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The Design of Intelligent Information Management Systems in the Geothermal Plants

Zhu Jialing[1], Liu Zhengguang[2], Ye Jianhua[2]

[1]Tianjin Geothermal Research and Training Center, Tianjin University, Tianjin, 300072 China

[2]School of Electrical Engineering & Automation, Tianjin University, Tianjin, 300072, China

zhujl@tju.edu.cn, zh_liu, jh_ye@tju.edu.cn

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ABSTRACT

The paper mainly describes network interface and interspaced database on the data collections from the geothermal plants, information statistics, transfer through the internet to the main control center, and intelligentized managements system , which based on the platform of design methods of logic structure. The data control, running state monitoring, and alarm for the error case are handled in the management systems. As the system design of the management information system (MIS), geography information system (GIS), intelligent management system, computer network, communications and dimensional database, it can be proved all data and information to be reasonable for geothermal resources evaluation, utilization available and improving management efficiency as well.

1. INTRODUCTION

China is rich in geothermal energy and has great potency in exploitation and utilization. Through researching and exploiting in recent 30 years, great development has been achieved. Direct use amount has reached 16531GWh, and it is the first place in the world. The fields of utilization are expanding, from industry utilization to space heating, tour, and physical therapy, etc. Through renovation of technology, many new technologies of geothermal energy utilization have been developed, and efficiency has been improved. On the view of develop trend, the geothermal energy storing in deep strata and utilization of low-temperature energy appear great potency in the future.

Geothermal utilization develops high efficiency in China, such as district heating, hot water supplying, greenhouse, fishing, etc. The energy application efficiency is growing up from 50% to 95%, and almost closes to 100%. There are 10 geothermal anomaly fields, which are mainly covered by 8700km2 in Tianjin. The typical geothermal characteristic is controlled by geology tectonic. The foundation type controls the geothermal distribution as well (See Figure 1 and Table 1).

For a moment, 258 geothermal production wells are operating in Tianjin. The mounts of geothermal production per annum is 25,838×103 m3 , reinjection 4,093 × 103 m3 and 15.8% of total exploration rate; more than 12,000×103m2 of buildings are using geothermal resources for heating and 100×103 families are using geothermal hot water.

Considering the situation for data collection and management, people have to travel to each of the heating plant to read and record the data. Then bring them back to the office and input to the computer year by year. The job costs a lot time, labor and money. However, once a heating plant occurs some problems, the operating data would be lost. In additional, because the resources shall be paid (1.5-2Yuan/Ton) by the plant, the amounts of geothermal water month by month shall be taken an account. So if the data is lost, it is hard to accumulate them.

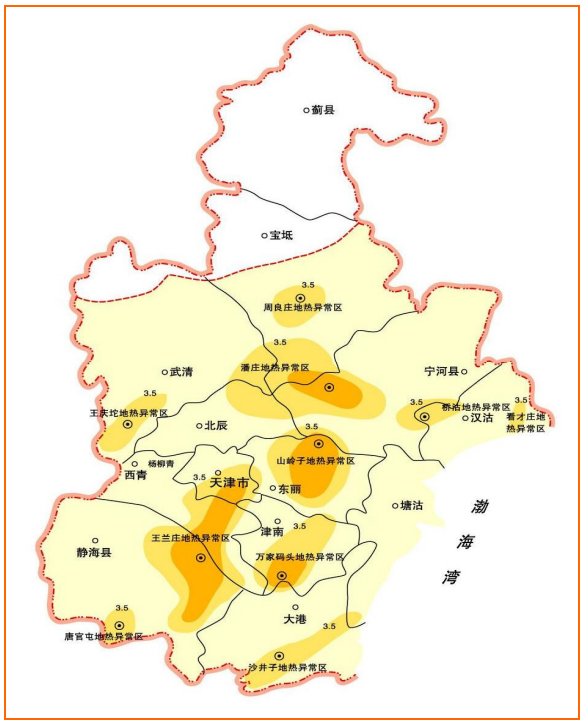

Figure 1: Geothermal Resources Distribution in Tianjin.

The geothermal intelligent information management system had been developing since mid 1990s. It was financial support from the mineral resources compensation by the geothermal administrative department. 215 geothermal heating plants have installed the system by 2008, (See Figure 2). Topographic measurements mainly include static and dynamic water level, the corresponding temperature, production and reinjection rate, monthly and annual statistic of production rate and reinjection rate, and synchronous monitoring in the beginning and at the end of the space heating period. The collected data is automatically transmitted to the central control station through the network.

Table 1: Typical Geothermal Characteristics in Tianjin

Name	Tectonic	Area (km2)	Geothermal gradient(℃/100m)
Wanglanzhuang	Shuangyao upfold	534	8.0
Shanlingzi	Dongzhuang upfold	315	8.3
Wanjiamatou	Xiaohanzhuang upfold	235	8.8
Panzhuang	Panzhuang upfold	610	6.9
Zhoiuliangzhuang	Wangcaozhuang upfold	180	5.5
Qiaogu	Ninghe upfold	90	5.5
Wangqingtuo	Dacheng upfold	114	5.0
Shajingzi	Tectonic belt	190	4.5
Tangguantun	Tectonic belt	40	7.6
Ninghe	Ninghe upfold	20	5.5

Figure 2: The Installation at the Geothermal Heating plant.

2. THE COMPONENTS OF GEOTHERMAL INTELLIGENT MANAGEMENT SYSTEM

2.1 Management Information System

Management information system (MIS) is a comprehensive, systematic and boundary subject, which is based on management science, information science, computer science, statistics and operations (See Figure 3).

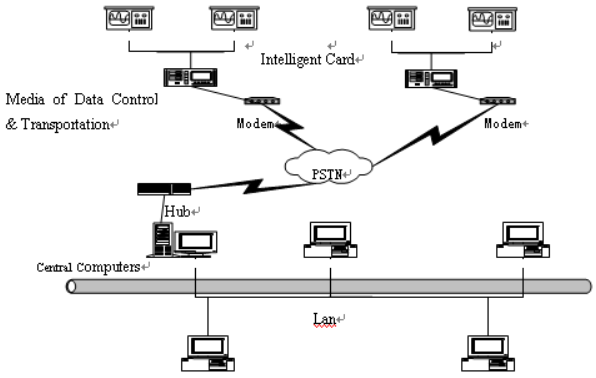

Figure 3: Scheme of MIS.

MIS can be used for information collection, information transfer, information storage, information processing, and information utilization. From the definition, it's not only a technical system, but also a management system. It's high efficient for managers to store, process and manage the information by MIS.

2.2 Geographical Information System

Geographic Information System (GIS) is related to geographical information base on geographical databases. GIS collects, stores, manages, operates, analyzes, simulates, displays space-related data . Through geographic modal analysis, it provides a lot of special and dynamic geographic information and management, and gives a comprehensive assessment, analyzes quantitatively and makes decisions. By using the function of the spatial data analysis, GIS can put the data into vector map and find the direct relationship between the map and the data. GIS can find the map information from the data and it can also find the data from the map. This system makes an intuitive analysis on all kinds of information to find some useful information from the text data. It means that GIS has made information system's data visible and put information into maps.

2.3 Intelligent Information System

Intelligent Information System (IIS) is an application system that information technology and artificial intelligence technology are applied in specific fields. By using information processing techniques and computational intelligence, IIS can solve the problems through complex and a large number of data processing and logic analysis. In the 1980s, with interdisciplinary research in depth, operations research was applied to management information system and it has been a new intelligent information discipline in Descision Support System (DDS). Intelligent System plays an important role in realization of geothermal data's intelligent judgment. The system can warn the geothermal sites, which don't regulate the operations according to the intelligent computation and judgment. This can save a lot of manpower, at the same time; it can constrain and limit the interference of the human factors.

2.4 Computer Network

Network Transmission is the media which should transmit the collected information accurately and efficiently. Up to now, the most common way is the three-tier network composed by networking client, server and host. The outermost layer node of the typical three-tier network is a personal computer, which has connected to the local server. The computer stores data and manages hundreds of the external equipments used by clients. So, as long as the manager has a computer, which has been connected to the three-tier system, he will be able to get all kinds of parameters of the local server and the host.

2.5 Wireless Communications

The rapid growth of the communication technology is of great significant trend to the information system, especially the mobile communication. Because of the built-in wireless computer modem, it's easier for computers to connect each other and thus it increases computers' capacity and adaptability.

3. FUNCTION OF INTELLIGENT MANAGEMENT SYSTEM

The development of the geothermal resources uses the system's monitoring capability, especially monitoring the production volume, quality and the dynamic parameters. Its purpose is not only to collect the necessary dynamic data, but also to detect the situation of the system's operation and to manage the collected data together to provide visible management system environment. Management system

server is responsible for receiving dynamic monitored data from all remote data transmission terminals and then it aggregates and organizes. The software on the server can analyze the data and assess the situation of the system's operation.

Microsoft Access has been used as a database platform and Visual Basic 6 as a development tool.

In order to provide human management interface all the property information of the geothermal sites could link to the spatial information closely and enhance visualization of intelligent management system, geographical information system is included into the intelligent management system. The system includes historical data statistics, report creation, printing, trend forecasting, warning and the implement to the warned sites. The system also could connect and monitor any site timely

To sum up, upper-management system with powerful management functions and control methods has the function, which can support a variety of communication networks, communication methods and communication rules. Through monitoring all the geographical sites, the system can keep informed of all the operation process. Therefore, As for resource management, all kinds of human factors can be eliminated and it truly becomes a system with scientific and standardized management, as shown in Figure 4.

4. DESIGN OF INTELLIGENT MANAGEMENT SYSTEM

4.1 Structural Design of Management System

There is a geographic information system, which can manage and monitor the dynamic city geothermal resources on the data terminal and it has also been a remote control geothermal management system based on geothermal information system.

Because the control centre wants to achieve network management, it's needed to develop a database system with a client/ server architecture in order to share data on the server (Microsoft SQL Server, Oracle).

(1) Oracle is the first commercialized relational database management system. Up to now, it's also a widely used client/server system with powerful function. As a common database system, Oracle has comprehensive data management functions including storing a lot of data and definitions, manipulating data, concurrency control, security control, integrity control, fault recovery, interface with high-level language and so on. Oracle is also a distributed database system, which supports all kinds of distributed functions, especially dealing with internet. As an application development environment, Oracle provides a fully functional development tool with a friendly interface, which gives the user a good development environment. Oracle uses PS/SQL to operate and it is open, portable, scaleable.

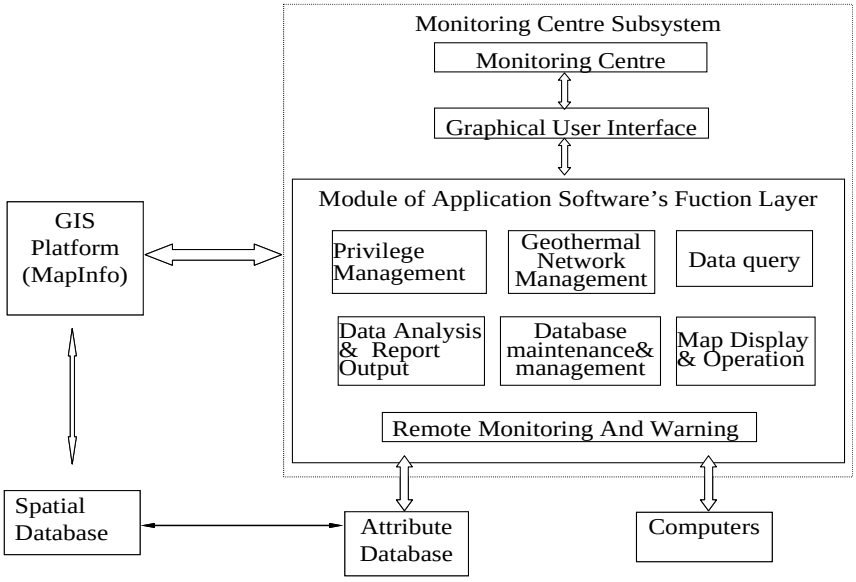

Figure 4: Sketch of Configuration on Internet Management Systems.

(2) Microsoft SQL Server is a typical client/server relational database management system, which uses Transact-SQL transmits requests and responses between server and client. Microsoft SQL Server can run on many operating systems. Microsoft SQL Server is reliable, available, scalable and manageable so that it offers a complete database system solution for the project.

4.2 Designs for Geographic Information System

At present, the applications of GIS are: geospatial data management, comprehensive analysis and evaluation, spatial query and spatial analysis, cartography, the establishment of special information system and regional information system, combination of geographic information system and remote sensing image processing system. Because GIS is a very strong professional specialized software, it can't solve all the problems if system just rely on the GIS. So a specific function must be developed through secondary development function and it must ensure seamless integration which provides users a unified operation interface, as shown in Figure 5.

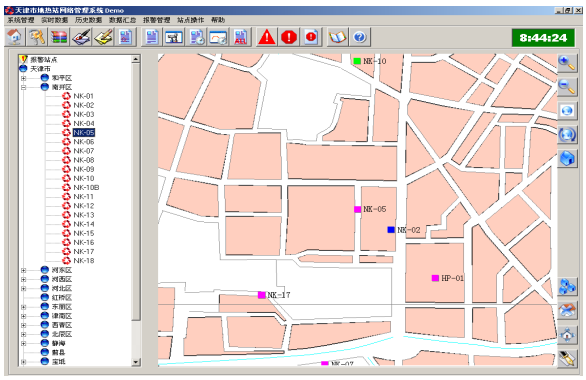

Figure 5: The Management Interface of Geothermal Information Monitoring (GIS).

The integrated GIS mainly consists of four parts: computer hardware, computer software system, geographic data and management operator. The core of the system consists of hardware and software, spatial data reflects, the geographic content of GIS. All of the database design and system structure is based on optimization management, reliable data of collection, stable transmission. Geographical Information System (GIS) Structure Design and Function Structure Design of the GIS Software are showed in Figure 6 and Figure 7 respectively.

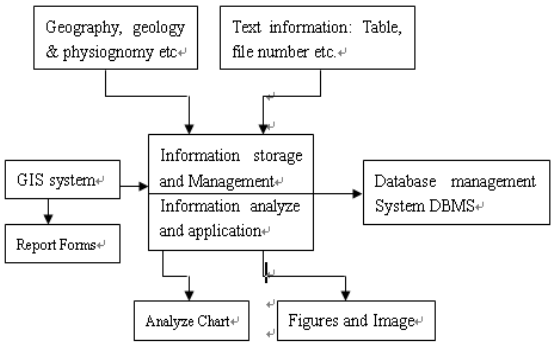

Figure 6: Geographical Information System (GIS) Structure Design.

The system primarily consists of five subsystems: chief menu management subsystem, GIS analysis subsystem, terrestrial heat analysis system, terrestrial heat database operation platform and bottom database. It combines information management, resource assessment and scientific decision-making into one part and combines scientific evaluation of resources and decision-making into another part, GIS technology will integrate the geothermal engineering analysis as the foundation of resource evaluation.

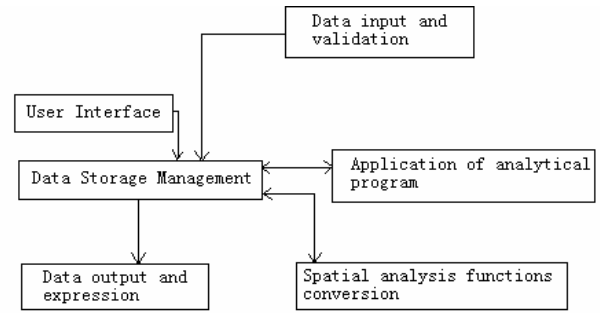

Figure 7: Function Structure Design of the GIS Software.

4.3 Management Subsystem Structure

The cluster system can improve system availability effectively. If server A or application procedures collapse, at the same time server B of cluster system will take over the responsibility of the server, the system will still work, shortening the maximum user server and application program downtime. See Figure 8.

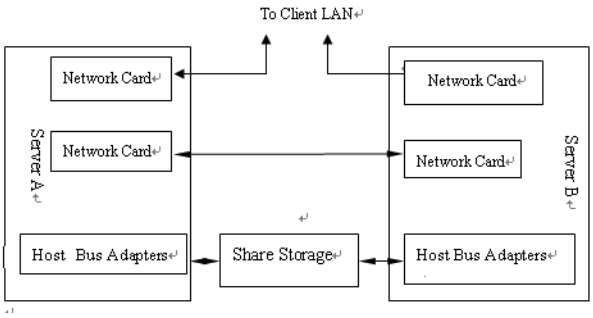

Figure 8: Topological Structure of the Control Center.

4.4 Visualization Management Module

Geographic information system uses electronic map with MapInfo format, which possesses the same function as a common electronic map with enlarging, decrease, roaming and full size show and so on. In addition based on the special requirements of Geothermal system, with the database connection, the module increases special features, such as showing site information, adding new sites and deleting the site, editing site (adjusted basic information, etc.), shifting site and updating information. Just click on a site in the list, electronic maps can automatically locate the site and show the pop-up detailed information to facilitate the search of the site.

4.5 Alarm Module

Due to the distribution of scattered geothermal sites, it is slightly weak in the monitoring effort. Therefore, some staff of manufacturing sites make illusion, with stealing or less timekeeping occurred sometimes. Therefore, Alarm, automatic processing of accidents have become an important function of management systems. When a site appears a malicious data error, through functional relationship between mining flow, submersible pump current and frequency judgment, after confirmation, making a correction will give the whistle alarm immediately to the master control management system, and locate irregularities site location, name of the site and contact accurately in the electronic map; Management System will add the alarming site and the fault conditions to the database to record. Based on the circumstances, the managers can decide to adopt an approach, and through remote control signal to fault the scene.

4.6 Communication Module

The systems mainly monitor the data transmission between monitoring system and management system, so the communications system design has become an important part.

4.6.1 Telephone Communications (Wired Communications)

Transmission of data through the telephone network is a very common way for a transmission network. It only needs to install the telephone lines and modems around the monitoring system of the geothermal site, and the data transmission can be realized. Utilization of phones is widespread, which have the characteristics of stable performance, commonality and lower installation costs etc.

4.6.2 Broadband Network Communications（Internet）

Data transmission through the Internet will get a higher speed, reliability and stability. However, due to the initial installation fee for broadband network installation is more expensive, it fits for geothermal station equipped with broadband network. Secondly, the more popular ADSL although has the characteristics of broadband network, which still needs to work with the cable.

4.6.3 Wireless Communications

The way that data transmission via mobile networks, supports a wide range of communication design, which can be applied to different geothermal sites and different circumstances, lazed at various geothermal networking requirements, and has powerful universal ability. But since it is wireless, the quality of signal will be influenced by the condition and environment. If geothermal stations are located in the basement, or the framework of the structure of buildings, it will affect the quality of signal transmission. Therefore, the geothermal stations are not suitable to use wireless communications. It is more reliable to use a cable communication.

4.7 Data Transmission Module

When the management systems communicate with monitoring system, it is one-to-many communication. It needs cycle inquiry. It is relatively simple for a monitoring system to initialize the communication with the management system, because it is a one-on-one communication. In order to avoid potential conflicts appearing in bi-directional communication, the system allocates different period of time for each form of communication, each geothermal station will upload the data of one day to management system; the rest of the time the monitoring system uploads the abnormal data, and it has a priority level, once unusual circumstances appears, the situation will be reported at any time.

The management system software possesses many functions, such as uploading real-time data, painting curve data, making list, and displaying dynamically based on real-time data. This real-time communications happen except a specified time, as long as the alarm does not occur (automatic alarm system owns the highest level of priority), Managers can monitor the operational status of any site at any time, as it is showed in Figure 9. If the manager wants to know the geothermal information (e.g. flow-rate, temperature, pressure, etc) of certain geothermal station, he just needs to click a menu item, and a dialog box will show

up on the screen. The manager can set the site information and click upload button, then the geothermal information of the site will show in a table. The set will not only satisfy the geothermal station management requirements, but also avoid unnecessary conflict effectively. When a site uploads data abnormally the certification can be carried out directly through this function, and it will provide the managers an appropriate measure.

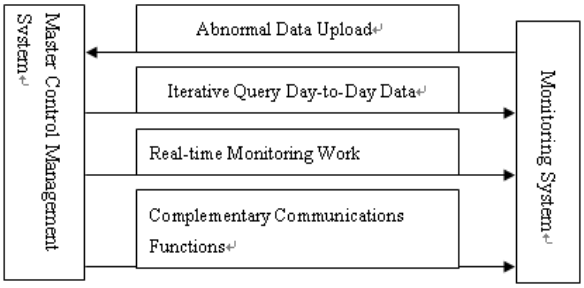

Figure 9: Sketch of Communication Structure.

4.8 Statistics Module

Statistics is an important function of geothermal intelligent management. Management system provide the data of the site showing the diurnal fluctuation, monthly fluctuation and yearly fluctuation in the curve, it is convenient for managers to analyze the trend of terrestrial heat mining at any time. So in order to draw up the quantity of mineral resources of every geothermal sites intuitively; the module record the total produced quantity, the situation of payment and charge and the situation of defaulting or not in the payment, and the data are displayed on the monitoring system at any time, it realizes the intelligent management of payment and charge for all sites. In addition, the module also provides the management of the linking failure sites and the alarming sites. It will establish records for the sites which had defect. The records can be searched at any time, and get hold of the operational aspect in time.

Besides in the design it also includes database module, output module, management module of user license, and so on. The designs further strengthen the database information management, data classification, retrieval, as well as the security of thermal management system and the function of confidentiality.

CONCLUSIONS

The integrated GIS mainly consists of four parts: computer hardware, computer software system, geographic data and management operator. The core of system consists of hardware and software, spatial data reflect, the geographic content of GIS. All of the database design and system structure are based on optimization management, reliable data of collection, stable transmission.

The GIMS consists of the data collect system, management system, long-distance monitoring system and network system. The design should fit the intelligent management, including data transmission from the geothermal heating plants to the central station, database set up and statistics.

Long-term monitoring system of the geothermal field and heating plants have been established. It will be improved and equipped, so that any changes and state of operating will be observed as soon as possible.

As real data of operating, such as temperature, flow-rate, pressure drop of well-head, or in the reservoir, water chemical quality changes, etc, it is important to evaluate the geothermal reservoir situations and life-time of exploration.

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