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Development of Road Maintenance Management System Based on WebGIS

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***Abstract*—**Based on an analysis of the current research and application of Road maintenance, geographic information system (WebGIS) and ArcGIS Server, the platform overhead construction for Road maintenance development is studied and the key issues are presented, including the organization and design of spatial data on the basis of the geodatabase technology, middleware technology, tiles cache index technology and dynamic segmentation of WebGIS. Road maintenance geographic information platform is put forward through the researching ideas of analysis of the system design. The design and application of WebGIS system are discussed on the basis of a case study of BaNan district of Chongqing highway maintenance management .The feasibility of the theories and methods are validated through the system.

***Keywords*—**WebGIS, Tile, Road maintenance, dynamic segmentation

I. Introduction

IN the existing management of highway maintenance in China, it has been in lack of necessary maintenance, and maintenance information can not be saved due to the numerous competent authorities and different institutions with different jurisdiction. In order to ensure the structural safety of roads and bridges and protracted nature and planning of highway maintenance, the maintenance information and spatial data of roads and bridges should be published in Internet based on WebGIS, users can browse information on the web map, and query and analysis the dimensional information and attributive information conveniently, which will improve greatly on application of GIS in bridge maintenance[1,2].

At present, some results were got about the research and application of GIS on transportation. Literature[3]discussed the mentality of highway GIS construction based on Web/Internet. Literature [4,5] developed T-GIS system based on WebGIS using Java, which solved the problem of dynamic segmentation and conversion between mileage and stake satisfactorily. Literature [6]solved the problem of map buffer perfectly by ArcGIS and ArcGIS Server. Publishment of highway GIS based upon MapXtreme for NT platform was realized in Literature [7]. But the deficiencies of most T-GIS are as follows: Desktop System that is single machine version or client/server mode is difficult and costly to develop and maintain, whose all business logic and the interface of client or server are completed on clients; The upgrade and transplant of the traditional WebGIS system which lack of processing ability on Distributed Geographical Information is inconvenient; The client cannot realize the demand of visual expression, meanwhile, spatial analysis and query result cannot express clearly;

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There is no good solution on data integration among spatial data, attribute data and image data, resulting in data model that does not support dynamic segmentation, data structure and link relation without topological relation, reestablishing topological data structure when search optimal path using dynamic segmentation.

Based on an analysis of the global research and application development of traffic geographic information system, a distributed highway WebGIS architecture is studied on the basis of the WebGIS and ArcGIS Server technology and the key issues for distributed highway WebGIS development are presented. Such issues as highway spatial data organization mechanism, ,and dynamic segmentation of WebGIS are investigated. The distance management of highway maintenance information,web publishment and the frame structure of query analysis are put forward based on the analysis of the design idea of road maintenance system.

II. System Structure

Based on the ArcGIS Server plat, the function of GIS is realized in server terminal, resulting in load balance with multiuser. At the same time, ArcGIS Server is a server manager which is used to manage geographical resources. GIS developers can use ArcGIS Server to construct Web application, Web services and enterprise application in J2EE Web server, also to construct desktop-GIS that communicate with the server by Client/Server model. The system structure use "light client" form and the client terminal can use any browser while data originates the database combines the ArcSDE and SQL Server 2005, which realize true sense of combining spatial data with attribute data. ArcGIS Server architecture can be generalized for client terminal, Web server, GIS server, data resources and desktop resources(see Fig.1).

III. Realization of Key Technologies in the System Designing and Developing

A. Organization of Spatial and Attribute data

Compared with raster data, vector data is convenient for spatial retrieve, integration of attribute information and occupies little memory, also is with high displaying precision, but organization and storage of which are more complex than raster data. This paper victorizes scanning road map of Nanan distract of Chongqing at the scales of 1:5000. First the paper map is scanned into raster graphic by (Microtek) Filescan 1520 scanner; and next is image registration using Xian 1980 Coordinate System to Gauss-Kruger projection, the precise feature points of geodetic coordinate is required in image registration, so in this research the feature points of geodetic coordinate are acquired from GPS surveying, average position

precision of which is centimeter degree, and practical application indicates that the precision of the designed system is satisfying; then the vectorization is performed.

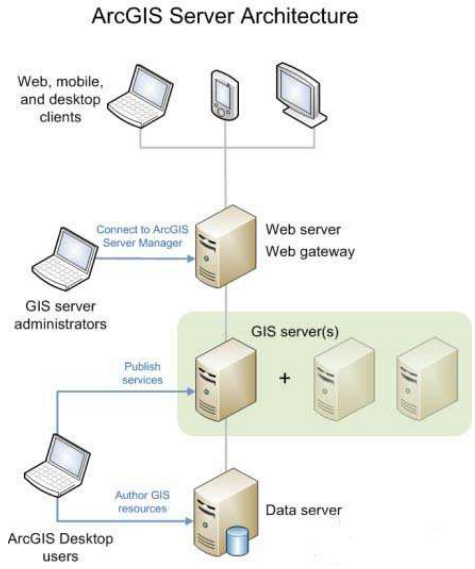


Fig. 1 Architecture of ArcGIS Server system

Classify the spatial data of geographical information platform for highway maintenance into roads, bridges, washout data and base map layers based on the characteristics of the highway maintenance data. Road condition information includes routes information, checked information of road condition and washout management, meanwhile there is management information, checked information and statistical information for the bridges management information, and washout management information includes basic information, statistical information of washout. The base map layers provide the basis geographic information, such as administrative districts, roads, railways, rivers, lakes and so on, resulting in a data integrity, visualize and agility of electronic map for highway maintenance. Attribute data include the attributes of special data, interrelated files, administrative documents and pictures of special data.

B. Middleware Technology

SDE is a middleware technology and in the intermediate state between application programs and relational database management system for storing and managing complex spatial geography data, which carries on spatial relation computation and spatial analyze, meanwhile, solves the problem of interface between relational database and application program. Users can access the spatial geography data transparently, and not have to concerned about data format, storage location and mode, data structure and so on[8]. In this open Client/Server Architecture of ArcSDE(see Fig.3-1) TCP/IP connection is established to receive the data requests from the client applications. Data transferring adopts asynchronous buffer mechanism between server and clients.

Data model of Geodatabase is standard ORDBMS that offers advantages of RDBMS in data management, and geodatabase supports complete topology and different type of data source, what is true geographical database. Spacial data that includes commercial database table, layer tables, feature table and spatial index table is stored and managed in the unit of layer, that is to say, adding shape column to the existing datasheet the spatial data types is added to the relational database. Three-level grid is established on area research based on the spatial index mechanism of ArcSDE.That storing grid information in index table accelerate the speed of operating space target. The version management mechanism of ArcSDE will generate the operations for users in a new version, resulting in a "version tree" shaped by all versions. System checked data consistency before transactions end up submitting of data, which solve the problem of data consistency during multi user editing, and at the same time offer credible guarantee in technique for off-line editing.

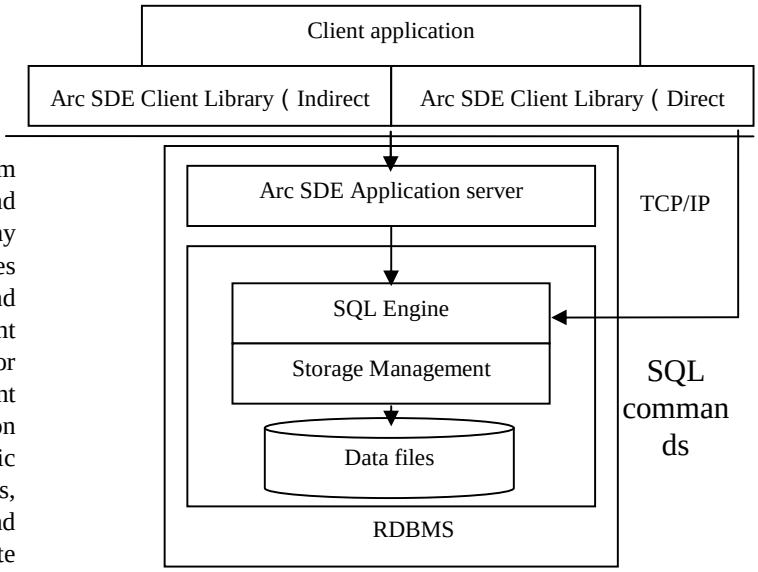


Fig. 2 Structure of Arc SDE system

C. Space Dynamic Segmentation Technique

Dynamic segmentation is process that calculates the location of the events along the path. Path is a linear element with linear measurement systems of the storage geometric features such as roads and rivers. Events are linear referencing data that happen along the path such as the area of pavement breakage, traffic accidents along the highways. Position of linear referencing data is deviation distance or the distance from known points, such as milepost reference that decide mileage point from the mileage starting point along the highway. Dynamic segmentation process link the events with the path, so the event can be displayed and analysis with other geo-referenced data. The built-in measuring system of the path should be set up if we want to use the path and linear referencing data together. Geodatabase data model make path as line elements types, of which geometric values include x, y, m: x and y values decide

the position of the linear elements coordinate system, m values relate with the path of the linear measurement system. Based on the linear measurement system, the events and paths are linked together, in which process it is unnecessary to divided road into sections, and different types of events such as road conditions, traffic accidents can be plotted on one road. Events can be point events or linear events, in order to relate the event to the path, there must be path identification code, location and properties of the event for the point, and path identification code, start and end measure for the line. From the data management perspective: dynamic segmentation can be used to establish the same line feature with different path and can build a database with road transport network to meet the transportation modeling requires, also can provide the division of highway maintenance based on the same highway database. From the data perspective: once the event table link with the path event table has the characteristics of geographical reference and can be used as a feature layer. Layers of display in terms of events is no different with the rivers and other layers, that is to say, point events can be displaced with point symbols, and line events with line symbols. From the perspective of data queries: It can deal with the event table and the related event for the attribute data queries and the spatial data queries. For example, we can query a point event to select the path to the recent overhaul of road sections. Attribute query can be displayed in the event table, also can be displayed in the event layer. It can perform spatial queries on the recent the past overhaul of a range of sections to investigate to make sure the recent overhaul reason and whether it has the same situation in the past. From the data analysis perspective: Path and events can be used as input data for data analysis. For example, the road for damage on analyzing the reasons of the nonhuman, we can put a distance of path into buffer, operate and analysis with the factors in the buffer (such as rainfall, catchment area, etc.). Layers can be analysis like any other point-line layers after the event into a layer. Data analysis can be carried out between the layers in the two events; the relationship can be analyzed between the road damage and volume of traffic in the highway path. It is shown the visualization figure of table for the rate-limiting event in the road network as reference path in Fig.3, and different colors reflect running speed.

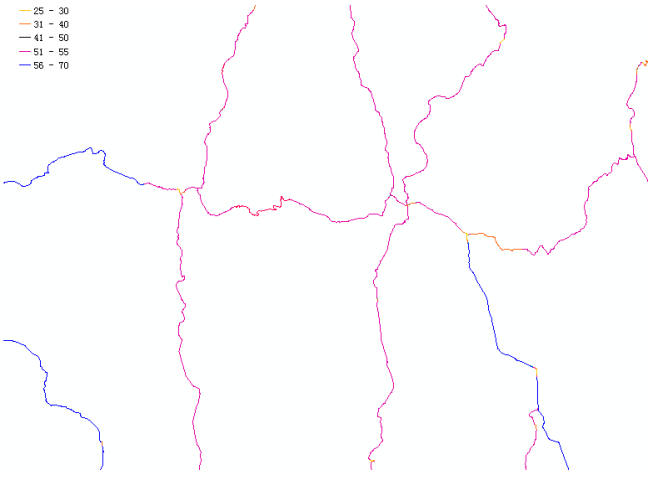


Fig. 3 Speed-limiting diagram of Road network

D.Quick Access Mechanism Based on Quadtree Ttile

At present, most maps controls based on WebGIS application are all used stepless zoom technology. After client sends a request to access that processed by the GIS server, small-capacity map data format (. Pag) will be returned to the client in real-time. Stepless zoom technology can be used in small amount of data and the Web of a single client group. For the maintenance of spatial information publishment, there are ordinary users, also professional who are from different industry,IIS must try to reduce the burden of GIS server considering the multi-user concurrent access to the load balancing problem. Therefore, ArcGIS Server use quadtree tiles indexing.Tile cache are established in GIS server. Based on the demand of users, spatial resolution, and the reasonable requests of map display scale, Png format map tiles of the regulations scale are generated in advance which store in the directory of the Web server's Cache with tile indexing technology, resulting in fast access to spatial data in the client. Quadtree tile indexing technology works on the basis rules of analyzing spatial data sub-block of road maintenance, the tiles of overlap with the query window to meet the resolution requirements can be searched quickly by fast search algorithm for the target tiles, the coarse to fine and layers of strategy to promote. Meanwhile, GIS servers send the tile of meet user needs to the client terminal using highly efficient tile logical address and physical address mapping strategy. Further more, this paper adopts the tile request prediction based on the "high", "medium" and "low" priority in view of the large amount of data space data services. Realizing reasonable data cache by forecasting the tiles request, thus reduce response time and improve throughput rate. Quick access mechanism based on quatree tiles is shown in Fig.4.

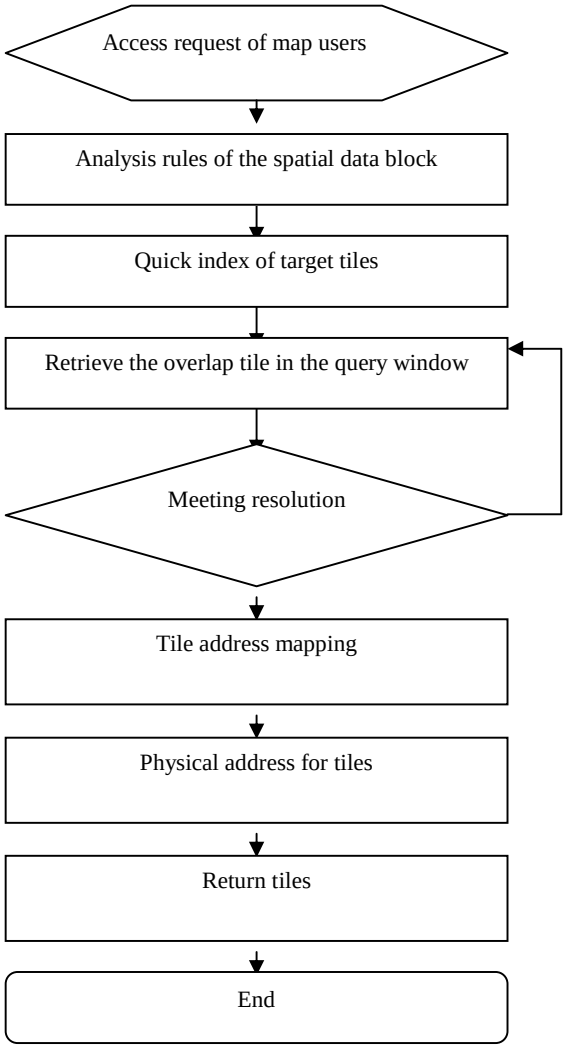


Fig. 4 Quick access mechanism based on Quadtree tiles method

E. System applications

In the integrating environment of visual studio2005. net, the platform of road maintenance WebGIS geographic information is developed. Server operating system platform is Windows xp, Database server is SQLServer2005,Web server is IIS, and GIS server is Arcgis server9.3. This experimental platform has been used in maintenance system for city-highway of Banan District, Chongqing in China. System interface shows in Fig.5 .Fig. 6 show that if you want to query the attributes according to the map, the researched layer should be specified, and you can query the information by point selecting or in rectangle, circular and any polygon drawed by user on the ichnography. Fig. 7 show that if you want to query geometry information according to the attributes. Point selecting or rectangle selecting will be displayed in the Results, the results of attribute inquires are shown in Fig. 8. Clicking the button of thematic map, thematic maps can be generated automatically, and attribute information and geometry information corresponds. According to the actual needs of road maintenance department, it can inquire profile information of sections and the detailed information of the maintenance manager who is in charge of the sections. Related information of roads and bridges can be statistics, and thematic maps are shown in Fig.9.

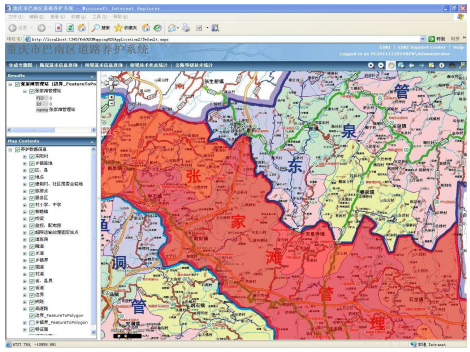


Fig. 5 The system client interface

Fig. 6 Buffer inquires

Fig. 7 The bridge foundation information query

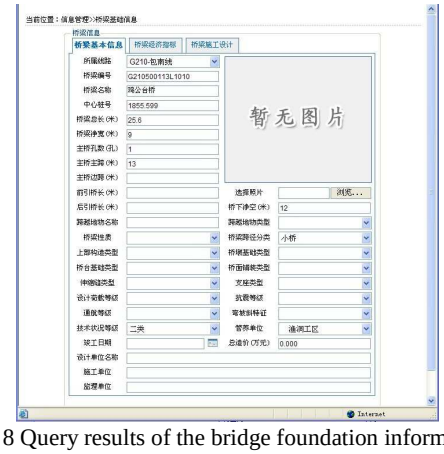
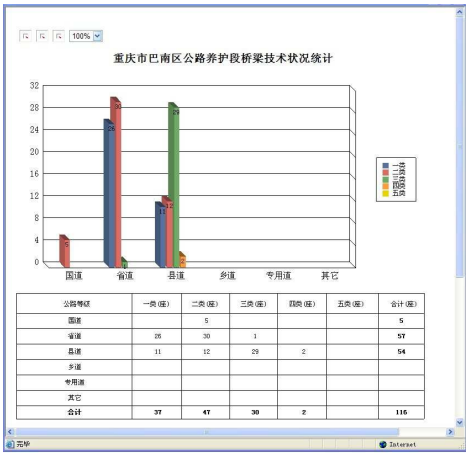


Fig. 8 Query results of the bridge foundation information



公路等级	一类(座)	二类(座)	三类(座)	四类(座)	五类(座)	合计(座)
国道		5				5
省道	26	30	1			57
县道	11	12	29	2		54
乡道						
专用道						
其它						
合计	37	47	30	2		116

Fig. 9 Statistical results of Bridge technology

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