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Original Paper

The Development and Exploration of Smart Port

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Abstract

Smart port is the core of the intersection of logistics. According to the data-driven Internet of Things information platform, the logistics chain and value chain are highly integrated to realize intelligent management and decision-making. In the future, smart ports will continue to promote the development prospects of logistics, business innovation and operation, promote the high integration of the port and the shipping industry, and enhance the comprehensive competitiveness of the port. At the same time, the construction of green and smart ports will become an important direction of future development, and promote the development of ports to a greener and more intelligent direction.

Keywords

smart port, green development, intelligent

1. Smart Port Overview

1.1 Definition and Characteristics of Smart Ports

Logistics system, as an indispensable part of the regional economic system, is of great significance to the development of coastal cities. Under the grand background of smart city construction and regional economic development, the intelligent upgrading of port logistics system has become a crucial strategy. The function of the port has been transformed, from a single loading and unloading center to a service center, and then to the logistics center today, and its role in the supply chain has become increasingly prominent. In this process, modern information technology and management methods have played a decisive role. (Bao, 2013)

With the rapid development of electronic data exchange and the Internet, the information exchange and data flow between ports have become more convenient and efficient. A lot of research has been carried out at home and abroad, and the related technologies have become increasingly mature. In recent years, the new concept of smart port came into being. The system is based on information perception, processing and sharing, and the system effectively improves the comprehensive service capability of the port by innovating various functions, technologies and services of the port. Smart port is not only a

major innovation in the field of logistics, but also a model of the deep integration of modern technology and traditional ports.

Smart port, with information technology as the cornerstone, to build an efficient data exchange platform and comprehensive management system, to realize the intelligent control and automatic operation of all links of the port. Using cutting-edge technologies such as the Internet of Things, cloud computing, big data and artificial intelligence to closely connect the port with freight companies, customs, storage enterprises and other parties, optimize cargo transport planning, improve loading and unloading efficiency, realize multimodal transport, improve navigation, customs clearance and other processes, and improve port safety and efficiency. While retaining the functions of traditional ports, smart ports realize intelligent, efficient and green operation through advanced technologies, greatly improving logistics efficiency, reducing operating costs, and actively contributing to environmental protection and sustainable development.

Taking the Internet of Things technology as an example, smart ports deploy many sensors and equipment to monitor and manage all kinds of equipment and goods in the port in real time, enhance the safety and accuracy of operations, and enable the management party to grasp the operation situation in real time and make scientific and reasonable decisions. Data show that smart ports using the Internet of Things technology have achieved significant improvements in key indicators such as cargo throughput and operational efficiency.

At the same time, the smart port pays attention to the coordinated development with the surrounding industries and cities, builds a smart logistics system, realizes the smooth connection between the port and the inland transportation, storage, distribution and other links, and improves the efficiency and competitiveness of the whole logistics chain. This interconnected development model promotes the coordinated development of regional economy and provides solid support for the stable and efficient operation of the global supply chain.

1.2 Position of Smart Port in the Logistics System

Smart port occupies a pivotal position in the logistics system. With the continuous global trade and the increasing overall demand for logistics, the operation mode of traditional ports is difficult to meet the high efficiency, environmental protection and safety of modern logistics. As the master of modern port technology, smart port has successfully used 5G communication technology, Internet-of-things technology, artificial intelligence and big data to carry out intelligent transformation and upgrading of existing infrastructure.

Smart port fully connects and coordinates various resources and participants in the port supply chain, presenting an unprecedented seamless connection mode. It has injected new vitality into the global logistics system, and promoted the sustainable development and innovation of the global logistics industry. Smart ports can also greatly improve the efficiency of collection and distribution, reduce capital costs, and reduce a large amount of emissions, contributing to environmental protection.

2. The Technical Basis of the Smart Port

2.1 Application of Internet of Things Technology in Smart Ports

The application of the Internet of Things technology in smart ports has brought profound changes to the field of port management. With the help of the Internet of Things technology, the port can realize the comprehensive real-time monitoring of goods, equipment and personnel, thus significantly improving the operational efficiency of the port. Key IoT technologies used in ports include RFID technology, sensor and sensor network technology, network and communication technology, and cloud computing technology.

In terms of cargo management, by installing RFID tags on the goods, the port can track the location and status of the goods in real time, ensuring the safe transportation of the goods in the port. In addition, the Internet of things technology in port also played an important role in equipment management, through the torque sensing, video monitoring technology, achieve comprehensive monitoring of equipment working status, for equipment scheduling, guidance and troubleshooting to provide strong support, so as to ensure production safety, reduce energy consumption, improve productivity and accuracy. (Geng, 2014)

The construction of smart port is closely related to the application of Internet of Things technology, and the cargo throughput keeps rising, which has become a strong embodiment of port competitiveness. (Ma & Chen, 2012) This significant improvement not only shortens the time of goods in the port, reduces the logistics cost, but also promotes the green development of the port, reduces the energy consumption of equipment, reduces environmental pollution, and realizes sustainable development.

As a typical example, Hamburg Port shows the application of the Internet of Things technology in port management. By deploying various sensor devices, the port is able to monitor each key link of its operation process in real time. It not only optimizes warehouse logistics and inventory management, but also promotes the automation process of cargo loading, scheduling and transportation, thus improving the overall operational efficiency and competitiveness of the port.

2.2 The Role of Big Data and Cloud Computing in Smart Ports

The efficient data collection, processing and analysis capabilities of big data technology make it widely concerned and highly used in all fields of society. With the increasing expansion of ship scale and the continuous increase of port throughput, the data volume involved in the process of port operation also shows a rapid growth trend. As an important node of the logistics chain, the port business management can be optimized and improved through big data processing and analysis, so as to improve the efficiency of port scheduling, management and business connection. (Yuan & Sui, 2022)

At present, the application of big data technology in ports mainly focuses on the collection of data and measurement indicators after the completion of ships, but the collection of data before operation, the improvement and wisdom of prediction, decision-making and other related aspects still need to be further strengthened and improved. However, after continuous research and development and optimization, the existing big data analysis system has successfully realized the efficient collection of

massive data for the whole process of automated container terminal operations, and on this basis, a highly intelligent decision-making big data knowledge database has been built. The establishment of this system provides strong support for improving the operation efficiency of the container terminal, optimizing the operation process and enhancing the scientific nature of the decision-making.

Taking Ningbo Zhoushan Port as an example, the port has actively introduced big data and cloud computing technology, and has successfully realized the comprehensive digital management of the port operation. Through the comprehensive collection and analysis of the data of ship entry and exit, cargo handling, equipment maintenance and other links, the port can accurately predict the key information such as cargo throughput and ship arrival time, so as to optimize the operation plan and improve the operation efficiency. At the same time, the cloud computing platform provides strong data storage and computing power for the port, enabling the port to realize the rapid processing and analysis of massive data, and providing strong support for decision-making.

2.3 Practice of Artificial Intelligence in Smart Ports

Artificial intelligence, as an emerging technology science, covers computer vision, intelligent decision-making and other fields. In the construction of smart ports, artificial intelligence has played an important role, mainly reflected in the following two aspects.

In the safety production management work of the port, the integration of artificial intelligence technology greatly improves the intelligence degree of the safety control system. At present, some ports have used advanced technologies such as face recognition, gesture recognition and vehicle recognition to establish an intelligent safety monitoring system, to implement comprehensive and real-time monitoring of personnel and vehicles in the operation area. These systems have a strong hidden danger identification ability, and can quickly make corresponding solutions, so as to ensure the safety and stability of the port operation process. Although the application of the port in this aspect is still in the initial stage and only in trial operation, with the continuous progress of artificial intelligence technology, the intelligence of the security control system will become an indispensable part of the smart port in the future. (Yuan & Sui, 2022)

In terms of intelligent scheduling, the application of artificial intelligence technology is also of great significance. As a key node in the logistics network, its core competitiveness stems from the high effect response and orderly operation of its terminal production and operation system. Therefore, the rational allocation and efficient scheduling of resources are particularly critical. However, under the current environment, the port industry lacks attention to the intelligent research and development of the scheduling module of the production control system. However, the comprehensive construction of smart ports requires not only intelligent upgrade at the equipment level, but also intelligent transformation at the management level. At present, domestic ports have begun to use automatic yard selection, loading and other modules, aiming to further improve the efficiency and accuracy of port transportation, to provide a strong guarantee for the efficient operation of the logistics industry. Taking Guangzhou Port as an example, through the use of AI safety officer assistant and the automated port

yard detection and management cloud platform based on AI visual identification, the yard management is more scientific and standardized. These systems use cameras and computers to replace human eyes to extract and analyze image features, and send early warning to managers in time, realizing a new mode of port operation of man-machine cooperation.

3. Construction and Management of Smart Ports

3.1 Challenges of Smart Port Planning and Construction

The planning and construction of smart ports face multiple challenges, among which information security is particularly prominent. Especially in the service application platform of "big data + port", this problem is particularly important. When providing digital services for ports, the platform highly relies on cutting-edge big data technologies such as artificial intelligence and the Internet of Things. The acquisition and transmission of information is mainly completed through the port network platform. Therefore, the application of big data in the construction of smart ports is accompanied by significant risk of information data security. (Meng, Zhang, Kuang, & Niu, 2022)

In addition, the issue of data ownership cannot be ignored. There are two main sources of data of smart ports: one is the original business data directly collected by the big data application platform, and the other is the corresponding data further processed by the service platform. In the process of data collection, data ownership has become a great obstacle to the application of big data in the construction of smart ports. Because data property right is different from material property right, but also similar to intellectual property right, it has the characteristics of easy confusion and great volatility. Therefore, in the routine business operation of port enterprises, although the application and processing of underlying big data such as commercial information is relatively standardized, the non-standard data use occurs from time to time in the development of different functions at different levels, which poses a challenge to the ordinary operation of port business.

3.2 Safety and Risk Control of Smart Ports

As an important innovation direction in the field of logistics, the stability and sustainable development of smart port cannot be separated from a solid foundation of security and risk control. In the planning and management of smart ports, it is very important to ensure that safety and risk control are always at the core position. Through the integration of cutting-edge technologies such as the Internet of Things, big data and artificial intelligence, smart ports realize real-time monitoring and early warning of the whole process of port operation, significantly improving the security and risk prevention and control capabilities of ports. However, the process of intelligence is also accompanied by risks, such as overall smart port planning, data process relationship between subsystems, underlying technology selection such as near field positioning and communication technology, and coordination between management and operation, which are all areas to be focused on. At present, new technologies and hardware emerge in an endless stream, and the choice of hardware network and other infrastructure puts forward the dual

challenges of both advanced and sustainable, which constitutes the difficulty in the development of smart port.

4. Economic Benefits and Social Impact of Smart Port

4.1 Improvement of Logistics Efficiency Achieved by Smart Port

As an important innovation direction in the field of logistics, smart port has a significant impact on the improvement of logistics efficiency. With the help of the extensive application of the Internet of Things technology, smart ports realize the real-time sharing and monitoring of cargo information, which significantly reduces the information asymmetry and transmission delay. Relevant data show that compared with traditional ports, the information processing speed of smart ports has increased by nearly 50%. This means that the time from port to port has been greatly shortened, and the logistics efficiency has been significantly improved.

In addition, the smart port also conducts deep mining and analysis of the port operation data through big data and cloud computing technology. This not only provides a more scientific and reasonable decision-making basis for port managers, but also can predict and deal with potential logistics bottlenecks and risks. Take the Qinzhou Port Automatic Wharf project as an example, this project has been put into operation. In this process, the introduction of advanced automatic loading and unloading equipment and horizontal transportation equipment, has provided a strong technical support for the operation of the container terminal. At the same time, the intelligent security protection system and the intelligent operation and maintenance platform system have been established, which makes the container terminal appear digital and normalized, and further improves the operation efficiency. The implementation of these measures not only improves the level of automation of the port operation, but also lays a solid foundation for the long-term development of the port. This proves that the operation efficiency of automatic wharf is much higher than that of traditional manual wharf, and the operators can reduce most of the workload. At the automated terminal of Qinzhou Port, a batch of containers carrying auto parts were accurately and quickly lifted into the cabin. After the successful completion of the packing work, the ship will set sail abroad. From the entry of the container to the completion of the shipment, the time of the whole process has been significantly reduced, which fully reflects the excellent effect of the smart port in improving the transportation efficiency and convenience.

4.2 Contribution of Smart Ports to Environmental Protection

As an important innovation direction in the logistics field, the positive impact of smart port on environmental protection cannot be ignored. In the process of traditional port operation, the waste gas, waste water and other pollutants discharged by trucks and ships have had a serious impact on the surrounding environment. However, through the integration of cutting-edge technologies such as the Internet of Things, big data and artificial intelligence, smart ports can realize the intelligent management of port operation and effectively reduce the level of environmental pollution.

Smart ports have significantly reduced the fuel consumption and pollutant emissions of trucks and ships by optimizing transportation routes and reducing empty driving rates. According to authoritative data, the application of intelligent scheduling systems has reduced the waiting time of trucks at ports by 30 percent and reduced fuel consumption by 20 percent, thus significantly reducing emissions of greenhouse gases such as carbon dioxide.

In addition, smart ports also actively introduce clean energy and environmental protection equipment to further reduce the burden on the environment. Take Ningbo Zhoushan Port, for example, where 241 electric container trucks have been put into use, which unload containers through remote automated bridge cranes. Compared with the annual fuel consumption of about 16 tons and 40 tons of carbon emissions of traditional container trucks, pure electric container trucks almost produce no carbon emissions, providing strong support for the port to achieve the goal of carbon peak and carbon neutrality. In the process of promoting the high-quality development of ports, intelligent transformation has become the only way.

5. The Development Trend of Smart Ports

5.1 Development Trend of Logistics

Port, as the key node and core in the logistics system, undertakes the important mission of the joint operation of the upstream and downstream links. In the future, the infrastructure of smart ports will be based on the data-driven Internet of Things information platform to realize the adjustment and summary of the information resources of the logistics chain and value chain data. The move is to eliminate information asymmetry, reduce logistics and transportation costs and improve transaction utility through intelligent governance and planning. Through the construction of this efficient information platform, various transportation modes such as railways, highways and waterways will achieve efficient coordination, data exchange and sharing, to ensure the efficient operation of the logistics system. In addition, the construction of smart ports will also promote the deep cooperation between enterprises and governments, promote the seamless connection and coordination of various resources in the upstream and downstream of the industrial chain and interested parties, inject new impetus into the facilitation process of logistics and trade, and further improve business efficiency and competitiveness. (Yin, 2019)

5.2 Development Trend of Business Innovation

The construction of smart port will continue to lead the innovative development in the field of concept, application and management, promote the continuous integration of big data technology and the corresponding port industries, and further expand the scope of port shipping finance, data service and other related businesses. Through the use of trade, logistics and transportation transaction scenarios, to build an efficient and convenient online payment system, and to establish a credit investigation system relying on powerful information resources, to ensure the effective use of capital and accurate control of risks. In addition, we will also provide diversified financial services such as online foreign exchange

purchase integration and insurance. As a key node in the field of logistics, the port has accumulated rich and valuable information resources, including port berths, ship time arrangement, trailer use, import and export goods and their flow direction, etc. We will deeply explore the hidden trade and logistics characteristics contained in these data, combine with the internal and external innovation strength of the enterprise, carry out industrial application design, promote the commercial application of data, and create a wider range of commercial value and social value for the society.

5.3 Development Trend of Operation

In the construction process of smart port, the importance of intelligent technology cannot be ignored. With the help of advanced artificial intelligence visual identification technology, the whole process of the container greatly improves the function and accuracy of the box identification, bringing innovation to the operation of port logistics. At the same time, the smooth implementation of the coordination scheme of driverless driving card and vehicle and road, thanks to the strong support of 5G communication technology and the continuous optimization of artificial intelligence algorithm, significantly enhances the safety of intelligent driving, and greatly reduces the transformation cost of the automated terminal, providing a solid support for the intelligent upgrade of the port. With the wide application of 5G technology, it has laid a solid foundation for the access of the highly intensive Internet of Things terminals, and further promoted more intelligent terminals and devices to play a key role in the terminal transportation. These significant advances not only promote the application of drones in the field of port safety monitoring, but also promote the wide application of robots in security inspection, and also provide strong support for the progress of driverless vehicles in the field of cargo transportation. In addition, advanced applications such as remote control of high-precision shore and Bridges have also been rapidly developed, which further improves the efficiency and safety of dock operations. After long-term data accumulation and in-depth analysis of artificial intelligence algorithm, the operation and management system is more rational, accurate and efficient in assisting the decision-making. This change not only innovates the traditional TOS operation model, but also significantly improves the level of scientific operation. (Yin, 2019)

6. The Future Development Direction of the Smart Port

The construction of green and smart ports plays a vital role in the future continuous development of port enterprises. In order to achieve green transformation, we need to take comprehensive social, economic and environmental considerations, and adopt comprehensive strategies. This requires us to strengthen the construction process of green ports while ensuring the efficient operation of the ports.[5] With the rapid development of the global shipping industry, energy saving and low-carbon environmental protection have become the core orientation of the future development of the port industry. In view of the international community's strict regulations on the release of sulfur oxides, the application of Liquefied Natural Gas (LNG), as a clean and environmentally friendly energy source, is gradually emerging and becoming the mainstream of the industry. At present, the United States, Japan,

China and other countries and regions are actively committed to promoting the popularization and development of LNG-fueled ships. (Dewey, 2017) In the context of international integration, the prosperity of international commerce has provided a huge space for the development of the modern shipping industry. The "Belt and Road" policy and strategy proposed by China provide a further opportunity for the transformation and upgrading of smart ports. We should seize this rare development opportunity and actively strengthen the cooperation and linkage among all regions with an attitude of openness and cooperation. In this process, we should highly integrate the Internet of Things, big data, intelligent equipment and other emerging technologies into every link of the port development, so as to promote the development of the port to a greener and more intelligent direction. By continuously strengthening the concept of green development and continuously improving the level of data information, we will be able to effectively promote the overall promotion of the competitive advantage of China's ports and make positive contributions to the sustainable development of the port industry.

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