CO-460

THE KEY TECHNOLOGIES ON ELECTRONIC NAVIGATION MAP DELTA UPDATING

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1. BACKGROUNG AND OBJECTIVES

As an important means for Intelligent Transportation Systems (ITS) the data's reality of electronic navigation map affects the accuracy of pedestrian and vehicular navigation directly. Existing methods for updating electronic navigation map mainly depend on updating the entire database through navigation data production. The CD-ROM with the updated navigation map is delivered to the end-users. Updating electronic navigation map by using this method is time-consuming and very expensive. This method can not meet the requirements of the car navigation systems to current situation of map data. Therefore, it is necessary to establish Delta updating. Delta updating updates the changed features in the latest updated navigation map, such as the new roads, as well as the new point of interest. With regard to traditional maps data updating, Delta data updating transfers changed data with the minimum amount of data, and users can get updating service with the best quality requiring the shortest time and less cost. Based on the delta updating of electronic navigation map, this paper will design a data model to support delta updating of the navigation which will ensure that the realization of delta updating.According to the data model, the paper will propose a method that find data changes through the different versions between the comparison . Based on fusion technology of multi-source data , dynamically realize data fusion of the delta updating data with the original data in the vehicle terminal,and achieve delta updating data of end-users .

2. APPROACH AND METHODS

2.1 .The analysis of electronic navigational map data updating method

Based on the existing conditions and user requirements, the current method of electronic navigational map updating includes the following three ways:

(1) Updating method that based on replacement of all the data .

Electronic navigation map production companies obtain the updated data of field operation (mainly the new repaired and changed roads, the new point of interesting), then make the new data with the original data fusion processing by indoor operation , and create a new version of the electronic navigational map data. The new map data will be made into a new production of CD-ROM. After that users will replace the electronic navigational map data through purchasing new data. Users that use card need to rewrite the map data in the specified map service store. This is the most important updating method of electronic navigation map data at present in China.

(2)Updating method that based on personal computer's on-line downloading data.

Users download the new whole map data through personal computers that connected to the Internet. Owing to the fact that the capacity of electronic navigation map data is usually very large (a version of the whole data of China is more than 3G), it is slow download speeds and low efficiency. However, this method is better than the first one.

(3) Updating method that based on wireless network data transmission.

Since most of the existing navigation terminals have no communication function, the terminals dynamically update navigation data to require the help of communication devices (such as mobile phones, etc.) through a wireless network. This method is convenient, fast, and real-time. However, the existing wireless communication data still has a narrow bandwidth, and low speed, which make the amount of data must be very small.

The updating method that based on wireless network data transmission is the best method within the above methods for its convenient, fast, and real-time. It is necessary to establish delta updating because the amount of transmissive data must be very small. It is the key technologies on electronic navigation map delta updating that establish data model to support delta updating navigation map data, find the changes of navigation map data quickly, and dynamically realize user terminals navigation map data updating dynamically.

2.2.The research on data model of supporting delta updating navigation map data

Navigation data is mainly used for Intelligent Transportation Systems to realize the path planning, orientation, navigation and route guidance. ISO (International Organization for Standardization) established the Draft International Standard GDF4.0 (Geographic Data Files – version 4.0) in 2001.The standard specifies the conceptual and logical data model and the exchange format for geographic data bases for Intelligent Transportation Systems (ITS) application. The GDF 4.0 defined all sorts of geographical features in the navigation digital map showing. It uses level classification method. The navigation geographical features are divided into 13 thematic layers. Each layer includes one or more Feature Classes, and Feature Classes shall contain all the Feature instances. Specific in Figure (1) below.

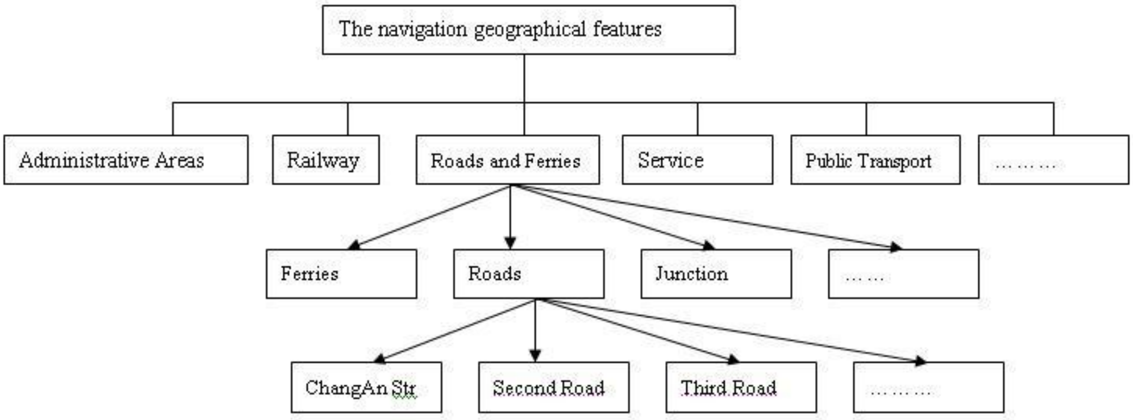

Figure 1 GDF4.0 Data Model of Feature Catalogue

Specific thematic layers have the following 13 layers:

Roads and Ferries ;
Service;
Public Transport ;
Administrative Areas ;
Named Areas;
Land Cover and Use;
Structures;
Railways ;
Waterways;
Road Furniture;
Chainage Referencing ;
General Features;
User-defined Features。

These navigation geographical features are the basis of organizing navigation digital map data, and are the carriers to obtain navigation information. In this paper, the designed navigation data mode is focuses on supporting delta updating.

The main purposes of delta updating are realizing data updating of navigation changing data fast and within real-time, as well as transfering the smallest amount of data to update the user's data. In real life, requirements are large range, detailed text and high precision on the navigation digital map data. This paper designs a physical storage model of multi-scale,multi-parcel,multi-thematic,multi-grade（level—parcel—layer—grade）)to achieve this requirement.

(1) Multi-scale electronic navigation map

It express the spatial entity from different levels.For example, it has 1:4000,000 1:1000,000, 1:250,000, 1:50,000, 1:10,000 and other in the same region because different scale maps data can express space entity in different levels of detail. This multi-scale data can make people from two different angles of global and local to obtain navigation information. The navigation data is massive, but the width of data transmission is limited. If all the data is not selectively transferred to users, it cannot achieve the real-time navigation because of accessing data slow.

(2) Multi-parcel electronic navigation map

It will be divided a range of navigation data into equidistant or not equidistant rectangular area at one scale. To ensure the navigation digital map data provided completely, the navigation digital map data in all areas is managed together by map database. When a user requests a particular area of electronic navigation map data, spatial database engine will find and extract the required data through the spatial index from the database quickly and pass the data to the user. When designing the area size, who consider different scales of data contains the rectangular area between the relations. For instance, a rectangular area in 1: 50,000 must be contained one rectangular area in 1: 250,000. Usually it is divided into rectangular area according to multistage structure of standard map sheet to Multi-parcel. See figure 2.

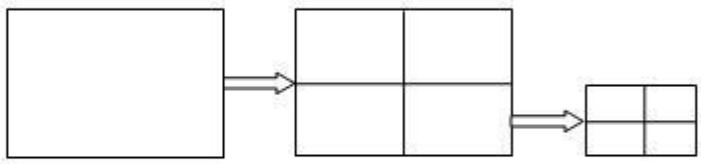

Figure 2 The division of region

(3) Multi-thematic electronic navigation map

The map data is organized according to the thematic layers.Mentioned front, the electronic navigation map usually contains 13 thematic layers. The data of 13 thematic layers are managed separately in the electronic navigation map database. Different layers may carry out the connections through key words.

(4) Multi-grade electronic navigation map

The map data is based on people with a hierarchical spatial cognitive characteristics to provide different detailed electronic navigation map data. This method is particularly suitable regaridng obtaining navigation information for people within a short period of time.

In actual using, we need more comprehensive application of several models designed to support delta updating navigation data model. It is the diagram that supports the delta updating navigation data model .See figure 3.

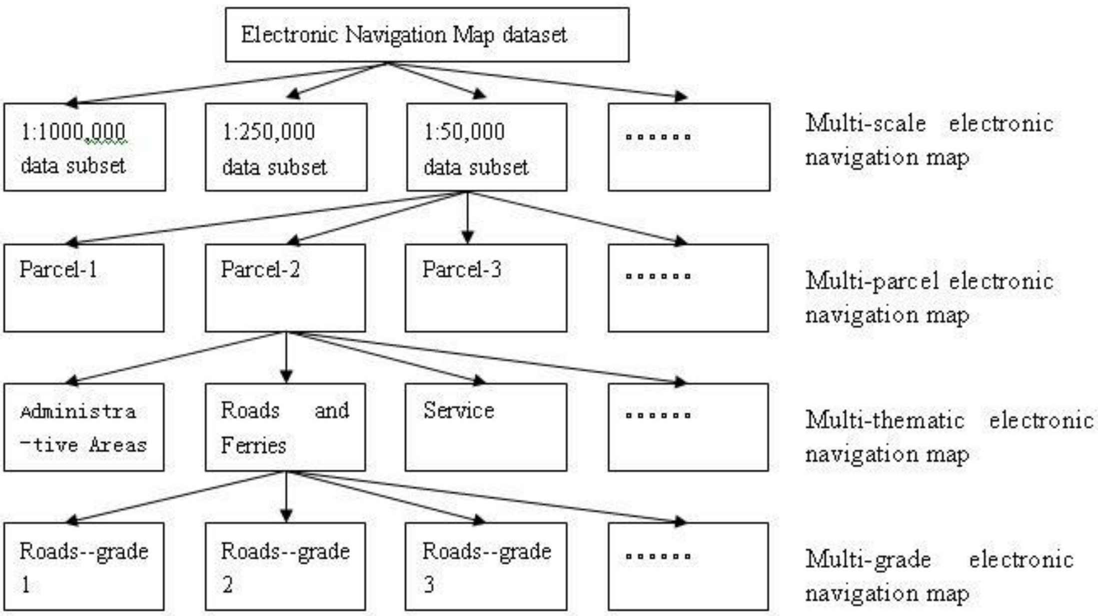

Figure 3 The navigation data model of supporting delta updating

The navigation data model satisfies the data requirements from different users, regarding specified scale with Multi-scale electronic navigation map, realizes data seamless connection with Multi- parcel electronic navigation map. Data of thematic layers in each scale and each parcel are managed separately with Multi-thematic electronic navigation map. Each thematic layer is divided into several grades with Multi-grade electronic navigation map. Therefore, it will minimize the unit of data. When the electronic navigation map data changes, users can get the smallest delta data changed to meet the minimum data transmission by using this model.

In physical storage, each thematic layer in each parcel is accessed according to the geometric data, attribute data, topological data and relational data. Geometric data and attribute data, which are the most basic data, contain all location information, attribute information and temporal information, and imply all the topology information and relationship information of the electronic navigation data. Topological data, relational data and metadata are generated on the basis of basic data through some algorithms. For the same feature in different data, what may build connection through FeatureID which is feature's unique identification number. In order to ensure the realization of the delta updating, FeatureID Number will be permanent data..The road network topological data files are associated with adjacency list. The adjacency list is realized using a chain list, while the chain list is very convenient for the additions and deletions of elements. This is extremely useful on the dynamic adjustment of topological relationships in navigation digital map road network.

In order to realize the path planning and the route guidance in the wide areas, it is necessary to establish the index relational data among the different parcel data . The index relational data describes node labeling information in the space position of the same point between the different parcel. See figure 4 and table 1.

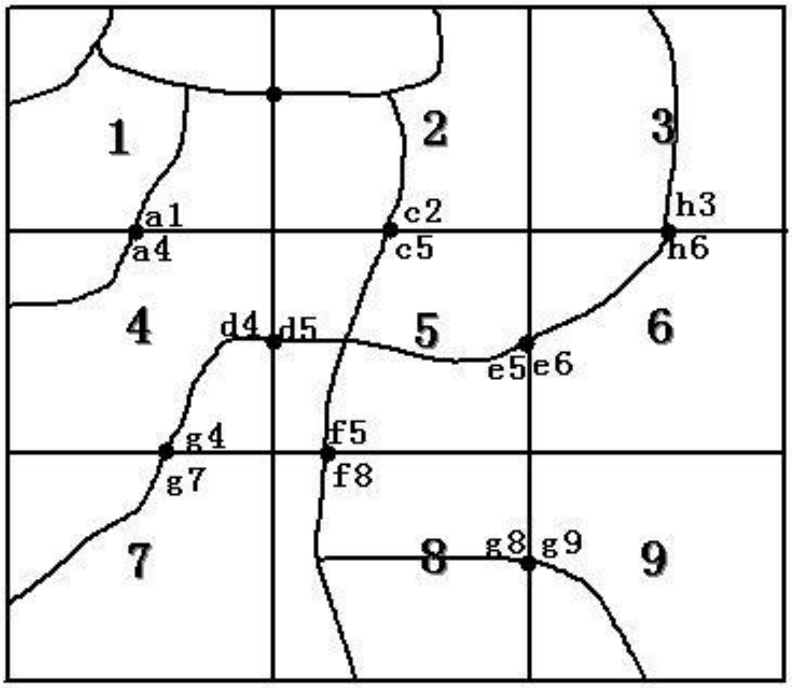

Figure 4 The roads and link nodes in the different parcel

Table 1 The index table about link nodes of different parcels

LinkNode_ID	InParcelID	LinkNode_ID	InParcelID
LinkNode_a1	ParcelID1	LinkNode_a4	ParcelID4
LinkNode_c2	ParcelID2	LinkNode_c5	ParcelID5
LinkNode_d4	ParcelID4	LinkNode_d5	ParcelID5
LinkNode_e5	ParcelID5	LinkNode_e6	ParcelID6
……………	……………	………………	………………

If users need to find map data quickly from the electronic navigation map database, it needs to establish different scale map data index, parcel index and other indexes in map database. These indexes files will be stored separately, and will be updated with the changes in the range of data in real time.

2.3.The research on finding delta changes quickly in electronic navigation map database

Electronic navigation map data usually includes 13 thematic layers data which contain roads and ferries ,service, public transport, administrative areas and etc.Roads and ferries data are used for path planning and route guidance. Service and public transportation data are mainly used for orientation and navigation. Other layer features are mainly used as background show. Therefore, the roads and ferries data are the key data of electronic navigation map. This paper takes the roads and ferries as the example, introduces research of quickly finding delta changes in electronic navigation map database. Known to the navigation data model, the roads and ferries data are composed by geometric data, attribute data, topological data and relational data. Therefore, several data above must be tested when finding changes in electronic navigation map database.The difference detection is based on different versions of electronic navigation map data.

(1) The change detection of additional features and deleted features

In order to achieve delta updating , each feature has a unique identification number FeatureID, and depends on the FeatureID to establish relations in different geometric data file, attribute data file, topological data file and relational data file. Compares FeatureID in attribute data file between different versions. FeatureID can be found in the new version, but can not be found in the old version in which the feature is the additional feature. On the contrary, FeatureID can be found in the old version, but can not be found in the new version in which the feature is the deleted feature.

(2) The change detection of feature's partial coordinates position changed

In the real world, roads often are changed in some region. Additionally, with regard to geometry coordinates of the feature detect changes a road will be split into two or more roads in database because of the addition of the new road.The change of starting point or ending point indicates that the road junction with other road is changed. On the other side, the change of coordinating points number, length and the middle point coordinate of the road demonstrates that some points of the road feature are updated.

(3) The change detection of attribute data

In the electronic navigate map data, each road's attribute is described by many attribute field values.It can get the attribute data's changes by comparing field values for each attribute of the feature that has the same FeatureID between the different versions.

(4) The change detection of topological data

The topological data of road and road's connections is the most important data, usually has node topology and arc topology. A node can be connected with which several arc, and an arc is connected by which of two nodes. Corresponding to the real world, that a crossroad has been connected with which several roads, and a road is connected with which of two crossroads. The topological data changes can be found by comparing the node topology and arc topology data between the two versions.

(5) The change detection of relational data

The road's relational data usually describe the relationship of the road is prohibited. It uses the point, the arc, the labeled symbols of the prohibition to describe their relations . Corresponding to the real world, it will be the prohibitive relations of the road junctions and the road. Can not pass crossroads reach the road with it connected because of the limit such as forbidden left, forbidden right, forbidden straight, forbidden U-turn and etc. The relational data changes can be found by comparing the relational table between the two versions.

In practical application, several data change detection methods mentioned above need to be used multipurpose. Once the change detection of additional features and deleted features is done, the features that have been tested above will no longer be detected in the coordinate change detection and attribute change detection. This method can improve the efficiency of data change detection.

According to detection methods that mentioned previously, features that changed have been detected within different versions. The features to be detected are just the delta data that require to be updated. Delta data, compared to the original data, is only a very small part, and sometimes it is less than 1/1000 of the original data. When a user needs updating data, the database may transmit incremental data packet to user through the wireless network. It can realize the real-time updating because the incremental data amount is small and transmission speed is very fast.

2.4. Dynamically realize data fusion of the new data with the original data

The resource of embedded device is limited, and the capacity of RAM and ROM is very small, so electronic navigation map data is stored in binary files in the vehicle terminals. Electronic navigation map data is composed by geometric data, attribute data, topological data, relational data , metadata and so on in the vehicle terminals. When the vehicle terminals receive incremental data packet from the server,the packet will be unpacked and analysed, and make the unpacked data fusion with the various data mentioned above to produce the updated terminal data. The main steps are as follows.

(1) Confirm the level of the updating data scale

Known from the previous model ,the electronic navigation data is stored in the database by level—parcel—layer—grade model. In the vehicle terminals, users usually need path planning, route guidance and the road display. In addition, the planning data and display data usually require at least two or more of the data levels. Different level of updated data is sometimes in the same packet, sometimes alone packaged. Through unpacking and analysing the packet, we need to determine the level first.

(2) Confirm the parcel of the updating data area

After confirming the level, the parcels of the changed features passing will be confirmed. Changed features, compared with the original features, only a very small part, so the updating parcels are very small part too. The data parcels that influenced by the changed map features contain the data parcels not only passed by the map features, but also the ones adjacent to the above data parcels, and the starting nodes or ending nodes are at the edge of them.

(3) Update geometric data

The changes of map features include additional features, deleted features and modified features. For additional and deleted features can directly add and delete in the geometric data file. Addition and deletion is very convenient in binary files. It can simplify delete first, then add for modified features. It need judge the the coordinate points number of modified feature. If coordinate points number is less than the original number, at first remove the original location, then add. If the coordinate points number is greater than the original, it need to add feature in the reserved space. Or use pointer to point to the new location of the address.

(4) Update attribute data

Attribute data updating is easier than geometric data updating.A feature's number of coordinate points is variable, while number of the attribute's fields and field length are fixed in electronic navigation map data. For addition and deleted features can directly add and delete in the attribute data file. For features of some field valuses changed ,it can directly point to the location of the features'field value by the pointer, first delete the field value, then write the new field value in the original position.

(5) Update topological data

The topological data is the most important data in electronic navigation map data, usually has node topology and arc topology. Topological relationships of Figure 5 is described as follows:

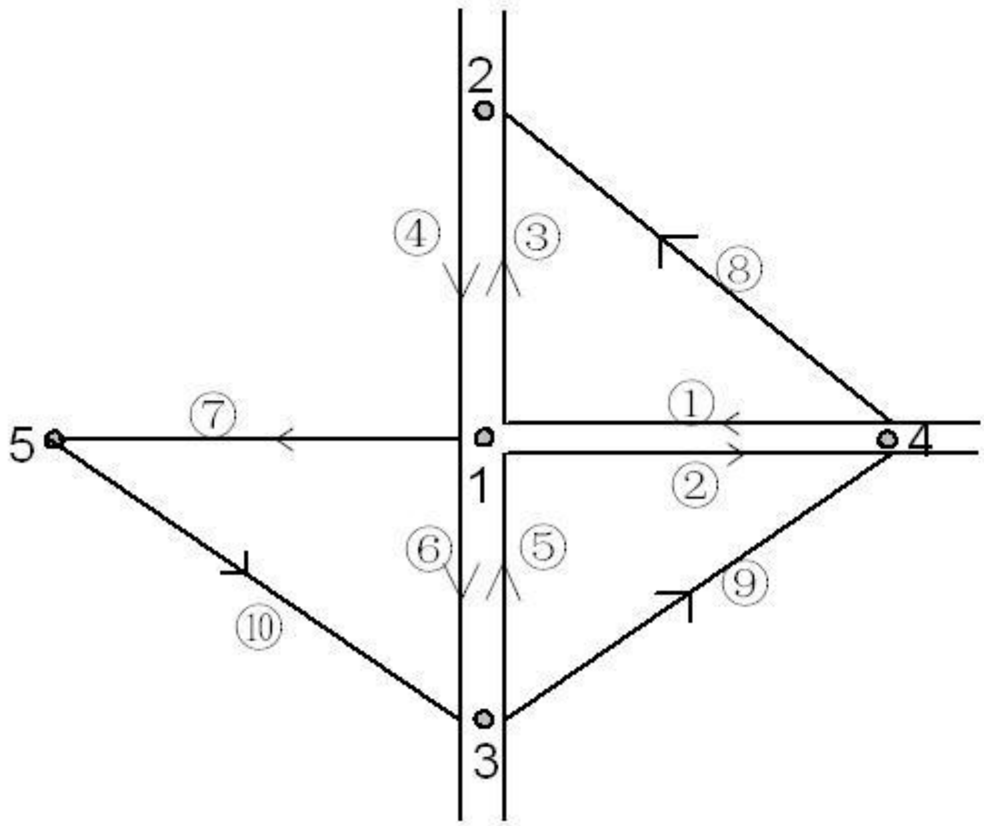

Figure5 The topological relationship of roads and crossroads

Table2 Node topology describes a crossroad connected with which several roads

NodeID	LinkIDNum	LinkID1~LinkIDn	emarks
1	7	①②③④⑤⑥⑦	
2	3	③④⑧	
3	4	⑤⑥⑨⑩	
4	4	①②⑧⑨	
5	2	⑦⑩	
……	……	……	

Table3 Arc topology describes a road connected with which of two crossroads

LikeID	StartID	EndID	emarks
①	4	1	
②	1	4	
③	1	2	
④	2	1	
⑤	3	1	
⑥	1	3	
⑦	1	5	
⑧	4	2	
……	……	……	

Updating topology data, we must consider the relationship with the geometric data and attribute data.

① The additional roads' topology updating

First, we need update the arc topology. We will need to figure out the starting nodes and ending nodes of the additional road through the geometric data file. Then add arc records in arc topology.

Second update the node topology. At the node, the number of connecting arc will increase one, and the arc will be inserted into the node records.

② The deleted roads' topology updating

First update the arc topology. Find the arc records of the deleted roads and directly delete them. When deleting the arc records in arc topology, the starting and ending nodes must be recorded. Therefore, we manage to update the node topology. Second, the recorded nodes will be matched with original nodes in the node topology. At the node, the number of connecting arc will reduce one, and the arc will be deleted in the node records.

③ The modified roads' topology updating

Whether is the starting or the ending nodes of the modified road changed, if the starting and the ending nodes both are not changed, the topological data does not need to be changed. If the two nodes all changed, we need to delete the road topology first, and then add the new road topology. If either the starting node or ending node changed, we need to modify arc topology first, then modify the node topology.

(6) Update relational data

The road's relational data usually describe the relationships of the road is prohibited. The first road can not turn left into the sixth road, not turn right into the third road in figure 5 map. It is described as follow.

Table 4 Roads' relational data

GroupID	inLinkID	OutLinkID	CondTYPE	CRID
1	①	⑥	left	1 (Emergency vehicles can enter)
1	①	③	right	0 (No vehicles can enter)
……	……	……	……	……

GroupID—The number of group nodes.(Group node is a combination of multiple nodes,such as a crossroad is described Group node.)

inLinkID—The number of entering the road.

outLinkID—The number of exiting the road.

CondTYPE —The type of traffic restrictions.

CRID—The type of condition limit.

Relational data updating are usually carried out after attribute data updating.Usually the starting node and ending node are described in the attribute data, such as left-turn and U-turn is prohibited on the end node. Only the field values describing the relationship in attribute data are changed, the relational data needs to be updated, otherwise not to be updated. Parcels that need to be updated will move from the 3th step to the 6th step of operation until all parcels finish updating.

3. RESULTS

3.1. The overall process of the delta updating

The server of electronic navigation map stores and manages the updating data source in map database. When the updating request is sent by the vehicle terminals, the server will generate delta data packet based on user's demand and transmits the delta data packet to the vehicle terminal through the wireless network. When the vehicle terminal receives delta data packet from the server, the packet will be unpacked and analysed. The unpacked data will merge with the local electronic navigation data to produce the updated terminal data. The basic framework of the delta updating service is shown as below. See figure 6.

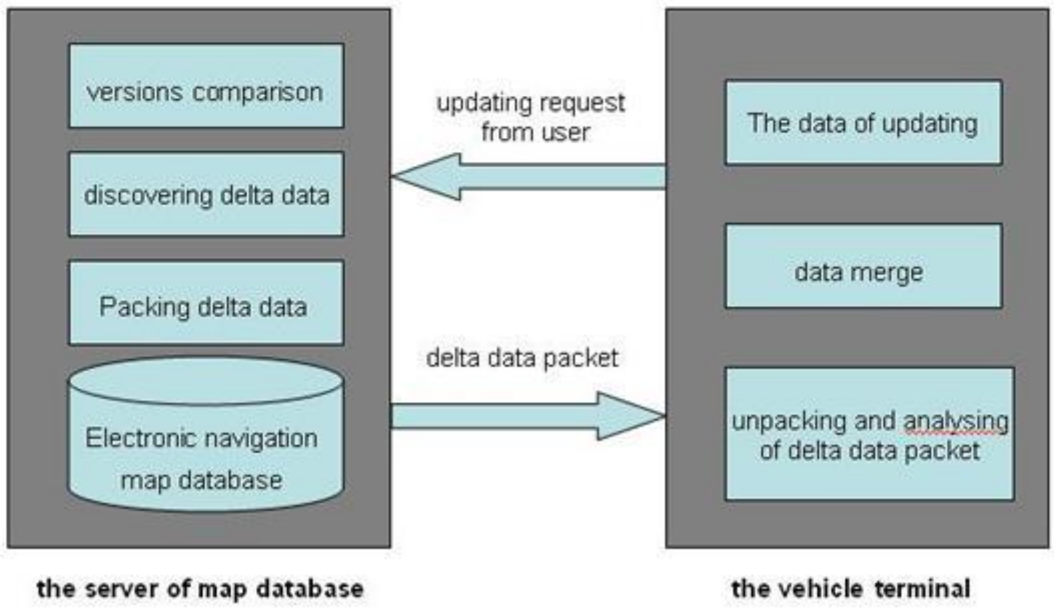

Figure 6 The basic framework of the delta updating service

3.2.Experiment of the delta updating

The database management system is based on Oracle in Server. Spatial data engine uses Oracle Spatial. Independently developed the software of map display, map editing and map updating by vc + + in server. Windows CE embedded operating system is used in vehicle terminals. The software of spatial data engine, map display, map updating, path planning, orientation, navigation and route guidance in the vehicle terminals is developed with C language. 1000 parcels of data were selected to test on the server. The range of Latitude and longitude for each parcel is 45 "* 30". When the updating feature is less than 1‰ of the total (only consider the number of statistical features, not consider the various storage capacity of the features), updating is very fast. The updating time will not exceed 1.5 minutes. The time of updating includes generating incremental update packet time in the server, transmiting packet time through the wireless network, unpacking and analysing time and merging data time in the vehicle terminal. The updating speed is related to the performance of the server, the speed of the network, the performance of vehicle terminal and memory card. With the acceleration of network speed, especially the improvement of the vehicle terminal performance, the updating speed will be further accelerated. When updating features are too much,, data fusion will not be done in the vehicle terminal because the calculation speed of the vehicle terminal is slower than in server. If the network speed allows, the overall data of the parcel changed will be transmitted to replace the vehicle terminal parcel data, thus the updating speed will be faster.

4. CONCLUSION

The experimental result shows that realizing delta updating is completely feasible by using the data model of level—parcel—layer—grade storing electronic navigation map data. Discovering the difference of between different versions of electronic navigation map data in the server is high efficiency and high speed. Realizing delta data fusion and updating in the vehicle terminal will serve as effective compensation for the current slow speed of wireless network transmission . The paper concludes the key technological problem of realizing delta updating which are building data model, discovering data difference and merging incremental data. However, owing to the influence and constriction of the vehicle terminal performance, network environment and other factors, there are still many other problems that need to be solved to realize the real-time delta updating of electronic navigation map.

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