BUILDING DISTRIBUTED GEOGRAPHIC INFORMATION SYSTEM FOR OCEAN TRANSPORTATION (GIS-OT)

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ABSTRACT

With the development of world economy, ocean transportation is becoming heavier and more important than before. Its data's mass, real-time, multiple and distributed features make us very difficult to deal with them. The development of Internet and Distributed Computing make it possible and convenient to process mass and distributed ocean transportation data. Most of ocean transportation data are spatial-temporal in nature, so integration of GIS and transportation technology is the powerful solution to resolve sophisticated ocean transportation. This paper researches into how to build the distributed GIS-OT.

1. INTRODUCTION

With the development of world economy, transportation has become heavier than before. In ocean transportation, it needs more real-time, mass and multiple ocean transportation data along with the increase of ship numbers, improvement of ship speed and diversification of cargo. Therefore, it becomes more complicated to process ocean transportation information. In order to manage the intricate ocean transportation information, many departments in different places and different fields build their own computing and data model to resolve problems in their own applications. But most of these models are fragmented, multiple and incompatible. Data is redundant and often conflicting data acquisition efforts. They cannot coordinate to manage ocean transportation information in whole. Ocean transportation can be looked as a large network, it links distributed department of the whole world both geographically and socially. Therefore, we need new approach to deal with such complicated ocean transportation network. In recent years, the development of the two key technologies (Internet and GIS) brings forward the new approach to storage, issue, share and analyze ocean transportation information.

2. FEATURES OF INTERNET-BASED DISTRIBUTED GEOGRAPHIC INFORMATION SYSTEM FOR OCEAN TRANSPORTATION (GIS-OT)

Ocean transportation information have their special features, we cannot adopt normal data model to describe them. But most of them are spatial-temporal in nature, e.g. traffic volumes, congestion, incidents, sea route, etc. GIS is a new technology to integrate, analyze and display spatial-temporal information. Therefore, GIS is the power tool to deal with ocean transportation information. But traditional GIS is largely utilized in a workstation environment, where data are accessed locally, stored in their own data model and used by their own computing model. Currently, many advanced ocean transportation applications require the ability to handle spatial data dynamically and in real-time, and these data in many cases need to be assembled from different source. Internet provides convenient approach to transmit, issue and share ocean transportation geographic information in different places and different fields. Therefore, the emerging of distributed geographic information system combining Internet and GIS provides a new approach to access, share and disseminate ocean transportation information. The reformation brought by the Internet-based GIS-OT mainly described as follows:

2.1 Sharing And Interoperation Of Ocean Transportation Geographic Information

In brief, ocean transportation geographic information can be simply classified into two parts: static ocean geographic environment information and dynamic ocean transportation information. Ocean geographic environment information includes coastline, isobaths, reef, etc. They describe detail about geographic information and attributes of ocean which ships voyage on. The information was seldom changed and maintained by some departments of government. Ocean transportation information can be farther classified into unitary information (sea route, ocean traffic volumes, incidents, etc) and personal information (every ship's geographic, historic track, velocity, etc.). Personal ocean transportation information was maintained by every ship. Unitary ocean transportation information was maintained by ship company and some other marine management and monitoring departments and was partly formed by all ship's transportation information.

Whether ocean geographic environment information or ocean transportation information, they all have different data providers and data receivers, such as seaway survey department, ocean transportation monitoring and management department, ship companies, ECDIS producing companies, etc. Differences mainly focus on three aspects: First, different data providers provide different data model and different spatial accuracy. Second, different data users have different definitions and demands of the same transportation objects. Third, different applications require different levels of details in spatial data representation.

IHO-S57 is the international standard of ECDIS transmission, and most ECDIS producing companies and research communities support this standard now, therefore, we can create a sharing model based on this standard to resolve the sharing of ocean geographic environment information. But the sharing of dynamic ocean transportation information should be resolved by another approach. In our research project, we adopt a basic

transportation data-sharing model and some distributed data acquisition network intermediate components to share ocean transportation. The basic transportation data-sharing model is the core model of sharing of ocean transportation information. It includes common features of ocean transportation data. But it is not a large integrated data model, it is a seed model which can be extracted and extended conveniently in data, data structure and data type (it is not include the basic data structure and data type). This model is an object-oriented data model. Due to the differences we talked above, especially the second and the third differences, we establish some intermediate components to derive data from basic data model. With the derivation, we achieve dynamic extension for the basic data model and form the new chart for application. In derivation, we adopt the standard rules of information generalization and some intelligent data extraction and mining technology, such as Artificial Intelligence, Rough Set, etc. to satisfy the consistence of derivation. These functions are carried out in Data Extension Model.

2.2 Distributed Computing

In ocean transportation field, transportation decisions supported by GIS-OTs must often be made by many stakeholder groups who are distributed both geographically and socially, such as ocean transportation monitoring and management departments, ship companies, ships, etc. In addition, stakeholder groups are often located in different tiers of the administrative hierarchy. Data providers and users may also be distributed. They use different sophisticated software to process GIS-OT data. Different departments have different demands to GIS-OT and use different combinations of computing and analysis models. We cannot satisfy so many differences if we still use traditional approach (All data and computing models located in server, users send their demands through client to server) to deal with transportation information.

With the development of Web technology and considering the differences and the balance of network workload, we should adopt distributed computing approach. All data, computing models and analysis models of GIS-OT (all computing models and analysis models must be separated into independent function components, which cannot be divided more and each component can achieve a basic function of ocean transportation) are maintained by their own providers, ocean transportation decision makers, users, etc. and located in distributed servers. But these separated data and models are not messy and disordered. Their locations and usages are ruled by a uniform standard of Computing And Analysis Cooperation Service. Different users send their request to computing and analysis cooperation service, the service returns the appropriate combination of computing and analysis models based on user's request, and organize data from distributed servers to get the request results.

2.3 Acquisition And Integration Of Real-time Information

One of the most important features of GIS-OT is real-time. The main research object in GIS-OT is voyaging ship; go further and say, is ship features of each ship and all kinds of statistical results of all voyaging ships. But the information are changed each minute, even each second, in other words, is real-time. The main characters of real-time data are mass and messy. And different department have different demand to real-time data. For example, ocean transportation monitoring and management department only need statistical historical ocean transportation data every day, every month or every year to analyze, make decision and plan, but a single ship may need real-time data of its own or other ships every second to make decision when it in emergency. Thus, there are mainly three problems to deal with real-time data. First, real-time data is mass data, and was collected from many land sensors and ship equipments that are geographic distributed. But the bandwidth is limited. Second, because real-time data were collected from different sensors, they have different formats. The third, different land sensors and ship equipments give different data accuracy, some data very accurate, but others are not. On the whole, how to establish quicker access data models, more

powerful spatial data fusion techniques and dynamic routing algorithms to storage, retrieval, processing and analysis are bottleneck to deal with real-time data of GIS-OT.

In GIS-OT, for each different kind of sensors and ship equipments, we rectify the equipment error of real-time source data through special error correction function integrated in Real-time Information Error Correction Service. And we also provide different data transform functions for different kinds of data acquisition sensors and equipments in Real-time Information Acquisition Service. Through these data transform functions, we transform different data formats into standard of GIS-OT and stored in local database as a distributed server cooperated by Computing And Analysis Cooperation Service.

3. BUILD INTERNET-BASED DISTRIBUTED GIS-OT MODEL

In general, Internet-based distributed GIS-OT mainly consists of three parts: Background Ocean Transportation Information (Including geographic information, navigation information and other data), Basic System of Geographic Information for Ocean Transportation (The basic parts of Ocean Transportation System, which includes the basic functional components), and Applications to different users. Considering the Browser/Server architecture, network balance of front-end system and background service, and the features of ocean transportation, distributed GIS-OT can be divided into several keys functional parts described as follows. The general architecture of GIS-OT is shown in Figure 1.

3.1 Data Service

This service is the basic service of GIS-OT, it includes all data models to storage and process ocean transportation data from all different sources:
- Basic Data Sharing Model: This is the core data model; it represents the basic elements of ocean transportation and can be extended.
- Data Extension Model: Through this model, we can extend Basic Data Sharing Model to satisfy the development of ocean transportation.
- IHO-S57 International Transmit Standard Model.
- Real-time Information Acquisition Service: This service obtains real-time data from different sensors, and transforms them into standard model.
- Real-time Information Error Correction Service: This service rectifies the equipment errors of different real-time source data.

3.2 System Service

The system service provides background service for GIS-OT, All its models are independent of application, satisfy the demand of distributed computing environment, and manage the distributed system. It includes:
- Security Management: This service satisfy multi-users request in distributed environment and manage access privilege of different user to guarantee the security of GIS-OT.
- Metadata: Metadata provides more efficient approach to search and use distributed ocean transportation data, and aid to assign and balance the data and operation.
- Event Management: This service deal with the request to different component.
- Data Connection: This service provides a unitary access interface for heterogeneous data.

3.3 Computing And Analysis Cooperation Service

This service is the core service of GIS-OT. It includes all components about computing, analysis and statistic model of ocean transportation information, and achieves the common functions of GIS-OT. The main functional components of Computing and Analysis Cooperation Service are:
- Cartography Service: Different departments provide ocean transportation information to system through this service.

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- Data Indexing and Retrieval Service: This service links Data Service and other functional components, and provides convenient approaches to retrieve data.
- Spatial-temporal Data Topology Analysis Service: This service analyzes geographic information and navigation information to make decision and forecast.
- Algorithms Library: All basic algorithms of ocean transportation.
- Display and Edit Service: Through this service, users can display and edit static geographic information and dynamic transportation information. Through it we can construct the friendly user interface.

3.4 User Application Service

Based on different users special demands, this service provides additional application component to satisfy user.

4. CONCLUSION

Through the discussion above, we can see that the distributed GIS-OT can get perfect result and give a development direction to

resolve sophisticated ocean transportation. But there are still many difficulties to overcome in some key technologies. We still need do more research in this field.

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Different User Application

| Auto Navigation System | Avoiding System | Search and Rescue System | Monitor System |

INTERNET

Computing And Analysis Cooperation Service

Algorithms Library ⟺

Spatial-temporal Data Topology Analysis Service ⟺

Cartography Service

Display and Edit Service ⟺

Data Indexing and Retrieval Service

System Service

Event Management

Security Management

Metadata

Data Connection

All kinds of heterogeneous data

Digitizing

Scan

Remote Sensing

Real-time Information Acquisition Service ⟺ Real-time Information Error Correction Service

Data Service

All kinds of sensors

IHO-S57 International Transmit Standard Model → Ocean Geographic Information

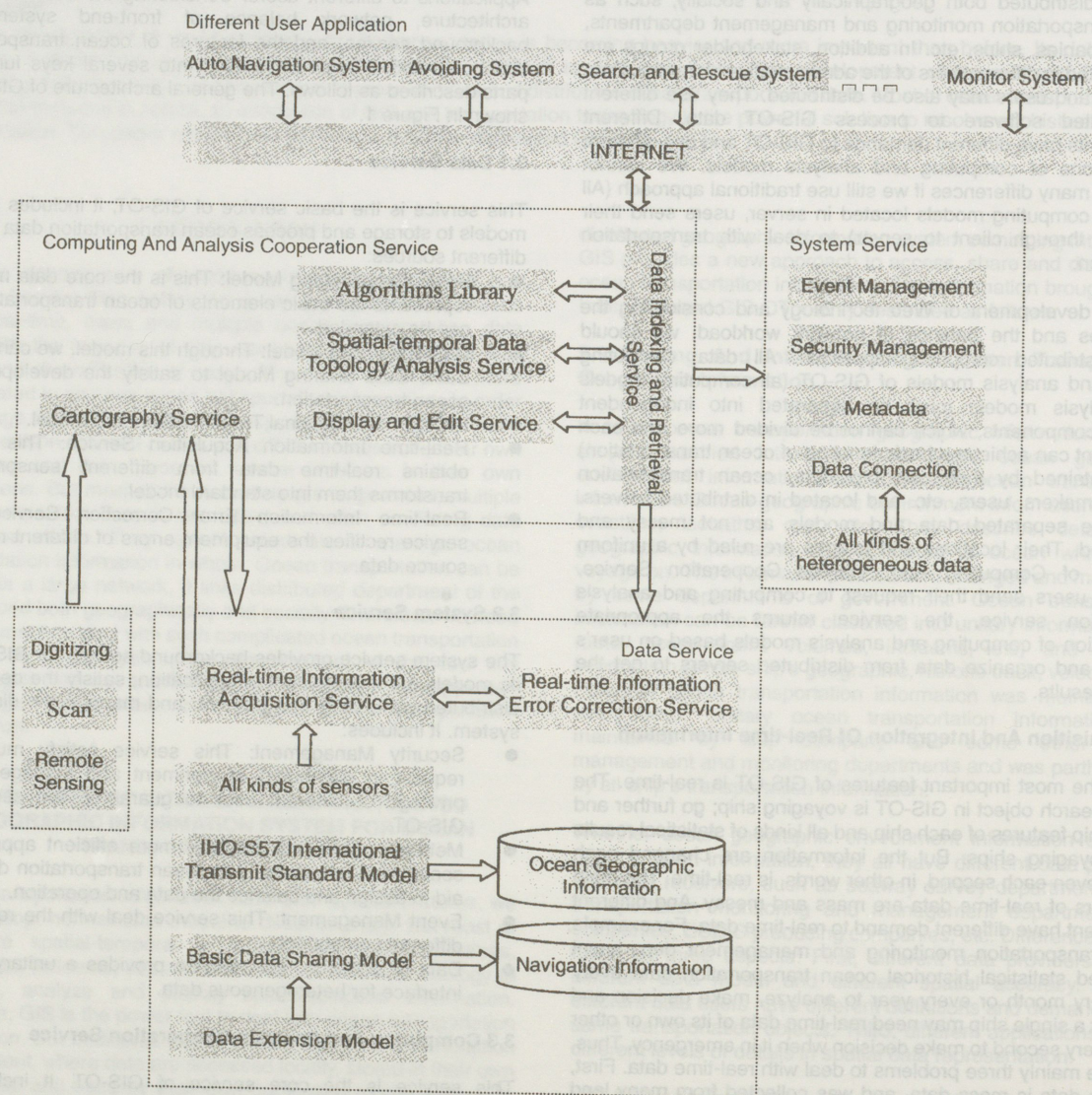Basic Data Sharing Model → Navigation Information

Data Extension Model

Figure 1. The general architecture of GIS-OT