

A Super Data-sharing Model in Common Platform of Geographic Information

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Abstract—Geospatial framework is the foundation of digital nation, digital province and digital city. Common platform of geographic information that belongs to geospatial framework can provide online services that include geo-information services and function services for the governments, industry, public and so on. A data-sharing model in the common platform of geographic information is studied and put forward in the paper. The data model architecture in the common platform is mainly composed of the entity-oriented vector data model in the three-dimensional space, the layer and tile pyramid grid data, the relationship table or WORD files and so on. The data model was realized in C/C++ development environment in Windows XP. The model has been successfully applied to “digital city” geospatial framework pilot city such as the digital Taiyuan, the digital Qianjiang, the digital Jiaxing and so on, and “digital region” geospatial framework pilot region such as the digital Sanxia and so on, which were hosted by the State Bureau of Surveying and Mapping, China.

Keywords—common platform of geographic information, data-sharing model, public platform dataset, digital city

I. INTRODUCTION

Now an important informatization development is to informize the natural, social, economic, cultural, environmental and other features in the real world, and to integrate information in the geographical space to build the digital city, digital area, digital state and even digital Earth [1].

Geo-spatial framework is the basis of digital nation, digital province and digital city. Standardized and

scientific geospatial framework can provide governments for transport, water, land, statistics, public security, civil affairs, environment, energy and so on with scientific, accurate and timely geospatial information services. It is a basic information platform to provide information for the national and local research strategies, decision-making, planning, emergency response and implementation of all major strategic initiatives.

Application systems of various departments in real time use these basic data provided by the geographic information platform and overlay the sector thematic data. So the location-based spatial query, analysis and application functions come true through these application systems. It is urgent to build the data-sharing model for the geographic information platform so that each application sector can load sector data to provide the basis of spatial orientation to governments and its departments, enterprises for informatization and social service in the early stages of geo-spatial framework construction.

Domestic and foreign scholars established a variety of three-dimensional data models for different applications and description, such as the vector-based data model, the raster-based data model, the vector grid hybrid data model and the entity-oriented data model and so on.

The main methods to build vector data model include the wire frame, the surface subdivision method, the boundary representation [2], the entity-oriented model [3] and the three-dimension formal data model [4][5].

Raster data models mainly include the cell decomposition, the spatial enumeration, the tetrahedral grid, the K-simplex subdivision and so on [6][7].

The hybrid data model is to integrate two or more data models to form a new model with the unified structure, like the integrated data model based on CSG, TIN and Octree [8], the hybrid data model based on Octree and TEN [9], the integrated data model based on TIN and CSG, and the general 3D spatial data model based on vector and raster integration [10]. However, these data models are only built for one specific problem, and do not realize data sharing and integrated management of geographic information. Although some papers have proposed a data sharing model [11], but the model cannot realize the distributed-mode storage and logical concentration of spatial data for network utilization.

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One purpose of building geographical information common platform is to integrate different information of same entity stored in different servers and to manage these data in one unified platform [12][13][14] to meet requirements of information sharing and interoperability of different spatial data. The information system for geographic information management can provide information services for government departments, enterprises and public. In order to well make use of geographic information platform in the networked and distributed environment, the data-sharing model must be called by application systems that run in different platform and operation system, and quickly and easily integrate their professional information. Based on the functional characteristics of common platform of geographic information, a super data-sharing model to describe common platform data set is studied in order that common platform data set are efficiently integrated and managed.

II. COMMON PLATFORM OF GEOGRAPHIC INFORMATION

Basic geographic information public services are those that are provided by the sectors designated by the government to the government, the public and the industry with geographical information browsing, location, data registration and distribution of geographic information. The government is administrative departments at all levels. The industries include not only industries direct operating spatial information (such as land, city planning, transportation, pipeline, water, tourism, environmental protection), but also other industries (for which the spatial information is an important supplementary information and reference background, such as population, industry and commerce, taxation, public security, civil affairs, and even schools, public health, and urban services facilities management). The public includes the individual, group and organization which use or apply geographic information.

Based on the geographical mapping information platform, the national, provincial and municipal authorities provide geographic information services to the government, industry and public. Based on GIS data, the geographic information platform on-line meets what the government departments, enterprises, institutes and the public need about the geographic information, spatial location, and spatial analysis with the secondary development personalized applications interface and scalable space. Platforms integrate data, software and its supporting environment in general that realize application service functions of geospatial framework.

Support environment is the public geographical information platform for the protection of conditions of service, including service system, network (such as Government Intranet Administration web, government Extranet Administration Web and public Web), storage equipment, backup equipment and so on.

According to scale of basic geographic information, the common geographical information platform is divided into the national level, the provincial level and

the city or county level. Each level platform consists of several nodes, and each node uses basically same technical structure and relatively independently provides services through network. Adjacent region common geographical information platforms achieve convergence. The common geographical information platforms with difference levels should vertically associate with each other. The data scales of national geographic information platform include 1:1 000 000 and 1:50 000 with different resolutions of 30m, 15m, 5m and 2.5m. The data scale of provincial-level geographic information platform data include 1:10 000 or 1:5 000 with different resolutions of 1m or 0.5m. The data scale of city or county level geographic information platform include 1:2 000, 1:1,000 and 1:500 with different resolutions of 0.5m and 0.2m.

A geographical information platform consists of data set, exchange management system, online services and support environment.

Through the portal, the online service system provides at least the certificate service, catalog service, metadata service, map application service, geo-coding service, data interface service, personalized service, data publishing service, service registry management, second development service and so on to meet customers online access and application geographic information, as well as build fast distributed special application systems.

Common platform of geographic information is composed of data set and online service system. Common platform data set is the kernel part of common platform of geographic information, which includes geographical entities, image data, map data, geographical names and address, three-dimensional landscapes, catalogs and metadata, and thematic data [15].

A. *Geographical Entities Data*

To link the socio-economic and natural information, adapt to network operation, basic geographic information should be re-organized and the data model should be rebuilt by object-oriented methods to form geographical entity data.

B. *Image Data*

Based on the basic geographic information data, after stitching, uniform color, contrast, ghosting, mosaic processing and image pyramid building, image data are formed.

C. *Map Data*

Map data include terrain map, government electronic map and public electronic map that the basic geographic information data are processed through the symbolic processing and surface finishing.

Government electronic map is extracted from basic geographic information through expansion and restructuring process and integration socio-economic information that government concerns and user needs. These maps mainly include basic geographic information such as water, transportation, residential areas, topography, and thematic information such as

administrative organs, public service facilities to product geographic map to meet the e-government.

Public electronic map is data that are extracted from basic geographic information and expanded and restructured process, and public interested in information is added including school, hospital, hotel, stadium, etc. After security technology dealing, these data can meet the public requirement on location services.

D. *Geographical Names and Addresses*

By normalization of descriptive geographical names and addresses, one to one corresponding relationship between the spatial location and geographical names and addresses is established. So geographical names and addresses have spatial coordinate information to meet various topics requirements of spatial orientation. Geographical names and addresses include natural geographical names and human geographical names. Natural names include mountain name, peak name, river name, lake name and other names. Human geographical name include administrative region name, street name, residential name, door (building) site and so on.

E. *Three-dimensional Landscape Data*

Image data, digital elevation model data and geographical names and address are integrated, and expanded to to form a three-dimensional landscapes data in which difference government, enterprises and public are interested. Landscape data intuitively meet the government departments, enterprises, institutions and the public on the general needs of geographic information.

F. *Thematic Data*

In accordance with uniform standards, the relevant departments or units integrate their business data to be shared. These data can be physically stored data centers to service users in the form of expanded layers; They can be also physically stored in the department or unit data sub-centers, while their catalog and metadata are registered in a unified data center, to realize distributed storage and logical focus, but also to service users in the form of expanded layers.

G. *Catalog and Metadata*

Metadata includes cataloging information, identification information, content information, restricted information, data descriptive information, distribution information, data scope, spatial reference information, inheritance information, data quality information, product release information, etc.. Metadata has three levels, which are database level, map sheet level and feature level. Database-level metadata that is directory information, is a general description of the contents of the database. Mapsheet-level metadata is the content of each map sheet specific description, used to query the details of map sheet. Feature-level metadata is description of the important geographical entity for all kinds of important geographical elements query.

In order to show the relationship between information resources, catalog should be in a tree structure automatically generated based on different needs.

Data sets in the platform are used to describe the three-dimensional space from various angles with different displaying resolutions. Data set in the common platform includes not only vector data such as geographic entities, data, locations and address data, thematic data, three-dimensional landscape data, and raster data such as maps in DOM, PNG or JPEG format, but also catalogs and metadata in form of relation tables or WORD files.

Online service system can provide data and function services for government departments, enterprises and public to make their application systems onlinely access to and use geographic information.

III. SUPER DATA-SHARING MODEL

Traditional way that represents various geographical entities is to recorder coordinates of points, lines, surfaces and other basic elements, which inherits advantages of cartographic methods and benefit to spatial data processing and storage with the computer technology.

But the traditional description of spatial entities cannot meet spatial information sharing requirements, mainly because the traditional description of spatial entities based on the description of elements only describes the relationship between the elements without expressing relationship between spatial entities. It is difficult for the traditional method to integrate different formation when the different information of the same spatial entities is stored in different servers.

For example, if a company's location information is in the surveying and mapping bureau, the registration information is in the business administration, its real estate data is in the housing authority, and its management of information is in the company, then the traditional method to describe the spatial entity is powerless to achieve integrated management of all information.

Entity-oriented data description method can integrate and manage the geometry and attribute information of geographic entities, which benefits to data integration and interoperability of spatial information in distributed network environment. Spatial information sharing and distributed management come ture.

A. *Description of Entity*

The entity is a complete geographical object with its geographical name and address. So each entity has name, address, geometric data, and attribution data. One entity can be further divided into physical elements. Physical elements of entity can be described with point, line, surface and body. These four geometric objects are determined with nodes, edges, and plane geometry. Finally, data model of public platform can be built.

Definition 1. The entity is an object that has completely social and physical meanings in three-dimensional physical space. Its social meaning

matches the concept of human cognitive, and physical meaning is determined by its own physical characteristics. One entity is made of one or more entity elements.

Definition 2. Entity element is an object that has complete social meaning and physical meaning and contained in a specific entity. Its social meaning must match the concept of human cognitive, and physical meaning must be determined by its own physical characteristics. Entity element is made of one or more unit entity.

Definition 3. Unit entity is an object that has complete physical meaning but hasn't complete social meaning.

Chinese Academy of Surveying and Mapping, China, as an example to illustrate an entity, entity element and unit entity, is made of entity elements, such as office building that is made of unit entity such as main part and appendages like air-conditions, apartment buildings, staff canteen, lamps, roads, trees and so on, where office building is made of unit entity such as main part and appendages.

Unit entity is made of one or more geometric object. In a three-dimensional Euclid space, unit entity can be abstracted as four classes of spatial objects, that is, point, line, surface and body. The spatial object can be made of more simple geometrical elements like node, edge, and surface. Those geometrical elements can be described by following equations

$$Node = (x, y, z) \tag{1}$$

$$Edge = \langle Node_1, Node_2 \rangle \tag{2}$$

$$Face = \langle Edge_1, \dots, Edge_n \rangle \tag{3}$$

Formal description of four classes of geometric objects (point, line, surface and body) can be described as

$$Point = \langle Node_k \rangle \tag{4}$$

$$Line = \langle Node_1, \dots, Node_n \rangle \tag{5}$$

$$Surface = \langle Face_1, \dots, Face_n \rangle \tag{6}$$

$$Body = \langle Face_1, \dots, Face_n \rangle \tag{7}$$

One entity is made of one or more entity element. Every entity element is made of one or more unit entity. Unit entity is made of one or more geometric objects. Those can be described by following equations

$$UnitEntity = \langle Body_1, \dots, Body_n \rangle \cup \langle Surface_1, \dots, Surface_n \rangle \cup \langle Line_1, \dots, Line_n \rangle \cup \langle Point_1, \dots, Point_n \rangle \tag{8}$$

$$EntityElement = \langle UnitEntity_1, \dots, UnitEntity_n \rangle \tag{9}$$

$$Entity = \langle EntityElement_1, \dots, EntityElement_n \rangle \tag{10}$$

B. Description of map and image

Operations of maps and images display mainly include maps and images roaming and zooming in or out. Test proves that main data operations are maps or images

roaming and high-power map or image narrowing [16]. In order to improve the speed of map or images zooming in or out and quick access to information of different scale maps or different resolution images, map or image pyramid must be generated. According to different display, different scale map or different resolution images can be accessed so that maps or images quick zooming in or out comes true [17][18].

Since raster data that are stored by rows or columns are displayed to locate and read data several times, which reduces the displaying efficiency of these data. In order to improve data displaying speed, it is necessary to divide raster maps into blocks and display only the visible area of data access [19]. At the same time when using regular blocks, the adjacent relationship between blocks can be determined by its array subscript.

So, to quickly browse and zoom images and maps in the platform data, the layer and tile pyramid must be established. The way to create an image pyramid is similar as that to create a map pyramid. Here an example to create a pyramid of map is shown as following.

Firstly, pyramid is established according to scale of map. The scales of national-level map data are 1:1 000 000, 1:250 000, 1:10 000 and 1:50 000; and the scales of provincial-level map data are 1:10 000 and 1:5 000; while the scales of city-level map data are 1:2 000, 1:1 000 and 1:500.

There are 7 layers such as boundaries of national, provincial or city, water, vegetation, transportation, residential areas and facilities, landscapes, vegetation and soil at every level

Each layer in accordance with the k*k pixels in size is divided to form m*n tiles, which can be positioned by row and column of tile, namely i, j. Formal description of tiles is

$$Tile = \langle Scale, Layer, i, j \rangle \tag{11}$$

where, Scale is the level of tile; Layer is the title layer whose values are boundaries of national, provincial or city, water, vegetation, transportation, residential areas and facilities, landscape and vegetation and soil; i and j are the row number and column number of tile whose size is k*k pixels, respectively.

C. Public Platform Data Model

According to data model of entity, map and image, a super data sharing model is established, shown in Fig 1, where OID that is identifier of object has mutually exclusive; attribute is the attribution of object; relation refers to the correspondence between objects, such as the one to one, one to many, many to one mapping, etc, Type refers to the classification of unit entity attributions, including mainbody, character and adjunct.

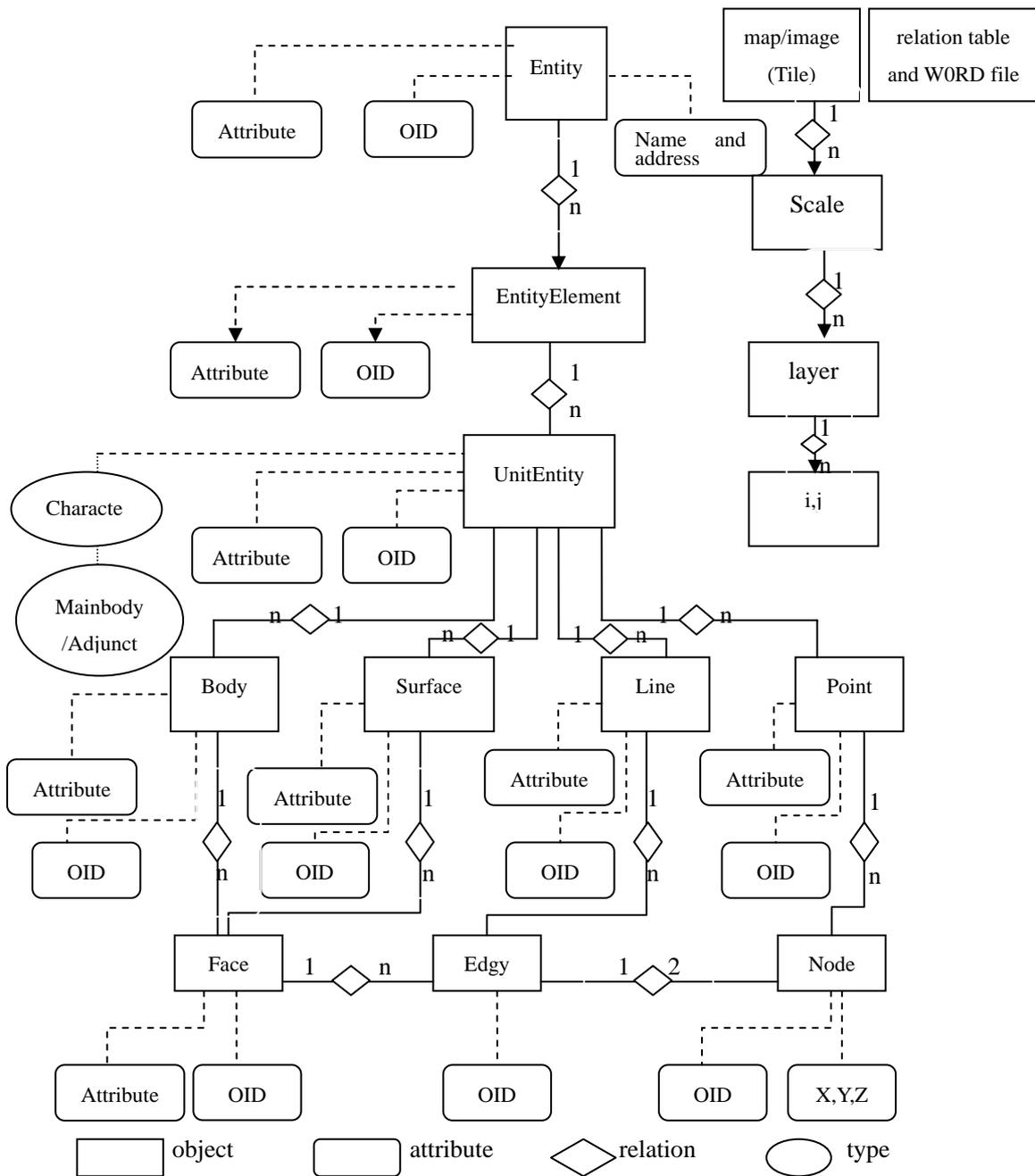


Figure 1 data-sharing model of public platform of geographic information

IV. EXPERIMENTAL CASE

Geographic entity and three-dimensional landscape can be generated and displayed using C/C++ language in Windows XP operation system. At the same time, thematic data from different units can also be loaded. Layer and block map pyramid and image pyramid were constructed, and the progressive transmission of image or map [20] realizes quickly displaying images or maps when maps or images are high-power zoomed out or maps or image are roamed. This data-sharing model has been successively applied to geospatial frameworks of digital cities such as “digital Taiyuan”, “digital

Qianjiang” and “digital Jiaying” and so on, digital region geospatial framework, such as “digital Sanxia”, and it has been checked and accepted by the State Bureau of Surveying and Mapping, China. Application systems on different platforms of government departments, enterprise, institutions and the general public can in real time call geographical entities, name and address, image data, three-dimensional landscape, maps and thematic data provided by the common platform and integrate with thematic data in the sector. So the sharing of geospatial framework data set comes true.

V. CONCLUSION

Entity-oriented data model describes vector data such as geographical entities, geographical name and address, three-dimensional landscape and thematic data. The model can efficiently integrate spatial data, attribute data and geographical names and build the connection between name and address. In order to quickly browse maps and images, these data were organized as layer and block pyramid model. Catalogs, metadata, and thematic data were organized as a relational table data or WORD file. The data sharing model can ensure data sharing and interoperation in distributed systems. In the C/C++ environment, the data-sharing model was built, which can physically store geographical data in distributed servers, and efficiently integrate and manage these distributed data in logically centralized common platform. Now the model has been successfully applied to the geographic space frame construction in the digital city and region hosted by State Bureau of Surveying and Mapping, China.

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