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Architecture Research and Design of the IoT Middleware for Marine Logistics

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ABSTRACT

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Modern marine logistics is a kind of integrated logistics. The data collected and transmitted has the characteristics of a large number, a wide variety and a high degree of heterogeneity. Based on the above characteristics, this paper presents a design scheme of internet of things (IoT) middleware, focusing on the application system and communication system structure of the marine logistics IoT middleware. The configuration middleware is used to complete the routing configuration and topology adjustment of the communication system. The hierarchical and modular design scheme is combined with the adaptive fractional interval equalization method to optimize the communication network middleware and improve the signal stability. The data sensing layer, the data and equipment control layer, and the business management layer constitute the application system of the marine logistics IoT middleware, and the functions are analyzed and designed. Finally, the effective management, state monitoring and interaction of the marine logistics are realized.

ADDITIONAL INDEX WORDS: *Marine logistics, internet of things (IoT), communication middleware, application middleware.*

INTRODUCTION

With the development of science and technology and the continuous deepening of economic exchanges, international economic and trade development is very rapid (Vieira *et al*., 2018; Supsomboon, and Varodhomwathana, 2017). Among them, the importance of ocean-going vessels and ocean ports in the process of transportation and collection of logistics goods is increasing day by day, and its role is becoming more and more obvious (Endrerud, Liyanage, and Keseric, 2014). Modern oceans are integrated logistics that require scientific, rapid, and accurate tracking, scheduling, management, and decision making. Up to now, the management of many ports and vessels has relied on manual and telephone calls (Wang *et al*., 2009; Lam, and Notteboom, 2014). This method is slow and efficient. Even with information processing technology, centralized management and data sharing of massive data are affected by different manufacturers and models. Serious constraints, so these methods need to be highly valued by people (Bergantino, Musso, and Porcelli, 2013).

The IoT is a massive end device and facility that will be installed on multiple objects, including sensors with "intrinsic intelligence", mobile terminals, industrial systems, CNC systems, video surveillance systems, etc., and "external enablement" of "intelligence" (Gubbi *et al*., 2013; Atzori, Iera, , and Morabito, 2010). Facility or animal" or "smart dust", through various wireless or wired communication networks to achieve interconnection and application integration, in the Internet environment, using appropriate information security mechanisms to provide security, control, and even personalized real-time Online monitoring, positioning and tracing, alarm linkage, dispatching command, plan management, remote control, security defense, remote maintenance, online upgrade and other management and service functions, to achieve efficient sharing of massive data, complete management process of "management, control, Camp" integration (Dalvi, and Shaikh, 2017). Therefore, the application of the IoT technology to the field of marine logistics has become a research hotspot.

There are many kinds of information related to the goods involved in the industry, such as the transportation of ocean-going vessels, the loading and unloading of goods, the storage situation, the entry and exit of ports, the monitoring and control of dangerous goods, and the accumulation of port items (Song, and Parola, 2015). Information sharing and integration of these different types and a large number of data, and the completion of data conversion from information resources to decision support to achieve more effective logistics management (John, Menachof, and Talas, 2019). Most of the middleware systems of the IoT can only use sensors to monitor process and transmit the status of goods, which cannot meet the application requirements of multi-class data analysis and centralized processing of modern marine port logistics (Cerchecci *et al*., 2018).

In view of the business characteristics of marine logistics and better serving IoT technology to marine logistics, it is necessary to research and apply the middleware of the IoT to improve the application efficiency and value of the IoT (Endrerud, Liyan-

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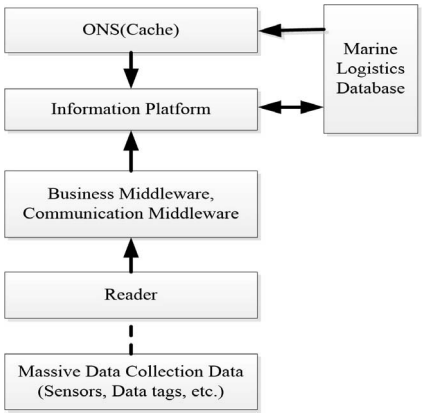

Figure 1. The IoT network architecture diagram.

age, and Keseric, 2014). Due to the particularity of marine logistics, the variety of heterogeneous items involved is huge, and the middleware design needs to fully consider compatibility, scalability and forward-looking (Panahi, Nie, and Lin, 2011).

METHODS

Electronic Product Code (EPC) aims to establish a global and open labeling standard for each piece of products, to achieve tracking and traceability of single-piece products on a global scale, thereby effectively improving the level of supply chain management and reducing logistics costs (Zhao, and Shi, 2013). EPC is a complete and complex, integrated system. In the design of this system, it is divided into five parts: data acquisition, data reading, middleware, etc. The composition of the IoT is shown in Figure 1.

In the process of marine logistics, each container will be equipped with an RFID tag, and the value is unique (Zhang *et al*., 2011). At the same time, physical sensors such as temperature, humidity and PH value are installed. Therefore, in the process of transportation, storage and other logistics, the reader is discovering it. When there is an EPC electronic chip in the transmission range, the relevant data will be automatically read to obtain the cargo information and location information of the container, and the environmental parameters in the container will be uploaded to the IoT middleware in real time by the sensor. After obtaining the data, the middleware uses its keyword to query the object name resolution server (ONS) for the network address associated with the tag, and the middleware accesses the data parsing, data cleaning, and heterogeneous data isomorphization processing (Yan *et al*., 2013).

Communication middleware is the core of data transmission. It completes the routing configuration and topology adjustment of communication system. It adopts hierarchical and modular design scheme combined with adaptive fractional interval equalization method to realize communication network middleware optimization design, reduce output distortion and improve signal stability.

In the face of massive data, numerous heterogeneous data, and abnormal data, if data processing, data cleaning, data transmission, and isomorphization are the key technologies in IoT logistics, in order to achieve efficient and scientific management goals, the system passes Networked middleware technology is implemented.

RESULTS

The middleware is located between the reader and the information platform, which acts as a bridge. It realizes the data exchange and transmission between the upper and lower layers and the isomorphism of the heterogeneous data. The treatment has played a crucial role in the processing of marine logistics information.

Sensor Device Management

The IoT and the perception process are obtained by acquiring a large number of data acquisition readers that can read and write different types of tags and sensors, thereby further obtaining various feature data such as attributes and states of the articles, and utilizing the characteristics of limited reader perception. Combine GPS and GIS to complete the accurate positioning of the goods. The quantity, quality and effectiveness of these data acquisitions will play an extremely important role in the operation of the entire system and the conversion of data to information. The role of the IoT middleware is to control and manage a large number of multi-type readers and sensors, so that they can run stably and transmit quickly and stably through the communication network, ensuring effective and efficient operation of the entire IoT.

Data Cleaning

Due to the industry characteristics of marine logistics, there are many kinds of information related to the goods involved in the industry. The data collected is relatively isomerized and the data is abnormal. For example, similar sensors read the same product at the same time, and chance. The temperature sensing data is obviously abnormal, etc., which requires data cleaning in the middle layer, such as: eliminating obvious abnormal data, eliminating duplicate data, intelligent selection of multiple data of the same item at the same time.

Data Analysis and Business Services

In the IoT, middleware realizes information fusion through its equipped device interface, thereby completing business sharing and data sharing of marine logistics data, and providing corresponding supporting services for background applications through data analysis and processing according to corresponding business information.

Communication Transmission

The data and device control layer and the data sensing layer are designed with communication middleware. According to the characteristics of large amount of data, high degree of mobility and complex operating environment, the use of distributed architecture and wireless sensing networking technology is considered. Routing link configuration for remote data transmission and terminal signal transmission control. The communication middleware is optimized, and the fractional interval equalization method is combined with the balanced configuration and channel optimization of the marine logistics

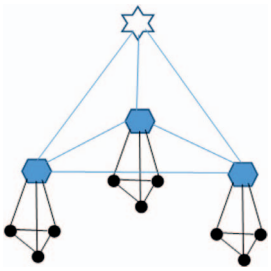

Figure 2. Marine logistics communication network structure.

mobile communication to improve the quality of mobile communication.

Standardization Process

The data collected by the sensors of the IoT has the characteristics of diversified categories and high degree of heterogeneity. In order to achieve high efficiency of post-processing, it is necessary to ensure data standardization during acquisition, communication and processing. To this end, the middleware will support a variety of standard protocols and standards, such as: Reader Protocol (RP), Interface Protocol (IP) and so on. The standardized processing method not only ensures the accuracy, high availability and high sharing of data, but also makes the sensing layer flexible and fast in terms of increasing or decreasing the sensor.

DISCUSSION

Marine Logistics IoT Middleware Communication System

In the network communication structure of marine logistics, a distributed architecture is adopted, which combines wireless sensor networking for routing configuration design to realize remote data transmission and signal transmission. The middleware realizes the security and stability of different ships and ports under distributed architecture and efficient transmission. The distributed architecture deployed in the monitoring area adopts a three-layer system design, namely: application support layer, network layer and routing link layer. The middleware base layer configuration, network layer configuration and software layer configuration are performed under the architecture. The distributed communication node embedded software architecture is shown in Figure 2.

The marine logistics mobile communication middleware and software platform under the distributed framework is built. At the network adaptation layer, the packet forwarding control protocol is used to carry out the business process mobile communication data packet of the ocean vessel and the port logistics. The middleware data link layer of the mobile communication network is responsible for multiplexing and modulation and demodulation of the communication data stream, and constructs a network communication protocol of the middleware by using a medium access control (MAC) layer protocol to perform data frame detection of the ship mobile communication.

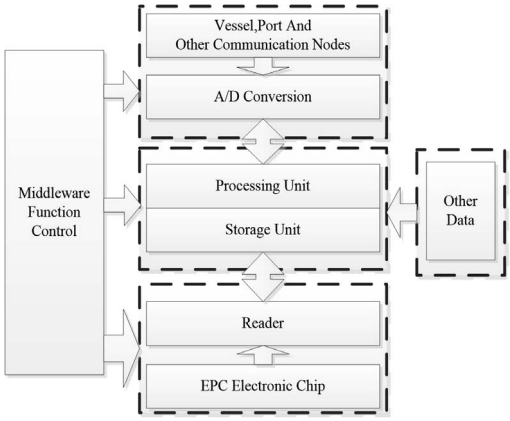

Figure 3. Marine logistics communication middleware composition diagram.

In the network layer of the middleware, the maximum effective power (PA) routing algorithm and the shortest path algorithm are used to design the routing protocol, thereby reducing the link overhead and lossy power consumption of the mobile communication node of the ship, and improving the life cycle of the network. The routing middleware and topology adjustment of the marine logistics mobile communication are completed by using the configuration middleware. The middleware structure design of the mobile communication includes the reader module, the sensor module, the information processing module, the communication channel equalizer module and the like, and the system considers the power supply. The module performs the power supply mode of the middleware system and the solar power supply mode, as shown in Figure 3.

Marine Logistics IoT Middleware Application System

From the marine logistics IoT application system, the system from bottom to top is divided into: device layer, data sensing layer, data and device control layer, service management layer, application layer, etc., where the data sensing layer, data and device Control layer, The business management layer constituents the middleware of the marine logistics IoT. Its overall hierarchical structure is shown in Figure 4.

In the whole system architecture, the data sensing layer is at the bottom, and its main function is to connect with many types of sensor data and EPC tag readers installed in various logistics containers, ships and docks in the marine logistics IoT. The data between the two is mutually accessed. After the data is sensed, the abnormal data is cleaned, and the isomerized data is isomorphized. The layer performs the corresponding operations according to the requirements of the upper layer, and completes the business through the communication middleware control.

IoT application middleware schematic is shown in Figure 5.

The working control layer works by setting a plurality of virtual devices, that is, logical mapping of actual read/write devices in the middleware, and each virtual device corresponds to only one reading device, thereby implementing distributed

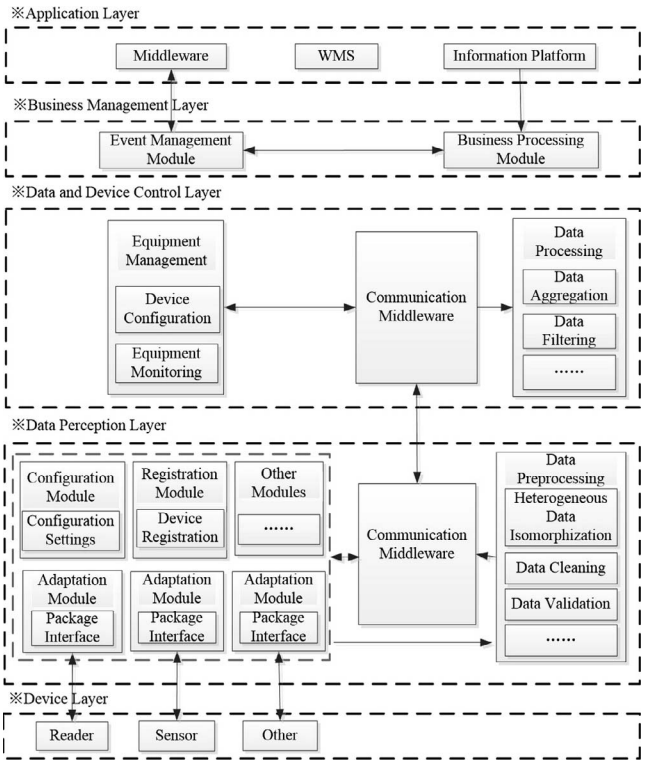

Figure 4. Middleware structure diagram of marine logistics IoT application system.

management. The device management central control module in the management control layer has a one-to-many relationship with the virtual device in the bottom layer, and the centralized management of the reader/writer is implemented.

CONCLUSIONS

This paper analyzes the logistics characteristics of the logistics of the Internet of Logistics, and gives a design scheme of the IoT middleware. The article focuses on the application system and communication system structure of the marine logistics IoT middleware. The configuration and middleware are used to complete the routing configuration and topology adjustment of the marine logistics communication system. The hierarchical and modular design scheme combined with the adaptive fractional interval equalization method is used to optimize the communication network middleware and improve the signal stability. The article adopts data sensing layer, data and equipment control layer, business management layer to form the application system of marine logistics IoT middleware, and analyzes and designs the function, realizes effective management, state monitoring and interaction of marine logistics.

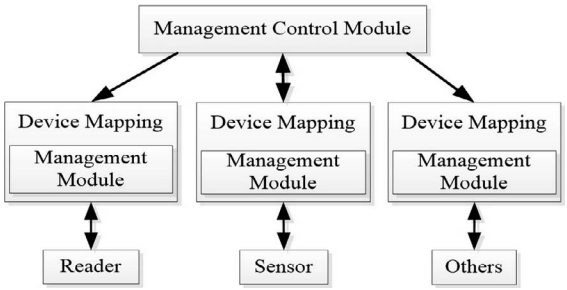

Figure 5. IoT application middleware schematic.

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