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Marine Integrated Database Management System Based on Improved Object-Relational Mapping Technology

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ABSTRACT

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In order to adapt to the development of information technology and prevent "data chimneys" and "data islands" caused by data isolation among multiple systems in the ocean, this paper proposes an improved adaptive object-relational mapping (ORM) framework and builds a feasible set based on this framework. The integrated marine database management system integrates all data related to the marine field into a comprehensive marine database to achieve unified management and unified maintenance of data and also provides strong data support for the marine information system by establishing a reasonable data retrieval mechanism.

ADDITIONAL INDEX WORDS: *ORM, data integration, ocean information, comprehensive database.*

INTRODUCTION

With the development of marine technology and information technology, access to marine information has become complex; the types of data are numerous; and the data scale is huge. Ocean data are part of a typical and complex multisource heterogeneous big data system. Guangxi Ocean Informatization Construction started recently, and it attaches great importance to turning data into information. In order to adapt to the development of information technology, Guangxi plans to start from basic data and build a practical and feasible marine core database system to integrate all data related to the marine field into the marine core database to create unified management and unified maintenance of data. And by establishing a reasonable data collection mechanism, Guangxi provides powerful data support for the marine information system to meet information application needs (Qiu *et al*., 2018).

Under the premise of consolidating the space foundation, in order to achieve comprehensive sea management, it is necessary to integrate various nonspatial attributes of marine ecologic, environmental, and economic data into a unified space. With the help of GIS, this project adopts a unified space–time reference coordinate system to integrate spatio-temporal multisource heterogeneous ocean data through spatial target attachment and time matching of various marine attribute data and initially forms a map of ocean management. A new management model with a picture of the sea can be achieved (Tan *et al*., 2018).

Taking the sea–land integrated spatial data as the working base map and the marine stereoscopic observation network as the real-time data source, this model provides real-time data display, historical data retrieval, trend analysis, and comparative analysis of the marine environment. Moreover, the model displays the distribution information of marine biodiversity. Water quality assessment; observation and prediction of ocean tides, temperature, and salt; marine disasters (red tide, storm surge, coastal erosion, and seawater intrusion); bulletin and early warning; *etc*. provide an auxiliary decision-making function for marine environmental protection work (Ingle *et al*., 2018).

The types of marine sensors are diverse; the observation mechanism is different; and the data storage format is different. Owing to the lack of sharable description models and scientific association methods, the closed and isolated status is presented. Under the premise of not changing the existing storage management mode of the ocean observation network, the project has developed extraction, transformation, and loading tools for ocean observation data by means of web services technology and has extracted and converted ocean data at the same frequency as the ocean observation frequency (Horler *et al*., 2018).

With land and sea coordination, the problems of multisource heterogeneity of marine basic spatial data, the separation of marine spatial data from terrestrial spatial data, and the lack of a unified spatial foundation make it difficult to support decision-making when measuring land and sea. This project uses GIS, electronic maps, high-resolution remote sensing imagery, and three-dimensional seabed topography as spatial data sources. With the transformation of the space coordinate system and geometric registration based on spatially identical points, the coordination of spatial data sea–land integration technology was developed in order to unify marine space resources. The integration has supported data management of the ocean and laid the spatial information foundation for integrated marine and land management.

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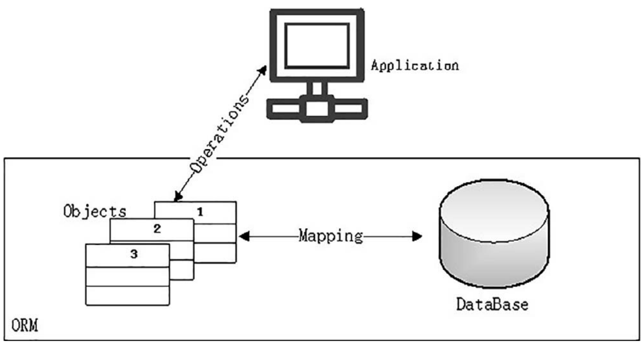

Figure 1. Framework design structure of the marine integrated database.

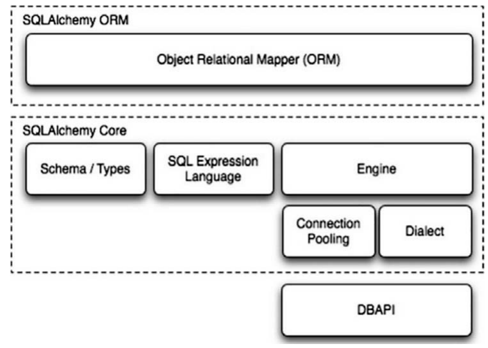

Figure 2. Summary of data for ORM technology applications.

THEORETICAL BACKGROUND

The Overall Framework Design of the Marine Field

Based on the relevant national and marine industry database standards, combined with the needs of Guangxi Beibu Gulf, standardization, normalization, spatial organization, and construction of various data in the marine industry are achieved with the support of a mature business technology and standards system. To form unified storage, unified management, and unified maintenance of marine data to support the generation of information products for the new generation of marine business applications and multimodal information release and services, Figure 1 shows the framework structure of the traditional marine integrated database.

Figure 1 shows how the overall structure of the Guangxi Marine Integrated Database adopts a layered architecture. The basic principle of layering is that the layers of the system are relatively independent; any layer of the system depends only on layers below it and is completely independent of layers above it. Hierarchical partitioning of the system will be very beneficial to the logic design and implementation of the system and can effectively isolate the problems that need to be solved at different levels. The system is divided into data application layers, data management layers, and data resource layers, with an operating environment from top to bottom.

Marine information is the main basis for marine scientific research, teaching, engineering design, planning management, environmental monitoring and evaluation, sustainable development of marine economy, and military marine environmental conditions. Therefore, the collection, processing, and database construction of marine scientific data have an effect on the resulting data systems. Physical oceanography is the basis of marine scientific research and application. Marine hydrological data centered on parameters such as seawater temperature, salinity, and density include climate and marine environmental ecological research, environmental prediction and evaluation, engineering design, disaster reduction, and disaster prevention. Figure 2 shows the prototype of the object-relational mapping (ORM) technology that was applied.

In addition to the parts shown in Figure 2, China's Yunnan, Huang, East, and South China Seas are parts of the world's oceans, and their changes are interrelated and deeply influenced by the world's oceans. To study and predict changes in the marine environment in China's offshore and adjacent oceans, large-scale, long-term, synchronized ocean observations must be carried out. Such a marine survey requires huge investment, and it is impossible for any unit, department, or even country to conduct large-scale ocean research work solely on its own investigative power or on data that has not been systematically compiled. Therefore, the construction of a marine hydrological database not only has important use value, but also has expensive output value and significant social commonality. At the same time, it must be carried out according to scientific and reasonable construction specifications. The measurement object of Figure 3 shows the database management system analyzing wind speed data.

Figure 3 shows that international marine hydrological information is the main source of data for marine hydrological databases. The international marine hydrological data have wide variety, long time series, wide spatial distribution, a large amount of information, and rapid accumulation. These data come from dozens of countries and regions around the world; the observation instruments used vary widely; the data collation methods vary; the calculation methods and formulas for the derived parameters vary; the method of interpolating the standard layers from the measured layer data also has its own length. Even the data processing standards and recordings used, as well as the format of the recorded data, are still in the process of unification. Therefore, standardized construction

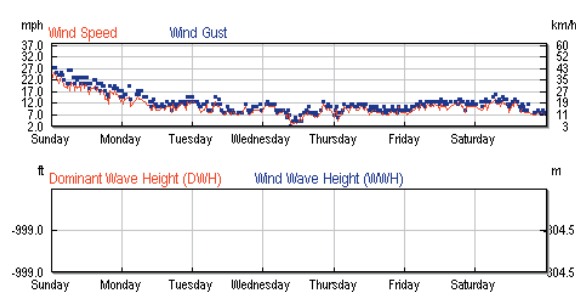

Figure 3. Marine integrated data detection based on ORM technology.

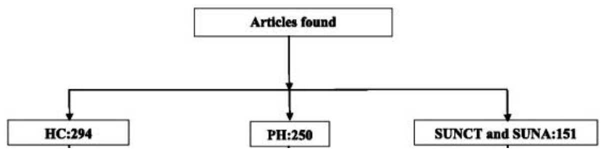

Figure 4. Improved ORM adaptive framework.

methods and standardized construction processes, as well as advanced weight-receiving technology and strict quality control methods, are prerequisites for ensuring the construction of a reasonable and applicable marine information management system.

METHODS

The Cyless Silver electroplating solution (Technic, Inc.) and 1 M KCl solution were used for the Ag/AgCl electroplating process. The object-relation mapping relationship is used to solve the problem that the relational database and the object-oriented database do not match each other. It converts between the relational data and the object model. The ORM technology defines a corresponding description object in the code for each data table. By describing the mapping relationship between the object and the data table, the administrator can design the database without needing to know any SQL language.

Improved Adaptive ORM Framework

Although the ORM framework is available, it can be seen from Figure 3 that the traditional ORM framework still has some drawbacks. For example, when the structure of the data table changes, the code of the management system must also change to adapt to the changes in the database structure. Not only does it make it impossible for users to modify the database structure, but it will greatly increase the maintenance cost of the system. Therefore, in response to this problem, the authors propose an improved ORM adaptive framework, as shown in Figure 4.

Figure 4 shows the traditional ORM framework. This paper adds an XML mapping layer, which implements the multiple mapping relationships of XML configuration file → database table, XML configuration file → entity class, replacing the traditional database table. When the database table structure is modified, the user only needs to modify the corresponding XML configuration file and the system will automatically read the XML configuration, dynamically generate the corresponding entity class according to the configuration, thereby modifying the database structure without modifying the software code so that the system architecture becomes more flexible and reusable.

In order to achieve centralized management of marine integrated data such as marine environmental data, sea resources, and marine economic data, the system uses the ORM technical framework to design the object description model of the marine comprehensive database and develop front and back separation technologies. The system is divided into a data service layer, an application layer, and a browser. The browser uses AJAX technology to send data requests over HTTP. After receiving the data request from the browser, the server application performs permission filtering on the user's request and submits the request filtered by the authority to the ORM, and the ORM requests the requirement. The data are analyzed, and the database where the data are located is obtained. Then a corresponding SQL request is generated to send a data request to the database, and the result of the request is fed back to the server application. Thus the server application compiles the data into JSON format and sends the data to the browser, thereby completing one data request service.

The metadata includes spatial data metadata and attribute data metadata. The spatial data (*i.e.* digital image map DOM, digital elevation model DEM, digital line graph DLG) metadata have national specifications that mainly include related data sources and data points, layers, result attribution, spatial reference systems, data quality (including data accuracy and data evaluation), data updates, frame bordering, *etc*. Attributing metadata has no national norms so far, mainly referring to spatial data metadata national normative design, which includes information about data sources, data classification, results attribution, data quality, and data updates. Metadata is a description of various data itself, including description of data information, spatial data organization information, data source, nature, quality, formation time, coordinate system, data producer, data quality, *etc*.

The marine data resource catalog first addresses the problem of classification of marine data resources. In order to facilitate management and use, the marine data resources with common business attributes or characteristics are merged together, and the marine data resources are distinguished by the attributes or features of the categories to establish a marine data resource directory classification system in order to collect data resources, manage data, query services, and share for orderly management and development to leverage marine data resources. From the perspective of marine systems in the region, the marine data resource catalog is divided into a business catalog, a resource catalog, and a shared demand catalog.

Business Directory. The classification of business catalogues is divided according to each unit and department and then it is carried out step by step with the main business nodes in respective business matters, business subitems, and handling procedures.

Resource Directory. In order to facilitate management and use, the resource catalog is also divided into units and departments, and then the marine data resources of the respective business items and first-level subitems are merged together, while the resources are distinguished by the attributes or characteristics of the categories. Establishing a marine data resource catalogue classification system, specifically accomplishing the collection, management, query service, and sharing of marine data resources, is necessary to manage, develop, and use marine data resources.

Sharing requirements directory. The shared demand catalogue is a data resource provided by other departments and units in combination with the actual business operations of the units at all levels.

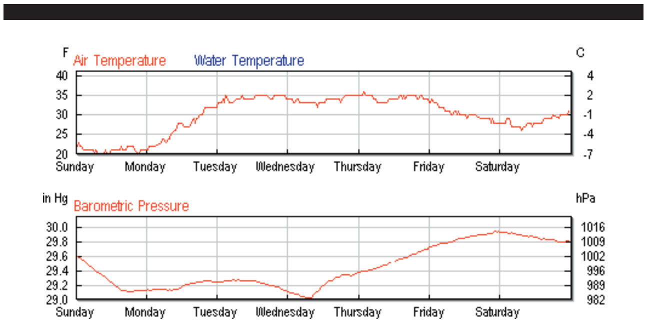

Figure 5. Spatial data integration data for sea and land.

RESULTS AND DISCUSSION

The system achieves the functions of data collection, system management, data quality control, metadata management, and maintenance, and it also monitors site data, Internet data, shared data of Beihai Marine Environmental Monitoring Center Station, and data distributed by superior forecasting centers in one platform. Moreover, it also supports editing operations such as inputting, modifying, updating, and deleting metadata, displaying the metadata tree structure, reflecting the internal architecture of the metadata, and achieving professional-level management of the marine comprehensive database through simple and friendly interface operations (Tan *et al.*, 2018).

Along with land and sea pooling, the project is based on the multisource heterogeneity of ocean basic spatial data, the separation of ocean spatial data from terrestrial spatial data, and the lack of a unified spatial foundation to support sea and land planning decisions. This project uses GIS with electronic charts and maps. High-resolution remote sensing imagery and three-dimensional seabed topography are spatial data sources. With the transformation of space coordinate systems and geometric registration based on spatially identical points, the integration of spatial data sea–land integration technology has been developed to unify marine space resources. Integration, supporting the integrated data management of the ocean, has laid the spatial information foundation for integrated marine and land management, as shown in Figure 5.

Figure 5 shows the GPS/Beidou navigation and positioning system that is used to locate and track various sensor carriers that constitute the ocean stereoscopic observation network, achieving the real-time dynamic positioning of ocean observation data and integrating ocean observation data with ocean space data. And the fusion with other nonspatial attribute data provides accurate spatial correlation information.

The project also designs a drift alarm mechanism. Once the sensor leaves the predetermined space and exceeds a certain threshold, the sensor will issue an alarm to the Marine Integrated Management Information Platform Command Center, so that the command center can make timely response measures to ensure the long-term success of the ocean observation network.

The GPS/Beidou navigation and positioning system is used to locate and track various sensor carriers composing the ocean stereoscopic observation network, positioning real-time ocean observation data, integrating ocean observation data with ocean space data, and other nonspatial attributes. The fusion of data provides accurate spatial correlation information. The project also designed a drift alarm mechanism (Wei *et al.*, 2018).

CONCLUSIONS

This ORM-based system was created through the establishment of a complete, multisource heterogeneous marine integrated database management platform and integrating marine real-time observation data, historical observation data, basic geographic information data, socioeconomic data, remote sensing image data, historical marine disasters, and other data. The user management interface of the framework enables nonprofessional users to conveniently design and manage the database structure, and they are provided with special data for marine disaster early warning analysis, intelligent ocean big data mining, *etc.*, that greatly improve the knowledge management of marine authorities and laypeople.

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