelligent ports [1]. In recent years, many coastal countries, including Europe, America, Japan, South Korea, Singapore and other countries, attach great importance to the construction of port informatization, and begin actively to construct intelligent ports, and achieve significant results [2, 3]. With the popularization and application of the Internet of Things (IoT), many new Intelligent Ports has been started [4-8]. For example, New Damietta Port, Damietta in Egypt has announced the completion of the first Intelligent Ports in Mediterranean. In addition, the application of smart bayonet and Radio Frequency Identification (RFID) in many ports in America provides a strong guarantee for the logistics transparent supply chain, the safe transportation of goods, and international anti-terrorism [9-14]. The EU and China (Shenzhen) has started trade with ING project (Smart Container, intelligent shut, intelligent bayonet and other new techniques).

Intelligent Ports are a service system for port transportation based on modern electronic information technology, whose features are to provide multifarious information services for port participants based on the collection, processing, release, exchange, analysis, and usage of the relevant information [10]. Intelligent Ports are urgently needed to be closely integrated

This work is supported in part by NSFC 61233001, 61174172, 61203166, 61101220, 61104054, and the Early Career Development Award of SKLMCCS.

with IoT in order to achieve efficient data sharing and stability of port services. It other words, Intelligent Ports are new generation of ports, which has a new, intelligent port infrastructure and integrated and smart management and service [10].

IoT technology is the basis for the development of the Intelligent Ports. Sensor technology allows objects have the "perception"; RFID technology make them "speak"; machine-to-machine (M2M) let them "exchange"; finally, IoT let all objects in the world interconnect. So, the handling equipment, ships, containers, vehicles, and instruments, which are widely distributed in the global ports, are connected to this "net" [9-11]. IoT, extending human senses and collecting directly business data from operation terminal in ports, can eliminate manual collection errors, improve the collection efficiency, and deliver instantly to every corner of the earth through Internet.

At present, the typical applications of IoT in ports' production and management include: Container RFID, electronic seals, port equipment condition monitoring, engineering equipment asset management, wireless automatic meter reading, etc. [10]

In this paper, the needs of Intelligent Ports are analyzed in detail. The ToT's key technologies, overall solution and the detailed design of the functional modules are proposed.

II. THE SPECIFIC CONSTRUCTION NEEDS OF INTELLIGENT PORTS

The specific construction needs of Intelligent Ports mainly involve:

- 1) Intelligent Ports can create a more efficient, fast, safe, low-cost business environment.
- 2) The high standards of supervision and customs clearance of Customs and CIQ, such as the real-time, intelligent, visual supervision of goods and regulatory grounds. Therefore, the

smart card port, midway monitoring, video surveillance, logistics monitoring platform and integrated communications network are needed to be established to support intelligent regulatory system, to implement the declaration of information technology, to promote the information and intelligence of customs clearance operations of the ports.

- 3) The more efficient and low-cost production and management goals in terminal yards. The use of many IoT technology in the port docks (such as: RFID electronic license plate, RFID electronic customs lock, intelligent container, electronic platform scales, IC card identification, etc.) can achieve strict supervision and efficient customs clearance to save labor and cost, which can implement intelligent production scheduling at the Yard, and improve terminal production scheduling efficiency. In addition, GPS, GIS, RIFD and other IoT technology can be realized for container tracking and monitoring, truck transport path optimization, and optimal scheduling.
- 4) The improvement requirement of management, decision-making and command level. The managers need to keep abreast of the situation of port operations; The port supervision departments need real-time to know the operation of ports and a variety of real-time information, such as: the environment, security information, etc.; The field operations units need to keep abreast of port operations, future environmental change, traffic safety, logistics and e-commerce information; And, all types of enterprises need timely to understand all kinds of logistics information and related regulations, policies, work processes.
- 5) The timely response of sudden public security incidents, which need a reasonable response, fast processing, properly addressed, and adequate solution.

III. THE KEY TECHNOLOGIES OF IOT TO CONSTRUCT INTELLIGENT PORTS

Many key technologies and products of IoT are needed in the construction of Intelligent Ports, whose performance requirements such as high security, high reliability, high recognition rate, high stability are put forward.

A. Sensor

Sensor, a kind of detecting apparatus, can feel the information to be measured, and convert it into an electrical signal or other form according to certain rules, in order to meet information transmission, processing, storage, display, record and control requirements. It is the primary link to achieve automatic detection and automatic control. It can detect, feel the outside signal, the physical conditions (such as light, heat, humidity, pressure) or chemical composition (e.g., smoke), and transmit them the upper layer of IoT by the information communication technologies. Sensor, responsible for the collection of IoT information, is not only the basis of perception of the real world, but also the services and applications of the IoT.

B. RFID

RFID technology (RFID tag and reader), a kind of non-contact automatic identification and short-range wireless communications technology, can automatically identify objects and access relevant data through RF signal. It is passive, low cost, new technology to again change the retail settlement, logistics and product tracking mode, following the bar code technology. It also has many characteristics, like read distance, penetration ability, wear-free, non-contact, high efficiency, the large amount of information, automation, long-range, omnidirectional, stain wet, which are not found in bar code.

RFID is a technology that allows items "speak". RFID tags store normative information which can be collected automatically through a wireless data communication network to a central information system, to achieve the identification of the goods (products), and then to achieve information exchange and sharing through open computer network.

C. Wireless Sensor Network (WSN)

WSN, combining sensors, embedded systems, networking and wireless communications, distributed information processing technology, etc. can collaborative real-time monitor, perceive, and acquire the information of environment and monitor objects through a variety of integrated micro-sensors, and process information through the embedded system, then transmit information to the user terminal by random self-organizing wireless communication network, in order to realize "ubiquitous computing".

D. Network Communication Technology

The network communication technology throughout sensor, divided into two categories: short-range communication (IEEE 502.15.4 and 2.4 Ghz) and WAN communications (IPv6, 2G/3G/4G mobile communications, satellite communications technology), can provide transmission channel for IoT data. Especially, the next generation of Internet technology, IPv6, can assign an IP address for each sensor, to create a good foundation for the development of IoT.

E. Machine to Machine (M2M)

M2M refers to send data from one terminal (machine) to another. M2M is the general technology to enhance the general machinery and equipment communication technology and network capabilities.

F. Vehicle terminal

The vehicle terminal can be used for smart yard, intelligent warehouse, and large vehicles such as container truck, forklift and tools. It can transmit the RFID information of tools vehicle or cargo to the monitoring center by 3G or WiFi short-range wireless communication, to achieve the purpose of real-time monitoring.

G. Handheld mobile terminal

Handheld mobile terminal can be used for smart card port, smart yard, intelligent warehousing and customs supervision

center, to achieve remote video and data monitoring of transport and cargo.

IV. THE OVERALL FRAMEWORK OF INTELLIGENT PORTS

It can online real-time monitor the vehicle, the container, the cargo, the ship, and clearance process, ultimately to form a whole-process, intelligently, and visually visualization monitoring system. Firstly, the unified data standardization system and data exchange system are built to do business carding and data needs analysis. Then, taking IoT technology as basic infrastructure, using such technologies as RFID, sensors, WSN, wireless communications, cloud computing, 3D virtual reality, the fast automatic supervision, acquisition and tracking of containers, transport vehicles and goods can be achieved, to achieve information networking and real-time data exchange of ports, yards, warehousing, customs, freights, to form the intelligent management of traffic flow, logistics, and information flow.

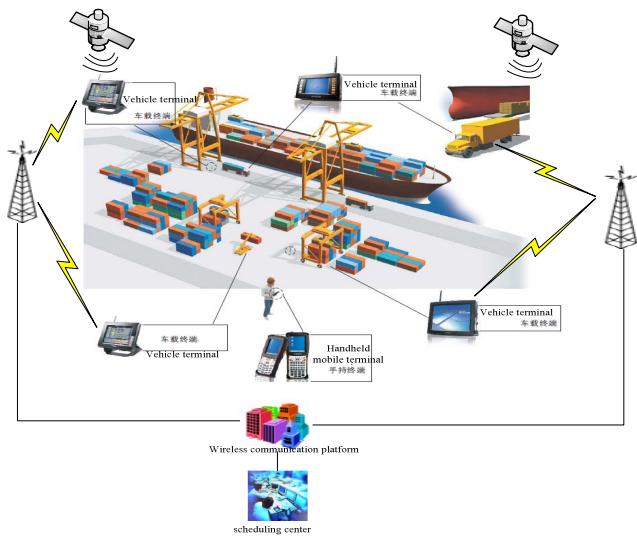


Fig. 1. Intelligent production scheduling management system

A. Intelligent production scheduling management system

Using such technologies as GPS, WiFi wireless terminal, 3D virtual reality technology, many functions, including 3D scene management, smart jobs, intelligent scheduling management, set card scheduling in dock container yards can be realized, to achieve visualization, intellectualization, real-time dynamic management and monitoring of the whole process, to achieve high scheduling optimization, to improve operational efficiency, and to save operating and maintenance costs, to increase safety and traceability. Specifically, the whole terminal field area is covered by wireless network or wireless base stations; vehicle wireless terminals, which have GPS communication function at the same time, are installed on autotucks, forklifts, cranes and other vehicles; The control personnel send real-time perating instructions to the vehicles in yards using 3D three-dimensional model of the control scheduling system, forklifts, bridge, and accept the feedback of instruction completion at the same time. In addition, the 3D models of yard container stockpiling can also be updated in

real time to achieve the same scene in the control center system and the actual yard operation.

B. Intelligent bayonet system

Using RFID (electronic license), photoelectric sensors (Box Number recognition), pressure sensors (electronic loadometer), magnetic sensors (inductive positioning chart), GPS and many other base sensor network components, the local IoT can be composed, to automatically collect a variety of information of the person IC card, electronic license plate, electronic customs lock, the container number, weighbridge weight of containers, container vehicles and personnel, then the "inspection" or "release" instruction can be sent automatically after collecting, matching, and processing these information with the background Intelligent bayonetnuclear data of customs systems. It can reduce the time from 10 minutes by artificial cards to 15-20 seconds by smart cards. It includes mainly the following subsystems: container automatic identification systems, the electronic automatic license plate recognition system, electronic customs lock management system, electronic weighbridge acquisition system, identification systems, human-computer interaction system, automatic clearance control system, video intercom system, centralized monitoring system, etc.

C. Intelligent Warehouse Management System

As shown in Figure 2, by means of RFID technology, data acquisition and processing can be fast, accurate, achieved, and warehouse business processes can be optimized. Then, the customs supervision warehouse goods out of warehouses are intelligent real-time monitored, to improve the speed and efficiency of supervision customs clearance, and to reduce the cost of warehousing. In addition, the system of human-computer is interacted with 3D virtual reality technology, to real-time, dynamically display warehouse, and support immersion-style roaming goods locating hidden features to facilitate enterprises to understand the situation of the goods in a warehouse, and greatly improve work efficiency, reduce operating costs.

Specifically, using RFID identification technology, the regular goods, which have regular to be stored on the shelf, can be installed with the RFID UHF passive tags at their shelf locations and cargo pallets. The irregular goods can be identified by UHF RFID tags according to storage units and the circumstances. Fixed RFID UHF reader should be installed at inbound and outbound Kurakado of warehouse. And, the computers, RFID UHF reader and WiFi wireless communication module should be installed in the operating forklift. And, server should be connected to a wireless WiFi network to cover the whole warehouse. Under overall layout of the system, all data of the warehouse goods into the library, delivery of cargo from storage, loading, inventory, goods location adjustment, the site location commodity query, etc. can be obtained in large quantities and transmitted real-time and two-way.

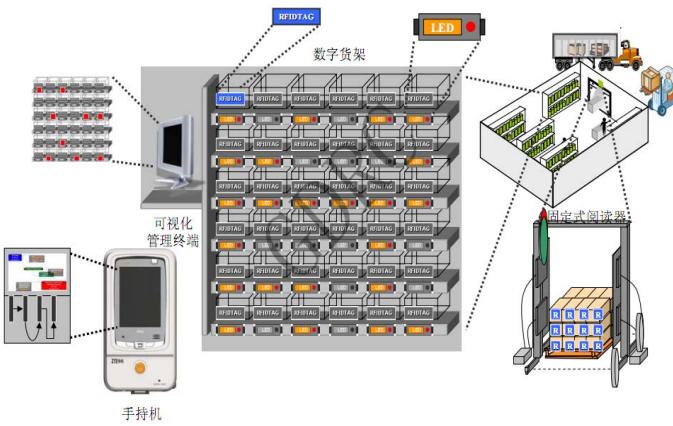


Fig. 2. Intelligent Warehouse Management System

D. Intelligent Vehicle (container) management system

The container vehicles, installed with unified or compatible RFID electronic license plate, GPS, electronic shut/closed or other smart devices, can be identified by RFID readers at Minato, logistics parks, the station bayonet. So, the import and containerown property and other information can be identified, recorded, and shared with other regulatory systems, to achieve real-time monitoring of vehicles and containers dynamic security monitoring and management.

E. Smart Ship Management System

Using the Automatic Identification System (AIS) technology, chart GIS technology, GPS, as well as Electronic Data Interchange (EDI) technology, Smart Ship Management System can be formed. By it, the Joint Inspection Units at ports (Customs, CIQ, maritime, border, etc.) will be able to understand the ships' reporting and approval by the same system, so as to enhance the real-time location and supervision of the ships. In addition, it can be connected with the customs GPS management system of the small vessels, to closely monitor the import and export declarations on the ship, the out of port procedures for approval, as well as the safety of the ship by AIS system.

F. Electronic monitoring channel

Using RFID, short-range wireless communication, automatic detection, intelligent control and many other technologies, equipped together with RFID electronic seals (RFID electronic shut), cargo regulatory base station (the wireless transmission base station with visual function), the transmission of information can be completed through the equipment and control center, to constitute electronic monitoring channel, to achieve real-time visual monitor and manage of transport vehicles and cargo of the customs regulatory sites during transit (through customs), to improve the supervision of vehicles and goods and operation efficiency.

G. Unified platform for monitoring command center

The logistics data of transport and cargo and video information of all docks, yards, bayonets and special supervision areas can be integrated into a unified logistics

information exchange platform, to achieve real-time, efficient and safe intelligent monitoring of cargo, containers, cars, boats, trains etc. Through the monitoring center, emergency situations and emergency command can be timely and effectively responded, to protect the normal production and operation, and to establish an efficient linkage of the port supervision departments and coordination mechanisms to create favorable security conditions.

H. Regional data center

Regional data center is services data source of Intelligent Ports and its aggregators and switching center. It is combined by Electronic Port Data Center (foreign trade) with transport and logistics data center (internal). By cloud computing and massive data processing means, it can exchange, integrate, and process the Internal and external trade data.

V. FUTURE PROSPECTS

The changing of development patterns of ports is a strategic task, whose restructuring target is modern service industry. The construction goals of intelligent ports will transmit from the pursuit of the single port logistics efficiency and cost optimization to the close cooperation between the various participants of the entire supply chain of marine logistics and land logistics to achieve adaptive dynamic optimization in order to achieve win-win cooperation and sustainable development. IoT technology-based intelligent ports can achieve information sharing and dynamic collaboration between deferent things, to improve the efficiency, accuracy, visualization, safety and smoothness, environmental protection of port operations.

At present, IoT technology has been applied in the container terminal and taken some progress. In the future, IoT technology will penetrate into the development and construction of the Intelligent Ports, which has an important economic value and significance.

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