THE WEBGIS BASED JIANGSU OILFIELD MANAGEMENT SYSTEM IMPLEMENTED WITH A SPATIO-TEMPORAL DATA MODEL

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ABSTRACT:

Planning and assessment in maintenance, renewal and working status of oil field facilities and oil production management are evolving toward complex, spatially explicit regional assessments. These problems have to be addressed with object-oriented spatio-temporal data models that can restore, manage, query and visualize various historic and updated basic information concerning with oil field facilities and production activities as well as compute and evaluate the working status of those facilities so as to provide online forecasting to oil field leaders on renewal, maintenance of those facilities and the planning of safe and reasonable oil production activities at different spatial and temporal scales. The extensive data requirements and the difficult task of building input parameter files, however, have long been an obstacle to the timely and cost-effective use of such complex models by resource managers. The college of Geo-science, Nanjing University, in cooperation with the Jiangsu Oil field Company, has developed a web-GIS based management system to facilitate this process. The frequent changes of pipeline (water and oil) locations and dynamic build-up and abandon of oil wells, together with the relevant adjustments on pipeline and the station facilities have led to many difficulties for the development of the Web-GIS Based Jiangsu Oilfield Management System. In terms of the spatial and temporal characteristics of historic and currently available information on facility and oil production of the Jiangsu oilfield, we designed an object-oriented spatio-temporal data model that combines spatial, attribute and temporal information to implement the management system. Using this system, we can update, query and analyze oilfield information as well as manage historical data, and a visualization tool was provided to help the user interpret results. The utility of the system has been demonstrated on the production activities of the Jiangsu Oilfield Company.

1. INTRODUCTION

Planning and assessment in maintenance, renewal and working status of oil field facilities and oil production management has been the goal of researchers and policy makers of oil-field companies for more than a century. As the science has evolved, fully integrated oil production assessment and oil field management tools for support in enterprise management and oil research are becoming established tools in both basic and applied research. At the core of many of these tools are spatially distributed models because they provide a mechanism for investigating interactions among various oil field facilities as they affect security and oil productions. However, frequent changes of pipeline (water and oil) locations and dynamic build-up and abandon of oil wells, together with the relevant adjustments on the changes of pipeline and the station facilities characterize the whole production activities of many oil field companies, such situation is much significant especially for those poorly managed enterprises in China. Moreover, spatially distributed models are by definition data-intensive, and if these models are to be applied on an operational basis, there is a critical need for automated PC-based procedures to store, access, query and prepare data for modelling. Therefore, the Web-GIS based tool was designed to meet the basic requirement of the system.

The traditional GIS spatial database only gives a snapshot of the real world. It can neither predict the future of objects nor reflect the objects' historic changes. Temporal GIS improved the traditional GIS which added temporal information in the traditional GIS database. Using temporal GIS, we can analysis historic data and predict the developing trend of objects. The core of temporal GIS is spatio-temporal data model. We designed an object-oriented data model according to the characteristic of the oilfield on the basis of previous research.

This manuscript presents the Web-GIS Based Jiangsu Oilfield Management System tool, a multipurpose oil field production and management analysis system for use by enterprise managers and scientists in performing oil field production and management studies. It was developed under the following guidelines:

1. Provide a simple, direct, and repeatable databank for updating, querying and analyzing oilfield information as well as managing historical data;
2. Use only basic, attainable GIS data;
3. Be compatible with other customized geospatial and office software;
4. Be useful for security forecasting on facility maintenance and renewals at multiple scales.

The Web-GIS Based Jiangsu Oilfield Management System is distributed freely via the internet, open-source suite of

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programs (http://172.16.126.36:8080/mapguide/jsof/forepage/). However, for the sake of system safety and information security, the databank was designed for accessing in two categories of users, for the system manager and the management officers of the company, the databank is fully accessible and, for the other users, only part of data can be accessed.

2. DESIGN OF THE OBJECT-ORIENTED DATA MODEL

In recent decades, many researches have been done on the data models of GIS corresponding to different spatial and temporal characteristics of the studied objectives world widely. Many representative data models aiming to best characterize the individuality meanwhile keeping the satisfied performance in descriptions of the commonness of the objectives have been developed, among which the sequence of snapshots model, base state with amendments model, space-time model, N1NF model and object-oriented model are the most representative. Concerning with the characteristics of our study object, the object-oriented data model was selected in our system.

Initially, object-oriented data model is only a software design idea. Later, it became an approach to analyze and simulate the real world. Using object-oriented data model, one can combine object attribute information with actions into one object, which makes it easy and convenient to identify each objects. Figure 1 shows the data model we designed for the oilfield information management system.

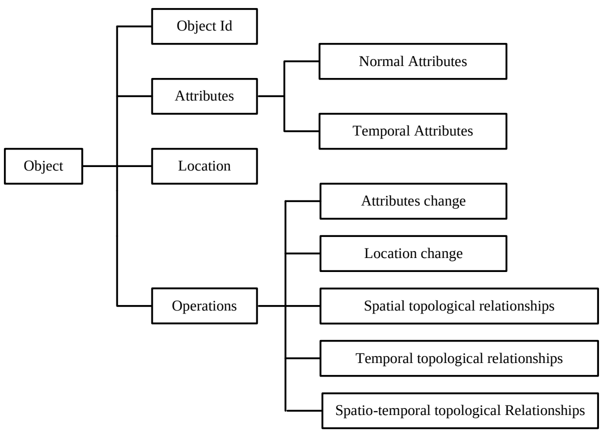

Figure 1. The structure of the object-oriented data model adopted in our developed Web-GIS Based Jiangsu Oil-field Management System

As the figure 1 indicated, every object contains several fields as indexes to characterize the behaviour or status of the object, such as object id, attributes, location and operations. Object id is unique for any specific object, and is used to identify targets and can not be changed in the lifecycle. Attributes contains normal attributes and temporal attributes. Normal attributes characterize the commonness of the objects. It could be stored as text, numerical, or the visualized picture, images…etc. Temporal attributes describe the individualities of the objects, especially the temporal changes of the objects, and it contains valid time and transaction time. Valid time represents the real begin and end time of object, while transaction time is the time when the object imported into database. Spatial attribute describe objects' location and shapes. It could be either vector data such as point, line or polygon or raster data. Operation collection contains all the operations on the object. They can be grouped into five categories, two of which are about amending attributes, three of which are about topological relationships between objects.

The shortcomings of the object orientated data model are redundancy in operation and inconvenient for querying spatial relationship between objects. Fortunately, only a few spatial analyses operations are involved in the system and the objects' attributes are mostly fixed such as well, pipeline and stations.

3. DATABASE OF THE SYSTEM

Various information and data are needed to be stored in the system. According to their characteristics, those information and data can be subdivided into three categories. The first category is spatial data. It mainly contains the information of the geographic locations, geometric shapes of oil field facilities, such as oil-wells, water-wells, oil pipelines, hot water pipelines, pipelines for injection, stations, roads and so on, as well as their image data. The second category is production data. It primarily contains maintenance, renewal record of equipments and instruments. The third category is remote sensing images. Data belonging to the first and second category are stored in the database, while remote sensing images are stored as file format.

The spatial data can be stored as point, line or polygon type. In order to avoid digitalizing the feature's boundary, some polygon features are stored as point such as kettle, pump, working rooms and so on. Every feature type is stored as a table in the database and every spatial table is displayed as a layer in the MapGuide software. Totally twelve layers can be viewed.

In order to introduce the table records of production activities convenient and simple, Table 1 shows the structure of the well table as an example, the field 'featid' is the key of the table and the value of 'featid' is unique in the table. The field 'id' is well's id. One well only has one id. The fields 'ssc' and 'ssd' are used to define the owner of the well. The clients who are not authorized as owner of the well are not able to modify the information of the well. The fields 'starttime' and 'endtime' reflect the well's life cycle. The 'endtime' of every running well is infinite. We use '3000-12-12' to replace infinite. If the well owner modifies the attributes of the well, the current information of the well will be deleted, and a new one will be created to store the modified information. For example, there were three wells drilled in January of 2001. Well 1 and well 2 were used in February of 2001. In March of 2001, we modified the information of well 1. In April of 2001, we modified the information of well 2. At April of 2007, the well 1 was abandoned. The information of the table at the time of 2007-04 was thus changed as shown in table 2.

Field name	Field type	Introduction
featid	bigint(20)	Id，Key
id	bigint(20)	Object id
mc	varchar(20)	Well name
ssc	varchar(20)	Owner company
ssd	varchar(20)	Owner team
tysj	varchar(20)	Use time
starttime	varchar(20)	Start time
endtime	varchar(20)	End time
……		
…….		
geometry	Geometry	Spatial data

Table 1. Well table's structure

featid	id	mc	tysj	starttime	endtime	……
1	1	Well 1		2000-01-20	2000-02-22	
2	2	Well 2		2000-01-20	2000-02-22	
3	3	Well 3		2000-01-20	3000-12-12	
4	1	Well 1	2000-02-22	2000-02-22	2000-03-21	
5	2	Well 2	2000-02-22	2000-02-22	2000-04-01	
6	1	Well 1	2000-02-22	2000-03-21	2007-04-12	
7	2	Well 2	2000-02-22	2000-04-01	3000-12-12	

Table 2. Value of well table at April 2007

4. IMPLEMENTATION OF THE SYSTEM

4.1 Structure of the system

The data structure of the system was designed as multi-layered, in general three data layers can be subdivided, i. e. data, logic and visualization layer, respectively. The great advantage of Multi-layer structure lies in its strong capacity for expanding and for quick data loading.

Figure 2 gives the graph of architecture of the system. Every component of the system can be introduced briefly from left to right as follow: Log4j is a tool to help the programmer output log statements to a variety of output targets. Smartupload is a server-side component that can be used to upload files from a client's machine to the server. MapGuide is a web-based platform that used to develop and deploy web mapping applications and geospatial web services. Jxl is used specifically to access excel files to meet the needs to store large amounts of production activity report being compiled in excel format in the oil field company. JFreeChart is a free 100% Java chart library that makes it easy for developers to display professionally qualified charts in their applications.

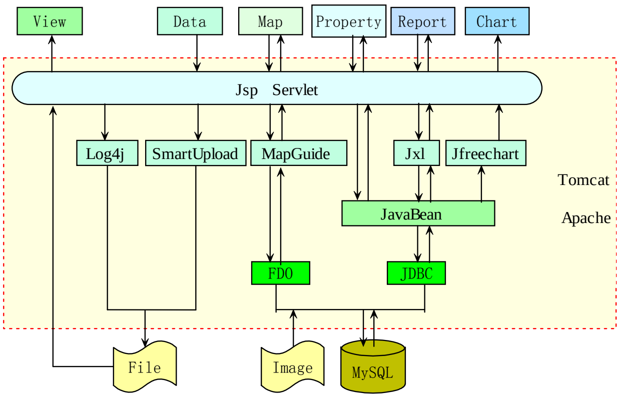

Figure 2. Graph showing the architecture design of the system

To thin clients, users only need a browser to view the data, no any extra plug-ins is need to be installed before browsering. Jsp and servlet files are compiled and executed by tomcat and apache. Mapguide software was adopted as GIS server, which uses fdo to connect mysql database and Quickbird images.

4.2 The development of the system

4.2.1 Struts MVC framework

Model-view-controller (MVC) is an architectural pattern used in software engineering. Successful use of the pattern isolates business logic from user interface considerations, resulting in an application where it is easier to modify either the visual appearance of the application or the underlying business rules without affecting the other. In MVC, the Model represents the information (the data) of the application and the business rules used to manipulate the data, the View corresponds to elements of the user interface such as text, checkbox items, and so forth, and the Controller manages details involving the communication to the model of user actions such as keystrokes and mouse movements.

4.2.2 FastCGI

FastCGI is a protocol for interfacing interactive programs with a web server. FastCGI is a variation on the earlier Common Gateway Interface (CGI); FastCGI's main aim is to reduce the overhead associated with interfacing the web server and CGI

programs, allowing a server to handle more web page requests at once.

4.2.3 Tile cache

To speed up accessing speed, we separate large images into small pieces and cache them in a file folder. For every request, the server first look up the folder, if the tile was cached in the folder, the server will read the tile, if not, it will read the remote sensing image and create new tile, then they will be stored in a specific folder. The adoption of tile cache technique in the developed system dramatically decreases the loading time consumed for high quality image visualizations.

4.3 Implementation of the system

4.3.1 Basic functions

Basic functions of the system mainly contain view, zoom, pan, distance measuring, thematic mapping and simple spatial analyses…etc. User can find object's location via attribute and vice versa. Figure 3 exhibits the start page of the Web-GIS Based Jiangsu Oilfield Management System. The relative geographic location of every oil field can be viewed clearly. From this page, user can click icon of any oil field to access the corresponding target information system as Figure 4 presented. The oil field information system contains several clickable menus, such as layer control panel, property panel, map panel, toolbar, status bar, taskbar. If one would like to browse a specific oil field, only one click, an ichnography of the oil field will quickly appear on screen. As an example, Figure 5 shows an ichnography of Caozhuang oil field in Jiangsu province.

Figure 3. Start page of the Web-GIS Based Jiangsu Oilfield Management System

Figure 4. Graph showing the interface of Jiangsu Oil-field Web-GIS based Information Management System.

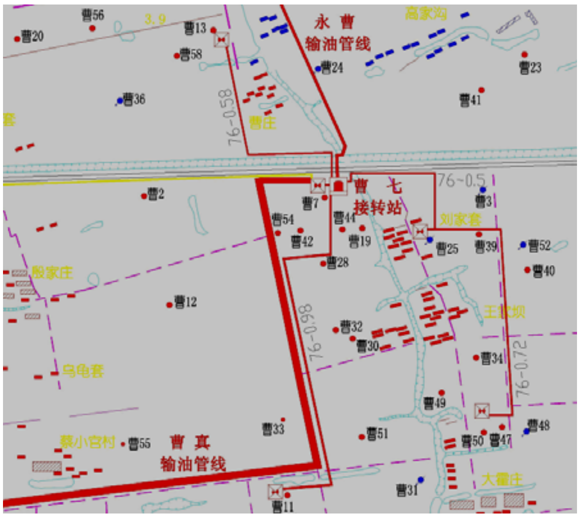

Figure 5. An example of ichnography of Caozhuang oil field

4.3.2 Danger warning

For safe production, pipelines utilized for transferring either oil or water as well as pumping equipments are the most fragile for safety events. When those equipments lack of sustainable maintenance or the equipments are used too long time not being renewal, a danger warning module was developed to automatically alarming. What we have to do is just set the alarm condition. For example, wells have been repaired for three times, pipelines have been used for more than eight years will be alarmed to warn the workers for checking or renewal.

4.3.3 Map management

Different users were assigned different rights to access the database of the system by identity discrimination module. Administrator has the rights to add new wells, add new pipelines, modify attributes of facilities and delete objects, and own the absolute right to fully access the database. Common users can only browse the part of data and information that open to public, Stuffs in charge of specific tasks have the right to manage system data under their proper rights. Data and information updating periodically to database of the system adopts two ways, one is importing data from excel, and another digitalizing the maps. Figure 6 shows the interface telling how to create a new object. The right part is the guideline.

Figure 6. The guideline telling how to create a new oil well information

Figure 7 shows the way to delete an object. If one clicks the delete button, the corresponding object will be deleted. In fact, the object was not deleted physically, what the system has done is changed its 'endtime' value to a new one. If the value of 'endtime' is not '3000-12-12', it will not be displayed in the map, so it seems the object was deleted.

Figure 7. Operations on objects

4.3.4 Historical data review

If one wants to look up historical data and information, just inputs a historical date time, the historical data process model will switch the system to the historical date time by selecting proper data from the database. To meet with multi-user concurrent access, the selected data was stored into a temporary layer which is associated with user's "sessionid". The system deals with every request according to its "sessionid".

5. CONCLUSIONS

The Jiangsu Oil-field Web-GIS based Information Management System was developed based on open source software. Using open source software, we can develop powerful system with low cost. All the data except remote sensing images are stored in the database, so it is convenient for system management and up-grading. Using spatio-temporal data model, we can look up historical information and execute historical data analysis. Although redundancy in data storage of the system still affects the best performance of the system, the data model we designed can meet the system need on the whole.

Future research and development of the system will focus on the application of the system in a range of oil production activity settings through the use of historical data to ensure that the tool can be widely applied with confidence under a range of conditions.

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