Development of information management system of dams in China based on WebGIS

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Abstract: The development of information management system of dams based on WebGIS is discussed, analyzing thoroughly the characteristic and the structure of spatial and attribute data of dams over 30 meters. The modern information techniques of network, database and GIS are applied in this system. The attribute data of 4681 dams over 30 meters are provided by Chinese National Committee on Large Dams. The spatial data are registered based on 1:1,000,000 fundamental geographic information. The code of large dam data, construction of database and design of map layers are finished. Then the WebGIS system of spatial dam information query and share service is structured. The informatization level of dam information management and share service ability of dam information are increased greatly in China.

Key words: WebGIS; dam; information management system; spatial data; information sharing

1. Introduction

According to statistics by Chinese National Committee on Large Dams, the number of dams had reached 84083 by the end of 1999, which ranked the first in the world. Currently, the dams over 30 meters in China have already attained more than 4680, and the high dams over 100 meters have already above one hundred. For a long period of time, building dam and making use of reservoir to regulate natural amount of water are the demand that the mankind prevent flood and drought disaster and develop water resources with reasonable. And the large dams are very important for agricultural irrigation, urban water supply, flood control, hydropower development and improvement shipping etc. Specially in China, because of inadequate amount of water resources, and very uneven distribution of space-time and region, the demand of water shortage region and season can't be satisfied, depending on nature inflow 2,812,400 million m^3/a. If flooding can't be controlled, it is also impossible to guarantee the normal operation of social activities and the progress of society [1]. So, Chinese has considered water conservancy from of old, such as control and regulation of water resources. One of the effective ways which solve water resources inconsistency between supply and demand is to build reservoir and construct dam enough.

Since the founding of new China, dam construction had achieved great development at much aspect, such as quantity, quality and technique etc. The dam also achieves tremendous benefits on flood control, irrigate, water supply, electricity generate, shipping, aquaculture and tour etc. But in the meantime, because of natural deficiency of design and construction and posteriori maladjustment of management and maintenance, a large number of aging dam caused serious consequences for engineering performance and safety [2]. Currently, the disease and dangerous dams of all are much in China. They distribute widely, threat large scope, and the accident of broken dams is more. So the compensation needs large-scale investment, and the reinforce mission is very huge [3].

Because of these above reasons, we need to develop information management system of dams urgently, in order to make the disease dam reinforced in time, remove the insecurity factors, develop function well, and raise the management level. WebGIS based on the network technique provides new way to distribute, share, query and analysis for geographic spatial data, and have the application foreground widely. Therefore, the information management system of Chinese dams is structured based on the network and WebGIS technique, making use of network resources well, sharing the dam information on the internet. It can provide information query, statistics and sharing service in the maximum scope.

2. Overall structure of system

2.1 Software environment

The ArcIMS is the WebGIS software based on JAVA technique, developed by Environment System Research Institute (ESRI), Inc of America. The ArcIMS components are composed of a few independent function units such as Author, Designer, Administrator and Manager etc [4]. It can make map service, develop the web page which communication with map service easily, and carry on web site management, so the client can use vector or raster map expediently, and fulfill graphical operation, query, display, statistical analysis and spatial analysis. The ArcMIS can distribute or share various data on the internet, and it adopts distributed component and three-layer architecture, so the operation efficiency of system is high, and the function of upgrade is strong. Therefore, The ArcIMS software is selected to organize data, manage data, query information, analyze information and distribute result etc.

The software environment of the system design and development is following:

Operate System: UNIX/Solaris;

GIS Software: ArcGIS Desktop 8.0, ArcIMS 4.0;

Web Server: Apache, Jakarta-Tomcat and Java 2 SDK Standard Edition;

Database: Microsoft SQL Server 2000.

2.2 System structure

The system provides the WebGIS service by the ArcIMS, and uses SQL Server as the database to provide data service. The system structure is shown as figure 1. Apache and Tomcat are used as Web server, which organize spatial dam data. The ArcIMS can create the Web Service which customer could browse, and distribute graphical information by Web Server. In the client side, users send request and receive response connecting with Web Server by HTTP, then they can browse and look the graphical interface and the non-graphical data in the Web Browser. The server connects with client through the Internet, and the information management system of dams in China based on ArcIMS browser/server (B/S) has been constructed.

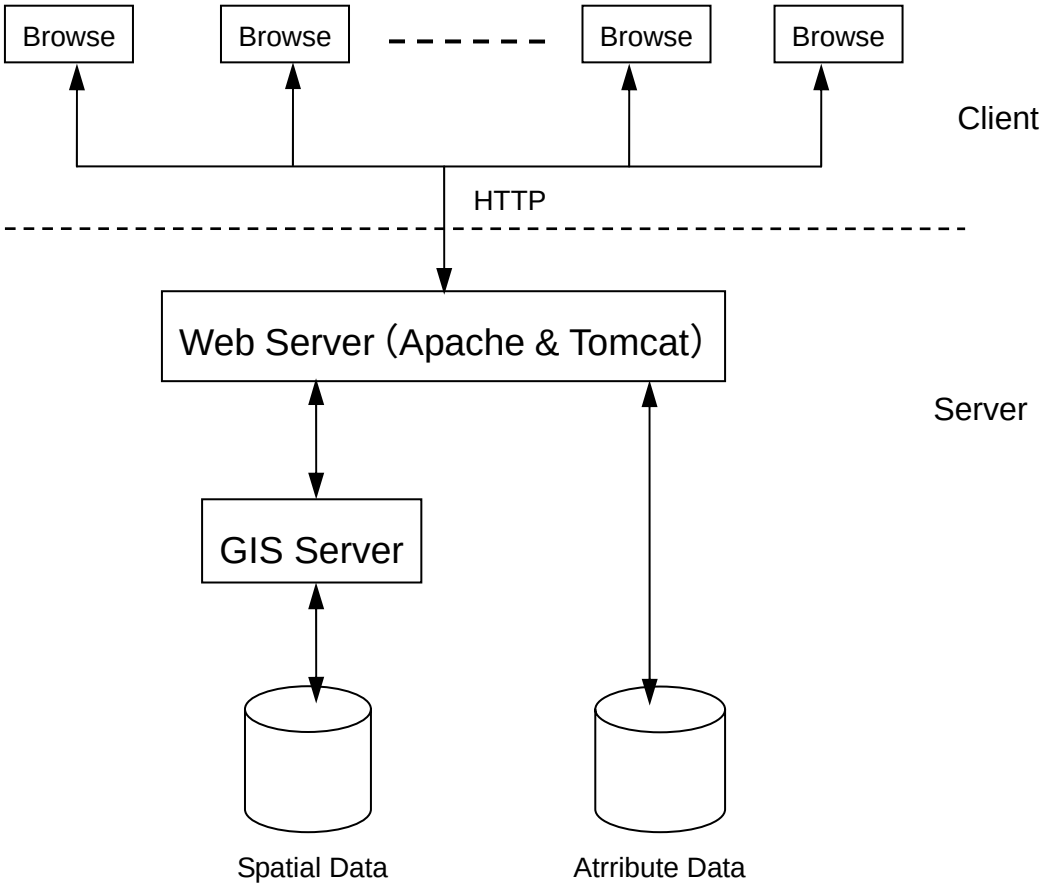

Figure 1 Chinese dam information management system construction

2.3 System platform design

The system platform is designed and developed by the ArcIMS and JAVA technique, following the principle of B/S structure and the request of thin clients, and using the best maintenance mode of “zero maintenance” in clients. Because the system based java program which is independent on whatever platforms is no limit on the platform, it can easily be transplanted to other platforms, and can suit majority of computers and operating system. Figure 2 shows the main interface of the system.

Figure 2 The main interface of Chinese dam information management system

2.4 Customizing client viewers

The ArcIMS provides two major client viewers: Java Viewer and HTML Viewer. Java Viewer provides map services and information queries by Java Applets, and can support several map services at the same time. HTML Viewer can be used to acquire image and tabular data. We can fulfill the interaction between graph and attribute, and we can provide map service which is dynamic, concentrated and interactive by embedding in any web sites for users by HTML Viewer.

Java Viewer is regarded as a “thicker” client viewer. Almost all map interaction and processing operations are done on client side and not on server. Server sends Java Applets to client viewers, and then users can fulfill interaction with server through Applets. HTML Viewer is typical “thin” client viewer. Request is created and response is parsed on the client side, and all operation must be processed on server side. So, HTML Viewer is used in this paper.

3. System database design

3.1 Data analysis

The data resources in this research are attribute dam data which altitude is over 30 meters and spatial data which scale is 1:1,000,000. The normal secant conic conformal projection is used in spatial data. The projection uses 25°N and 47°N as two standard parallel, and 105°E as central meridian. Presently, statistic dams of China have reached 4681, and all of them have own attribute database. In 4681 dams, 2584 dams have been registered, and other dams will be fulfilled spatial registration gradually with implementing of project.

3.2 Space database

Space database comprises fundamental geographic information of China and spatial dam data over 30 meters.

The fundamental geographic information adopt the data of 1:1,000,000 scales offered by the National Geomatics Center of China, including national boundaries, coastline, provincial boundaries,

municipality boundaries, county boundaries, special administrative region boundaries, province government position, city government position, perennial river, season river, trench, lake, reservoir and so on.

Spatial dam data are registered under the software platform of ArcGIS 8.0 based on 1:1000000 terrain maps, and inputted by digital tablet. After finishing collection of data, they will be edited and processed by ArcGIS software. According to height, dams are divided into four layers: 30 meters, 50 meters, 100 meters and 150 meters, in order to achieve layer displaying in system development. And spatial data format are converted into ESRI shapefiles.

3.3 Attribute database

The attribute data are managed by SQL Server database. The attribute database contains many tables, such as the basic information table of dams, the hydrology character table of dams, the dam body character table of dams, the sluice building character of dams and the benefit character of dams etc. Each table is connected by only dam code. Also, spatial data is linked with attribute data by dam code. Dam data in the system are provided by Chinese National Committee on Large Dams.

4 Principal functions of system

Based on GIS, network and database technique, centered on spatial information and attribute information, dam information are effectively managed and synthetically analyzed in the system. Using powerful information processing functions of GIS, the system can make the result of query and analysis shown out in many kinds of map, text, chart and multimedia etc. Thus the system is visual, intuitionistic and vivid.

4.1 Map releasing

ArcXML is map releasing language based on XML in ArcIMS, and the standard communicating language between client side and server side. When the client side sends a request to the map service running in the ArcIMS spatial server, the requested information is described with ArcXML. In the ArcIMS, ArcXML is used to release the vector or raster data on the web, such as, data definition, graphic attribute, character display, sending and receiving data, etc.

4.2 Basic function

The dam information management system has all basic operation functions of GIS, such as zoom in, zoom out, pan, full extent, selecting, measuring etc, and all these functions can come true on client side directly. If data which are needed have been sent to client cache, these data can be displayed depending on browse request on the client. If data have not been transferred to the clients, or not been transferred to the clients entirely. For example, the map is moved to the new extent, but some data in the certain extent are not transferred. Then the client send new request to server in order to fulfill this operation.

4.3 Query function

Query is one of the main functions. User can acquire dam information by using different query manner, such as positional query, spatial query and conditional query. And, the particular dam information can be displayed by table, text, image, cartoon and so on, realizing integration of image, text and table.

Positional query is from “image” to “attribute”, namely acquiring the attribute information of dam by using the mouse to click the queried object on electronic map window. The following figure shows the result of query.

Figure 3 Query result of dam attribute information

Spatial query is from “attribute” to “image”, namely locating spatial position of dam by the attribute of it. And the selected feature is highlighted on the map.

Conditional query is also known as SQL, user can acquire dam data according with the condition by selecting name, province, basin, water system, or dam height etc. Figure 4 shows the result interface of conditional query. In the following figure, the particular information can be browsed by clicking the name of dam.

Figure 4 The result interface of conditional query

4.4 Statistic function

The system provides the function of dam statistic. For example, the number of dams in province, the number of dams in basin, and the primary economic indicators of large reservoir, reservoir storage over billion m^3, dam height upward 100 meters and medium reservoir etc. Figure 5 shows the primary economic indicators of dams established and establishing.

Figure 5 The primary economic indicators of dams established and establishing

5 Conclusions

The networked distribution management system of spatial and attribute information of dams in China has been built based on database and WebGIS technique. The system provides dam information sharing for science research, engineering management, and social public. With the application of the system, the level of information sharing and informatization management will be impelled powerfully. And using efficiency of dam resource will be advanced. The new information island will be avoided. So the system is available in application. With updating of dam information, and changing of requirement, the system will be perfected and be developed more function like spatial data analysis, integration research. And the decision-making ability of the system will be enhanced.

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