SPECIAL TOPIC

# Application of GIS in Network Equipment Management

**Abstract:**
Telecom equipment operating on telecom networks is varied and from different vendors. There is no location information about it. Therefore, the equipment location and the areas covered are unknowable. Certainly, this will bring difficulties to equipment management. The solution is to adopt Geographic Information System (GIS) in the network equipment management system. GIS supports collection, storage, and display of geographic and spatial data, and correlates them to related reference data for information query and analysis. This article puts forward a management system of network equipment using the GIS technology and introduces its framework, modules, and management flow. It is concluded that this solution can effectively manage and maintain network devices.

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With the introduction of diversified network technologies, a variety of devices supplied by many equipment vendors are serving the communication networks, which certainly brings difficulty to equipment management.

Geographic Information System (GIS) supports collection, storage, and display of geographic and spatial data. With GIS, the network management system can place all devices on the interface in a network topology analogous to the real network structure and make them consistent with actual network connection.

## 1 Management System of Network Equipment

A typical management system of the network equipment consists of 4 parts: the manager, Management Information Base (MIB), management agent, and trusted agent. Generally, the first three parts are necessary and the fourth one is optional.

In the management system of network equipment, the manager helps the network administrator perform management of the whole network. Its network management software requires the management agent to collect periodically important information about equipment, which is used to determine whether network equipment and the whole network are running normally. The manager should periodically inquire about information collected by the management agent such as the equipment running state, configuration, and performance.

In order to enable specific network management, the MIB specifies that the agent maintains all variables and the administrator has access to the MIB. Information in the MIB is considered the managed resource in the network management that can be represented by objects. Each object represents a certain attribute of the managed resource and a collection of these objects forms an MIB. Each variable in the MIB records current content of every connected network including status, traffic statistical data, errors, and internal data structure. Through access to the MIB, the network administrator can perform five major functions of network management such as configuration management, performance management, fault management, security management, and billing management.

The management agent is a special software or firmware that contains information about the specified device and its environment. The device equipped with a management agent is called the managed device. The management agent can obtain relative information about its resident device such as running state, system features, and configuration.

The manager installed on the network management workstation collects device information from the management agent in two modes—polling and interrupting. The network management workstation

can obtain device information through the polling–based management agent, modify, add or delete items in the agent, and set the threshold for a specified event of the device. If an exception occurs or a certain threshold exceeds the preset value, the management agent will immediately send "trap" information to the network management workstation and adopt the interrupting mode to notify it of this exception.

In some special cases, a specified device can not be equipped with the management agent due to scarce system resources or failure in supporting transmission protocols necessary for the management agent. However, the trusted agent technology can be used. The trusted agent runs on another device other than on the managed network device. It translates all received commands of the network management workstation into the ones that are supported by the device to be entrusted. Therefore, the trusted agent serves as an application program gateway or a bridge between the equipment manager software of the standard network and the system that doesn't directly support the management agent.

The manager and the management agent must comply with certain specified protocols when they communicate via the network. The most commonly used protocol is Simple Network Management Protocol (SNMP), which is a distributed management protocol. A system can play not only a single role of the SNMP manager or the SNMP agent, but also both roles. If a system serves as both the SNMP manager and the SNMP agent, another manager may be needed to query the managed device and provide information summary.[1–4]

## 2 Geographic Information System

The geographic information system is a software designed to describe and process relative geographic information. It is a fundamental tool used in the management process including collection, storage, update, analysis, transfer, and query of geographic information. Geographic information is a generic term of digits, letters, images, and graphs for representing quantity,

quality, distribution feature, relation, rule, and other factors of the geographic system.

The geographic information system provides the following basic functions.

(1) Data Input

Data input involves input of graph, grid and attribute data. Graph data are input via digitizer and scanner. Grid related data contain various remotely sensed data, air survey data, photographic image data, and aerial radar data. Attribute data are used to describe object features and managed via the related database management system.

(2) Data Correction

Data correction refers to quality check and correction of input data as well as setup of spatial topology structure for the next data management, spatial query and analysis, and data presentation by means of observation, statistical and logical analysis. It involves graph data correction and attribute data correction. The former involves setup and correction of polygonal topology relation, graph edit, graph mosaicing, and projection transformation, while the latter is always combined with data management.

(3) Data Management

Data management involves constructing and organizing appropriate location of geographic elements, connection relationship and attribute data to facilitate computer processing and system user understanding. The computer program used to organize the database is known as a database management system, which involves selection and conversion of data format as well as data coupling, query, and extraction. Data management contains spatial database management and map base management. As the core of GIS, spatial database management is the greatly featured part that stores graphic and image information with strict logic structure. In terms of GIS application and data type, the spatial database is divided into vector–based, grid–based and hybrid data structure. A large area shall be divided into numerous map sheets as it can hardly be represented by one. To effectively manage the data of number of map sheets and enable query and analysis of different sheets, it is necessary to perform map database management. The map database management involves adding, deleting, and mosaicing map sheets, searching different sheets, and maintaining map base.

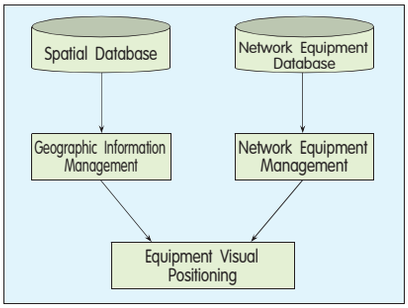
(4) Spatial Data Query and Analysis

The spatial data query and analysis is the most important function of GIS. It is an essential feature that makes GIS different from other information systems. Making full use of geographic and other professional information, spatial data query and analysis is responsible for digital conversion of scale and projection, data processing and analysis, and establishment of geographic or spatial model. The spatial data query provides GIS with abundant query functions including attribute query, graph query, and crossed attribute and graph query. The data analysis is actually a series of computation and query conducted for spatial data. Different applications have different contents, methods, and processes for computation and query. That is to say, those are different application models. An application model refers to an abstract of the objective law concluded based on lots of special research on the specific object and process. These application models are classified into a series of typical computation and query commands. Therefore, the issue of spatial data analysis for a certain special field can be solved.

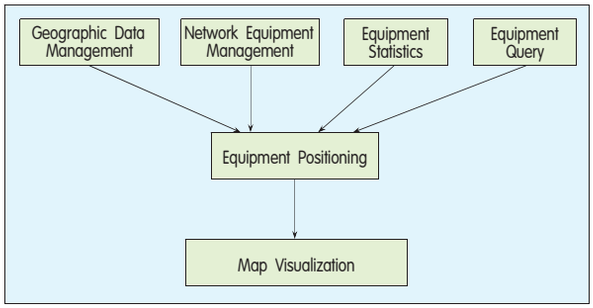
## 3 Design and Implementation of the Management System of Network Equipment

### 3.1 System Framework

The management system of network




▲ Figure 1. Composition of the management system of network equipment.

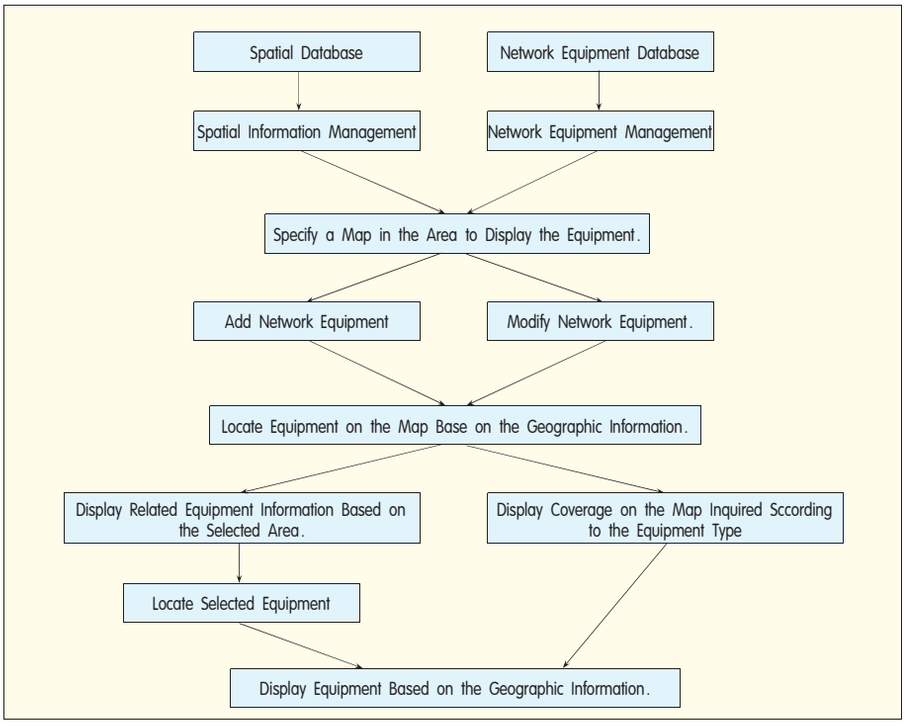



▲ Figure 2. Architecture of the management system of network equipment.

equipment provides a means of managing, querying, and locating the equipment. By adding related geographic location information to different types of network equipment, it solves the problem of displaying, maintaining, and locating and making coverage statistics of current network equipment. In addition, it achieves efficient network equipment management. With geographic location information, the management system of network equipment makes possible the location positioning. In addition, it can have equipment in each area displayed on the management system of network equipment and inquire about specific location and coverage according to the network equipment.

The management system of network equipment is made up of 5 parts—spatial database, network equipment database, geographic information management, network equipment management, and equipment visual positioning, as shown in Figure 1.

The spatial database is used to store spatial data information. The geographic information management is used to manage geographic data information. The network equipment database is used to store attribute information such as network equipment type, IP address, and geographic location. The network equipment management is used to manage related attribute information such as network equipment type, IP address, and geographic location. The equipment visual positioning is used to locate the equipment to a specified location based on its geographic location information and to complete visual positioning based on the result of equipment location and attribute query.




▲ Figure 3. Management processs of the management system of network equipment.

### 3.2 System Modules

The management system of network equipment consists of several modules such as the geographic data management module, network equipment management module, equipment statistics module, equipment query module, equipment positioning module, and map visualization module, as shown in Figure 2.

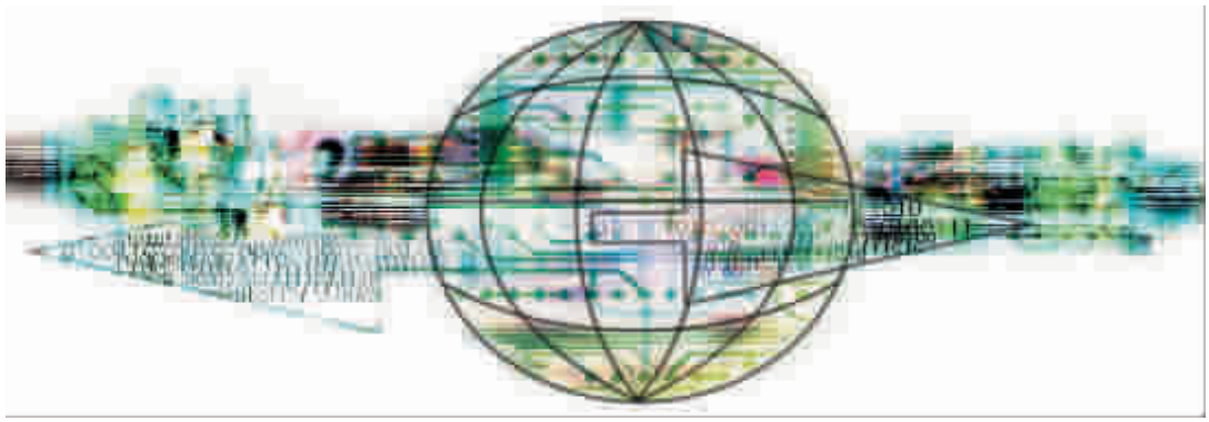
The geographic data management module is used to manage geographic data information and set up the corresponding relationship between the geographic data information and the map visualization. The management module of network equipment is used to store attribute information such as network equipment type, IP address, and geographic location and to complete visual positioning of the equipment in the map visualization module based on its geographic location. The equipment statistics module is used to display quantity and location of the related equipment type based on the specified area or equipment type. The equipment query module is used to inquire about equipment based on the equipment type or geographical area and location. The equipment positioning module is used to locate equipment based on its geographic location information. The map visualization module is used for visual display of equipment on the map based on the geographic data information.

### 3.3 Management Process

Management process of the management system of network equipment helps to locate equipment on the map based on the geographic information, as shown in Figure 3.

The management process of the management system of network equipment is described as follows.

(1) Display visually spatial and



geographic information on the map via the geographic data management module. When a user is in a different area, the corresponding relationship between the spatial and geographic information and the location information on the map can be set up. The set up is by means of the default spatial and geographic information data and map that can be loaded and set dynamically.

(2)Add or modify network equipment. Select the name of geographic location provided by the geographic information management module or select the descendant geographic location name in a recursive cascade mode to store the equipment location information in the network equipment management database. Next, locate the equipment in the map visualization module based on its location information.

(3)Query the network equipment management database, obtain actual conditions of all network elements connected through the links and have them displayed in the map visualization module in orderly and intuitive manner.

(4)Extract default spatial and geographic information as well as related descendant geographic information from the spatial information database. The user can inquire about location information in the network equipment database by clicking the tree-shaped user geographic area or selecting to inquire about current geographic location. The information about geographic location, type, and quantity of the related equipment can be displayed on the corresponding interface location. The user can inquire about all descendant geographic information in the network equipment database by clicking the descendant geographic area or selecting to inquire about descendant geographic information. In addition, the user can query on the network equipment database by clicking the geographic location or related equipment and display related equipment information in the map visualization module via the spatial positioning module.

(5) Query the network equipment database to obtain the network equipment type used in a specified area and display information about geographic location, type, and quantity of the equipment on the corresponding interface location; then click the descendant geographic area or select to inquire about descendant geographic information to obtain all descendant geographic information. The user can be allowed to click the geographic location or related equipment to query the network equipment database and to display related equipment information in the map visualization module via the spatial positioning module.

## 4 Conclusions

With a tree structure for geographic location, the management system of network equipment enables query based on the geographic location and selected area as well as query and positioning based on the network equipment attribute. It can obtain statistical and detailed information about the network equipment.

By using the GIS technology, the management system of network equipment can provide a method or build a system to enable management that is more efficient and maintenance of network equipment.

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