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Overview of Digital Mine

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Abstract: At the background of developing digital mine rapidly, this study discusses the main contents of digital mine and gives brief descriptions of the components of digital mine. It also introduces the development of 3D technology in detail, describes the present developments and the existing problems of digital mine and shows the direction for creating a safe, high-yield and high-efficiency digital mine.

Key words: Information technology, framework, digital mine, 3D model

INTRODUCTION

With the developments of computer network technology, software technology, virtual reality, scientific visualization, operational research and automation, the idea of being digital has been deep into every profession. The concepts of Digital Earth and Digital China have affected our daily life deeply. In recent years, mining firms in our country also make the digital construction one by one. But compared with the developed countries, the degree of mine information is not enough. In order to create high yield and high efficiency mining production, mining enterprises should develop Digital Mine rapidly.

Mining industry is a profession with the aim of mining natural resources. Its progress directly influences the development of national economy. Our country is a big mining country. The statistics show that our country has built more than 10,000 large and medium-size mining enterprises and more than 110,000 small-size mining enterprises. Mining accidents frequently happen in our country, according to incomplete statistics, more than 110 mining accidents happened in 2005, more than 300 in 2006, more than 150 in 2007, more than 120 in 2008 and more than 70 in 2009. There are more than 150 mining accidents every year on average. The frequently-happened mining accidents tremendously affect our living and production and they also bring severe hurt to the miner's family.

In a word, to achieve the fine management of production and digitalization of safety management so as to provide the decision support and information assurance for the safe, high-yield and high-efficiency digital mine, based on the current development situation, it is significantly meaningful to develop digital mine rapidly.

COMPONENTS OF DIGITAL MINE

Many institutions and scholars at home and abroad proposed their own opinions and thoughts for the key technology and construction scheme of digital mine from every aspect (Lixin *et al*., 2000, 2003, 2004; Lixin, 2000, 2008; Qing *et al*., 2004; Daiyong *et al*., 2005; Yinuang,, 2005; Dexian *et al*., 2005; Dewen *et al*., 2005; Liguan *et al*., 2006; Binbin and Junwen, 2007; Shen *et al*., 2007; Li, 2009; Yaowei *et al*., 2009). Digital mine is an intelligent being based on the digitization of the mine. It can provide the precise and real-time information collection, the networking transmission, the normalized integration, the visual show, the automated operation and the intelligent services to the mining enterprises, the framework of digital mine is shown in the Fig. 1 (Xinming and Hong, 2010).

Network platform is at bottom of the framework and it is the main source of the fundamental data. This platform can realize the digital transmission through intranet. With exploration, measuring and sensing data of multimedia and real-time database, this platform can realize the information collecting, transferring, storing, analyzing, decision-making, releasing and querying. It not only ensures information to be interchanged, but also guarantees the security, reliability and instantaneity of information.

Data warehouse of mine is mainly responsible for the integration of polyphyletic heterogeneous data. The geological data has characteristics of complexity,

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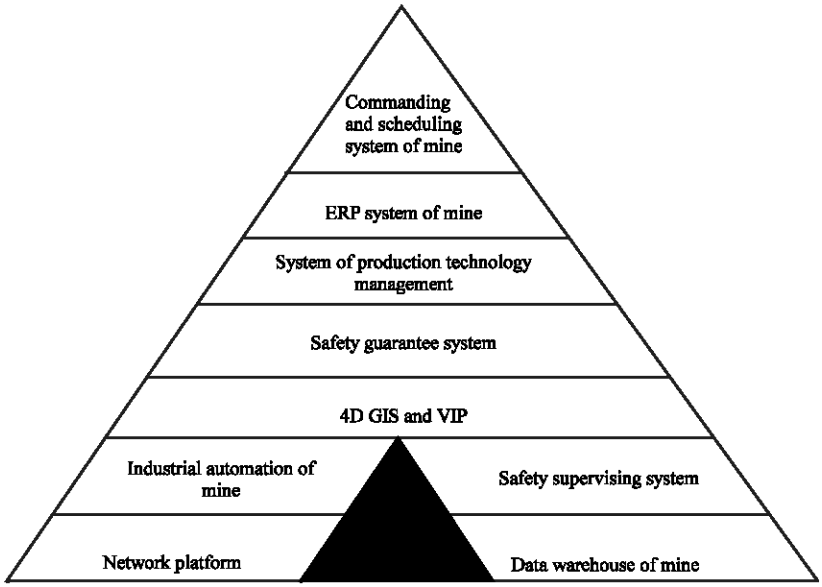

Fig. 1: The framework of the digital mine

large quantity, heterogeneity, dynamics, multi-precision, multi-date and multi-scale, so we should establish the standard thematic layer, set up the normal database structure and define the normal metadata, the indexed data and the data cube so as to import and export data conveniently or mine data automatically.

Industrial automation of mine can effectively collaborate with the data warehouse, the safety supervising system, the safety guarantee system, system of production technology management and scheduling system to implement the automatic and remote control through the software system of integrated platform.

Through monitoring the production environment, hydrology, underground pressure, gas and surface rock movement, the safety supervising system provides the real-time data to the data warehouse, the safety guarantee system and scheduling system and these data can be scheduled by decision support system.

Four-Dimensional Geographic Information System, (4D GIS) and Visual Integration Platform (VIP) are to build true three-dimensional model of mining geographic information that includes building, stratum, ore deposit, ore body, roadway engineering, stope, mining cell and so on. Through 3S (Global Positioning System, GPS; Remote Sensing, RS; Geographic Information System, GIS) technology, various methods of exploration, measurement and collection, the dynamic information is obtained so that the model attributes could be corrected in real-time and then the complete four-dimensional temporal geographic information system is formed. In other words, it means to establish the unified 4D GIS based on space and time.

Safety guarantee system realizes the transparent management for all objects of ground floor and underground based on 4D GIS. The specific contents are shown as follows:

- Establishing the intrinsic safety inspection, supervision and evaluation system
- Establishing the mechanism study of the important mine disasters and the accident simulation system
- Establishing the hazard identification and disaster early-warning system
- Establishing the hidden danger investigation and accident-forecasting system
- Establishing the decision support system of disaster prevention

System of production technology management is the core content of digital mine, it mainly includes geological survey GIS, mining collaborative design system, intelligent mine ventilation and prevention system, power transmission and distribution GIS and industrial pipe network GIS.

The ERP system of mine is an information assurance system for achieving fine managements of mine. It mainly includes human resource management system, equipment management system, materials management system, transportation management system, production planning management system, property management system, budget and cost management system, financial management system and office automation system.

Commanding and scheduling system of mine can implement the function of supervisory control,

communication and personnel localization based on 3D visualization platform. It is an integration of safety guarantee system, system of production technology management and ERP system of mine. It can automatically assemble the required data, document, graphics, multimedia and 3D model through data mining tool that are provided to decision-making team to implement the operations of superposition, sectioning, computation, simulation and so on. It can be decision-supported with the relevant approach library when necessary. Once disaster happens, besides decision analysis and fault diagnosis of the system, we can take advantage of the ability of time-space management and quick reaction to achieve optimal scheduling and emergency command of visualization, so that the loss can be minimized.

THE DEVELOPMENT OF 3D MODEL IN DIGITAL MINE

The 3D geological modeling is one of the key technologies that are used to implement digital mine, so it has become one of the hotspots of geological research at home and abroad (Breuning, 1999; Daiyong and Zhangang, 2004; Wei *et al*., 2004). In mining area, people use visualization technology to show those extremely irregular entities in a visual way that include geologic structure, ore body, exploration engineering, roadway and so on, which can help the geological workers to deal with large volume data of field surveying and sample analyzing, effectively guide the mining development and reduce the risk of solid exploration. Therefore, there are many 3D geological modeling theories and methods, for instance, S.W. Houlding proposed the concept of 3D geological modeling, J.L. Mallet proposed the 3D geological modeling of the DSI (Discrete Smooth Interpolation, DSI) and D.G. Krige proposed the Kriging method of geostatistics.

With the deep development of the 3D geological modeling and the basic theory of visualization, the geological industry of home and abroad began to introduce the 3D visualization technology into the area of production. There are a number of 3D visualization softwares, such as Australian Micromine, Geocom, MinCom, Surpac, MineMap and Vulcan, British Datamine and Minescape, American MineSight, Mintec and MVS, Canadian LYNX and MicroLynx and so on. There are also some modeling softwares of oil industry, such as French GOCAD, British 3Dmove, American Petrel and so on.

The CAD (Computer Aided Design, CAD) is to use computer and its graphic devices to help people to do the designing work. it is the main tool for 3D modeling. The application of CAD technology in the mining industry started earlier and it is almost synchronously developed with computer graphics technology.

In 1980s, there were some mining CAD software systems with relatively-complete function. For example, D. Hartly *et al.* developed the design software of underground mine. By the mid-1980s, there were several commercial software systems that were applied to surveying calculation of geology and mining aided design, such as Minex3D, Surpac, Minesight, Geo-Model, Geostat, Lynx, Mincromine, E2gales, MinCom, Datamine, Vulcan, Earthwork and so on. These softwares were used to describe deposits and manage raw data of mine. In 1990s, overseas mining software developed rapidly, especially in 3D geological modeling, it involves geological data processing, geological modeling and mining aided design.

THE PRESENT PROGRESS OF DIGITAL MINE

In the domestic mining industry, some mining softwares have been developed. These softwares are mainly used to solve some specific and professional problems. For example, CAD software for stripping-mining plan of open-pit mine which is developed by Black Metallurgical and Mining Design Institute of Anshan use CAD technology to make the short-medium term stripping plan of open-pit mine, its original data are plans and profiles of geologic layer which are used to complete the computer simulation of stripping-mining plan of open-pit mine and output the engineering drawings. The ENFI (Central Engineering Institute for Non-Ferrous Metallurgical Industries, ENFI) mainly use statistical methods to analyze the geological explorating data, build grade-tonnage model, lithology model, relief model and output various block diagrams of plan and profile, these operations provide the basis for the mining design of deposits. The DM and MCAD software system developed by Central South University can draw geological plans, profiles and engineering drawings of mine.

Shandong University of Science and Technology and Shandong Lionking Software Company Ltd have made a breakthrough on the software development of digital mine and the construction of mine information. They have developed the basic system platform, Lionking Geography Information System and CAD Platform of 3D Underground Engineering, which have the complete independent intellectual property right and powerful function. Based on these platforms, the Lionking digital mine platform software owning the CAD core and GIS core have solved a series of difficult problems, such as

mine ventilation system and the model algorithm of nonlinear pipeline networks (Xinming, 1988, 1989), the detection about rock burst of mining roof (Yunliang *et al*., 2000), the interaction between supporting structure and surrounding rocks of circle tunnel (Baoguo and Xuedong, 2004) new method for modeling the parametric drawing system of mining CAD (Xingli *et al*., 2010), new algorithm of constructing the 3D pipe wireframe model (Xianmei and Xinming, 2004), modeling the complicated geological body containing cross-bedded faults (Jingjing *et al*., 2007) and so on.

Based on the Lionking digital mine software platform, the research group has developed many seamlessly-integrated software system, such as geological survey GIS, mining collaborative design system, intelligent mine ventilation and prevention system, power transmission and distribution GIS, commanding and scheduling system of mine based on GIS, safe management decision support system, water supply and drainage CAD system, equipment management system, human resource management system, materials management system and so on. These systems are widely used in large scale coal mine, gold mine, iron mine and geological prospecting department, which lay the foundation of fulfilling digital mine.

THE EXISTING PROBLEMS OF DIGITAL MINING TECHNOLOGY

For creating digital mine, many mining enterprises in China have increased investments in the information construction. In view of the current digital mining technology, there are some problems to be resolved:

The function of CAD platform is poor. Besides the poor scalability of graphical library, linear library and lithologic library, the functions of drawing and editing the graphics are less comparing with AutoCAD and the generated mining maps do not conform to the standards of Chinese mining industry.

The intelligence of 3D modeling and reserve evaluating is poor. With regard to the stratiform structure, massive structure, lenticularity, complex ore bodies and the non-integrated complicated geological structure that contains reversed normal faults and collapse column, the system does not provide the precise high-intelligent automatic modeling method. Most software has to rely on human-computer interaction which can not guarantee the uniqueness and accuracy of the model. For reserves estimation, the exploration data, the minerogenetic map and the information of geologic structure can not be fully used by vary methods, such as geostatistics method, bilinear interpolation method, distance power inverse ratio method, Thiessen polygon method, trend surface method, spline interpolation method, artificial neural networks, fractal geometry and so on. Reserves evaluating results are also not scientific, reasonable and standard.

There are no unified standards of mining database. Only some drilling data formats, ventilation network data formats and some logging data formats are similar to those of the international standards, the other data mining formats are different. This problem brings great difficulties in data exchanging and sharing.

The mining design is non-systematic. It doesn't own the ability of automatic layout for roadway engineering and it is also lack of integrated collaborative design with mining, transporting, ventilating, safely monitoring and so on.

The aim of developing mining technology is to achieve digital mining and remote mining. For achieving these objectives, based on the precise 3D modeling and VIP, we should establish the standard mining data warehouse, study and develop software packages of intelligent mining, collaborative design and programme evaluation system and implement intelligent scheduling system and safe guarantee system based on 4D GIS.

CONCLUSIONS

Combined with the research of domestic and foreign digital mine, this paper discuses the developments of digital mine. The main contents are listed as below:

- Introducing the main framework and the components of digital mine
- Analyzing the current developments of 3D technology
- Pointing out the present developments and the existing problems of digital mine

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