2011 International Conference on Computer Science and Information Technology (ICCSIT 2011)
IPCSIT vol. 51 (2012) © (2012) IACSIT Press, Singapore
DOI: 10.7763/IPCSIT.2012.V51.45

A Method for Modeling Power Spatial Data Based on Object-Relational Model

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Abstract. According to the characteristics of spatial data in Geographic Information System for power, compared to the traditional spatial data models, introducing the relationship to the construction of the object model, the paper proposes a new object-relational model,discusses the cognitive process and structure of spatial data model of power, and illustrates the construction of the model and the methods to organize, manage, and query spatial data based on the model. And proves the model is feasible, it can represent the topology of power network better, simplify the management operation, and improve the stability and sharing of spatial data.

Keywords-object-relational model, spatial data, topology, power GIS

1. Introduction

To meet the demand for automation and information of power production, power GIS has been highly developed. Spatial data is the most basic part of GIS, since the features like the dispersion and diversity of power facilities, the real-time and security of grid operation, and the dynamic of topology, the data of power GIS is more complex than the general GIS, and then leads to many issues to manage power spatial data, such as it is complicated to operate, difficult to describe topological relations, slow to data analysis, can not to share data and so on. The efficiency of the management of spatial data relies heavily on the structure of spatial data model, how to build an efficient power spatial data model, to simplify the spatial database management and operations, has become a new research topic.

Based on the characteristics of power spatial data, the limitations of spatial data processing using the relational model, and the restrictions that object-oriented method does not support SQL in industry standard, using today's advanced object-relational database technology, combined with the topology model and the object-oriented model, the paper proposes a method for modeling power spatial data based on object-relational model, and discusses the methods to organize, manage, and query spatial data based on the model.

2. Spatial Data Modeling

2.1. The development of spatial data model

With the GIS software development from the traditional stand-alone mode to client / server system model, spatial data model has the development process from the CAD model to the Coverage relationship spatial data model, to the Geodatabase object-oriented spatial data model, so far the spatial database model.

CAD data model stored in binary file format; Coverage data model stored as binary files with index, attribute data is stored in the data table, the spatial data contact corresponding attribute data with a unique identification code; Geodatabase data model is an object-oriented data model, both spatial data and attribute

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data are stored in a relational database, adding a relational database engine module in the top, by defining the object function to realize the organization and management of spatial data. The current mainstream GIS software also manages graphics and attribute data in this way, such as foreign ARC / INFO, GEOMEDIA, domestic MAPGIS, GEOSTAR, SUPERMAP and so on. The spatial data model based on spatial database contains the framework which integrates geometric and attribute data, supports the spatial entities of point, line, surface and other types, provides the function interface for the management and analysis of spatial data,that is integrates the function of engine into database.

2.2. Object - Relational Technology

There are two main ways to implement spatial database currently: the object-oriented database approach and object-relational database approach. Due to the current object database technology is not yet mature, so, object-relational database becomes the main technology of spatial database. Combining relational database and object-oriented technology, it defines the geographic entity as object, and supports a variety of simple and complex object structures, at the same time by storing the relationship between objects, it is easy to perform spatial data query, indexing, security, concurrency, consistency / integrity and so on management operations. Therefore, using object-relational technology to achieve spatial database is the best way, and modeling spatial data in this way is the key. Currently, a number of important database vendors have also introduced a dedicated module for spatial data management, such as the Spatial Data Blade Module of IBM Informix, Spatial Extender of IBM DB2, and Oracle Spatial of Oracle, etc., and this has brought great convenience to the development of GIS software[1].

Object-relational model is applying the theory of object-oriented to relational database, abstracting and organizing geographic entities to the corresponding geometric object in gis, which include basic objects like point, line, surface and a variety of complex objects combing by basic objects. Any entities that could be Separated Conceptually in its area are identified as objects regardless of size, their location, attributes and topological relationships are stored in a relational database. The model emphasizes the individual entities, objective of the study is the independent geographic entities and their relationships. In gis, the entity objects model represent with the vector data, it able to show the position and shape information of geographical entities better, and it has the advantages of small storage capacity and topological relations between data items can be extracted from the point coordinates chain.

Object-relational model can completely integrate the topology model with spatial entity model. Compared to Geodatabase, it enhances the ability of spatial objects expression, making the model expressed in GIS Closer to the real world. By encapsulating the object, the management and analysis of spatial data are more convenient and efficient. By extending functions of sql analyzer in relational database, we can easily define some operations function or process for spatial data, such as storage, indexing, query cache, real-time updates and other operations of spatial entities, developers can call these functions through the API interface to expand the system functionality.

3. Structure of power spatial data model

3.1. Composition of Power Spatial Information

Grid is to contact the facilities and equipment of power generation and electrical, It is mainly formed by a network of transmission lines, substations, power distribution and composition distribution lines. The information can be divided into two categories: one is a variety of attribute information of grid equipment and user, the other is spatial information of geographic location and relationship. The information referred both are geographic information, and hall be stored in the power GIS.

In Oracle Spatial, gis spatial objects can be divided into basic entity types like point, line, surface. The grid structure is also composed with the 3 basic objects, all grid equipments can be instantiated as oracle spatial point, line and surface objects. Power equipments which operate independently can be expressed as point object, such as towers, users, monitoring points, etc.; the transmission and distribution lines are Line objects; the stations, platforms are surface object. In addition to geometry, the power spatial data also need to store the various relationships between the electrical equipment, including electrical connections between

lines and stations, inclusion relations between stations and equipment s in station like bus lines, surge arresters and so on, and the topology of grid operation.

3.2. Architecture of object-relational model

Object-relational model is designed to comply with OpenGIS ODBC / SQL specification geospatial elements, supports to show a variety of spatial entity types as objects, consistent with restrictions of industry standards-based SQL statements. Model implementation based on object relational data model abstracts the geographical entities in GIS as different geographical objects, maps the attribute information of entity to columns in data table, expresses the location information in SDO_GEOMETRY type and behavior information as a variety of methods, functions or process for operating object data by expansion of the standard sql. The definition of the model packages the position, attributes and methods of each object together, and establish links between objects, it is a good representation of the spatial relationship of entities in the real world.

Spatial entity is stored as an object instance in single row, its geometry data and attribute data are liked through a unique identifier, the management and operations of these objects can be realized by calling the object method interface, At the same time the object can be expanded using standard sql to achieve a specific behavior.

A collection of spatial objects with similar attribute information are represented as a layer in gis, to reduce redundant data, the same attributes and associated spatial index of entities in the same layer can be stored in a same data table. Architecture of object-relational model is shown in Figure 1.

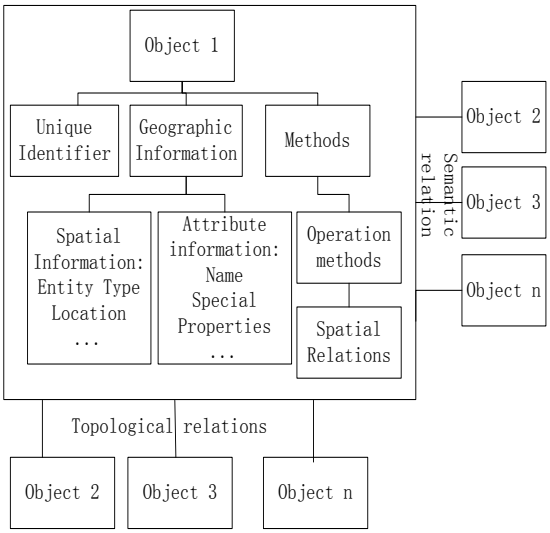

Figure 1. architecture of object-relational model diagram

4. Modeling and data management example

4.1. Storage structure of spatial data model

Stored in the database, spatial attributes of entities are stored by the Geometry of database, point device by a pair of coordinates, Line equipment expressed as a string of coordinates which are taken a few important points in the line, surface is a combination of lines and represented as a sum of the coordinates of points which the first overlap the last. Non-spatial attributes are stored directly into a relational database table field, property value of each entity has a row, Spatial attributes and non-spatial attribute is linked through the only code of the instance. The behavior and updating information of object can be expressed by specific process or procedure which is defined by extending the sql of a relational database. The spatial database builder in the technology can make a better simulation of the geometry, attributes and behavior information in real world, stored the spatial data and non-spatial data in the same system, it makes the spatial data management and maintenance more convenient and efficient.

The model defines the topology table to represent the topological relations between entities. Using the proposed special model, users can first define the needed topological connections relationship, then create different topological tables for electricity facilities to show the connection state between facilities. On this basis, through the appropriate tracking search algorithm, we can deduce the topology of power facilities. Object-relational model in a relational database storage structure that is shown in Figure 2.

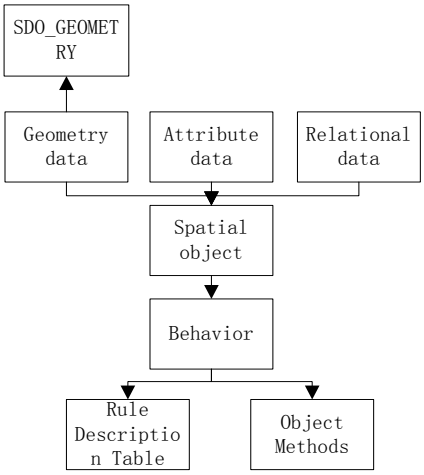

Figure 2. Storage structure of object-relational model

4.2. Work Order Management Mechanism of spatial data

A very important point of spatial data management is the requirement for Multi-user concurrent use and data consistency / integrity, data management workflow is to meet the need that users edit spatial data including adding, deleting, changing and data rights management, and provides a more detailed system log management for data manipulation. In the paper, work order mechanism is the core to meet the needs of the various data operations, such as data rights management, version control, transaction processing and so on rely on this. Lock mechanism can be used together at the same time to complete the conflict resolution of concurrent operation of data. Work order system to provide some mechanism to control the flow of data editing; locking mechanism to provide the conflict resolution of manipulate the data submitted.

Each operation of data corresponds to a work order, in the work order system, the spatial data is divided into official data and editing data. Editing data including the status of pending data (EDIT, ADD, DELETE), posted data (POSTED), abandoned data (ABANDONED). All operations on data are stored in a temporary database table (data modification table) as pending data, do not directly to update official data. This data table records all the work order operations on data, binds work order number, corresponding updates status field to EDIT, ADD, DELETE, POSTED or ABANDONED. Dynamic work order as shown in Figure 3.

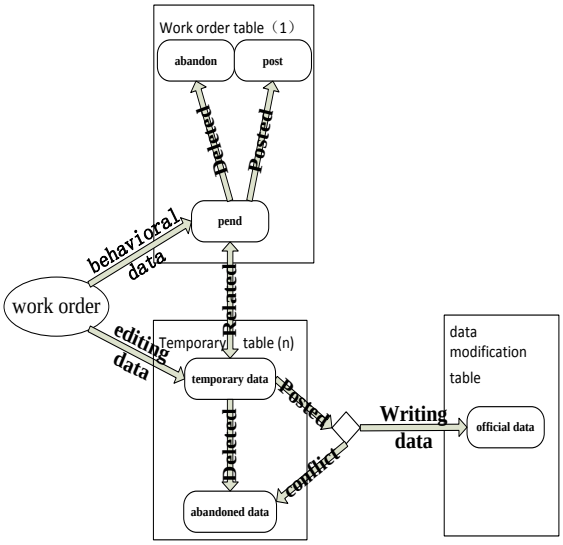

Figure 3. dynamic work order

4.3. Two-tier structure of spatial data queries

Spatial data query can use the two-tier query model of Oracle Spatial, accurate results data set can be obtained by two filter, to solve spatial data query and spatial topology operation, etc.

1) The first filter

The first filter mainly produces a major subset of similar data quickly by comparing spatial entities, to speed up the processing efficiency of the secondary filter, the subset is the candidate for it.

2) The secondary filter

The operating object of second filter is the data set obtained by the first filter, it can generates the exact results of queries through the accurate calculation. The filter need to be responsible and precise for calculation, its algorithm is complex, but dealing with the limited data set, than handling the entire data set, the cost of calculation is relatively low.

Depending on the query requirements, the query operation are not the same, dealing with a number of inquiries, just the first filter is enough, for example, to query the data intersect with a boundary .

4.4. Multi-level spatial data indexing mechanism

The index of spatial database is the key technology to improve the storage efficiency and spatial retrieval performance, and power GIS is the enterprise-class, multi-user applications, facing massive data, to improve the efficiency of space data acquisition is one of the most important issues. Because of the spatial object is multi-dimensional, the traditional database indexing techniques such as B trees, B + trees mainly focus on characters, numbers and other query problems of one-dimensional data object, so do not apply to spatial data. In view of this, we propose a multi-level spatial indexing mechanism. The indexing algorithm divides the study area into several large grid to establish an index, and establishes secondary index based on R tree for each grid. It effectively saves storage space, and limits the scope of spatial objects to operate, improves the efficiency of operation.

4.5. Metadata management for spatial data

Metadata is descriptive information about data. through the metadata management it is better to implement the data sharing and version control, metadata for spatial data primarily record the information of dimension of spatial entities, the border of attributes, the type of data, etc., this information is updated through the metadata view, table 1 is the definition of metadata view.

TABLE I. METADATA VIEW DEFINITION

Field	Data Type
TABLE_NAME	VARCHAR(32)
COLUMN_NAME	VARCHAR(32)
DIMINFO	MDSYS.SDO_DIM_ARRAY
SRID	NUMBER

5. Conclusion

The spatial data model designed by the above analysis can meet the requirements of power GIS, can accurately represent the spatial location and physical attributes, it is convenient to represent spatial entities and topological relations, and easy for analysis of grid topology. Implementing the spatial query and analysis object-oriented simplify the spatial database management and data sharing operations. All the features packaged as objects makes us can simulate the complex entity types in GIS, there is the ability to continually expand and update.

6. Acknowledgements

This work is Supported by "the Fundamental Research Funds for the Central Universities"(Grant No. 10QX40)

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