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Spatial Database of Traffic Management Design and Implementation

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Abstract: As we all know that ITS of large and medium-size cities is relatively independent and inquiring its information is inconvenient. Because of this, this paper proposes a spatial database solution based on Geodatabase, successfully applies this solution to the design of spatial-database of Kunming traffic road management and successfully realizes the effective organization, storage, management and application of traffic-related data which are complex and multi-source.

Key words: Traffic management, geodatabase, GIS, data integration

INTRODUCTION

As the urban population and the cars are increasing, traffic becomes a worldwide problem plaguing big cities. In many large cities, along with the economic development and the fast urbanization, due to an excess of cars, traffic congestion, even traffic jams and traffic accidents occur frequently. In China, the speed of the road construction in many cities failed to catch up with that of vehicle growth and the potential of traffic management failed to bring into full play: inefficient road network and traffic jam are more serious. Traffic problems become the bottleneck of the development of cities, people's livelihood and economy (Chen *et al*., 2006).

The establishment of ITS is one of the effective ways to solve traffic problems which cities are facing at present. ITS effectively combines the advanced information technology, modern communications technology, electronic sensing and control technologies and computer software technology, etc. together (Aranıpatzis *et al*., 2004). It is an efficient, safe, comfortable, real time and accurate integrated transportation management system and working for the entire surface transportation management on a large scale and in all ways.

Information construction has already been launched by China's traffic management departments in the big cities, such as Beijing, Shanghai, Guangzhou and other coastal and economically developed cities, while ITS in the Central and Western regions concentrated in the expressway toll system and urban ITS needs to build and improve (Shi and Li, 2004). In addition, the ITS the cities built still cannot meet the need of the application and development of the urban traffic management. The problems are as the following:

- Lack of a unified visualization information platform. The various systems cities have built are relatively independent and system features are single, which cause the user frequently switch between systems when locating related information in different systems and forms a complex operation system. The system is unpractical, inefficient in management (Li and Zhang, 2013). Such cases occurred in Beijing and Kunming. Ten ITSs has initially built in Beijing, including modernized traffic control systems, traffic incident automatic detection, alarm system, digital HD integrated monitoring system and intelligent regional traffic signal systems and so on and the various systems are relatively independent
- Lack of a unified, complete and open traffic information database. Intelligent traffic's development in China has been emphasizing intellectualization of traffic management but ignoring service of traffic information. Foreign successful experiences show that when its development reaches a certain stage, traffic information services of high levels should be the main part of the intelligent transportation (Yang *et al*., 2011; Wang *et al*., 2009). Now, database types of various systems cities have built are different and the way of access is not unified, so traffic data are difficult to efficiently store and manage and the existing data are difficult to analyze (Yang *et al*., 2010). Relocation between traffic information is often ignored

Therefore, the traffic management department of major cities urgently need to build a unified and full-featured visualized road traffic information platform by using modern IT, GIS and computer network technology, to establish traffic information database which has full

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historical data and integrates data construction, so as to achieve the management and analysis of visual integration of source traffic information to provide comprehensive, integrated, collaborative analysis and decision-support of traffic management (Liu and Li, 2005). The article, starting from the device management and traffic information service, integrates service of traffic management in cities and data storage of existing systems, integrates related data of various systems and establishes a unified and standardized transportation spatial database, so as to build a database for high-level traffic information service and traffic management departments? efficient management.

SPATIAL DATA ORGANIZATION AND DIVISION OF LAYERS

Data description: Through the analysis of traffic-related data, we can divide the data into spatial data, properties data and multimedia data:

- Spatial data mainly included basic geographic information, digital maps, area which the traffic polices are in charge of and cable lines and so on
- Attribute data refer to attribute table associated with spatial data. The data fully reflect the characteristics of spatial data, for example, traffic flow which has not the spatial reference is shown in maps in form of a heat map by associating and processing
- Multimedia data are an important part of traffic-related information. They are stored in the memory in the form of files, including digital video, electronic photos and Word documents etc

Spatial data organization: With regard to the design of spatial databases, it is not only necessary to establish a reasonable object reflecting the objective reality but also necessary to reduce the redundancy of data. It is necessary to fully take into account the normalization theory of relational database and to consider the transportation network of traffic management departments. In addition, the high-level of traffic information services are a way of convenient transportation services. In the data source for the entire system, both the data of transport infrastructure and the one of the video surveillance equipment have spatial property, so the organization and management of such data should be based on the geographic information management and maintain the advantages of traditional data management. Based on the application of data, we should on the one hand have effective management of data, on the other hand, we should storing the data for the

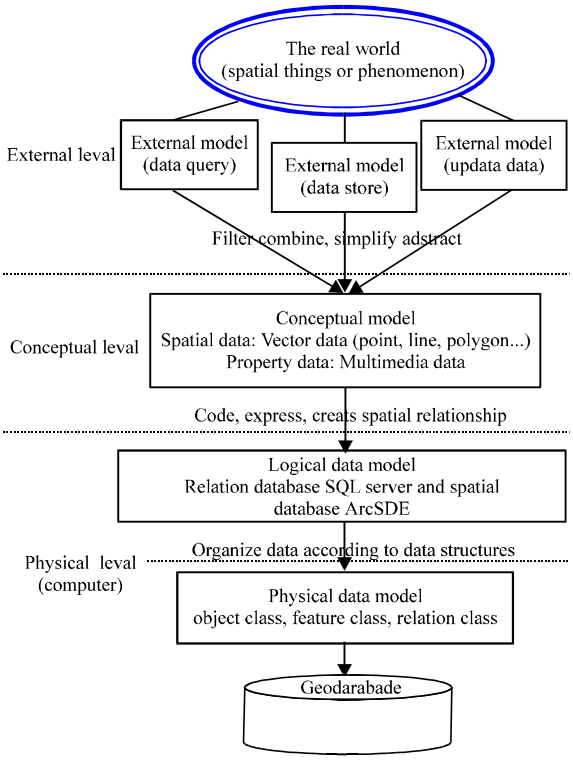

Fig. 1: Traffic spatial data model diagram

sake of using them, so how to quickly and easily access the stored data is a critical problem (Bai and Liu, 2012).

This used schema way of extended mode to make the data storage and access come true is shown in Fig. 1. The system analyzes business and needs of the traffic management department comprehensively and by the help of management object, abstracts concept data model and combines space data concept model Geodatabase?a more mature space data management. The system stores spatial data and property data in a unified DBMS and ArcSDE to manage data.

GeoDatabase is an essential element for the management and use geographical data. It is a collection of the data set of geographical elements, the object class and relation class combined in accordance with certain rules and the model. GIS Spatial database organizes geographical data in accordance with the hierarchy data objects, include Feature Dataset, Feature Class, Object Class.

Layer organization: In order to make the database structure clear and easy to design, develop and maintain, the transportation spatial databases organize geographical data in accordance with the hierarchical data objects and divide the entire geographic database into

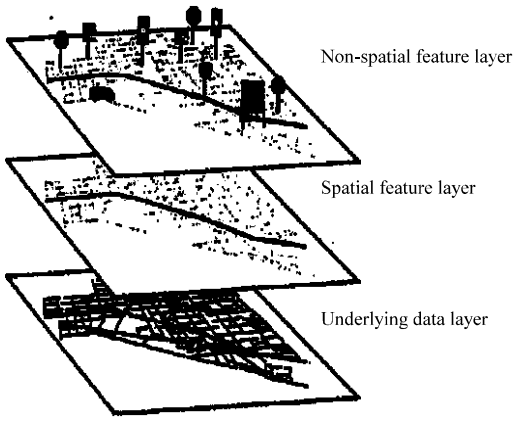

Fig. 2: Layer organization

Table 1: Objects of traffic geographic database of Kunming

Class	Entities	Purposes	Memo
Road network project	Road section, lane, information points, entrance, Roads, construction sections	Describe the elements that constitute the road network	Road section and information points should contain spatial information
Project	Describe project	Should contain spatial information	Should contain spatial information
Monitoring equipment	Equipment, signal, countdown, vehicle inspection, speed equipment, bayonet, electronic police, switches, virtual LANs, video cameras	Describe equipment related to monitoring equipment	
Business class	Accident,alarm,alarming,raffic flow	Describe accident and road traffic situation	Accident should contain spatial information

three levels: Underlying data layer, spatial feature layer, non-spatial feature layer, as shown in Fig. 2.

- **Underlying data layer:** The underlying data layer is mainly an electronic map, which shows the true geographical landscape. It mainly includes roads, neighborhoods, parking lots, water systems, green areas, hospitals, schools, offices and other geographic elements
- **Spatial feature layer:** Spatial feature layer describes the traffic objects that can be browsed on the map. The traffic objects contain spatial information, such as traffic information points, electronic police, video surveillance, traffic accidents, etc
- **Non-Spatial feature layer:** Non-spatial feature layer contains the necessary traffic management objects but they do not have geo-spatial information. So the spatial location of such objects needs to rely on spatial feature layer. In the practical application and development, we overly three layers to describe the entire traffic scene

DESIGNING AND IMPLEMENTATION OF TRAFFIC GEOGRAPHIC DATABASE OF KUNMING

By analyzing the business processes and requirements traffic management department of Kunming, Kunming city traffic information visualization platform is is aiming at intelligent management and advanced information services, its traffic geographic database's designing and building is following the steps as follows: Conceptual design, logical design and database implementation.

Conceptual design: We divide objects to be described in traffic geographical database into transportation networks, projects, monitoring equipment and business class. The abstracted main entities are shown in Table1, some relations between entities are shown in Fig. 3 (only some entities are taken as examples).

Figure 3 describes the relations between entities of the transportation space in the database. Information points and entries relate with each other through the connection. The relationship is described by N:1, meaning that you can have more than one entries and an information points. An entry contains more than one entry lane. A project may have multiple construction sections. Through M:N, Relations between sections and information show that there may be multiple points of information in a section, while an information point may be in more sections. Different relations are expressed and stored in the database through different data structures. Because relations between project, portals and signal device are too complex, they omitted in the Figure.

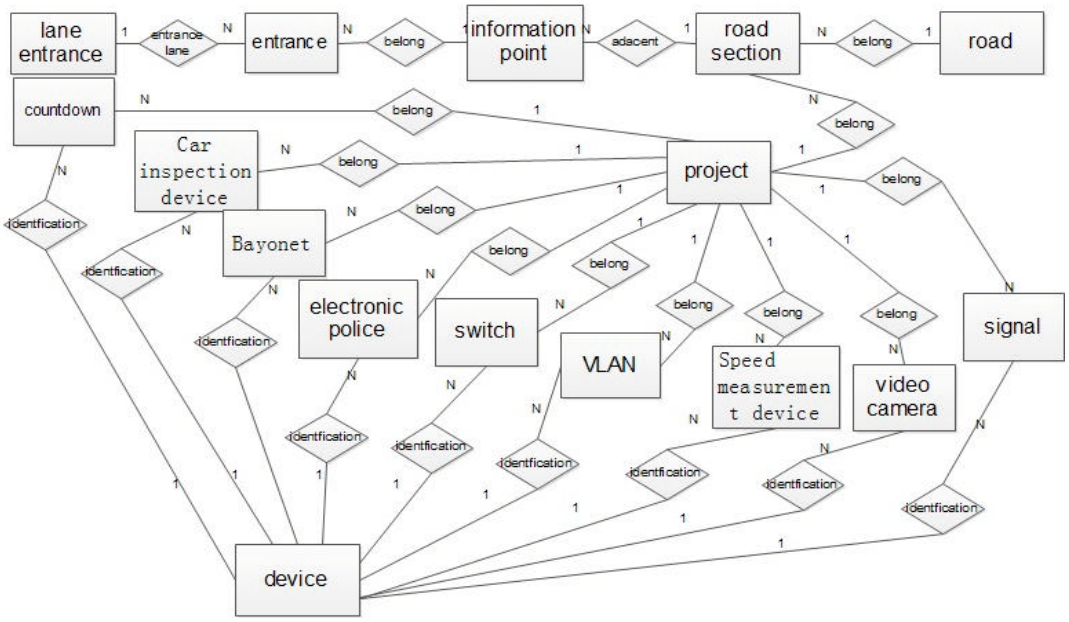

Fig. 3: Part of E-R diagram

Table 2: Video camera (One of feature class)

Name	Data type	IS NULL	Description
ObjectID	Integer	×	ObjectID
Device ID	Integer	×	Device ID
Belong information point	Integer	×	Information point Id
Using	String	√	Y/N
Address coding	String	√	Address ID
Device coding	Integer	√	Device ID
OSD device	Integer	√	Device ID
The OSD device	Integer	√	Device ID
Optical	Integer	√	Device ID
Parameter clean power	Integer	√	Device ID
For chassis	String	√	Y/N
Maintaining organization	Integer	√	Maintaining organization ID
Project belong	Integer	√	Project Id
Video camera	Integer	×	Device ID
VCR channel	Integer	√	VCR channel ID
Decoding	Integer	√	Device ID
DVR recorders	Integer	√	Device ID
Mode	String	√	Simulation, digital, video
Memo	String	√	

Because of too many objects involved, some related objects in traffic accident, such as alarm, alarm handling, alarming people.

Logical design: This article uses GeoDatabase as traffic geographical data model. Geographical database organizes geographical data according to the hierarchical data objects, including Feature Dataset, Feature Class and Object Class.

The dataset of elements are a collection sharing spatial reference system of elements. On the platform, the data set of elements has only one name: Geographic element. In geographic database, all elements in the same geographic element DataSet class must have the same spatial reference, that is, coordinate systems, spatial and precision are the same (Zhang and Ge, 2012).

Feature class is a collection storing elements of the same geometric and properties. Feature class is represented by a Table 2 logically. The Table 3 stores space information except property information of elements. A class of elements contains geometric objects

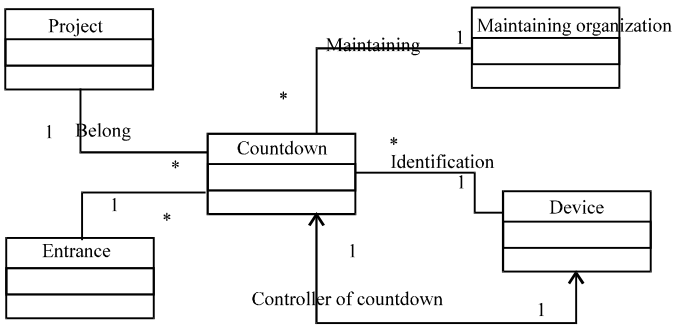

Fig. 4: Struct of countdown

Table 3: Project (one of object class)

Name	Data type	Is NULL	Description
ObjectID	Integer	×	ObjectID
Project Name	String	√	Project Name
Starting date	Date	√	Starting date
Ending date	Date	√	Ending date
funding sources	String	√	
Construction funds	Double	√	Amount (unit: yuan)
Construction of origination	Integer	√	ID of Construction origination
Authorized origination	Integer	√	ID of Authorized origination
Supervision companies	Integer	√	ID of Supervision companies
Design origination	Integer	√	ID of Design origination
Acceptance of the situation	String	√	
The transfer of the situation	String	√	

space similar to a series of geometric properties. In geographical database, all objects with spatial information belong to the element class. The object class is an object that does not contain spatial information, Compared to elements of class. The object class is typically used to store property information of geometric elements.

Relationship classes are mainly used to define the relationship between the storage objects. According to ideas of hierarchical organization of geographic data in Fig. 4-1 and implementation techniques of data's tiered storage in GeoDatabase, we abstract entities in the process of database conceptual design and its relationship realization.

Feature classes in traffic geographic database of Kunming are as the follows:

- **Information point:** Point object, which describes the collection related information of the collection points
- **Video camera:** Point object, which describes the video camera's related information
- **Road section:** Ine object, ase element of road

Object class includes:

- IP address (name: P)
- VLAN (name: LAN)

Relationship class: This class is shown in Fig. 4.

Following are part of object class and feature class in traffic geography database.

Inplementation of database conceptual design: Implementation of spatial database includes the following main steps:

Step 1: Through analysis, creating database modeling by using Professional Visio
Step 2: Based on ESRI ArcCatalog, through the model established in step (1)
Step 3: Data processing and importing
Step 4: The process of spatial database implementation is shown Fig. 5

Typical application of spatial database: This study used ArcGIS Server and. Net as a development platform, combined the Silverlight browser plug-in technology, made the map data and traffic data integrate in a unified platform and achieved visualization of urban road traffic information.

This study displayed the current information using the grading color and heat map on the electronic map, including the monitoring equipment and business data. Through spatial analysis of data, by the heat map and grading color chart, the information is displayed on the electronic map. Figure 6 is the spatial analysis diagram of camera.

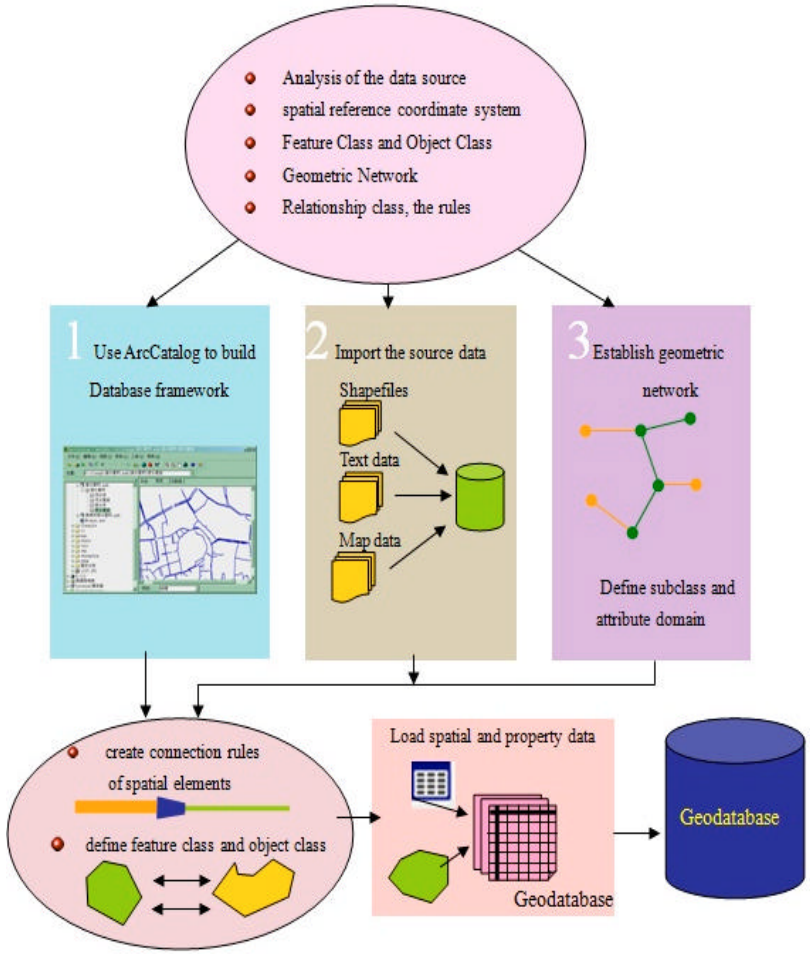

Fig. 5: Process of spatial database implementation

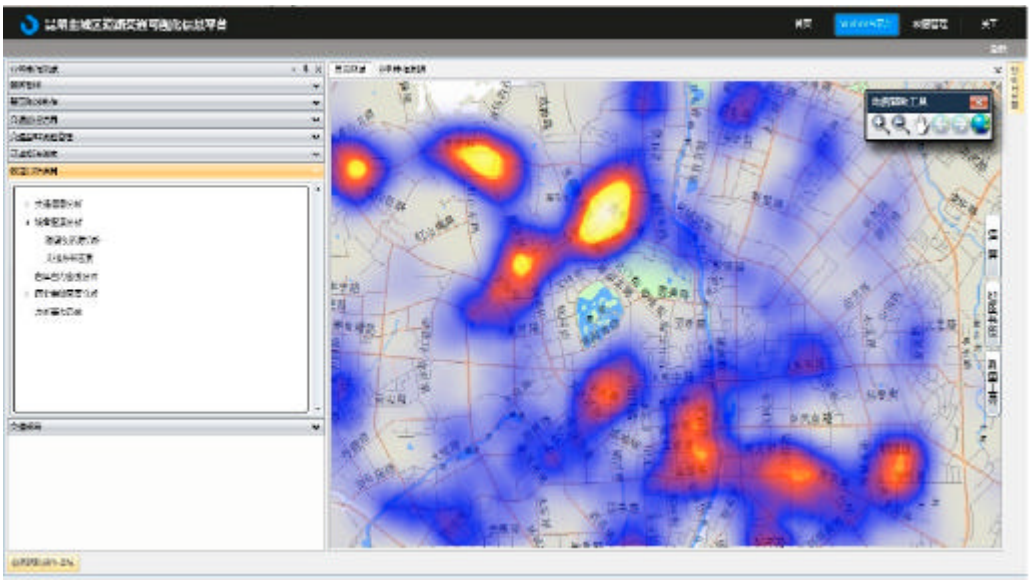

Fig. 6: Spatial analysis diagram of camera

SUMMARY

Based on Geodatabase data model, integrating theory and the object-oriented method, this paper uses ArcSDE to establish a traffic space database, which stores more source data of Kunming traffic preliminary information, traffic facilities and device, road video monitoring, traffic flow detection, traffic road information and traffic accident etc. The database greatly improves storage and management efficiency of space data and uses space database gained for supporting Kunming main city traffic information platform of visualization. The database has strong scalability and engineering practicality and convenient to maintain.

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