Research on Data Gateway for Ship Based on Dynamic Adaptation

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Abstract. In view of the immature status of the old-fashioned ship information collection and data analysis system in inland rivers, after analyzing the characteristics of ship navigation information, the problem of low efficiency, inaccuracy and poor real-time information collection is solved. Starting from ship equipment (such as main engine, power station, control system, etc.), a ship data acquisition gateway based on dynamic adaptation is designed. Based on the principle of making full use of the old system of marine equipment in the engine room, a multi-protocol data acquisition method based on an adaptive model is constructed, which realizes the separation of information acquisition and information use, eliminates all the close coupling relations between system equipment and applications, and realizes the integration of different data information on the ship and the dynamic display management function on the client.

Keywords. Information collection; multi-agreement; collection gateway; adaptation.

1. Introduction

On the background of growing Internet of Things (IoT), cloud technology, and big data, intelligent ships have become an inevitable development trend [1, 2]. At present, although the communication network has been built in the equipment control layer of ships in navigation, the application system has multi-source heterogeneity due to different standards among the devices, which can not fully meet the development needs of intelligent ships. Therefore, the interconnection among “information islands” is still an urgent problem to be solved. It is necessary to meet the personalized needs on different application scenarios, to avoid human operation in the process of data interaction as much as possible, to make the data interaction and adaptation more efficient and automatic.

DCS (distributed control system) and fieldbus have been widely used in ship control system. For example, Reference [3] uses DSP (Digital Signal Processing) technology to collect ship-related information. It can better solve the shortcomings of the current ship data acquisition system such as low data acquisition accuracy and slow data transmission speed; Reference [4] uses CAN bus technology to ensure the real-time and reliability of data acquisition and monitoring. Although these two general methods solve part of the problem of ship information integration, they do not solve the problem of heterogeneous data from multiple sources. Reference [5] proposed a dynamic adapter method based on USDI to realize automatic analysis of sensor data. In terms of integrated networking applications, in reference [6] satellite communication is adopted to realize ship data acquisition and remote monitoring. But it is more suitable for remote supervision of ocean ships, and higher cost. Reference [7] proposes a method for service adaptation between cloud services and end services through an event mechanism, it solves uncertainty and non-fully adapted puzzles. However, the
problem of data interaction needs underlying multi-source heterogeneous data integration and different application scenarios are not well solved.

Nowadays, the research of IoT data gateway mainly focuses on how to build a unified interface to shield the differences of underlying devices and achieve access with cloud platform (application) [8]. The research and application of the information collection and integration of navigation ships are becoming more and more mature, but the research on the dynamic data configuration of intelligent ships is still obviously insufficient. Reference [9] shows that real-time database and relational database are two completely different databases. Therefore, a data gateway for ship networking is designed, which can realize dynamic configuration in the process of different information interaction during ship navigation through dynamic adaptation.

2. The Structure of Ship’s Data Gateway

Through the establishment of a dynamically adapted ship networking data gateway, the information acquisition system and the upper application service communication are connected. The gateway can realize the conversion and communication of the data acquisition system. In order to solve the problems caused by the multi-source heterogeneity of ship-side data [10] and the personalized characteristics of cloud applications, a ship’s data gateway based on dynamic adaptation is proposed. Its architecture is shown in figure 1.

1) Data source: All types of ship equipment information and all the information of subsystems, such as data flow (control system), data table (application system), which is the basis of data conversion.

2) Interconnect: Including a variety of field communication networks (including: fieldbus, LORA wireless communication [11] and TCP/IP network [12], etc), all communication nodes through the communication network to transmit the underlying data to the ship network data gateway.

3) Data gateway: The establishment of the adaptation channel is used for data conversion, converting multi-source heterogeneous data into a unified data representation through a multi-adapted channel engine. The parsed data are oriented to integrated application system, and the data are provided to upper application by appropriate mode, and finally constitute the data gateway of ship networking with dynamic adaptation characteristics.

4) Application: Services, applications, programs, systems and interfaces that need to integrate ship information.

![Figure 1. The structure of ship’s data gateway.](image)

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This is a detailed explanation of the problem of data interaction in multi-source heterogeneous data systems. It discusses the limitations of current research and introduces a new data gateway for ship networking. The architecture of this gateway is explained in detail, including its components and functionalities. The diagram illustrates the structure of the data gateway, showing how it facilitates communication and conversion between various data sources and applications.
3. Dynamic Adaptation Pattern
In order to achieve multi-source heterogeneous data and diversification of applications, this puts forward higher requirements for the flexibility of the data collection and integration process. Need to realize the dynamic adaptation from the data facing the device layer and the interface facing the application layer.

3.1. Data Transfer Rule Description
Data transmission rules are independent constraint rules, which are established according to the data structure and semantic environment of the communication protocol or interface, such as data protocol rules and application service rules. Data protocol rules are common rules for data collection methods and expression forms, which are derived from the analysis of the communication protocol of the data source (ship equipment or system); Application service rules are the common rules of data transmission and reception methods, which are summarized according to application interfaces in different application scenarios.

3.2. Multi-adapter Channel Data Conversion Engine
In order to achieve smooth communication between data sources and application services, a multi-adapter channel data conversion engine has been established. According to the syntax and semantics of the protocol, the multi-source heterogeneous data source is parsed into data in the target format, and the demand characteristics of the application service are transmitted to their respective application services through different application interfaces. Such as: establishment of adaptation channels, conversion of adaptation protocols. The engine architecture is shown in figure 2.

![Multi-adapter Channel Data Conversion Engine Diagram](image-url)

**Figure 2.** Multi-adapter channel data conversion frame structure based on dynamic adaptation.

3.2.1. Multi-adapter Channel. The construction of multi-adaptation channels, including input adaptation channels for data sources and output adaptation channels for application services. The former faces the bottom layer of multi-source heterogeneous data, and the latter faces the upper layer application services. This constitutes the interface between data and application.
3.2.2. The Dynamic Adaptation. When the adaptation channel data conversion engine performs dynamic adaptation, it is subject to rule constraints for multi-source heterogeneous data with different underlying structures and different communication methods, as well as different upper layer application services and dynamic configuration.

4. Implementation and Application

This system is designed with full consideration of the special working environment on old ships. In order to ensure the stable operation of the gateway, the smallest system of Broadcom Raspberry Pi is built on hardware to meet the requirements of complex communication protocols and control algorithms for multi-protocol gateways. Ensuring high-speed transmission between heterogeneous equipment or systems. The software application adopts a modular mechanism, selects to load each module and uses the API function interface provided by the lower layer to complete the required functions, and finally realizes the dynamic deployment of the protocol, data analysis and processing, forwarding and storage and other functions. The realization process is shown in figure 3. Adaptation channels are represented in the dotted line box.

![Diagram](image)

**Figure 3.** Multi-adapted channel data integration based on dynamic adaptation.

Adaptation channel I: Data conversion is carried out for devices with free protocols. The visibility meter was selected as an example, and the communication protocol of visibility meter was written into the rule library. The dynamic data conversion channel was established according to the data analyzed by the adaptation engine, and the analysis and application adaptation of multi-source heterogeneous data were completed in the channel.
Adaptation channel II: Most of the installed sensors are analyzed using the standard Modbus-RTU communication protocol. The generality of these protocols is described as input rules using XML language.

Adaptation channel III: In the face of third-party database, communication can be carried out by reading the configuration software in the centralized control room operating platform, and through the establishment of standardized database access API. The constraints of communication rules and the database relational structure are all described by the rule library. By constraining the ship semantics and content adaptation rules, the semantic information that users can understand can be displayed on the Web page.

In order to test the adapted ship network data acquisition gateway, two medium sized bulk carriers and one passenger ship in transit were selected as the detection objects, and several voyage tests were carried out. The results show that the whole system runs stably, the real-time data acquisition is efficient, and can meet the needs of ship navigation.

5. Conclusions
With the continuous integration of “Internet +” and the traditional ship industry, the degree of automation and informatization of ships is getting higher and higher. It has become an inevitable trend to construct an open and shared information collection system for ships. Therefore, according to the actual needs of ships in navigation, a data gateway for ships based on dynamic adaptation is designed based on information integration technology, Internet of Things technology and mobile communication technology. The system has been tested on shipping vessels, and the result shows that the data collection and interaction are stable and safe, the timeliness and stability of the system can meet the navigation needs of ships, and it can effectively promote the further development of the digital ships in the inland river.

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