Integration and Application of Fundamental Geographical Information Framework for Digital City

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Abstract: The importance of Fundamental Geographical Information Framework for Digital City (FGFDC) is analysed, it provides all city agencies and units with uniform geographic references. Six kind of data are chosen as the core data sets of a FGDC, a web-based distributed mechanism is constructed to promote data sharing among different agencies. Elementary functional requirements of FGDC are analyzed, so that it can serve as a common distributed urban GIS. A practical FGFDC is developed for Yangzhou Development Administrative Region, and an 3D visualization system is developed within this framework.

Keywords: Fundamental Urban Geographic Information Framework, GIS, Digital City

1. Introduction

Urban GIS has been a wide and active application area of GIS, it has now come to a new significant point. Different agencies have been the main users of urban GIS, they used GIS as a tool to automate their daily works, such as land use administration, cadastral management, city planning, real estate management, traffic management. All these applications were established independently and serve in specific areas, the data were collected by different units and stored in different formats, different methods were used to analyze the data sets, and even the outlook of the systems differs greatly. Although these systems have boosted the applications of Urban GIS, the once reasonable style of GIS applications has confronted with new challenges of data sharing and interoperability, or to build applications within a common digital city. Fundamental geographic information framework is the key component embedded in a digital city, its data composition and techniques need to be studied

2. Fundamental Urban Geographic Information

City life has been a the most complex among society. Large volumes of information are generated all the time, most of them are spatial ones. These tremendous information can be classified into two categories according to their usage, one is called the data set of common use, the other is called the data sets of specific use. The previous one can also be called the fundamental data set because they can be used in many areas. For example, topographic maps can serve in many applications. The second one is those that can find usage in specific areas, for example cadastral information is only used and maintained in national Land Bureaus. For the fundamental geographic information, it's better that data collection, data organization, data storage, data management, data updating be done independently from all agencies, so that all applications can refer to a uniform geographic frame.

However, the actual situation is now much different. Most agencies related to GIS have built their application systems starting from data collection. The fundamental geographic information has been collected again and again. Not to mention the unnecessary great expenses, many frustrations have been occurring all the time. Since data are collected by different agencies, at different time, with different system, for different usage. There are many differences and sometime even serious contradictions. Data sharing is much difficult among these applications, and sometime people don't know what the real situation is because of the data contradiction.

For the specific data, it should be collected and maintained by the particular agency. With the fast extending of data sharing, some of the specific data should also be shared, and security-checking should be done to guarantee the interests of data owners

3. Structure of Fundamental Urban GIS Framework

In the age of internet, the fundamental urban GIS framework should be distributed networks that link together different data providers, data users and the public, so that data can flow in time to where it's needed

Figure 1 is a demonstration of the structure.

1) The Information Servers

There is one main server and a number of sub-servers, they are connected via wide area networks. The main server is used to store and serve the fundamental geographic information, while the sub-servers store and serve specific information.

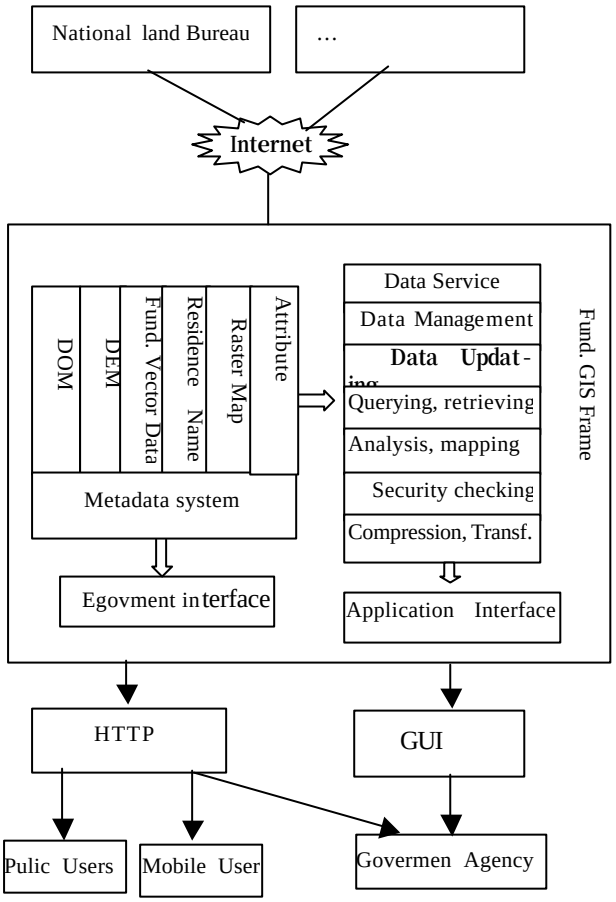

Fig. 1. Structure of FGFDC.

Each sub-server represent an agency, data specific to its application are stored in it, metadata bases and systems are equipped to manage the data, data service software is implemented to provide users with data.

2) Data Composition of FGFDC

Through investigating the status and requirements of main city agencies, and by referring to related national standard, we suggest the following type of data as the main components of fundamental urban geographic information framework:

(a) DOM. Digital orthogonal image data is the first level product of airborne or satellite photogrammetry. It can be used to directly represent the real spatial distribution of city features, such as infrastructures, buildings, parks. It's welcomed by all city units because a good image bears rich information.

(b) DEM. Digital elevation model data or digital topographic data is a key mean to describe the topography. All spatial related information systems need to refer to the topographic maps. All city features should be positioned onto the topography so that their real locations and spatial correlations can be displayed.

(c) Vector data of fundamental city features. according to national standards, in large scale city maps, fundamental features consists of the uniform geographic coordinate system, transportation route, water system, administration boundary, residence, name annotation, surface covering. All these data are stored into different layers, and they can be extracted or combined for particular applications.

(d) Digital raster maps. In the long history of city planning and management, a large number of maps have been accumulated, they represent the city of different times. They are invaluable properties. However, as they are in hardcopy format, it's inconvenient for long time storage and usage. To solve this problem, all maps can be scanned into raster data and stored in historical archives.

(e) Residence names. Residence names are very important data, and they should be stored in the data center for all users.

(f) Attribute data. All the above spatial data will be accompanied by their attribute data.

(g) Metadata. The metadata of the above data should also be collected and stored in metadata databases, a metadata system should also be developed to manage them. It is used to retrieve quickly the databases to locate the data needed

3) Elementary Functionalities

FGFDC is a GIS for data sharing across the whole city, it's run within the wide area network environment. The elementary functionalities include the following:

(a) Data Service. It is able to provide data service to data users across the whole city. Any valid user can request data from FGFDC. The request is submitted in standard form and will be processed by servers to extract the exact data, finally data will be transferred to the data user

(b) Data management. Since the data are distributed in multi-servers, they should be managed in a consistent way so that data flow can be done correctly and efficiently.

(c) Data updating. The value of the data lies on their currency, or the data should be updated timely. As the data are managed by different agencies, a reasonable updating methodology should be established so that new data can enter the database on time, and the database can remain consistence after updating.

(d) Querying and retrieving. Querying and retrieving are used to find the data sets needed, they can be started in text or spatial format. Retrieving is used to locate databases, it's accomplished by processing the metadata databases. Querying is used to extract data subsets from databases, it's usually accomplished by spatial data computations.

(e) Spatial analysis. Spatial analysis is used to analyze the complex interrelationships among multiple geographic features. Typical spatial analysis includes buffer analysis, network analysis, neighborhood analysis, spatial measurements, and model analysis.

(f) Thematic Mapping. Thematic mapping is used to produce thematic maps from the databases. It should be able to extract the necessary data from databases, ar-

range them in a common display, and represent them in different symbols, line types and fillings.

(g) Security checking. The data has some degree of secrecy, only those who are permitted can access the data. The data is distributed across the wide area network, it should be able to get rid of unfriendly attacks. Multi-layered security check should be implemented.

(h) Data compression and transfer. The volume of data is very large and the data flow of FGFDC is very often, in order to raise the efficiency, high efficient data compression techniques should be utilized.

(i)Application interface. A standard application interface should be developed for all applications to utilize the data and analysis resources of FGFDC. All application systems can be designed and developed with the help of this interface. Through this interface, the application system can get the necessary data without knowing the exact structure of databases, the analysis can be done in the server and the result is transferred to the application.

4) User Group

The user group consists of government agencies, enterprises, private sectors, universities, and the public. They can be fixed users or mobile users. The interface to users can be of HTTP or GUI, public users use HTTP, whereas government users can use both of them.

4. An Example

Supported by state key 863 project "3S application demonstration in key areas—small and medium cities", we have designed a prototype FGFDC in Yangzhou. The framework is composed of one main server and three sub-servers for national land bureau, bureau of city planning, bureau of real estates. The total volume of the data is about 20G, they are organized in respective databases, metadata are collected and stored into metadata databases. Oracle 9i is used as the supporting database system, a national GIS software is selected as tools for handling the spatial data. Functionalities are developed. Figure 2 shows its abilities of data service.

An 3D visualization system is developed on the basis of the prototype FGFDC, this proves that the concept of FGFDC is reasonable and practical, it can be of great help in building future type application systems

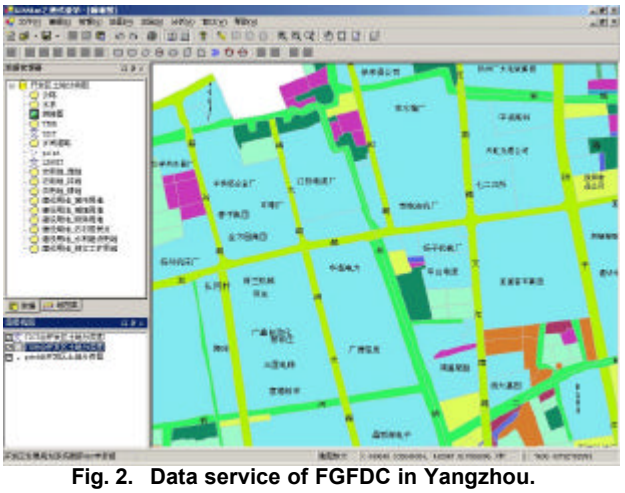

Fig. 2. Data service of FGFDC in Yangzhou.

5. Conclusions

Uban GIS applications have come to a new stage of wide spatial data sharing, the fundamental urban geographic information framework can be used to provide uniform spatial reference for all spatial application systems across the whole city. Within the FGFDC, six kind of spatial data of common interest are organized in the main data server, the data for particular usage can be stored in sub-servers. All data servers are linked via wide area networks to form a distributed mechanism for data sharing, elementary data service and analysis abilities are implemented in the servers, so as to provide frame data service to all urban applications. The construction of Yangzhou fundamental geographic information framework and the application system demonstrate that the concept of FGFDC is successful

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