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Design and Construction of System for Marine Geophysics Data Sharing Based on WebGIS

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ABSTRACT: A browser/server system has been developed for the purpose of marine geophysical data sharing based on WebGIS technology, which uses MapServer open source system and ORACLE Database Management System. The main steps during development, including system design and implementation, are discussed in this article. The system can provide convenient, efficient, and interactive marine geophysical information sharing and visualization services through Internet or Intranet to improve data exchange and utilization.
KEY WORDS: WebGIS, marine geophysics, MapServer, information sharing system.

INTRODUCTION

The technology of seabed data acquisition has been developed rapidly in recent decades. In the process of seabed survey and research, extensive use of advanced technology has led to a rapid increase of the marine information. The efficient management and sharing of massive, multisource, and heterogeneous submarine information has caused widespread concern.

"Digital Earth" has been issued since 1998 and the relative theories and technologies have been developed at a fast pace. As a result, advanced spatial information technology and network sharing technology have been widely used in marine scientific investigation and research. A number of marine geoscience databases and data centers, which can provide data sharing services for marine scientists through the network, have been established in many countries, such as U.S. Marine Geology & Geophysics Data, SPRILIB ice and snow database, Chinese Polar Science Database System, and so on.

However, the existing marine data management and sharing system are basically displayed in the form of texts and tables where multisource and heterogeneous marine spatial data cannot be displayed graphically. As a result, the spatial characteristics of the geologic objects and surrounding environment cannot be clearly understood. To overcome these obstacles and to make good use of the marine geophysical data, it is necessary to establish an information sharing system that could provide an interactive and user-friendly graphic interface that allows visitors to browse and query quickly and conveniently online based on digital map (Shi et al., 2010).

Peng and Tsou (2003) pointed out that WebGIS

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is a distribute GIS application across computer network, which can integrate, disseminate, and communicate geographic information on the worldwide Web (Mathiyalagana et al., 2005). In this article, a new marine geophysical information sharing system (MGISS) was designed, configured, and developed based on WebGIS technology by using MapServer open source system to provide convenient, efficient, and interactive marine geophysical information sharing and visualization service through Internet or Intranet.

SYSTEM DESIGN

According to the practical requirements of marine scientific research and marine resources exploration, the following functions of MGISS should be provided.

(1) The system needs to possess extensive geoprocessing capabilities.

(2) It should afford a rapid online visualization of large amounts of spatial vectors and raster data sets.

(3) It can support direct and visual browsing, interacting, querying, and downloading of marine geophysical data.

To meet the above requirements, a three-tier browser/server architecture, which includes presentation tier, application tier, and data tier, is adopted in the system. The general system architecture is shown in Fig. 1.

The presentation tier is developed using JavaScript, PHP, and HTML and can provide a user-friendly interface that accepts requests, performs multitude of map-centric tasks, dynamically displays the results, and downloads marine geophysical data.

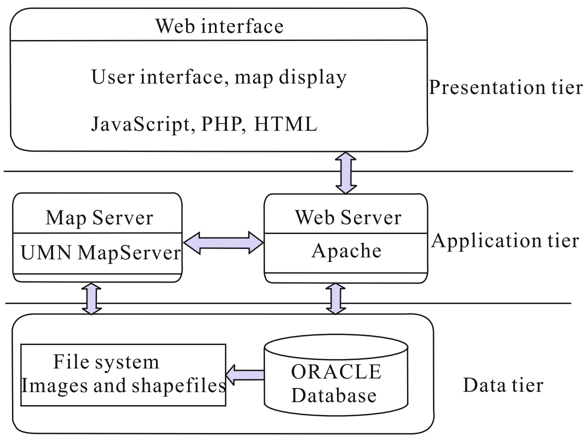

Figure 1. The system architecture of MGISS.

The presentation tier provides a main toolbar that allows users to perform basic GIS operations such as navigating and browsing information on the digital map, performing queries based on geographical layers to retrieve data for downloading in ZIP format.

In the application tier, Apache is utilized as the Web Server, whereas UMN MapServer is used as the server for spatial data processing and visualization. When a browser requests a certain URL through HTTP, the Map Server executes the request and launches the available map service in the service registry. Then, the result output is delivered back to the browser through Web Server (Ghaemi et al., 2009).

In the data tier, marine geophysical data are stored in the database. Because the volume of marine geophysical data is particularly large, ORACLE is chosen as the database server whose stability, security, and massive data processing capacities could meet the requirements of the system. The geospatial data are classified into vector and raster according to the spatial characteristics, which are managed in ESRI shape file format and ESRI ASCII GRID formats, respectively. The MGISS database handles the geospatial data sets or "layers", including the following subjects.

(1) Base layers, such as natural and manmade landmarks (e.g., city-name and county-name), national boundaries, and water depth.

(2) Gravity data (absolute gravity value, Bouguer gravity anomaly, zero drift, etc.).

(3) Magnetic data (magnetic field intensity, geomagnetic diurnal variation, etc.).

(4) Seismic data (shot interval, source power, channel interval, channel number, fold number, etc.).

KEY TECHOLOGY

Data Preprocessing

Both map layers and raw data should be preprocessed because the data obtained at different times may be incomplete in contents and inconsistent in standards. There are two main processes needed to be handled, including data cleaning and data integration.

Data cleaning: Some raw data are redundant or incorrect. We therefore need to eliminate the abnormal data, smooth the noisy data, and fill the missing data.

Data integration: The system's data come from different databases, archives, and maps, so it needs to integrate these data into the system according to the same standard. When doing data integration, the entity identification and data redundancy should be considered. Creating metadata (the data describe other data) is a better way to avoid entity identification errors, whereas correlation analysis is used to discover some of the data redundancy.

Mapfile Configuration

Various spatial elements are organized into the system by configuring mapfile (Sheng et al., 2007). The Mapfile is a structured text configuration and object definitions. It defines the relationship between objects, points out where the data are, and defines how things are to be drawn. It points the area of the map and the extent where it to be outputted. It also defines the map layers for their name, group, metadata, and projections.

Displaying the Map with MapScript

MapScript is a scripting interface to MapServer, which contains standard language functionality. That means you have the access to almost all of the MapServer C API. The API, exposed now in the scripting language through the MapScript module, allows you to do many GIS-like operations on spatial data, including read-write access to shapefiles, reprojection of data, and many others.

To display a map, the following major map initialization process should be used.

(1) Create an instance of the MapObj object using the constructor.

(2) Call the draw method of the map object to render the image defined by the map file.

(3) Call the save WebImage method to generate the image file, and it returns a string that represents the URL as defined in the mapfile.

To add zoom and pan capabilities, the following methods and objects should be called.

(1) The setextent method of the map object "$map->setextent(double minx, double miny, double maxx, double maxy)" was called to grab the extent requested by the viewer and set the extent of the map.

(2) The constructors of PointObj "$point=ms_newPointObj()" was used to declare a new point object.

To do both zooming and panning actions, the zoompoint method "zoompoint(int ZoomFactor, int ImageWidth, int ImageHeight…)" was called. A zoomfactor tells zoompoint how to operate the map, and a positive value indicates zoom in.

Tile Control

It is unnecessary to search throughout a large shapefile or images although the users are going to display only a small area. By dividing the shapefile or images into small tiles and creating a tile index, MapServer can search and operate the data purposefully and rapidly.

In Fig. 2, the small box at the top right of the map filled with turquoise is a piece of map tile. The tag <blockdiv> is used to locate the tiles of the map, whereas the tag <viewdiv> indicates the user's viewing area.

When a user is panning the map from position A to B, the MapServer checks the needless tiles and replaces them with three other new tiles as shown in Fig. 2.

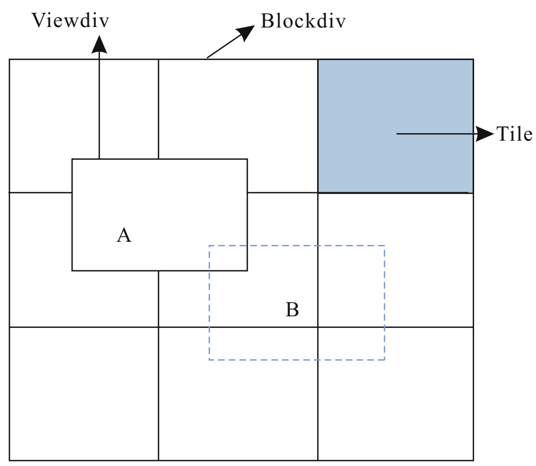

Figure 2. Pan the map by moving the tiles.

Data Access Security

For the sake of data access security, the system uses the secure HTTPS protocol to seal off geospatial data (Song et al., 2008) and the access to those geospatial data must go through WSS4J security filtering, which is a framework that can be used to sign and verify SOAP Messages with WS-Security information.

In this system, users are divided into three categories, including common user, professional user, and administrator. Common user can only browse the visual information based on digital map; professional user can query, browse, and download the geophysical data, and administrator has the highest authorities to maintain the system and database.

SYSTEM IMPLEMENTATION

Based on MapServer open source software and ORACLE database management, the system is developed using PHP and MapScript language according to the system design and technology described above. The interface of the system is illustrated in Fig. 3. Various geospatial data layers can be selected in the “layer lists” on the left-hand side freely, and users can browse and

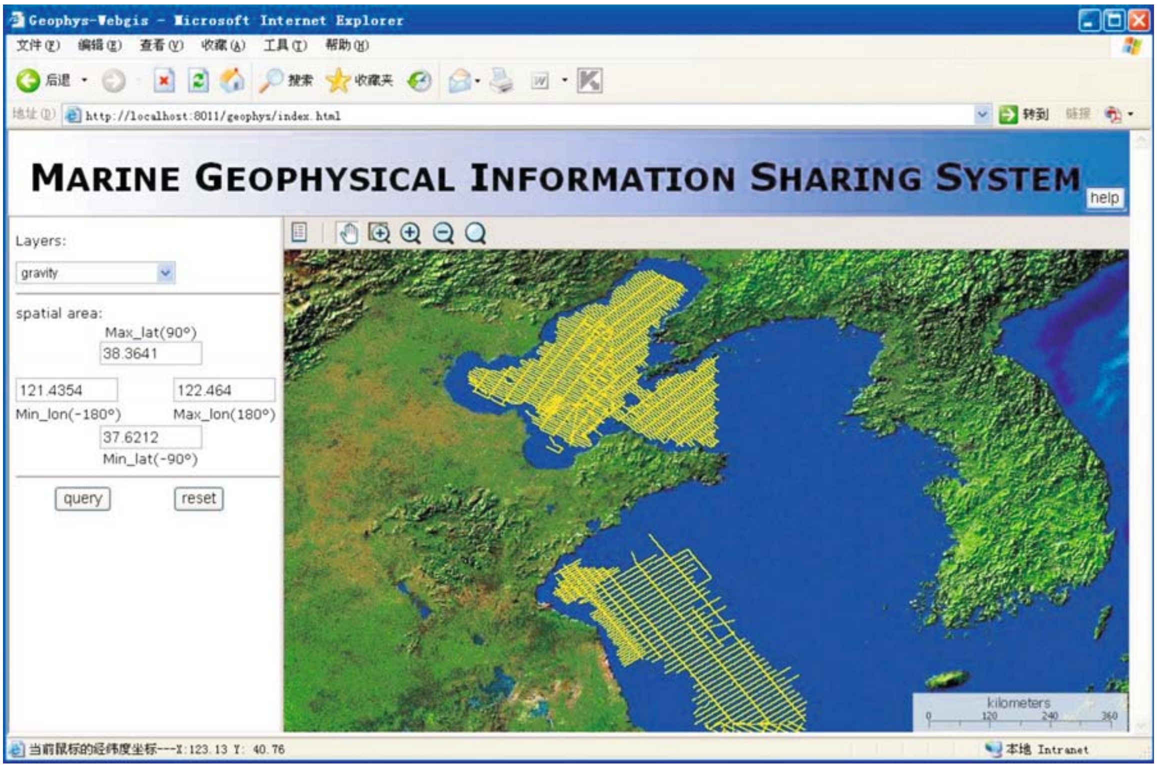

Figure 3. The initial interface system operation.

Figure 4. The interface of downloading the datafiles.

operate the spatial data in map view through a toolbar stood on top-right hand. First, an authorized user clicks the target layer name in the "layer lists" to activate the target layer. Then, he can navigate and select the interest area of the target layer to query, browse, and download the geophysical data sets (Fig. 4).

CONCLUSIONS

A WebGIS-based system for marine geophysical data sharing has been designed and implemented in this article based on MapServer open source software and ORACLE database management. The system can afford a quick and easy way for users to browse the marine geophysical data graphically and download their interested data through Internet or Intranet directly and rapidly.

However, the functions for dynamic generation of geospatial data in ESRI shape format, ESRI ASCII raster format, or geodatabase format are poor in MapServer. For further improvement, it is better to call ArcObject components to make geospatial data generation and analysis dynamically according to various requirements.

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