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Design and Realization of National Environmental Monitoring Spatial Data Platform

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Abstract. Some new technologies including Remote Sensing, Geographic Information System, and Global Position System have been widely applied in environmental monitoring. However, the application of these new technologies in environmental monitoring has been limited, due to the lack of systematic and standardized management of massive spatial data for national environmental monitoring. In order to meet the needs of national environmental monitoring information construction, we designed and realized the management and operation of national environmental monitoring spatial data platform based on the large commercial relational database system and Spatial Data Engine(SDE). The application showed that this data platform can achieve many functions such as quick response for spatial data, visual characterization, query and browsing, spatial analysis and assessment. Meanwhile, the platform can meet evolving needs of national environmental monitoring operation by taking extensibility and variability into account.

Keywords: environmental monitoring, spatial data platform, 3S technologies.

1. Introduction

New technologies such as Remote Sensing (RS), Geographic Information Systems (GIS), Global Positioning systems (GPS), and spatial statistics have been applied in a growing number of fields of environmental monitoring [1-4]. The application of these new technologies facilitates the expression and Visualization level of environmental monitoring data, providing scientific and intuitive information for processing, analyzing and managing data for environmental monitoring department. Consequentially, the ability of environmental monitoring has been improved in many aspects such as network optimization, data analysis and quality assessment, in particular the ability of emergency monitoring and reaction for environmental pollution accident. Application of GIS and other spatial information technologies often lie on the spatial data. Currently, how to organize and manage massive spatial data has been a major problem in the development and application of large-scale GIS [5].In China, management and application of massive spatial data including basic topographic data in fields of national environmental monitoring has been in a fragmented and confused state, lacking in systematization and standardization. As a result, application and development of new technologies in fields of environmental monitoring has been limited.

At present, the major applications of spatial data in fields of national environmental monitoring are in the emergency monitoring and reaction system of sudden environmental pollution accident which was constructed by the China National Environmental Monitoring Center (CNEMC) in 2004. The system realized some functions including data analysis, decision making and other functions aiming at emergency monitoring of environmental pollution accident using WEBGIS technology based on 1:250000 basic topographic data. However, the spatial data in the system were mostly based on basic topographic maps. Thus, there is not a complete spatial data platform of environmental monitoring, and it is impossible to apply the spatial data to whole environmental monitoring operation.

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In order to meet demands of national environmental monitoring operation development, it is imperative to construct the spatial data platform of national environmental monitoring. Following the disciplines of standardization, stability, reliability and expansibility, we designed and realized the management and operation of spatial data platform of national environmental monitoring based on the large commercial relational database management system (RDBMS) and Spatial Data Engine (SDE). The spatial database platform included four types of spatial database: basic geographic database, thematic spatial database of environmental monitoring, environmental background database and remote sensing image database. Integrating GIS technology, database technology, internet technology and so on, the spatial database platform was build up with unified projection, coordinate system and data structure. The platform can realize seamless and continuous map manipulation between different scales, perform the management and update of massive spatial data, provide stable and robust foundation for future development and construction of environmental monitoring operation systems and information share services based on GIS and internet.

2. Construction content of the spatial data platform

Environmental monitoring spatial data platform is characterized with massive data, multi sources, multi-scales, complex data format. The data storage volume can reach nearly 1TB and the intermediate storage of data is 1.5 times of storage volume of data. The data sources included satellite remote sensing and air-borne images, vector topographic maps and digital elevation model (DEM) data, land use data, soil erosion data and environmental monitoring section data. The scales covered 1:50000, 1:250000, 1:1000000 to 1:4000000. The data formats included types of vector and raster data formats from different GIS platforms including ESRI, Mapinfo, Supermap as well as many types of image data formats.

- Basic topographic database

Basic topographic database were comprised with basic topographic map data and DEM data. Basic topographic maps covered many types of data including boundary, watershed (rivers, lakes, canals, etc.), residential areas (cities, towns, villages, etc.), transportation (road, railways). DEM was digital terrain model made by contour or depth data to reflect undulating terrain. The basic DEM data were used to produce three-dimension map by three-dimension simulation calculation model.

- Thematic spatial database of Environmental monitoring

The database included national monitoring section data for surface water environment and drinking-water source region, air monitoring section data of national key-city, national pollution source distribution data, national natural protection region distribution data, near costal seawaters monitoring section data, etc.

- Environmental background database

The database included national land use and land cover data with the scale of 1:1000000 and 1:100000, national soil erosion data with the scale of 1:100000, national 1-km grid phenomenon data such as precipitation, temperature and so on, national soil data and geologic data with 1:1000000, etc.

- Remote sensing images data

The database included multi-temporal LANDSAT images, CBERS images, SPOT satellite images of partial regions and cities, American Quickbird and IKONOS satellite images and other aero-photographs.

3. Design and realization of environmental monitoring spatial data platform

3.1. Design of spatial data platform

Spatial database is the core of spatial data platform. Currently, file server and relational database server are mainly used in the storage and management of spatial data. With the augment of amount of spatial data from KB and MB to GB and TB, and development from single-computer pattern to distribution pattern, regular file management pattern of spatial data is encountered with insuperable difficulties in information share, network communication, simultaneous control and data security. In this regard, spatial database pattern based on the RDBMS can realize seamless and systematic integration and management of multi-source massive spatial data. It has become inevitable choice in the construction of large-scale spatial data platform [6, 7].

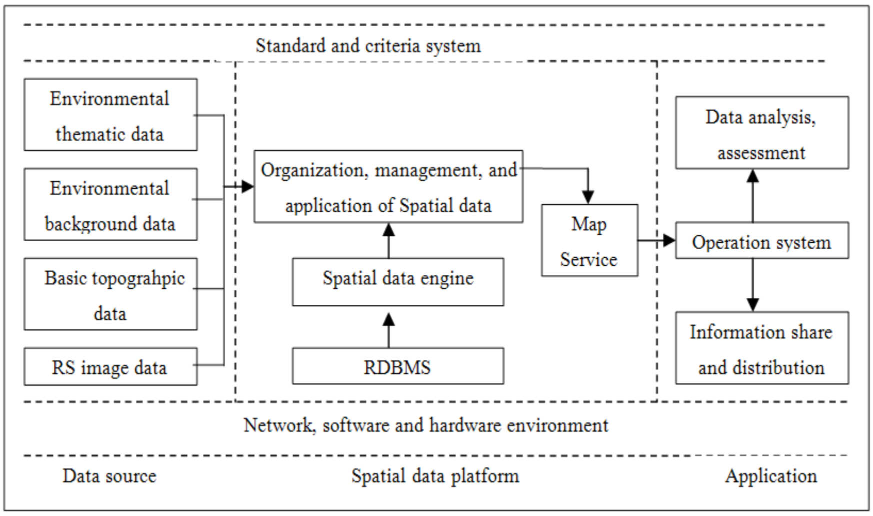

Fig. 1: Structure design of national environmental monitoring spatial data platform.

Currently, the amount of national environmental monitoring data platform has reached nearly 1TB. Advanced and effective RDBMS is necessary to storage and manage these data. Since the basic topographic data of 1:50000 belong to confidential data, spatial data platform must be constructed according to management standard of confidential data. Given the powerful capability of large commercial DBMS in data management and security, Oracle 10g enterprise edition was chosen as foundational database platform. At the meanwhile, Supermap SDX+ was utilized as spatial data engine. According to four specific types of spatial data including environmental monitoring thematic data, environmental background data, basic topographic data and remote sensing data, the platform was built up to form the spatial data platform with same coordination system and projection type. The platform was based on the intranet of CNEMC, whose logistic design uses four-level model of "spatial database-map service-application system-client", thus improving variability and security of storage, management and application of spatial data. Based on this platform, we have developed the application systems of different environmental monitoring elements to realize analysis, assessment and share of environmental monitoring data using spatial information technologies.

3.2. Technologic process of construction of spatial data platform

In accordance with construction destination and basic content of data platform, we prepared database construction schema, designed a series of major steps: data processing, database design, coding standardization, data validation and optimization, map production and data security (Fig.2).

Original spatial data have different sources and formats: basic topographic data with ESRI E00 format, environmental background data with ESRI COVERAGE or GRID format, remote sensing data with ERDAS IMAGE format, and environmental monitoring thematic data mainly with EXCEL format. Multi-source and multi-format data have been transformed to SUPERMAP vector and raster formats for next data processing and database integration.

Original data have two coordinate types: geographic coordinates and projection coordinates, the latter including Gaussian projection (1:50000 DLG data) and the UTM projection (city image data). For overlay display and analysis of different data, it is necessary to ingrate dissimilar projection into the same coordinates and projection. The detailed parameters are: the central meridian: 110.0 Degree, origin latitude:0.0 Degree, standard latitude :25.0 and 47.0 Degree, scale factor: 1.0；Geographic coordinate: Xi'an 1980 coordinates, reference ellipsoid: International_1975, ellipsoid long axe: 6378140.00m

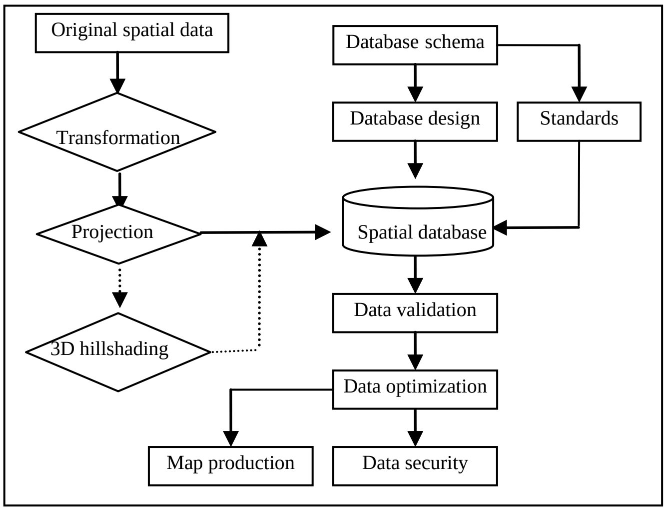

Fig. 2: Technologic process of construction of the spatial data platform.

Standards and criteria are composed of spatial database design and naming standards, coding criteria for environmental element monitoring section and watershed coding scheme for surface water environmental monitoring, etc. So far, we have finished <national surface water environment monitoring section coding criteria (draft)>, which standardized coding of national surface water section to relate with environmental monitoring attribution data as key field. Furthermore, through full investigation and comparison, we are considering establishing watershed coding criteria for surface water environmental monitoring based on the watershed coding criteria published by the State Bureau of Surveying and Mapping of China, making modification and/or supplement as necessary according to the specific circumstances of environmental monitoring.

For the database design, the physical storage and logistic storage design, user profiles, table space configuration and network environment etc. will be achieved through the Oracle database management system.

Many technologies including RAID physical storage, three-level indexing mechanism, and multi-scale display control will be applied in the data optimization in term of database optimization, spatial data organization, map configuration and so on to improve response and performance of spatial data access.

For map production, thematic maps of environmental monitoring will be produced in accordance with different environmental elements and different visualization characteristics. The maps follow national or departmental mapping standards and criteria and realize seamless and continuous map manipulation between different scales and different region. In addition, the maps can provide background support for the construction of environmental monitoring operational systems.

For data security, removable storage media and diskette array will be used as main backup media to make off-line and on-line backup of spatial data through Oracle database backup mechanism. In case servers or database fail, the database can be restored as soon as possible. Additionally, through strict security management mechanism of servers and database, data security can be guaranteed.

4. Result and discussion

This study has indicated: using advanced thoughts and technologies to construct national environmental monitoring spatial data platform can achieve many functions such as quick response for spatial data, visual characterization, query and browsing, spatial analysis and assessment. Meanwhile, the platform can meet evolving needs of national environmental monitoring operation by taking extensibility and variability into account.

Simultaneously, some problems need to be resolved:

Firstly, at the current stage, standardization of spatial data can not meet demands of construction and application of spatial data platform. Because of complexity of spatial data, problems of inconsistent standards have existed in the application of different departments during a long period. To realize standard and unified national environmental monitoring spatial data platform, coding standardization and regularization of environmental elements and themes need to be carried out.

Secondly, application level of spatial data in fields of environmental monitoring should be further improved. In order to further enhance the synthetical analysis and evaluation capability of environmental monitoring, it is necessary to construct environmental monitoring operational system based on the constructed spatial data platform, realizing transmission, analysis, assessment, visualization, mapping and distribution of environmental data.

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