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## Design and development of safety production management information system based on a digital coalmine

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### Abstract

Safety production management information system is an important component of digital coalmine. Based on the sufficient demand analysis of digital coalmine, this paper puts forward the structure of safety production management information system and construction of subsystem, and describes the functions of related subsystem.

*Keywords:* digital coalmine; safety production; management information system

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### 1. Introduction

Coalmine information is a kind of information which changes dynamically and relates closely with the spatial position. The rationalization management of information will directly influence the prediction and prevention of coalmine safety problems. How to realize the spatial information share and network service is very important since the information quantity involved is huge which includes geodetic surveying, ventilation safety, realtime monitor and supervision, and video data etc. Digital coalmine is complicated huge system[1]. The overall objective of digital coalmine is to realize coalmine safety production, green exploitation, high yield and high efficiency, and sustainable development under the uniform data management platform based on the technology of mechanical and electrical integration of coalmine, computer science, 3S (GIS, GPS, RS), modern enterprise management system, and network technology. In detail, digital coalmine can achieve the aim of multisource coalmine information collection, input, storage, index, query and professional spatial analysis. It can further make multimode output of multisource information, realtime online analysis, process and decision, expert consultation coalmine accident controlling. Digital coalmine is the integration outcome of traditional coalmine profession technology, mechanical & electrical integration, computer technology and 3S technology. The theories and technologies involved in digital coalmine are the forelands of current information technology development [2].

Generally speaking, digital coalmine comprises three subsystems under uniform data management platform, namely, monitor and supervision and other electromechanical equipments integration management subsystem, administration management (or office automation) subsystem, safety production management information subsystem. Nowadays, the development and application of the first two subsystems has obtained a stage achievement in China, and parts of their application shows remarkable results (such as office automation, gas

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monitor etc). The mechanism of research and development team and talents training is relatively mature. The weakest part of digital coalmine is the subsystem of safety production management information subsystem[3-4], that is, the development and application of safety production management information system. The reason of being weak can be listed as follows: 1) Theories and technique method fall behind; 2) The specialties are over-divided and can't be integrated. The cross-sectional research achievements among different specialties are relatively less; 3) Network techniques are not fully used; 4) The system has not been executed strictly according to the thought of software engineering and there is no an information-oriented management system; 5) Software development units have no sustainable core technique, management structure and economic strength.

Aiming at the above-mentioned problems, the joint laboratory for digital coalmine of the Institute of Remote Sensing and Geographical Information System of Peking University & Beijing Longruan Software Science and Technology Limited Company have made lots of research in recent years. They put forward the theory of grey geographical information system and a series of core technique and methods [5], and developed professional coalmine geographic information system platform and safety production management information system. The major purposes of the development of safety production management information system are: 1) Change the safety production management mode of the mining industry groups, namely, from the traditional manual management mode to the information based management mode in order to greatly improve the production techniques and safety management level and lower down safety problems. 2) Realize the information based management of mine production process of mining industry groups (such as geodetic surveying, ventilation and gas-proof, dust-proof, fire-proof, mining and power supply design, mechanic and electronic equipments management, scheduling, safety management, remote monitor and supervision, operation regulation compiling, dangerous source early warning, etc.), such as the automatic processing of figure and chart and decision-making analysis. 3) Implement the sharing and dynamic management of all production information by the group company, mine production related technique and management department based on the uniform geographic information system and database management platform, and get rid of "information isolated island". 4) Ensure the management and technical personnel can carry out querying, processing, analyzing and deciding of the mine production information as long as they can access the network. 5) Construct the collaboration platform according to the characteristics of multiregional distribution of production mine among mining industry groups, and achieve the aim of "normalized management, responsibility to person, keep in house, commanding the overall situation".

## **2. Structure of coalmine safety production management information system**

The design and structure of the system is listed as Fig. 1. This system can manage the data and graph of coalmine geology, surveying, hydrology, reserves, ventilation, design, safety, machine electricity, transportation, and digging based on C/S + B/S mode. Founded on the group company network platform, the system can also realize the function of multilayer (production and technique team, mine management team, group company decision-making team) user management, query and analysis, remote controlling, monitoring, and supervising base on WebGIS. According to the overall system structure, the graph system is developed under GIS mode, the database adopt SQL Server or Oracle, the remote management system is developed and integrated according to .NET environments, and the C/S mode of professional fundamental application system adopt VC++, etc. Furthermore, the graph processing system should provide the data interface of the format of AutoCAD, MapGIS and MapInfo as well as support the output in Excel format. Therefore, the system is a typical spatial information sharing and Web cooperation platform for geology, surveying, ventilation, and safety data variation management among multi-department, multi-specialty, and multilayer. Among the system, coalmine geodetic surveying data is an important part of system running and data processing whose change will result in the change of coalmine related theme map and group company theme graph. Geodetic surveying data is a kind of dynamic accumulated data and time series data. From the stage of resource prospecting, coalmine development to production process, geodetic surveying information becomes more and more huge which can more appropriately reflect the subterranean spatial entities. The increase of geodetic surveying information will result in the dynamic modification or adjustment of related production and safety information which needs long-term storage so that they can be called at any time to realize the information sharing, comprehensive analysis, application, and Web cooperative processing among multi-specialty.

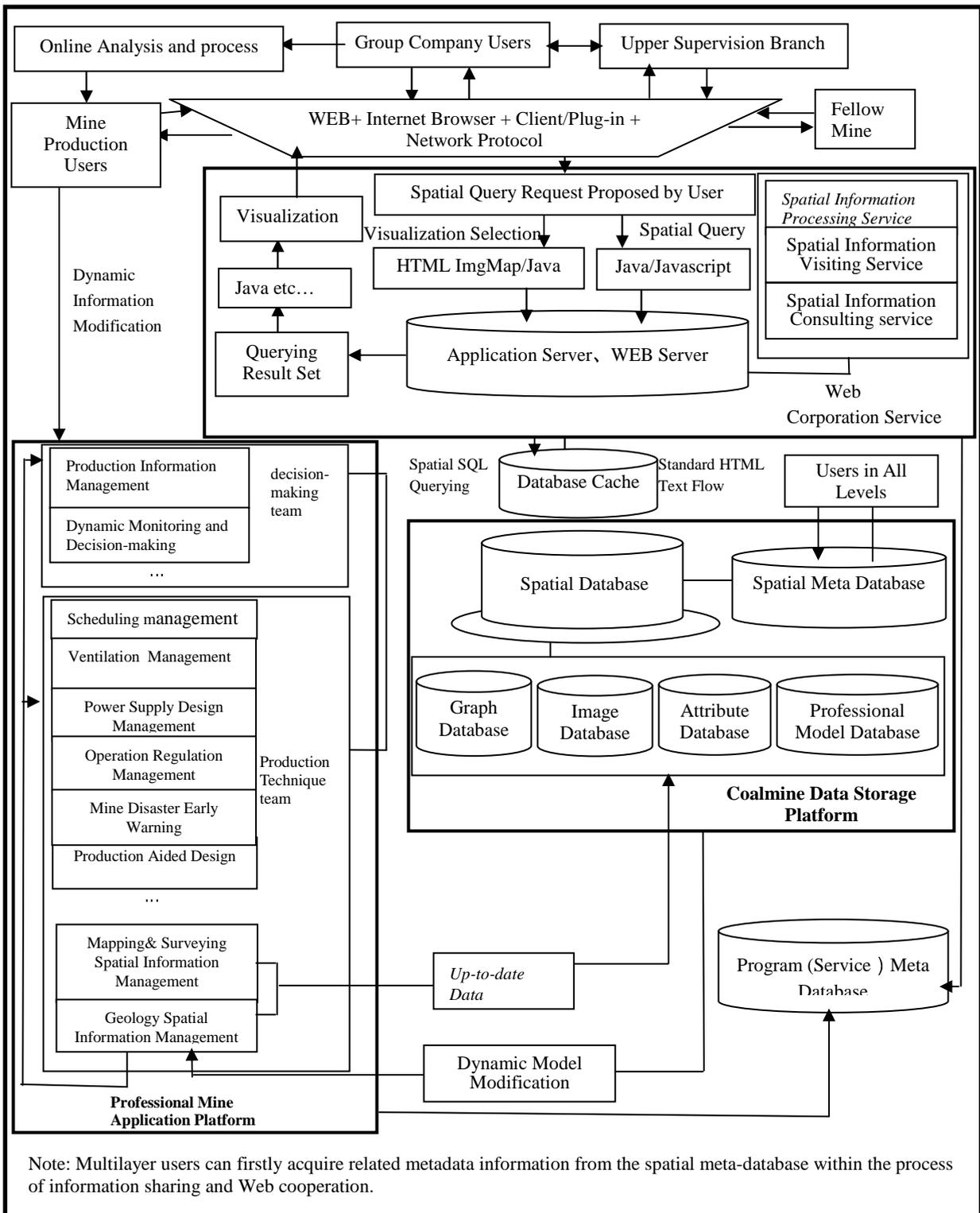


Fig.1. The structure of coalmine safety production management information system

### 3. Implementation of coalmine safety production management information system

Coalmine safety production information belongs to spatiotemporal information whose corresponding basic data processing platform should be geographical information system. According to the particularity of coalmine safety production data, its professional geographic information system should satisfy the following requirements: 1) It can integrate CAD, GIS and MIS and make the processing of selection, freezing, editing, copy, moving, mirroring, trim, and extension of the arbitrary graph and entity objects It can make calibration and vectorization of the scanned graphs and have adequate functions of measurement annotation, lithology filling, and parameter modification and snap. 2) It has complete functions of 2D GIS and 3D visualization, which means not only point object, arc object, area object and equipment object can be embedded, but also the topological analysis can be processed to satisfy the requirement of professional integration management. In addition, any graph element can be organized as professional object and connected with the database to make interactive query among graph, text, and database. Furthermore, users can also modify or establish database according to their own demands so as to make arbitrary extension and realize the 3D spatial management of surface and underground of mine.

It can automatically establish the 3D model of ground building, surface water, highway, terrain, laneway, drill, and tube road and directly generate 3D visualization graph based on 2D graphs (attribute included). The query result can be associated between 3D model and 2D object. Additionally, it can fulfill the function of 3D slicing, reserves calculation, production route setting and display, etc. 1) It can provide professional mining standard database by different category (such as symbol database, linetype database, and lithology database of geodetic surveying, mining, ventilation, power supply, water supply and drainage. All annotations should accord with national and industrial standard and can be expanded arbitrarily. 2) It can automatically generate all kinds of theme graphs according to the original data, such as planar graph, histogram, profile, and design graph. The laneway graph of the whole mine or mining area can be automatically sketched based on surveying data and the complicated spatial relationship of laneway can be automatically processed without modification and reedit. All the computation of reserve blocks and security pillar of coal seam can be carried on the graph directly. 3) The system can integrate a series professional function of the geodetic surveying spatial management information system, mining design system, ventilation and gas-proof, dust-proof, fire-proof management information system, power supply design system, and safety management information system etc. Users can customize the professional subsystem and implement the profession information sharing and dynamic linkage of various theme graphs in the system in order to provide a uniform visualization system for mine exploitation, design, safety, management and decision-making. 4) The system should provide the import and export function of multi-database (include SQL Sever, Oracle, DB2, Access, Excel, Foxpro, PostgreSQL, Txt etc). Users can make full use of the software system data developed by other units. 5) The system should fulfill the exchange of geometrical and attribute information among different systems such as AutoCAD, MapGIS and MapInfo and keep the integrity of symbol and filling. Not only the database report forms can be transferred into the format of Excel and Html, but also the related documents can be converted into the Word format for the convenience of communication and reediting. 6) Users can choose construction structure and operation mode (stand-alone mode, C/S mode, and B/S mode) flexibly according to their own circumstance. 7) The system should satisfy the business requirement of the functional department of the group company (general office, geodetic surveying department, production department, development department, machine and electricity department, ventilation center, and safety supervision bureau, etc) and provide the function of customization of report forms, integrated query, decision-making and alarm hinting.

According to the professional coalmine geographic information system and database management platform, coalmine safety production management system comprises the following subsystems:

#### *(1) Geodetic surveying spatial management information subsystem*

It mainly includes the management of graph and attributes data of geology, reserves, surveying and hydrology, etc. It also includes the complex computation and data sharing of various data. The system can construct 3D geometric model of mine and generate geodetic surveying theme graph automatically based on original geodetic surveying data.

The system possess the function of the inputting and processing of geodetic surveying book-keeping and graph, 3D geological modeling, reserves management, 3D visualization management, automatical generation of theme graph, modification and revision of geological reports. The compiling of theme map should accord with the national

and industrial standard. In addition, it can complete the calculation and graph processing of security coal pillar, and surface subsidence prediction etc..

*(2) Ventilation and gas-proof, dust-proof, fire-proof management information system*

This system can implement the tracing management aimed at the information of ventilation and gas-proof, dust-proof, fire-proof which mainly include the dynamic data computation and processing. It can also automatically alarm and dynamically highlight the potential disaster information, and make decision analysis by the leaders or supervision departments. In detail, the system has the following functions:

(2.1) Process ventilation system map, disaster avoiding path map, dust prevention system map, and ventilation network map.

(2.2) Select ventilator types, resolve network of natural splitting of air or according to need.

(2.3) Optimization design, reconstruction, adjustment and control of ventilators.

(2.4) Ventilation network management, ventilation reporting, fault diagnosis, and disaster processing.

(2.5) Provide a comprehensive solution to the problem of air volume step by step.

(2.6) Afford aided decision-making to unexpected incidents.

*(3) Production aided (mining) design management information system*

This subsystem mainly includes the design of working face, laneway intersection, laneway cross-section, blast-hole, water sump and power substation, etc. The subsystem provides design tools driven by parameters. For normal design, the system can automatically generate design map, plans drawing, project quantity form, and equipment and materials form. For the circumstance of parameter database provided, the system can carry on type selection and calculation of the belt, support, and support method, and draw conclusion.

*(4) Machine electricity design and management information system*

This system integrates the functions of mapping, calculation, management, optimization and statistics. In detail, it can fulfill the following function simultaneously:

(4.1) Establishment of equipments parameter database.

(4.2) Drawing of power supply system map, water supply and drainage design map and transportation system map.

(4.3) Data calling, annotation, modification, storage and output.

(4.4) Calculation of fault current, relay protection equipment adjusting and visualization management of power grid data.

For elevating transportation, system will establish detailed technological parameters, automatically plot elevating transportation system map and calculate all parameters in order to carry on equipment type selection. The system can save the information of technique renovation, malfunction, incident and backup equipments and carry on regular alarming and updating for the maintenance of the wire rope. All the technique renovation projects are organized under the computer environments from the beginning to the end.

*(5) Production technique management subsystem*

This subsystem mainly includes the management of work face information, laneway information, production information, linkage plan project, monthly linkage plan, yearly linkage plan and production technique report forms, etc.

*(6) Production scheduling management subsystem*

This subsystem mainly includes the management of raw coal of mine, coalmine digging, production prepare work, team attendance, day and night shift situation, basic-level unit cater supervision, scheduling record and safety production reporting, coal transportation, coal washing volume and road export, production forecast and prediction, key team work progress, daily safety situation, leading directions and important problems of leader, production analysis. The subsystem also establishes scheduling graph database and daily scheduling report form management database which can manage scheduling graph by category and manage daily scheduling report forms from remote distance respectively.

*(7) Emergency rescue controlling information system*

The system runs under the platform of coalmine LAN and cellular phone message. The system can realize high efficient, scientific and intelligent management of emergency responding and rescue controlling in the application information platform based on the improvement of current paper proposal and traditional corresponding methods.

*(8) Remote realtime monitoring management subsystem*

The system can realize realtime management of the on and/or off status of the gas, temperature, air volume and pressure, mine pressure, machine and electricity equipments. The main data source comes from the monitor and supervision systems, like KJ series and CONSPEC series, etc. By establishing uniform database form, the system can automatically read monitor and supervision data from the interface so that the realtime tracing of various data such as gas, temperature, etc. can be implemented and alarm can be made in case of problems detected. In addition, based on the visualization method of 2D or 3D, monitor and supervision data can be reflected not only in the illustrative excavation map, but also in the excavation engineering plane diagram or stereogram coming from the geodetic spatial management information system.

*(9) Early warning system for mine disaster*

The system can develop the model of disaster identification, forecasting, prediction, early warning and prevention based on the excavation engineering plan diagram, ventilation diagram, and gas geological map and implement the omnidirectional digital management of disaster prevention during production process based on the function of spatial analysis. The system comprises graph subsystem and remote management subsystem. The function of graph subsystem includes digging work face mapping, mining work face mapping, ventilation monitoring equipments appending, gas geology information mapping, mine disaster area location (for example, high gas area, fault, water bursting area, old laneway, coalmine water accumulated areas, collapse area, coal spontaneous combustion area, etc) and early warning evaluation for disaster based on spatial analysis technique.

*(10) Safety management information system*

This system establishes the management subsystems of official document, safety and surveillance organization, industrial accident, safety evaluation, safety technology training, and quality standardization according to coalmine safety management mode as well as provides accident tree model and check point disposing plan. One of the key techniques here is to analyze and calculate the diversified accident tree in order to inspect and eliminate the potential accidents and rectify the production system to meet the requirements of essential safety coalmines.

*(11) Quality standardization management subsystem*

This subsystem is used to carry on quality standardization evaluation management of mining industry groups, mine wells. The coalmine safety quality standardization includes the safety quality standardization of mining, digging, machine and electricity, transportation, ventilation and water safety.

*(12) Safe production management information system based on web*

The system can process the input, computation, statistics, analysis and output of the data of geodetic surveying, production scheduling, production technology, mine well safety, ventilation and gas-proof ,dust-proof,fire-proof, quality standardization and machine and electricity management roundly and fulfill the function of remote query, measure and analysis of coalmine maps based on WebGIS. System should also have elegant and user-friendly interface, easily understandable command, profession tailored authority and practical application. The system can reflect the realtime status of mine safety production, scheduling management and electromechanical maintainance thoroughly so that the leaders can acquire realtime information safely and reliably and make online decision analysis.

*(13) Digital archive library*

Here it mainly indicates the storage, management and query of safety production related multimedia (remote query based on network technique included).

#### 4. Conclusions

Though information-based construction of coalmine safety production has obtained certain achievements in our country within the last decades, its application has not reached the expected effect. For the problem existed in the information-based construction of coalmine safety production, author put forward the software development mode based on the uniform coalmine professional geographic information system and management platform and successfully develops coalmine safety production management system. This system has been widely used in 17 provinces, over 60 mining industry groups, nearly 600 large coalmines or coal enterprises among China which makes great contribution to digital coalmine construction.

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