The Design of Water Supply Network Based on GIS

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***Abstract*—Water supply pipeline network is a system which has a large of spatial attribute data. In order to improve the manage and work efficiency, reducing the workload of workers, the best way is that designing a water supply network based on GIS, the system based on Arc GIS platform, using Client-Server and Browser-Server model to form a new composite model to set up the system. The paper introduces every function and the key technology of this system in detail, such as seamless integration of GIS of water supply pipeline network and hydraulic model which based on building pipeline network concise model dynamic and use the hydraulic calculation function to guarantee the authenticity of hydraulic model, hydraulic model which can help to simulate the whole system and analyze the condition of pipeline network, the model of pipe blowout statistical can help operator to know the condition of water pipe every segment in the system and forecast the events of pipe blowout, and according to the requirements of system, the fast locating algorithm was modified to reduce the time of searching objects. All these important technologies can strengthen the security, improve the speed of locating objects and help operator to analyze the pipeline condition. The system was tested in the laboratory environment and ran successfully, because it accords with the requirements of water supply network.**

***Keywords*—GIS, Pipeline network, Arc GIS platform, Hydraulic model, Seamless integration.**

I. INTRODUCTION

Water supply pipeline network is a vital project of city infrastructure, and also is an important physical base of existent and developing city, With the rapid development of our country economy, the speed of constructing and rebuilding infrastructure accelerated, the scale of population is continuous extend, processing a large of informational data quickly and manage the system high efficient, all these factors ask the water supply system of city for more higher requirements at programming, manage and urgent repair of pipeline network, help professor to design the draft of network, analyze water supply network condition. However, the conventional manage mode of water supply is no longer fit the requirements which the water supply manage of city is increasingly heavy. A majority of work need be done in manual way, for example, account the consumption of user, looking for the aleak pipe segments, design the programming pipeline network drafts, modify the old pipeline network to adapt the new uptowns, analyze the network and so on. GIS (Geographic Information System) technology is a computer system that collect, store, mange, analyze, display and apply geographical data, it is a universal technology that analyze and process large geographical data, it's characteristic spatial analyze function and visual expression function are fit the character that relate to geographical position, property of area, dynamic and large data of water supply manage system. Many foreign cities have established water supply pipeline network systems based on GIS, using these systems manage the pipeline networks. Mostly of these systems are integrated by using spatial position analyze, mathematic model, optimal path analyze, analyze relation of topology and pipeline network accidents. Establishing water supply network GIS of city can fast improve the work efficiency of water supply department of city and make works more scientific and exact. The system can solve the conflict between the constructing of city rapidly developing and the behindhand manage mode of city water supply.

II. SYSTEM DESIGN AND FUNCTION

A. System Design

The water supply network GIS of city is a huge manage information system, the system introduce Browser-Server and Client-Server to form a new composite model, according to the water supply network requirements, several different function models were designed in this system, in order to realize the functions of pipeline network and help operator to use the system easily, pipeline network maps and other operation maps can be released through the Web server of system, user can browse and query maps and graphics by using the browser, professional manage maps and graphics by using the Client-Server model [1]. People using browser to query maps and graphics, this can reduce the workload of maintenance and it is propitious to integrate the information and management.

B. Systemic Function

The system is composed of nine function models, include manage pipeline network function, analyze pipeline network function, manage user function, assistant design function, program pipeline network function, manage map layers function, system tools function, maintain data function and Web serving function. All these functions are separated from this system, in other hand, all the function models are related one another. Systemic function is described by "Fig. 1".

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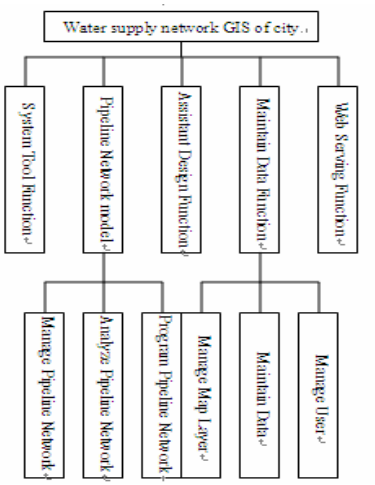

Figure 1. Structure of the system

1) Manage Pipeline Network Function: Locate objects rapidly and flexible, query information about orientation, length, pipe's material and pipe diameter of every segment of water pipe, linking tow pipe segments and diameter, type, water direction of conjoint valves and so on; according to the different pipe materials and pipe diameters calculate length and distribution of water pipe segments, work out the number of valves and display the distribution of valves form attribute data warehouse; professional can make statistics to record malfunctions and query by using the malfunction type, time, area and maintenance condition.

2) Analyze Pipeline Network Function: Include analyze water pipe blowout, establish hydraulic model and analyze the model, optimize the water supply tactic and analyze the aleak condition of uptown, and there is a large number of historical data in this system, by using these data can build analyze water pipe blowout model to help professional to realize the security of water pipe; hydraulic mode can supply the condition of pressure dynamic, this can help system control the pressure beyond the maximal pressure which the water pipe can load [3].

a) Analyze water pipe blowout: This function is used to build pipe blowout model based on a large of pipe blowout data of the past several years, we can find the most dangerous pipe segment in the network easily by using the function, so system may control the water pressure to prevent the dangerous pipe segment to blowout. It also can forecast the pipe blowout accidents at the same time.

b) Establish hydraulic model and analyze the model: Based on the network formation algorithm and flux sum up algorithm to build pipeline network concise model dynamic, and use the hydraulic calculation function to guarantee the authenticity of hydraulic model, according to the hydraulic model, we can simulate the whole pipeline system pressure condition, it can help professional to draw the optimization methods for cut off the water supply and build new water supply network.

c) Draw the optimal strategy of the water supply: Based on the water pipe blowout and hydraulic model, professional can establish the tactics to fit the real change condition. According to the tactics, decision-makers can draw the conclusion more exact and effective, improve the work efficiency. "Fig. 2" is the stop water supply simulation.

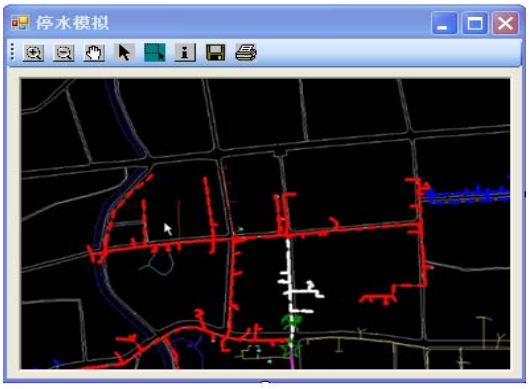

Figure 2. Stop water supply simulation

3) Manage User Function: Include query information, analyze users and design the data statistics of user, query the consumption of water and payment condition from the statistics, information of user include: name, address, registered date, water pipe type, water consumption, payment and so on. If some one wants to apply a new account, he must register with his detail information, and the worker can program the pipeline network based on your information which you supplied.

4) Assistant Design Function: Professional can use the digital map to design the network, function also include other operation, such as add, delete and modify digital maps.

5) Program Pipeline Network Function: When you choose a segment of water pipe on the digital map, the system can calculate the data of user, such as water consumption and the fluctuate condition of water consumption and so on which are correlate the pipe segment, by using these information, professional can draw more better plans to design new pipeline network and modify the old one. "Fig. 3" is program pipeline network interface.

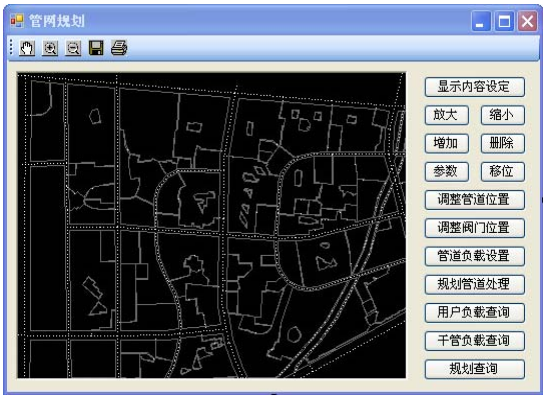

Figure 3. Program pipeline network interface

6) Manage Map Layers Function: Include setting privilege, display map and graphics and so on. Objects have the same attribute are stored into the same map layer, by this way, professional can manage the map easily, and it also reduce the time of access data in database. User can directly add and modify the attribute data and condition change into the map layer.

7) System Tools Function: Include setting parameters, mange log, and data backup and so on. Manage log can help user to master the condition of system running, so user can use the right method to solve the problems of system, reduce the loss of relational departments; data backup is a very important function for water supply network system, if some data lost, that maybe lead to system running abnormally, even lead to bad accident take place, so backup data is indispensable for the system in time.

8) Maintain Data Function: Include the basic geographical data, pipeline network data and user data maintenance. Using this function can realize that import geographical data and data conversion, classify and edit the geographical object and building the attribute database of graphic data. Data is very important to a system, so maintain data is an important function for this GIS of water supply network, it is the key that system can effectively and normally run.

9) Web Serving Function: User can use the database of attribute through the Web and go to the geographical object which you choose. If the layers can be modified and you have the privilege to modify the layers, then user can edit the attribute database directly. Restricting the browse privilege, systemic security and secrecy is intensified [5]. Corporation can release information of water supply to public immediately through the Web platform, for example, they can release the information which need urgently stop water supply, because of checking and modify the water pipe and building new pipeline network. Client can get the information in time by using the Web serving function, and client also can apply new account, query the condition of payment and make an account stated of water consumption.

C. System Development Environment

System based on Arc GIS of ESRI corporation platform, using Oracle 9i as background DBMS in this system, tow times development of Arc GIS by using C sharp in the Windows system environment. Arc GIS is a complete system for authoring, serving, and using geographic information. It is an integrated collection of GIS software products for building and deploying a complete GIS wherever it is needed—on desktops, servers, or custom applications; over the Web; or in the field; Oracle is a large relation database based on structure query language, popularly, it is a set which manipulate a large of well-regulated data by using convenient logic manage language, and is also one of the current popular database that the structure of Client-Server, and Oracle spatial has R-tree index and Quad-tree index, but the Quad-tree index is not encourage used, using the R-tree index can improve the speed of accessing spatial data in the database. C sharp is a new kind of Object Oriented language; programmer can use this language to compile application fast based on Microsoft .net platform. C sharp improves efficiency of developer compile program, and it try eliminate errors which will lead to serious results during the compile program.

III. KEY PROBLEM OF DESIGN SYSTEM

A. Choose Map Layers

The principle of choosing map layers is that store the graphics factor together which has the same mean of entity and spatial characteristic to form a layer. According to road, building, consume water units, pipeline network and their attributes to design the different map layers; graphics database organize the spatial data by describing spatial measure of geographical entity divisional form and slice form; spatial data separate from attribute database, but they connect each other in the graphics database, spatial data using the form of GIS map layer stored, attribute data stored in the GIS attribute tables directly, the other attribute data stored in the relation database. By this way, if professional want to modify some attribute of objects, he only choose the layer which object is belonged, it can reduce professional workload and improve the efficient of work. ”Fig. 4” is the main water pipe layer.

Figure 4. Main water pipe map layer

B. Coding Method

When organize the basic geographical information and water supply pipeline network data, design a suit of rational code can make manage information and sort order easily, can rapidly improve the query speed and convenient for analyze the pipeline network, reduce the burden of data maintenance to user. System coding use structural coding precepts to make the coding method accord with the state standard, at the same time system should pay more attention to the actual geographical condition and characteristic.

1) Road Code: The format of road code by using three bits digital code: sort code (one bit) + road-line code (tow bits).

2) Main Water Pipe Code: The format of main water pipe code by using six bits digital code: sort code (one bit) + road-name code (three bits) + order code (tow bits).

3) Water Distribution Pipe Code: The format of the water distribution code by using seven bits digital code: sort code (one bit) + road-name code (three bits) +order code (three bits).

C. *Link of Seamless Between Pipeline Network GIS and Hydraulic Model*

The hydraulic calculation which based on microcosmic models needs one pipeline network concise model, traditionally, manual construct this model is necessary, the workload is very large, and update the model is very difficult. The system has hydraulic calculation function, using model network formation algorithm and flux sum up algorithm to build pipeline network concise model dynamic, and use the hydraulic calculation function to guarantee the authenticity of hydraulic model. After hydraulic calculation, system can store the results in the attribute database of pipeline network GIS [7]. According to hydraulic information, can draw water supply area graphic, drawing water isobar graphic and dynamic simulation graphic of water, label the result, the ability of visual spatial data can make the hydraulic calculation result more useful and easy to understand by user.

D. *Pipe Blowout Statistical Model*

By using the pipe blowout records in recent twelve years (1996~2007) in the database of GIS, and using survival model to build pipe blowout statistical model, this model can simulate the pipeline condition during the water supply pipeline system running and provide the hydraulic condition, according the information, we can divide the water supply pipeline network into five secure grades, include safety grade, low dangerous grade, dangerous grade, high dangerous grade and extreme dangerous grade [9]. The pipe of extreme dangerous grade is the most weak segment pipe, so system must control the pressure of water pipe. Add this term into water pipeline network as a new restrictive condition can intensify security of running water pipeline network GIS [11].

E. *Technology of Database*

There are large spatial data and attribute data in water supply network GIS, and the data gradually increase, so using Oracle 9i as background DBMS in this system, Oracle 9i is one of the most stable large DBMS in the database industry, it organize and manage data by using technology of Spatial Database Engine, spatial data and attribute data can incorporate and seamless store in the same relation database, turn away the problem of rectify the map and map mosaic, improve the efficiency of accessing data, it also give a better way to integrate data, multi-user can accessing database to read and write data at the same time [14].

F. *Fast Locating Algorithm*

Fast locating is the most important in a large water supply network GIS, line locating and place-name locating is used in the whole pipeline network in this GIS, user can fast and easily locate to the specifically area and establishment in the pipeline network, that greatly improve manage efficiency for the whole system. In addition line locating system include tow grades line location, the first grade line locating be created by using one of ten thousand background map frame, the second grade line locating be created by using one of tow thousand background map frame; place-name locating based on name of city or name of building, by this way, operator can easily use the system.

G. *Analyze Profile*

Analysis of profile is base that programming and managing pipeline network, it also is indispensable information for the system. Pipeline analysis of profile is used to check the cross condition of pipeline which lay in profile and other pipeline in vertical direction, design the pipeline and built pipeline which underground realize the visual spatial model, it also can display the pipeline distributing condition, the basic algorithm of analysis of profile is that create source objects and factors variable and its values which is used to query information, look for the intersection which intersect with the source object in every map layer, get the object pipeline diameter and distance of tangential point to the point of intersection.

IV. SYSTEM INTEGRATION

According to the system total function frame, it has tow characters: centralized database manage and client of network model, there are water supply department user and internet public user to use the system, so during the system integration, because of tow different systems condition, using database oriented share incompact integration model and different developing way. All functions are integrated by designing the interface and installing software and hardware to form a friendly spatial data manage information system interface. “Fig. 5” is the interface of system.

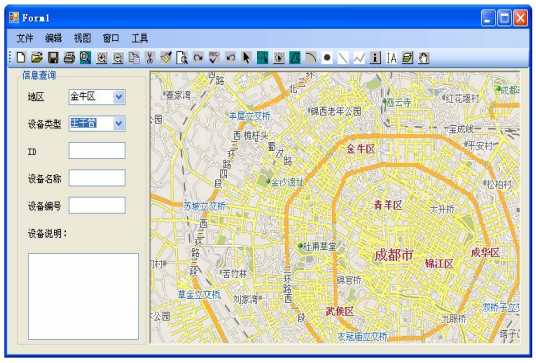

Figure 5. Interface of the system

V. CONCLUSIONS

With the rapidly developing in city construction of our country, the standardization, science and modern construction of city water supply network manage are more important and urgent, managing water supply network by using the technology of GIS, that is a effective way to realize manage pipeline network standardization, science and modern construction. The system has been completed preliminarily, and it has actualized all user requirements run in laboratory environment during the testing, especially that there are several key characteristic in this water supply network GIS, such as friendly systemic interface, use easily for operator, it can accord with the managing requirements of water supply corporation. Using the system will have great efficacy to programming, command, query information, fast maintaining, fast and accurate locating, assigning operator in optimization in water supply of city. However, the water supply network GIS

of city need advanced modify, because of the limit time of developing.

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