

## Research on a Heat-supply Network Dispatching System Based on Geographical Information System (GIS)

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**Abstract:** In order to reduce heating systematic operation and maintenance expenses, aimed at the current standards of a heat-supply network based on GIS, combine with a national program of 'tenth-five-year-plan', the authors have developed a Heat-supply Network Dispatching System (HNDS). The system, based on Oracle database and Mapgis 6.5, compiles with Visual C++ software. With computer and communication techniques, the system dynamic inspects parameters and information of a heat-supply network, achieves real-time dispatching and automatic information management. Based on a relief map, the system combines data on inspection equipment with those of the heat-supply network, intuitively displays the state of inspected equipment and the heat-supply network. Using the models of forecast and analysis, the system is reasonably configured for each heat supply dispatch system. Results applied to demonstration projects prove that the system possesses characteristics of stability and security.

**Keywords:** heat-supply network; GIS; dispatching

### 1. INTRODUCTION

Using the computer network technology to improve the city municipal integrated service management level and make the management of municipal administration public business including city comprehensive pipeline (heating, natural gas supply, water supply network, etc.) step into

standardizing, automatization and scientific track, it is the inevitable trend of city management.

GIS is a space information system set up for specifically applied goal, it can pretreatment, input, store, search and query, analyse, display, upgrade and offer the technological for space data based on computer hardware, software and network<sup>[1]</sup>. GIS is a new developing disciplines involved computer, geography, surveying, remote sensing, environmental, urban science, space theory, management and relevant disciplines, by unified managing the space position, character and time realm correlated with geographical information, organizing and using geographical information according to a kind of new way, GIS can analyse and produce new geographical information more effectively<sup>[2]</sup>.

Because GIS possess the powerful functions of managing and analyzing space data, it is extensive being applied to the urban comprehensive pipeline management. At present, the domestic researches on city geographical information system mostly concentrate on comprehensive pipeline, such as supplying and draining water, electricity and telecommunication, etc., there is less researches on geographical information system of the heating supply pipeline, only a few heating enterprises, such as Beijing, Chifeng, Huhehot, etc. have developed geographical information system of heat-supply

network, and the existing geographical information systems of heat-supply network majority still be in elementary phase of managing facilities and display due to the reasons of technology, the researches which heating enterprises urgently need about dispatching, fault diagnosis, hydraulic analyze and monitoring has not started yet. Aim at the current standards of heat-supply network based on GIS, combine with a National program of 'tenth-five-year-plan', authors develops the heat-supply network dispatching system(HNDS), results applying in demonstration engineering prove that the system possess characteristics of nicer stability and supernal security.

## 2. SYSTEM DEVISE

HNDS based on Oracle database and Mapgis 6.5, compiles with Visual C++ software. With computer and communication technique, the system dynamic inspects operation parameters and informations of heat-supply network, achieves real-time dispatching and roboticized information management. Based on relief map, the system combines the information of inspect equipment with situation of heat-supply network, intuitionistic displays the state of inspect equipment and estate of heat-supply network. Using the models of forecast and analysis, the system fulfills reasonable configure for each tache of heating supply dispatching.

### 2.1 System Software and Hardware Environment

HSNDS is a compositive system based on client/server framework, its software and hardware environment and network framework must respond to the certain request. Its hardware environment includes:

#### (1) Server

System has tow servers, one service for GIS to manage data of map and attribute, another service for database.

- GIS server: CPU/P4 2.0GHZ (more higher can be commended), MEMORY/256MB (512MB can be commended), MAPGIS6.5 hardware lock dog;

- Database server: IBM or HP server, CPU/P4 2.0GHZ (more higher can be commended), MEMORY/512MB (1GB can be commended) .

#### (2) Client server

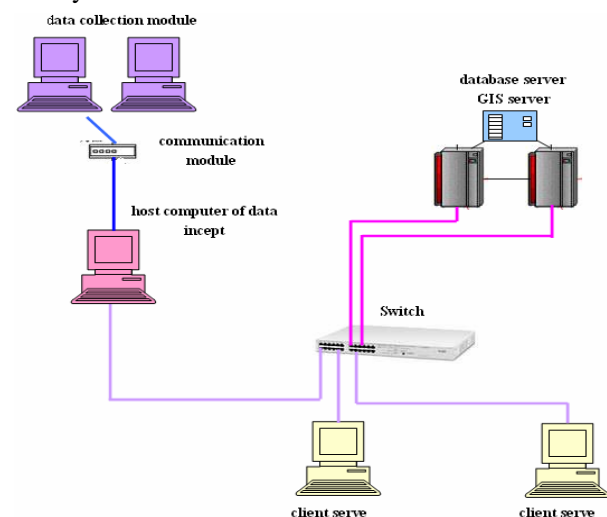
Client serve need disposal data and calculate.

- Client server : CPU/P4 2.0GHZ (more higher can be commended), MEMORY/256MB (512MB can be commended)

System software and hardware environment include:

- GIS server: Windows Server2000, MAPGIS 6.5 Server;
- Client server: Windows 2000/XP, Oracle 9i Client server, MAPGIS 6.5 Client server.

### 2.2 System Network



**Fig. 1 Network Framework of HNDS**

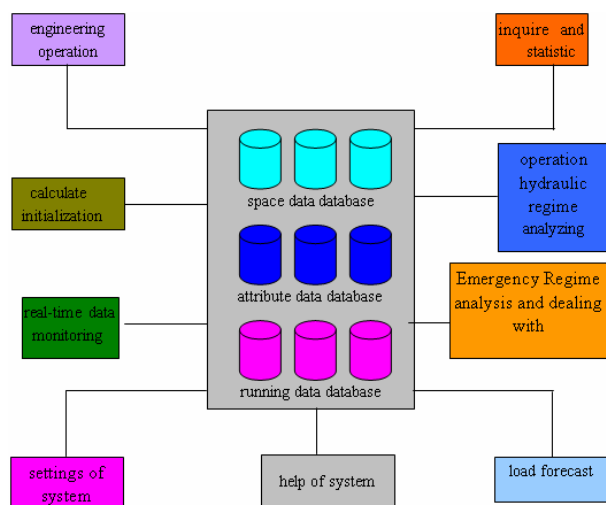
Heating communications network is a service network which have characteristic of heating system, it include diversiform communications equipment and framework of network. The developmental actuality of heating communications network is that diversiform equipment exist and diversiform network communicate and diversiform monitoring system independently circulate. If various kinds of monitoring system which are similar to the detached island and GIS system can be integrated and applied in management of heat-supply network, the real-time and dated data of heat-supply network, data of users, data of framework and data of graph can be integrated a whole communication system of heating supply, basal data of geography layer, equipment layer, physics layer and topological layer will be

offered to roboticized management and dispatching of heating supply system, and it will afford an administrant means for regulating and diagnosis of heat-supply network, consequently, it will resolve administrant difficult problems which more greater scale and more complicated framework of heat-supply network bring.

Network framework of HSND is the form of client/server, Network framework of HNDS is the mode of client/server, as Fig. 1 shows:

### 3. FUNCTIONS OF HNDS

According to functions, HNDS can be divided into engineering operation, inquire and statistic, calculate initialization, operation hydraulic regime analyzing, emergency regime analysis and dealing with, real-time data monitoring, settings of system, load forecast and helping of system nine subsystem. The concrete systematic functions relation is as Fig. 2 shows:



**Fig. 2 Functions Relation of HNDS**

#### 3.1 Engineering Operation

The engineering operation module can carry out flowing functions, such as loading, closing, saving, display usage and display content of Engineering of heat-supply network. Through using the module of showing the single pipe network can show the single scene of heating pipe network. For multiple source heating supply enterprise, it can show a certain hot water or steam network of the designate source

among all sources and carry on corresponding operation to it, for example shrinking and enlarging of the figure etc.. Through using the module of showing the pairs pipes network can show the network in pairs according to its concrete characteristic, simultaneously, show all points of these pipes (including heat sources, substations, users, valves and compensators,etc.).

#### 3.2 Inquire and Statistic

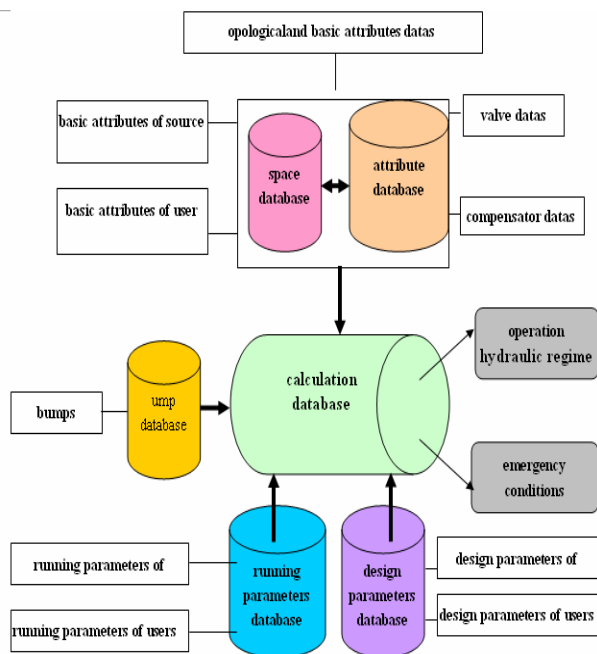
Through the subsystem of query and statistic, the information of the whole pipe network can be realized comprehensive statistics and inquired. The information kinds obtained from the subsystem of query and statistic are complete, the ways of information display are variously, it is interdynamic to totally accomplish pictures and texts. The subsystem of query and statistic include following function modules, such as flow simulation of heat medium, network inquiry, network statistics, space district inquiry, etc.. According to the pressure difference of starting and ending node of pipe, the module of flow simulation of heat medium can simulate the direction of heat medium, paint all pipes of network again, make the result of flowing displaying on the screen clearly. The module of network inquiry based on space data, according to present space type of datum, inquiry the informations relate with heat sources, substations, compensators, valves and users, content of informations obtained include basic attribute, image picture information and project drawing information. In additional, the inquiry functions from aboved can realize the way of two-way inquire and make a reservation in GIS drawing at the same time.

#### 3.3 Calculate Initialization

The subsystem of calculate initialization mainly include fundamental and calculated data initialization function modules.

The topological data of the network are essential terms of forming the heat-supply network, basic attributes, design parameters and operation parameters of heat sources, users and fittings and

accessories in heating pipeline are data foundation of hydraulic analysis of heat-supply network. So when hydraulic analyzing of heat-supply network, basic data of network must be initialized at first. Main function that the basic data initialization is distributing all kinds of data existing in different databases (including space database, attribute database, design parameter database, operate database, bump database, etc.) into unified calculation database, and setting up the unified data source for the calculation of operation and emergency regime operating mode, the concrete systematic functions relation is as Fig. 3 shows.



**Fig. 3 Functions Relation of Calculate Initialization**

The contents of calculation initialization including the following several respects mainly:

- (1) Space database loading: Loading topological and coordinate informations of pipe network and node of space data into calculation database, establishing topological relations of pipe network and node.
- (2) Attributes database loading: Loading basic attributes of space pipe network and node into calculation database.
- (3) Parameters of Bumps database loading: Loading parameters of many kinds of bumps into calculation database.

(4) Design parameter database loading: Loading design parameters of heat sources, users and heat-supply system into calculation database.

(5) Operation database loading: Loading operation parameters of heat sources, users and heat-supply system into calculation database.

### 3.4 Operation Hydraulic Regime Analyzing

The operation hydraulic regime analyzing subsystem can utilize all kinds of pipe network data gathered in real time and the existing topological data of network and design parameters to carry on operation hydraulic regime analyzing of the heating supply network, show the results of analyzing by way of report form and pressure diagram, afford the dispatching schemes of heat source, valve, pipe network and pump under different operating conditions, and carry on computational analysis for some kinds of modes of hot water heat-supply systems centralized regulation, for example constant flow control, variable flow control and centralized control with flow variable by steps, draw temperature adjustment curve.

### 3.5 Emergency Regime Analysis and Dealing with

Aiming at all kinds of troubles taking place in real time to the pipe network, the subsystem could calculate for emergency hydraulic regime, confirm the valve needing closing and the users needing stopping, provide the results of calculation by way of report form, and afford rational emergency dispatcher's scheme. The concrete function module includes turning off the valve calculation, emergency regime calculation, limited heating emergency regime calculation, hot water heat-supply system emergency regime calculation and dealing with.

### 3.6 Real-time Data Monitoring

The subsystem can gather long-distance informations of each monitoring point of the pipe network, judge and store the real-time data of pipe network state accepting, show the real-time operation conditions of each monitoring point of the pipe network in the form of chart and curve. The

subsystem including heat source data monitors, substation data monitors and monitoring data display three pieces of function module.

### 3.7 Load Forecast

The subsystem adopts simple load to forecast the tactics and prediction tactics based on neural network, forecast that the system in the following one days supports heating load and all kinds of operation parameters. Simple load forecast heating load, temperature of supply water and temperature of return water of the following one days, according to weather forecast and heat-supply network design parameter, and can be according to heating load to confirm that the operating numbers of boiler, the operating numbers and hours of heat exchanger, coal consumption and rate of water make-up. The load based on neural network predicts heating load, temperature of supply water and temperature of return water of the following one days according to the parameter of surveying, and according to heating load to calculate all kinds of above-mentioned indexes too.

### 3.8 Settings of System

The subsystem of settings of system can set up GIS environmental variable, safeguard all kinds of basic datas (including parameter of the boiler, parameters of pump, parameters of meteorological, heating load data for load estimation etc.) and design parameters of each monitoring point on the heat-supply network, maintenance warning parameter of heat-supply network.

### 3.9 Helping of System

The helping of system subsystem offer the help information correlating with system, including the theme help information and help information of the index, the help information of the theme is divided according to the system function subsystem mainly, the structure is comparatively clear, the help information of the index should carry on the search of help information according to the index key word that users input. All help information aim at solving the

knotty problem that users meet in the course of operating.

## 4. CHARACTERISTICS OF SYSTEM

HNDS has the following characteristic mainly:

- (1) HNDS and user's geographical information compact integrate. Because the whole system based on GIS environment, the dispatcher personnel can be convenient in the control room sees the monitoring data of each monitoring point of heat-supply network;
- (2) System analyse all kinds of datas arriving from monitor, forms dispatcher scheme of heat source and substation, make heat-supply network rationally running;
- (3) Utilize the advanced prediction model to carry on the prediction of all kinds of heating power parameters, dispose every operation parameter of the heat-supply network rationally;
- (4) Adopt the advanced emergency handling scheme to carry on emergency handling, make sure the emergency coverage is little, emergency handling is with high efficiency;
- (5) Systematic stability is good, with high efficiency. Because the HNDS develop with Visual C++ and ORACLE, and use some characteristics of ORACLE, it have had characteristics such as being more high-efficient and more steady;
- (6) The systematic security is high. The operator carries on the identity and proves through the IC card, it is more secure to systematic safe.

## 5. APPLICATION IN ACTUAL PROJECT OF HNDS

Because HNDS based on GIS combined the concrete operation data of LangFang economic and technological development zone heating network, its data have the characters of accurate and complete. So after the system is put into the actual project, have made very good result. For those networks with high automatic degree, through the Real-time Data Monitoring subsystem real-time collect and analyse data, the dispatcher personnel can assign dispatcher's

order with the newest data. As to those networks with low automatic degree, through Load Forecast subsystem forecast the following days heating load and Operation Hydraulic Regime Analyzing subsystem calculate the heating network operation parameters of different operating modes, offering different terms academic references for dispatcher personnel. At present, the feedback information from LangFang indicate that HNDS runs very well and user's satisfaction is relatively high.

## 6. CONCLUSIONS

The HNDS software based on GIS technology is a comprehensive platform software, it combine geographical information with many kinds of technology, such as data monitoring, load forecast,

emergency regime dealing with and operation hydraulic regime analyzing, etc.. The software uses the computer information technology, communication technology and modernly predicts technology, offers a kind of advanced scientific operation management tool to the heat-supply trade, thus improves the operation decision level of the heat-supply trade to the maximum extent.

## REFERENCES

- [1] Chao Zhang, BingXian Chen, Lun Wu. Geographical information system [M]. Beijing: Higher Education Press, 1995.(In Chinese)
- [2] XinCa Wu. The geographical principle of information system and method [M]. Beijing: Electronic Industry Press, 2002.(In Chinese)