Research on the distributed GIS for distribution network based on CIM

Y Q He¹, Y H Chen², H B He², C Liu¹ and X B Hou²

¹Institute of Economic and Technological of State Grid Hunan Power Corporation, Hunan Province, Tianxin District, Xinshao Road 398-410004, China.
²State Grid Hunan Power Corporation, Hunan Province, Shaoshan Road 428-410007, China.

Abstract: The geographic information system (GIS) should be more open and flexible, according to the development direction of distribution GIS for distribution network. And we must follow the electric power standard such as the CIM when we research the distributed GIS. In this paper, we will promote the integration of distributed distribution network GIS for the effective management and intelligent running of electric power enterprises. However, there are still some key technologies to resolve for distribution network GIS systematic development.

1. Introduction

With the rapid development of economic society, people face the pressure and the dilemma of electric power demand increasing and pressure on earth's energy resources, which are forcing countries to develop smart grid as the future direction, which is also the direction for electric power enterprise. However, the various business needs of power grid enterprises are based on the requirements of GIS, and the needs of GIS are especially based on spatial location and topology of the grid. Therefore, in this paper, we will research the spatial location and the topology of the grid. GIS can be widely used for large numbers spatial data [¹] and attribute data efficient management, and which topological analysis of the grid is widely used. The management and analysis capability of GIS can provide a good tool for the power grid enterprises intelligent development and secondary intelligence. GIS plays the role of grid data and topology computing in power grid enterprises. Therefore, the role of GIS is very important.

GIS is an important part of power system. There is an obvious feature of power distribution in the distribution network, which is the wire distribution in a large geographical area and the line is too long. The rural distribution network is complicated and the load is not concentrated. These problems are very difficult in the management for power enterprises. GIS uses the computer as the tool, which is used to create and describe the geographical entities and geographical phenomenon for an information system, GIS through space and time characteristics and time-space correlation characteristics for expression method, which also through this method effectively express spatial characteristics of information management and analysis. Therefore, it is necessary to introduce the suitable distribution network GIS, which has an effect on the efficient management about the network space and the attribute data directly.

With the development of smart grid, the International Electrotechnical Commission made the IEC61850 and IEC61970 standard, such as IEC61970 standard system for dispatching center, the CIM model [²] defines the equipment model in the power system and function model, and the CIM presents
the description of the typical data. The IEC 61850 standard is aimed at substation system, which models the substation structure, intelligent electronic equipment and communication system. In this paper, the data exchange between models is realized through the coordination of the class, relation and attribute of CIM model and object model.

This paper concludes that the research of distribution network geographic information exchange model can be used for the geographic information exchange between systems. The design of distribution network geographic information publishing and aggregation structure can satisfy the distribution network geographic information release and integration, and support the multi-stage polymerization of geographic information.

2. Principle of model construction

2.1. The system architecture for distribution network GIS

The distribution network GIS generally adopts distributed three-level architecture\(^{(3)}\), which is based on general GIS components, including data service tier, business logic tier and application service tier. The working mode of this architecture is C/S or B/S mode\(^{(4)}\). The architecture of the entire system is shown in figure 1.

![Figure 1. The system architecture of distribution network GIS.](image)

GIS client usually needs to obtain multiple kinds and large amounts of data in the database server, which is based on the various queries, statistics and business analysis of the distribution network GIS. If it needs to analyze all their work on the GIS client, the GIS client needs frequent interaction and large amounts of data on the database server commands, which will reduce the performance of the whole system in the condition of network resources under limited. We realize the business logic analysis through the functions of service components\(^{(5)}\), such as the DOOM, COM+, Web Service\(^{(6)}\), WCF and other standards encapsulate. These service components are then deployed on the business logic servers, which are as close to the database server as possible to provide some logic analysis services of business. And the functions of service components can provide business logic analysis services\(^{(7)}\) for the distribution network GIS client.

2.2. The distribution network GIS data model
The IEC 61970-301 and IEC 61968-11 define the CIM model\cite{8} of the power system, which contains all the classes and relationships that describe the power system models. Figure 2 is a part of the distribution network GIS data model, which describes network topology, device tolerance, measurement and listing information.

![Diagram of the GIS data model for distribution grid part one.](image)

(a) Core::Power System Resource
(b) Core::Measurement

Figure 2. The GIS data model for distribution grid part one.
The pole tower, cable well and other power resource supports are important for GIS, but these models are not defined in IEC 61970-301. The models of these supports are defined in the form of assets \[9\] in IEC 61968-11 Asset, InfAssets, as shown in figure 3.

![Figure 3. GIS data model for distribution grid part two.](image)

2.3. The spatial data exchange model
There is no new model developed in CIM. The GIS adopted GML standards, which was established by the open geographic information system (Open GIS) association \[10\]. The model is included in the InfGMLSupport package of CIM \[11\], and figure 4 is a simplified GML model.

![Figure 4. The spatial data exchange model.](image)
3. The research on data exchange mechanism

3.1. Data exchange under distributed computing environment
The data exchange between the GIS application systems [12] requires various network protocols (such as TCP/TP, UDP, HTTP, etc.) and the selected distributed computing environment (such as CORBA, DCOM, COM+, Java RMI, WCF, etc.). The order of data exchange between GIS application systems is determined by the selected network protocol and distributed computing environment. Figure 5 is a data exchange model under distributed computing environment.

![Data exchange model under distributed computing environment](image)

Figure 5. Data exchange model under distributed computing environment.

3.2. The CIM model of distribution network geographic information
The IEC 61968-11 has been extended on the GML standard [13] developed by OGC, and provides a class model of power geographic information in the InfGMLSupport package. In GIS system, the spatial data is organized into various layers according to the geography (such as line, tower, switch, measurement, etc.). Figure 6 is GML Support in IEC 61968-11.

![GML Support in IEC 61968-11](image)

Figure 6. GML support in IEC 61968-11.
3.3. Distribution model of distribution network GIS
The search criteria encoded which OGC Filter codes with geographic information \cite{14} requests is sent to geographical information providers. Service engine parses retrieval condition \cite{15} if the Filter is space operations and the analytical results will be passed to the GIS component system on the bottom. The corresponding space data through GIS components operations will be linked with geographical elements, and then extracted the non-spatial attributes of geographical elements though the database or file. Finally, according to the distributed network geographic information exchange model, it will be compiled into a geographic information exchange document and returned to the GIS client \cite{16}. Figure 7 is the publishing and retrieving of distribution network geographic information.

![Image 1]

Figure 7. Publishing and retrieving of distribution network geographic information.

3.4. Distribution network geographic information aggregation architecture \cite{17}
The geographic information aggregation of distribution network adopts multi-layer architecture, which includes data source tier, data provider tier, geographic information tier, geographic information aggregation tier and information re-release tier. The figure 8 shows the geographic information aggregation architecture of the distribution network.

![Image 2]

Figure 8. Framework of distribution network geographic information integration.
3.5 Distribution network 2D map positioning information
Distribution network 2D map positioning can be displayed accurately and quickly through real-time GIS platform. This platform can complete the electrical circuit and user's relative geographical location query, and add up the number of users, power failure capacity and other information in the power failure area. The figure 9 shows the 2D map positioning.

3.6 Distribution network 3D model System function implementation
The 3D model display and the 3D scene of the functions of roaming, scaling, rotation and flight are shown in figure 10.
Since GIS adopts CAD graphic data directly, which is easy to get the GIS coordinates of one point. So, we can find the perspective of 3D visual location through the GIS coordinates. We can set the appropriate 3D visual effects. The visual simulation interface of the region appears in the interface as shown in figure.11, which can be used to navigate, zoom, rotate and fly in 3d scene.

4. Conclusions
This article is based on common information model (CIM), according to the research on distribution network resource model, and topological structure of distribution network, and CIM data exchange model, and the key technology such as geographic information aggregation method, carries on the analysis and research. We realize the simulation process of 3d scene under combining with LOD technology. Hope to it can be helpful to the distributed distribution network GIS research.
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