Development of the database for intelligent ship management system

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Abstract. In order to provide a data management solution with higher performance, more flexible expansion and more convenient management, the overall scheme of intelligent ship database cluster is studied by the structure of MySQL database management system and MYCAT distributed database middleware. According to the specific requirements of a shipyard for data collection and use, this paper proposes the alarm point information base and alarm point coding mode from the perspective of practicability and convenient maintenance. Shipyard usage feedback indicates that the database is implemented for ship-wide data sharing.

1. Introduction

Data is the core of intelligent ships. Data links used for data collection, transmission, storage management, analysis and mining are important parts of the entire intelligent ship system. The standardization of the data chain and the accuracy of data analysis are the core issues that determine the results of the system. The intelligent ship database is designed to realize the standardized and systematic storage of the intelligent ship data, so as to ensure the integrity and accuracy of the data. The development and use of databases have always been a hot topic at home and abroad. Traditional databases are no longer able to meet the needs of the current stage, and domestic and foreign scholars have done much research on this.

Based on MongoDB, M.Y Pan [1] studied the construction of non-relational ship database from feasibility, data model and geographic index, and provided a new idea for the transformation of data storage model in the navigation field from relational database to non-relational database. The definition, function and architecture of the ship integrated platform management system (IPMS) and ship-shore integration are discussed and the design of the ship integrated network information platform (INIP) and the construction framework of the ship-shore integrated information platform are highlighted by X.J Qian [2]. Z.Y Lin [3] discussed research issues in the field of cloud databases, including data models, system architecture, transaction consistency, programming models, data security, performance optimization, and test benchmarks. H.D Wang [4] constructed the topology and data flow model of unmanned ship information management system based on time series database for the characteristics of six types of data in unmanned ship electronic information system, and designed a set of information suitable for unmanned ships. The performance test method of the management system solves the problem of massive information management of the unmanned ship during long-term flight. S Tummalapalli [5] presented that With Hadoop and Impala, data processing time can be faster than MySQL cluster and probably faster than Hive and Pig.
2. Construction of intelligent ship database

2.1 Data stream analysis

The demand analysis of the intelligent ship database mainly includes ship data type analysis, data characteristics, data format, storage requirements, processing requirements, security and integrity requirements [6]. The results of the demand analysis are mainly used for hardware configuration, operating system and storage engine selection, Basic configuration of MySQL parameters and database design. The data flow diagram of the intelligent ship database is shown in Fig. 1.

![Data flow diagram](image)

**Figure 1.** Data flow diagram.

2.2 Database structure

The logical design of the intelligent ship database is mainly in accordance with the conversion rules. Based on the E-R diagram, the logical relationship and storage structure between the ship entities are designed to obtain the final relational model [7]. This process needs to be carried out according to the database design paradigm. The appropriate database logic design can greatly reduce data redundancy and data maintenance anomalies. In addition, in order to ensure the security of the data, it is necessary to establish a user management table and the connection with the unified authentication module, thereby we can solve the permission problem.

![Database table structure](image)

**Figure 2.** Database table structure.
In summary, the database of smart ships is mainly divided into several parts: ship information table, user management table, equipment information table and alarm point table. After the table is built, the index can be set according to the actual data. The ship information table includes fields such as basic ship information, identification information, and ship certificate information. The device information table includes a device information table, an analog table, and a digital meter. The alarm point table includes an alarm point information table, an analog alarm point table, a digital alarm point table, an analog alarm value table, a digital alarm value table, and a historical alarm information table[8]. The experimental database structure is shown in Fig. 2.

3. Database implementation

3.1 Sub table design of database

According to the actual needs of the shipyard and the characteristics of each parameter, we select the appropriate data type and establish a basic information table for the intelligent ship (as shown in Table 1). The ship information table includes the basic information of the ship and the identification information (the ship certificate information can be added later).

Table 1. Intelligent ship basic information.

| field    | data type | description     |
|----------|-----------|-----------------|
| ship_id  | int       |                 |
| ship_name| varchar(50)|                |
| endurance| float     |                 |

The design of the table and corresponding ship information table created in MySQL is shown in Fig. 3.

Figure 3. Intelligent ship basic information sheet.

The device information table includes a device information table, an analog table and a digital table. The device information table has three fields: device area ID, ship ID, and description. The device area ID is available for the user to identify the location of the alarm point. The device information table facilitates the user to correctly query the corresponding device. Table contents are shown in Table 2 and Table 3.

Table 2. Device area ID.

| field name | data type | description     |
|------------|-----------|-----------------|
| eq_id      | int(3)    | filed ID        |
| ship_id    | int(4)    | ship ID         |
| desc       | varchar(50)| device area    |

Table 3. Device information.

| desc ID | description     |
|---------|-----------------|
| 10      | left main motor |
| 11      | right main motor|
| 12      | gear box        |
The alarm point table includes an alarm point information table, an analog alarm point table, a
digital alarm point table, an analog alarm value table, a digital alarm value table, and a historical alarm
information table. The alarm point ID is composed of 8-bit integers (Fig.4). The first digit is used to
distinguish whether the value of the alarm point is analog or digital. If it is analog, the digit value is 1.
If it is a digital quantity, the bit value is 2; the second and third digits are the device area ID; the fourth
and fifth digits are the device ID, and the sixth, seventh, and eighth digits are the numbers of the alarm
point in the area.

![Alarm point ID diagram](image)

In the design of the field, adding the device area ID to the alarm point ID is beneficial to querying
its area for convenient positioning; redundant device area information and alarm point information,
which is associated with the number, is beneficial to the modification of the database. In the analog
alarm value table, the first digit of the value ID is 1, indicating that the value is an analog alarm value;
in the digital alarm value table, the first digit of the value ID is 2, indicating that the value is a digital
alarm value. The value ID is set to increment by one each time. In order to improve the storage speed
of analog alarm value and digital alarm value, the solution will use the distributed database cluster to
read and write separation and load balancing of data transmission. At the same time, the storage
capacity of the data table will be reduced by regularly arranging historical data.

The structure of the intelligent ship history alarm point information table is shown in the above
table. Among them, the state is divided into alarm generation, alarm confirmation and alarm recover.
When a device alarm data maintenance time exceeds the delay time, the alarm point becomes an alarm
generation state. When the manager finds and starts processing the alarm point, it will manually set its
status to alarm acknowledgement; when the alarm point data returns to normal, its status changes to
alarm recovery. The historical alarm information table integrates the analog alarm point and the data
alarm point in the same table, which is conducive to unified storage and query of all historical alarm
information.

3.2 Front end display

After deploying the system, use the browser to open the login interface of the system, in which the
password entered by the front-end user is sent to the back-end after RSA encryption processing. Then
enter the correct username, password and verification code and click Login to jump to the home page.
The front end display of the analog historical data query interface is shown in Fig. 5.
Alarm information mines the value of data. Big data technology provides personalized information analysis and decision-making for different management objectives of ship systems, including refined management, predictive modeling, and intelligent assistance. Through the deep excavation of the data in the ship database, the ship is operated in the best and reasonable operation state. In order to better manage the data, Ajax is used to poll the data in the database, and the acquired data is displayed on the front-end interface in the form of a report. When the data changes, the report can also record the changed data in time, as shown in the following Fig. 6.

The monitoring function of the ship's cabin is represented by an intuitive graphical representation, as shown in Fig. 7. The graphical representation method is mainly divided into a graph representation, a trend graph representation, and a simulation graph representation.
4. Conclusion
Ship intelligence is an unstoppable trend, and the ship itself can be said to be a carrier of data, so data is the core of smart ships. As the backbone of data processing, the establishment of the database of ships is the key to the realization of ship intelligence. The overall scheme of the intelligent ship database cluster is implemented by the structure of the MySQL database management system and the MyCAT distributed database middleware. On this basis, combined with the actual needs of a shipyard, the function of the database is improved. This article focuses on the design of database tables. Starting from the actual needs of customers, the database of intelligent ships is mainly divided into several parts: ship information table, user management table, equipment information table and alarm point table. Application results show that the architecture has good stability and reliability. At the same time, the architecture also provides an efficient, flexible and stable solution for the design of other similar intelligent ship databases. From the experimental results, the program largely addresses the needs of shipyards, but there is still room for improvement in dealing with high concurrency events.

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