

Design and Implementation of Ship Water Pollution Supervision and Service Information System

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Abstract: In order to improve the ship pollutant discharge monitoring system, control the ship pollutant discharge, establish a more convenient and efficient information communication channel for ship pollutant discharge and receiving services, a ship water pollution discharge system is designed and implemented. This system is divided into three workbenches, namely ship workbenches, enterprise workbenches and supervision workbenches. It is developed based on the front-end and back-end separation mode. The front-end uses Vue framework to implement page function, and Element UI to complete page UI design, Mapbox to display maps, and ECharts component to draw charts. The back-end is implemented through the Spring Boot framework. Redis is used for data caching to improve concurrency and provide data interfaces. Spring Security + JWT is used to achieve single sign on and permission control. The Nginx service gateway is used to achieve service load balancing. MySQL database is used to storage the water pollution discharge information. AIS historical data storage is realized through the distributed database system of Doris cluster.

Keywords: Ship water pollution, Spring Boot, Vue, Multilevel storage architecture, Nginx

1. Introduction

There are many rivers and lakes and rich water resources in China which provides favourable transportation conditions for inland transportation. In recent years, with the rapid development of Chinese economy and society, the rise of water transportation has put forward higher requirements for the discharge of ship water pollution [1-2]. However, since the ship owners are one-sided in pursuit of economic interests, and the public awareness of environmental protection is weak, some ships do not discharge pollutants in accordance with the regulations, and it greatly exceeds the water area environmental load, bringing huge environmental impact to rivers and lakes that originally had a good environment.

Liu et al. conducted in-depth research on foreign ship pollution control technologies and proposed technical measures for zero emission of ship pollutants. The design of the environmental pollution control system has been discussed in depth. The purpose is to achieve zero pollution and focus on the comprehensive utilization of waste, including garbage recycling and sewage recycling, to reduce the pollution of the marine environment [3]. Mohtar et al. have investigated and analysed the pollution treatment process of inland ports, water service areas, locks, and other ships, and found that the pollution facilities are insufficient and it is difficult to transfer [4]. In view of the actual receiving situation of ship pollution at present, they propose to strengthen the informatization construction of joint supervision.

At present, there are very few relevant research materials on the ship water pollution discharge system. This paper has built a ship water pollution supervision and service information system. It aims to promote the electronic management of joint documents in the whole process of ship water pollutant receiving, transferring and disposal, and to provide online booking and handling services for relevant ships, ports, docks pollutant receiving, transferring, and processing companies. It also provides the relevant local management departments with the functions of real-time query and online supervision, and promotes the effective connection and mutual recognition of the joint receipt, transfer, and disposal information of ship water pollutants.

2. Requirement Analysis and System Design

2.1. Requirement Analysis

This system is divided into ship workbench, enterprise workbench and supervision workbench, corresponding to ship users, enterprise users and supervision users respectively. As shown in figure 1. Ship users mainly include information receiving and reminding, map positioning service of the discharge terminal, application for ship pollutant discharge, and receiving dispatching. Enterprise users mainly include management authorization service point, management of pollutant receiving ship, emission receiving and dispatching, pollutant storage and transfer management, query and statistics and other functions. Supervision users mainly include statistical analysis, unified display, pollution risk ship early warning, data connection with other maritime information systems, launching on-site inspection and supervision processes, electronic manifest display and other functions. The functions of the supervision workbench include ship dynamics, joint bill query, pollution risk early warning, occurrence statistics, receiving joint bill statistics, emission monitoring, message service, joint management information, operation unit and ship maintenance.

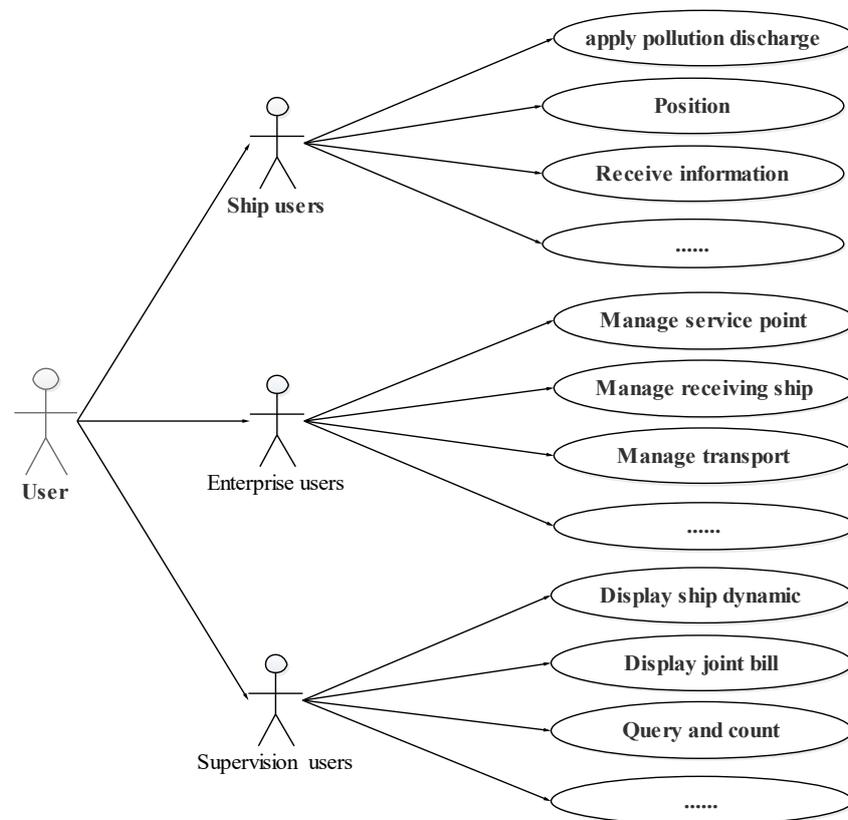


Figure 1: The system user case diagram

2.2. System Design

The system adopts the front-end and back-end separated development mode under the B/S architecture. The business service layer is mainly carried out on the server side, and the client only needs a browser to improve the stability of the system. JWT is used to ensure the safe transmission of information between parties. In the user login function, when the password or user name is transmitted by means of encryption, Spring Security needs to be used for decryption. After authentication, the back-end generates and returns a token. All requests initiated by Axios will carry the token to the back-end for resolution, allowing users to access the routing, static resources and other services corresponding to the token.

To ensure the stability of the system under high concurrency, Nginx can ensure the efficient distribution of client requests or network loads among multiple servers, while only one request needs to be sent to ordinary servers to ensure high availability and reliability [5]. Under the condition of uninterrupted business, server resources can be allocated flexibly on demand. The data layer mainly

assists MySQL through the Redis cluster to improve data response speed. The overall architecture is shown in Figure 2.

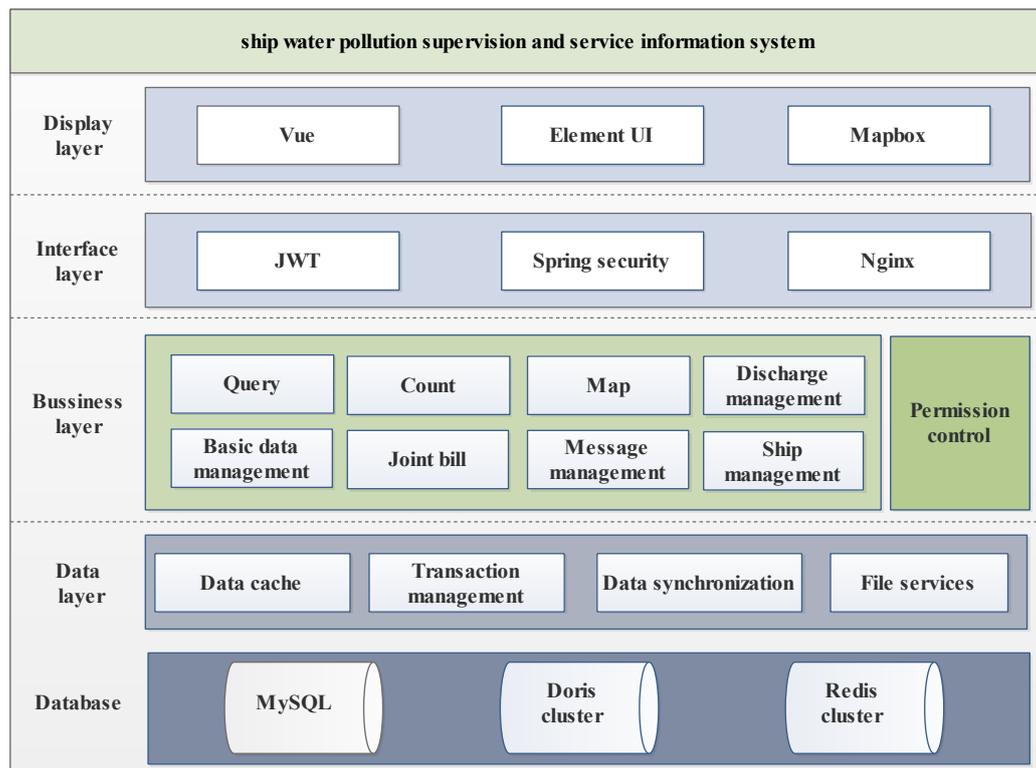


Figure 2: The system architecture

3. System implementation

3.1. Front-end and back-end separation mode

The front-end uses Axios to interact with the back-end, while the back-end does not return web pages, but only JSON data. The front-end uses Vue cli scaffolding to create projects. In the development process, the front-end project starts the service through webpack, and the front-end sends asynchronous requests through Axios to obtain various types of data returned by the back-end, which are rendered to tables, legends or layers in maps on the page.

The back-end uses a three-tier hierarchical architecture, and the `@RequestBody` annotation is used in the Controller layer to receive data. The service layer is mainly for the operation of specific problems. It obtains data from different databases and performs logical processing on the data, such as caching, computing, business rules, etc. The Dao layer mainly operates on the data in MySQL and Doris databases for data addition, deletion, modification and query. Spring Boot simplifies many configurations. The application. yml file is used to realize the automatic configuration of the Spring Boot project.

3.2. MySQL master-slave cluster

The joint bill data includes application form, receipt form, transshipment form and disposal form. Every single day has about 10000 pieces of data, which is more than 3 million pieces of data a year. Only one month's data is queried, which is 300000 pieces of data, involving the associated query of four tables. If query and transaction operations are placed in the same database, the process operation of water pollution discharge will be greatly affected. In order to ensure that ship transaction operations and query operations are not affected by each other, this paper designs a MySQL master-slave mechanism. There are a large number of complex queries for regulatory users and enterprise users. Ship users only need to operate based on transactions. Complex queries consume resources. A cluster is built based on MySQL binlog synchronization mechanism [6]. The master database is only responsible for writing, and the slave database is only responsible for reading.

To achieve read/write separation, you must first make master slave replication of MySQL, that is, build a master database and a slave database. Enable the binary log in the configuration file of the master library, and add the statement `read_only=1` to the configuration file of the slave library, indicating that the database is read-only. Next, create a slave user and grant permission. Configure the replication host on the slave database. Finally, enter the command `start slave` to enable the master slave replication function of the database. Figure 3 shows the architecture of MySQL master-slave cluster.

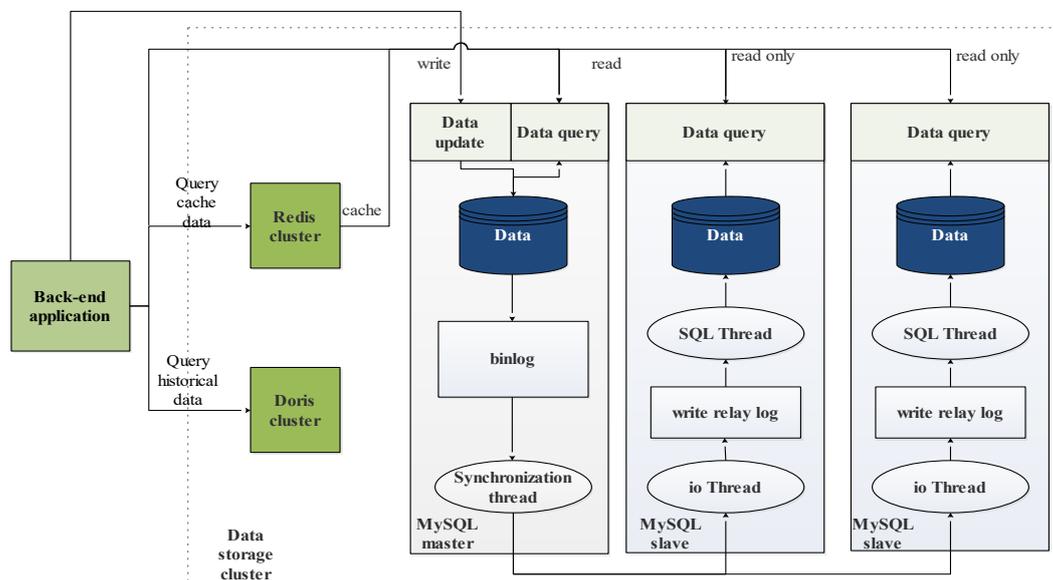


Figure 3: Multilevel storage architecture

3.3. Massive data query

More than ten thousand pieces of data are generated every day, and more than four million pieces of data are generated every year. The MySQL cluster with read/write separation alone cannot meet the requirements of real-time query. A single SQL statement involves JOIN operations on multiple tables, which often results in slow SQL execution. In order to meet the real-time query requirements of massive data, SQL statements need to be optimized.

The disposal of ship pollutants is divided into four processes, of which the disposal is the last process. Therefore, the joint document query uses the disposal table as the driving table, followed by JOIN transfer table, receipt table, and application form. Using small result sets to drive large result sets can reduce the amount of data in the outer cycle. Add indexes to the fields used for conditions in these JOIN tables. This method is called Index Nested Loop Join. Adding indexes can improve the speed of JOIN.

3.4. Dynamic display map

The ship information is real-time, and the real-time position of the ship will be updated on the map every other period of time to achieve the function of dynamic and real-time monitoring of ship pollution. Mapbox maps provide the Source component, which can request data in the GeoJSON format in the server, and then add it to the map layer through the `addLayer` method [7]. The traditional map implementation method is to delete the Layer first, and then delete the data in the Source. This will cause the ship labels on the map to disappear for a period of time, and will not reappear until the Source requests the data and calls the `addLayer` method again. Compared with traditional methods, Mapbox provides the `setData` method to directly replace the source data. The keyword `await` allows JS to wait until the fetch executes and returns its results. Finally, the response results are converted to JSON format, and the `setData` method can be used to replace the original data.

4. Conclusion

This paper discusses the design and implementation of the ship water pollution supervision and service information system, and introduces the research background, demand analysis, system architecture, detailed design and implementation of the system. According to the characteristics of joint

order data and ship trajectory data, it is of great significance for monitoring water pollution to track the ship pollutant discharge through multi-level storage architecture, master slave database and map visualization technology. The system covers hundreds of thousands of ships on the Yangtze River trunk, enabling data collection and tracking in the whole process from receipt to disposal, traceable and verifiable, and relying on the big data generated by the system for analysis, research and early warning.

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