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Research of Embedded GIS Data Management Strategies for Large Capacity

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Abstract

With the use of data for embedded GIS system continues to increase and the requirement of application for embedded GIS system continues to improve, the quad-tree index algorithms and block classification data organization mode that are currently used to handle large amounts of data reflects a certain limitation. Combining the characteristics of embedded GIS data, the authors put forward the multi-level data indexing and dynamic data loading, and realize the data loading when required, and enhance the real-time response speed, solves the limitation on large volume data.

Keywords*: Embedded GIS, Multi-level Data Indexing, Dynamic Data Loading*

1. Introduction

With the development of mobile technology (mobile phones, digital personal assistant), more and more people begin to feel the benefits of embedded GIS technology, and began to use in daily life of embedded GIS. Similar to the desktop GIS, spatial data management is also suitable for the embedded GIS system. It is responsible for how to organize the data in a file or database, how to manage the memory space when a program starts, and how to improve the retrieval efficiency in large amounts of data. But because of the constraint of terminal equipment resources of the embedded GIS, the author also need to consider the appropriate strategies to solve the contradiction between the limited storage and a large amount of data, and satisfy the real-time demand.

2. The Comparison of Characteristics for Common GIS Data and Embedded GIS Data

2.1. Characteristics of Common GIS Data

GIS database is the geographical features set in a certain region, mainly related to the management and organization for the graphics and attribute data. For ordinary database, GIS data has the following characteristics:

(1) the GIS database not only has the attribute data of geographical factor that is similar to common data base, but also has large number of spatial data, and they have inseparable contact.

(2) the geographic system is a complex giant system, which describes the resource and environment with a large amount of data, even if a tiny area, the applications are very broad, such as geographic research, environmental protection, land usage and planning, resource exploitation, ecological environment, municipal management, road construction and others. The characteristics mentioned above decide when establish a GIS database, we should follow and use the general principle and method of the common database, on the other hand, we must take some special techniques and methods to solve spatial data management that does not exist in other data. Because of the obvious spatial characteristics of GIS database, we call it spatial database [1].

2.2. Characteristics of Embedded GIS Data

With the development of embedded technology and GIS technology, the application of embedded GIS, which is the product of the combination of them ,expands with irresistible momentum of rapid development. Embedded GIS data, which not only has the characteristics of

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GIS data of large amount of complex data, but also has the characteristics of itself that the storage space is small and the calculation of retrieval is simple and quick. This leads to 2 major contradictions must be resolved in the development of embedded GIS data:

(1) The contradiction of large quantities of data and small storage space.

The complex space data relative to the traditional relational database data, the data quantity is larger, and the data distribution is more uneven. But in the embedded system, the storage space is very precious, which requires more effective structure and more effective way to make GIS data stored in less space and used in smaller memory.

(2) The contradiction between embedded calculation speed and complex spatial retrieval demand.

GIS query the database is the main reason related to spatial position and not directly attribute data which led to the GIS database is much more complicated than traditional database. But the shorter, faster process requirements in embedded system, and embedded processor itself processing speed, let us must use a mechanism more flexible than desktop operating system to meet the requirements of embedded system. The contradictions above are the characteristics of embedded GIS data [2].

To solve these 2 contradictions, 2 aspects can be considered:

(1) Using the appropriate data compression technology. The storage space of embedded devices is far less than the desktop computer storage space. Although the data can be stored in block or can be downloaded dynamically through the network, but the effective method for efficient compression of GIS data is the most effective and economical method.

(2) The reasonable spatial index and real-time response. The low processing speed and limited memory space of embedded processor, makes it impossible to load large amounts of data into memory for operation at the same time, To achieve real-time response for data operational request, the appropriate method of data index and data organization is needed to adopt to divide the data for reducing the amount of read data at once, and then the amount of calculation to CPU is reduced and the electric power is saved.

3. Analysis of the Data Management Strategy

3.1. Data Management Strategy for Embedded GIS Data

For embedded GIS, due to the limitation of CPU speed, battery power, internal memory capacity, external memory capacity and screen display quantity, we can not completely copy the data management based on PC into embedded GIS. Generally, the method which is combined region quad-tree index storage structure with the spatial data organization of blocking and layering is adopted for the map data. After dividing the map into block, the geographical features in the block are classified on the basis of the importance, and the classifications are organized by complementary non-redundant memory structure, in this way, it is realized that the data reading in the block according to the need of classification. The geographical features in the same classification are stored into layers, and are displayed by layers control. For the embedded GIS platform based on Windows mobile, data storage use CEDB or the combination of EDB with file form [3].

3.2. Data Management Optimization for Embedded GIS Platform

3.2.1. Shortage of Embedded GIS Platform for Data Management

The method which is combined region quad-tree index storage structure with the spatial data organization of blocking and layering solved the contradiction between large capacity data and limited storage space in a certain extent, but with its expanding range of application and increasing demand of business , it also reflects certain limitations [4].

1. Data Index and Organization:

(1) The block and classification method and layers control makes the data sent to memory as little as possible, but data in the layer are still all loaded into memory. Although embedded GIS application related to data modification operations, it rarely involved in the operation for all features in the layer. For layers that had no change or modified very small amount, there is no need to load all data into memory at one time.

(2) The inconvenience of data exchange to large GIS software. Because the data index and organization methods are used in different ways, before exchanged, data must be conversed into the structure of corresponding platform at first, this method hindered the sharing

and exchanging of data between platforms to some extent, also caused the conversion process too cumbersome.

2. *Data Storage:* Using CEDB as the database, we improved the efficiency of information query which is irrespective to spatial data. But CEDB as the database in practical application also reflected some shortcomings:

(1) The CEDB database does not support the PC terminal operating. Usually the attribute data is written into the file, when the program first runs, it reads the attribute data from the file to form database. So when the program is first running, it is usually suspended for the transient process of building database [5]. When the attribute data is too large (more than 5M) or the database table has too many fields (greater than 12), it may lead to failure of contribute database and affect the stable operation of the program.

(2) The fussy data query and modify operation lead to low efficiency.

CEDB database support only inquiry of a single field, the support for SQL is also very simple subset.

3.2.2. Optimization of Embedded GIS Platform for Data Management

The limitations of the embedded GIS platform reflected in terms of data management, especially the operation of the large amount of data in the city pipe network and other needed is particularly obvious. Using the multi-level data indexing, dynamic data loading and SQL Mobile database can solve these problems very well [6]. Optimizing in the data management of the embedded GIS platform is mainly from the following aspects:

1. Using Method of the Multi-level Data Indexing and Dynamic Data Loading to Optimize Data Indexing and Organization Mode:

(1) The multi-level data indexing: The whole map is divided and stored according to the administrative region as the unit, and the index of map is established to switch between administrative regions. For the bigger administrative region, the multi-level index can be established to storage and switch. For the data of single map, the data is organized by layers. Through the maximum and minimum display scale mark is added in each layer head information, the platform realizes the controlling of classification between layers ,and data will be loaded into the memory when displayed in the current scale. Through the method of multi-level data indexing, data organization is maintained consistent with GIS software on the PC for the exchanging and sharing of data with PC.

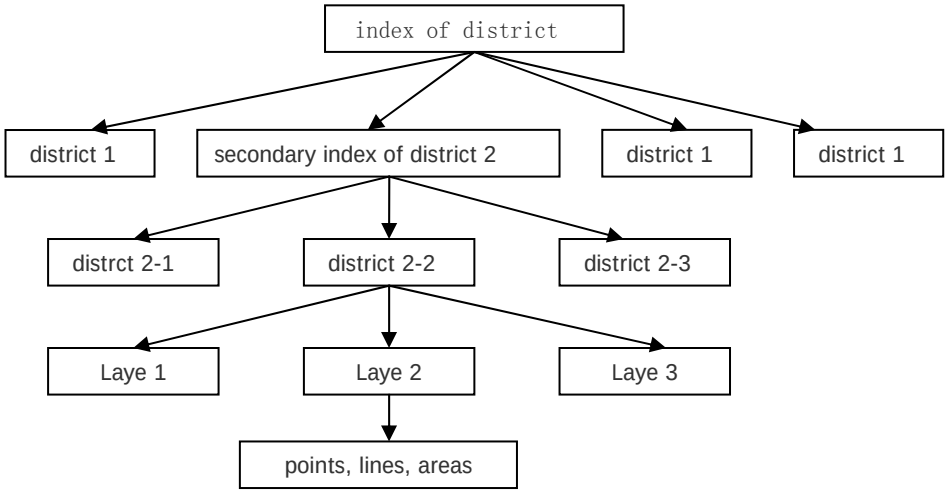

Figure 1. Multi-lever index of map

(2) Dynamic data loading based on layer: the layer processing is used for single map, at the same time, the method of dynamic data load is used in the map loading. During map loading, only the map layer index table is read and stored in memory permanently. Only when queried or modified, the data is read into memory for corresponding operation by seeking index

number of corresponding layer and feature from the map layer index table, and data is released from the memory after the operation. it save more memory space in this way.

2. Data Modification: Due to the data dynamic loading method and layer processing for single map, the data (including the spatial data and attribute data) modification is managed by dynamic index data table establishing.

(1) The modification of attribute data and its structure: By a unique number of the feature (ID), the feature attribute data index values is read from the layer index tables in memory, and then the attribute structure of the feature is read form file as well as data dynamic index table is established. When modification is finished, the index table and its contents are released, and the modified data is saved in the database.

(2) The modification for the spatial data is similar with attribute data, but due to the spatial data is used more frequently than the attribute data. In order to ensure the real-time response, the MapGIS-EMS platform is optimized. Through the optimization of operation, not only the ability and efficiency for MapGIS-EMS platform data management was increased, but also the process of data exchange was simplified. Before optimization, the data between embedded equipments or embedded equipment with PC are exchanged through switching platform in the form of file. After optimization, although data between the embedded device and PC are exchanged still in the form of file, but embedded devices can exchange data directly. By Using the multi-level data indexing, dynamic data loading and store the attribute data through the SQLMobile for map data, the efficiency comparison before optimization and after optimization is showed in table 1, 1:5 million map of Wuhan City (after conversion is 2.2M, 13 layers, 8747 features) is used:

Table 1. Comparative Efficiency Before and After Optimization

Test methods	Before optimization	After optimization
The SQLmobile is adopted to replace the original CEDB as the attribute database	A single database cannot be greater than 5M, the database table fields cannot more than 12	A single data table cannot be greater than 512M, the database cannot be greater than 4G, unlimited number of fields
The SQLmobile database and the same display menthod are adopted to first run the program to draw 1:1 map in real-time when the all layers on	35~38 seconds	18~20 seconds
SQLmobile database is adopte to query in the map with the condition that Highway grade is arterial road and name is luoshilu	1~2 seconds, and not good at surpporting the complex contition querying	Less than 1 second, and good at surpporting the complex contition querying
SQLmobile database is adopte to add the new field of manager and to insert default value in the new field in the communal facilities layer(1145 points)	About 2 seconds	Less than 1 second

4. Summary

Due to the characteristics of embedded GIS data itself, resulting in the particularity of its data management, and there are some limitations on the data management of embedded GIS platform used at present, this paper presents the use of data classification indexing, data dynamic loading as well as the SQLmobile database to optimize the embedded GIS data management module, the data access efficiency and support on large volume data can be significantly improved.

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