Study on Digital Mine and Related Key Technologies

Jinxing Hu[1] Lixin Wu[1] Zuoru Yin[2] Anwen Qi[1] Keming Yang[1] Chunbo Liu[3]

[1] *Dept. Resource Development Engineering*
Beijing Campus, China Uni. Mining & Tech. (CUMTB)
D11, Xueyuan Road, Beijing, P.R.China, 100083
Tel: 86-10-62331012, 86-10-62391035; Fax: 86-10-62325016
E-mail: hjx@mail.cumtb.edu.cn, wlx@mail.cumt.edu.cn

[2] *Kailuan Mining Bureau*
Tangshan, Heibei Province, P.R.China, 063000
Tel: 86-0315-2823811-22782
E-mail: yzru@ts-user.he.cninfor.net

[3]*CyberGIS Studio , Peking University*
Beijing, P.R.China, 100871
Tel: 86-10-62751962, 86-10-62751964, Fax: 86-10-62751964
E-mail: pklcb@263.net

ABSTRACT Digital Mine (DM) is an important part of Digital Earth (DE) or Digital China, which concerns the mine's production and the sustainable development of mine city. This paper analyzes the key technology of DM including Mine GIS (MGIS), 3D Geoscience Modeling (3DGM), network and distributed store, visualization, VR, Virtual GIS (VGIS), etc. Besides, the technical problems of MGIS, the working principle of MGIS, the networking architecture and networking data stream of Internet/Intranet MGIS, and the scheme of the development of DM are discussed.

KEY WORDS Digital Earth, Digital China, Digital Mine, Mine GIS, 3D Geoscience Modeling, Visualization, VR

1. Introduction

A new wave of technological innovation is allowing us to capture, store, process, display and utilize an unprecedented amount of information about our planet including environmental, social, economic and cultural phenomena. Today, we often find that we have far more information than what we do know-how. We have insatiable hunger for know-ledge, whereas a great deal of data remains unused. The key issue of taking advantage of this flood of geo-spatial information will be making sense of it – to turn raw data into understandable information. By using of the Digital Earth (DE), the geo-spatial information will be presented visually and help people to understand it. Thus, we say that, the DE is a virtual representation of our planet. It enables people to get perception and to make use of the vast amounts of natural, cultural, and historical data related to the Earth.

Informatization, networking and globalization are the main characters of the information era. The information technology will convert and affect our working, living and thinking manners. This conversion and affection will be tremendous, egregious and stirring. The presentation of the DE is no doubt the most important issue of information era.

As a long-term development strategy and a science & technique policy to promote the development of Geoscience, informatics and the associated industry, DE has been discussed more and more. The Development of DE and Digital China will be beneficial for the sustainable development of agriculture, the protection of environment, the mitigation of natural disasters, and the development of economy and human society. DE will play an important role in enhancing the quality and promoting the application of Geoscience-related fundamental researches.

In China, DE had been applied and made many achievements, such as Digital Yangtze River, Digital Hainan, and so on. Besides, the Government puts forward the strategy of Agriculture Informatization, which can be treated as the beginning of trade DE. Coal is the chief source of energy of China, developing Digital Mine (DM) is imperative. As an important part of DE or Digital China, DM mainly transacts the mine's production and the sustainable development of mine. DM will play an important role in enhancing the quality and promoting the mine's informatization construction, coal rational mining, environment protection, disasters avoiding, etc.

DE is based on computer and network communication technique, GIS, VR, Database, etc. DM not only has the characters of DE, but also has the mine characteristics and demands, such as

dynamic change of surface and underground environment, large scale Geo-engineering and 3D Geoscience modeling (3DGM) etc.

The information of a mine is massive. How to organize, store, process, display, shared and utilize the massive mining information are the critical problems. It has important meaning to apply the idea, theory of DE to DM. Based on this, this paper mainly study the key technology of DM and its solving scheme.

2. MGIS and 3DGM

Mine is a compound ecological system including social, economic and natural subsystems, and needs complexity, open, dynamic characterized, which is the important domain for GIS application. As a powerful technique guarantee to deal with and to analyze spatial mine data, MGIS is a typical engineering 3DGIS, mainly solved the problems of real 3D, dynamic modeling and multi-object planning in Geoscience and mine engineering fields. Its core technique is 3DGM. It utilizes geophysical exploration, boreholes to obtain different kinds of Geoscience information, applies GIS, Geomathematics, VRML and other techniques to build 3D spatial Geoscience model, conducts 3D Geoscience modeling, applies visualization technique to verisimilitude the appearance of the 3D Geoscience object by graphics and image. So, we can carry out 3D Geoscience analysis, excavation design, decision-making and mining planning based on MGIS. It is helpful to improve the quality of the exploration geological information, to make deep study and analysis for geological problem, to make accurate Geoscience analysis, to instruct effectively mining and to make full use of the rare mineral resource.

Modeling and simulation will give us new insights into the data that we are collecting about our planet. While MGIS needs a unique concept and approach to describe and to present the irregular, nonuniform and discrete geological objects, such as stratum, mineral body, fault, fold, and cavity etc. Besides, complex man-made and natural constructions such as tunnel, shaft, roadway, terrain, coal seam, galleries, mine-out areas, are also complex entities to be considered. The uniqueness derives from its ability to represent either simple or complex irregular shapes with equal efficiency and precision, to accommodate the interactive geological interpretation process, to apply geological control to the variable prediction and to apply geological volumetric determinations. The volume modeling technique can meet the requirement. This technique utilizes the advantages of many of the techniques that have been developed and applied in the past decades, and integrates and extends them to meet the requirement of MGIS so as to overcome the limitations and deficiencies of earlier techniques. The new technology is comprised of conventional statistical analysis, geostatistical analysis of spatial variability, geostatistical prediction of variables, 3D grid (or raster) models as data structures for representing of the spatial variation of variables, triangulated surface approach for creating models of relatively simple geological conditions, enhanced visualization techniques that have been evolved in graphics animation, and so on. It can be seen these from Fig1.

The Above are the original impulsion and goal for making our decision to develop MGIS. It can be seen from Fig.2 that the TT-MGIS software developed by CUMTB can realize some of these functions. Fig.2 illustrates a demo of the integrated management of mining map and the mutual query of the spatial graphic data and the non-graphic attribute data of Tangshan Mine.

The core technical problems of MGIS and 3DGM include: 1) 3D visualization; 2) 3D spatial interpolation; 3) 3D spatial data analysis; 4) Identification, interpretation, description, orientation, and presentation of strata, orebody, geological structure, which has uncertain spatial position, spatial distribution, spatial shape and spatial trend; 5) Uncertainty of the spatial relation, spatial statistic, spatial relevancy, spatial contrast, spatial trend and spatial movement. Besides, the visualization design, tenor model and influence analysis of the excavation space and its shoring, are the important engineering applications of 3DGM and MGIS.

3. Networked and Distributed Store

The characteristics of mine information is multi-mode, heterogeneity and isomery, not only includes the data, literal, graphical and form data, but also includes audio and video data. These information form hypertext and hypermedia that can be accessed and be manipulated by HTML, HTTP, and

URL at the Intranet/Internet so as to realize distributed store, manage and share. The data quality is then controlled to guarantee the precision, currency, completeness and reliability. But the informatization state of the mine is relatively backward and is waiting for rapid improving of the informatization state. And the present Intranet/Internet cannot meet the requirements of the DM. We must emphasize at developing the mine informatization construction and the Internet/Intranet

technology such as VBNS, Internet (NGI) and

Internet2. So the basis of DM, i.e., the open true. network and massive distributed store can come

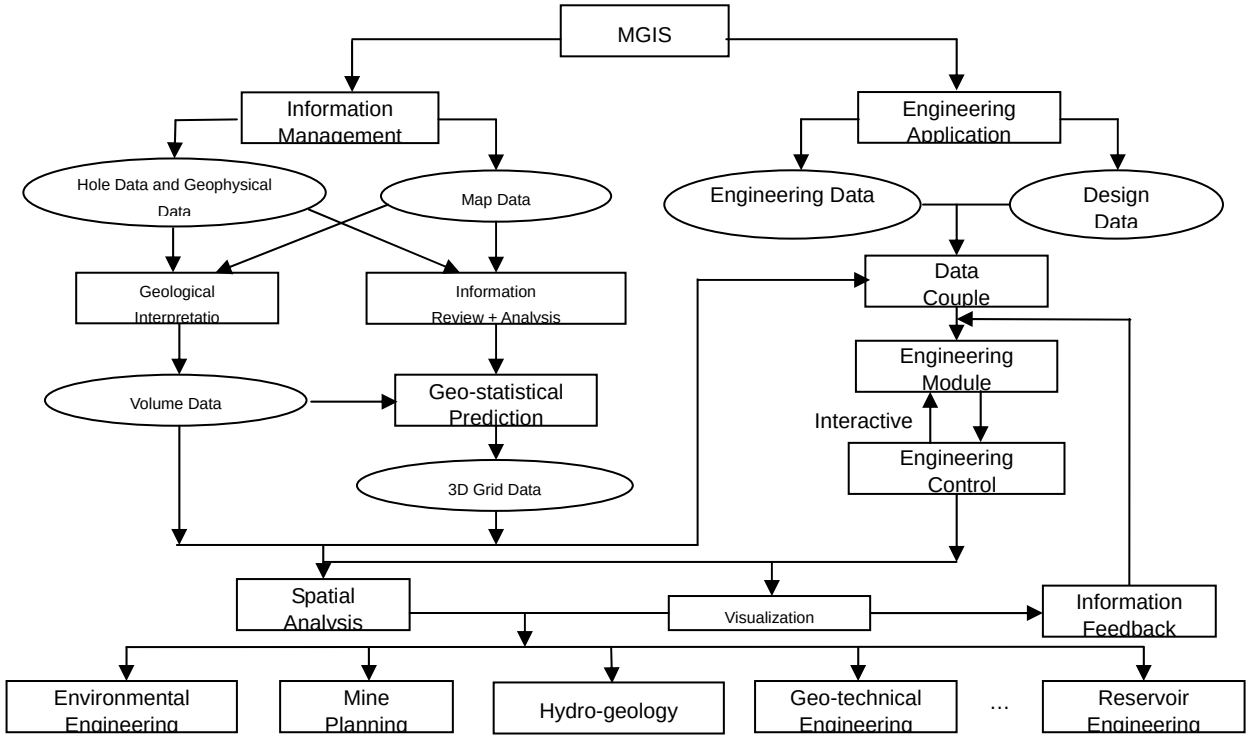
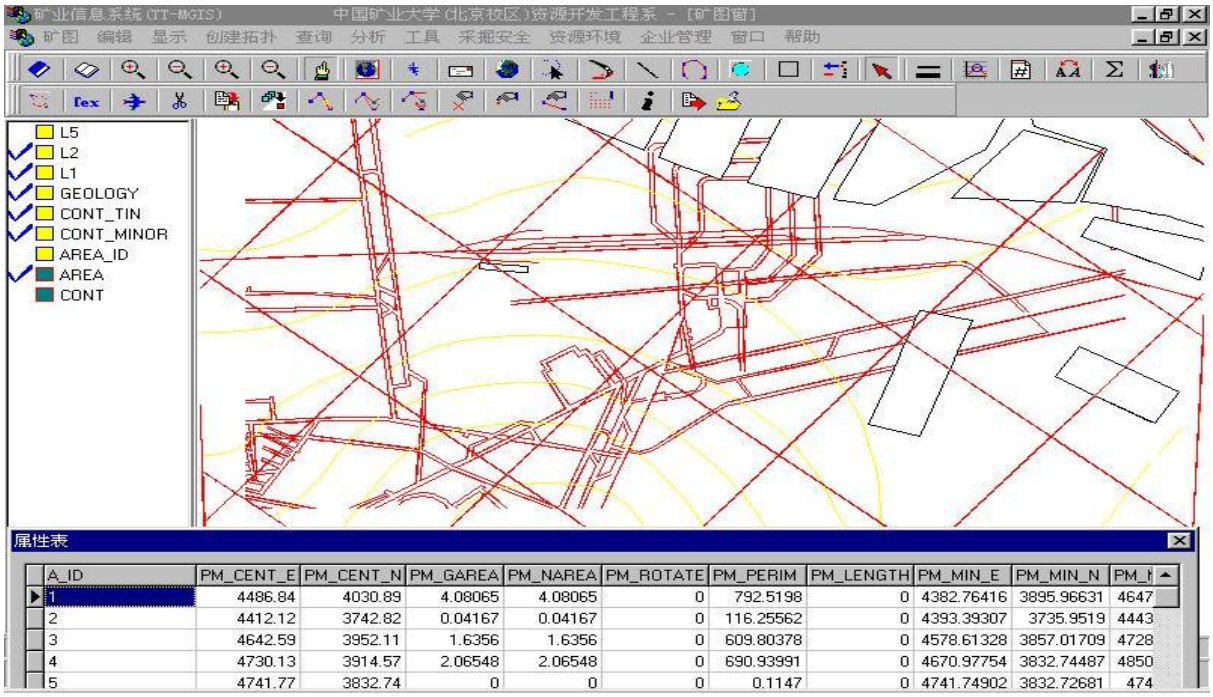


Fig.1. The working procedure scheme and data flow of 3DGM and MGIS



A_ID	PM_CENT_E	PM_CENT_N	PM_GAREA	PM_NAREA	PM_ROTATE	PM_PERIM	PM_LENGTH	PM_MIN_E	PM_MIN_N	PM_
1	4486.84	4030.89	4.08065	4.08065	0	792.5198	0	4382.76416	3895.96631	4647
2	4412.12	3742.82	0.04167	0.04167	0	116.25562	0	4393.39307	3735.9519	4443
3	4642.59	3952.11	1.6356	1.6356	0	609.80378	0	4578.61328	3857.01709	4728
4	4730.13	3914.57	2.06548	2.06548	0	690.93991	0	4670.97754	3832.74487	4850
5	4741.77	3832.74	0	0	0	0.1147	0	4741.74902	3832.72681	474

Fig.2. The mutual query of the spatial graphic data and the non-graphic attribute data of

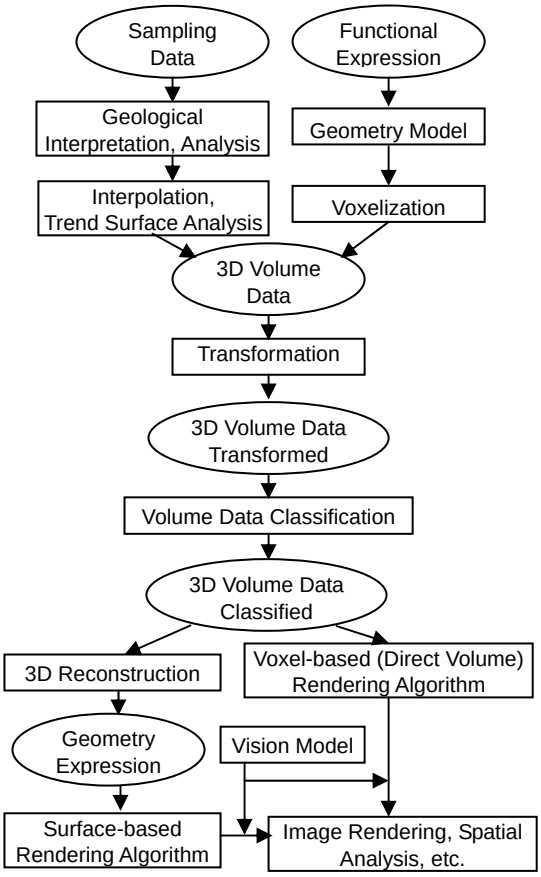


Fig.3 The general frame scheme of volume visualization of 3DGM and MGIS

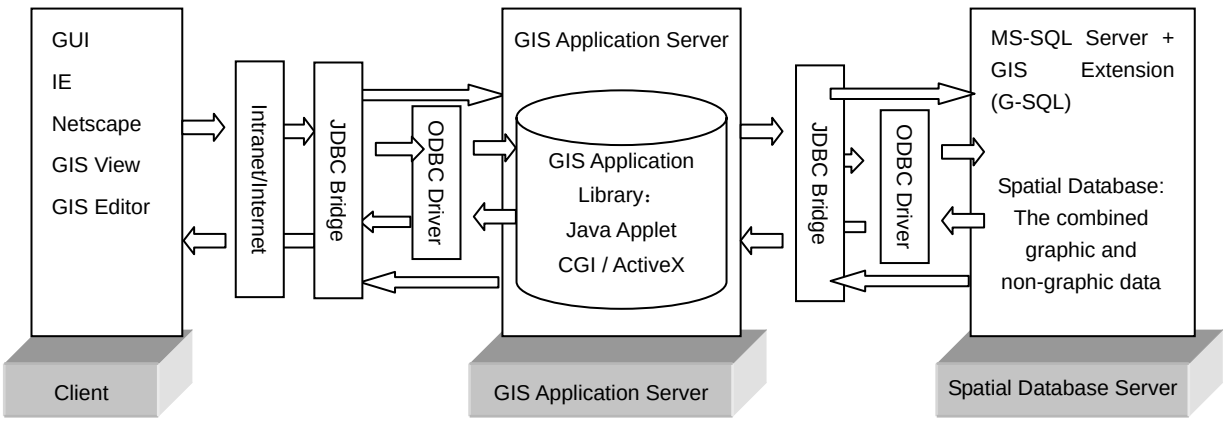


Fig.4 The distributed 3-layer C/S architecture and networking data stream of the Internet MGIS

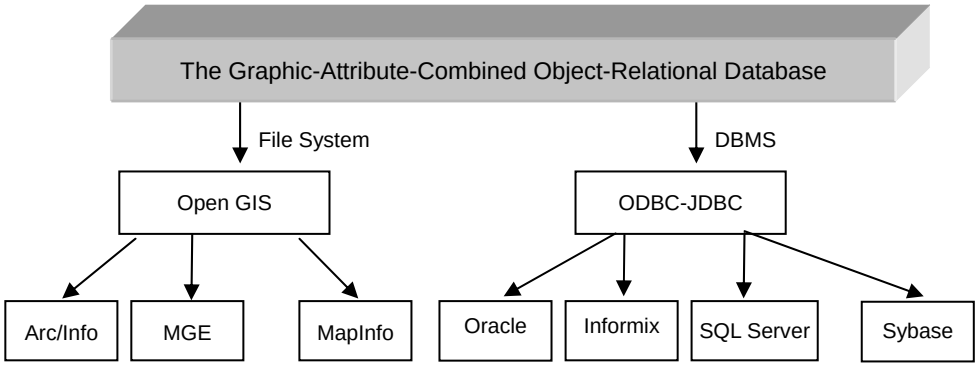


Fig.5 The Interoperation scheme of Internet MGIS

4. Visualization, VR and VGIS

Part of the problem has to do with the way by which the information is displayed.

Scientific visualization has become a hot issue in computer field. The volume visualization technique, as the important branch of the scientific visualization, is an intersected subject for studying volume data, which based on computer graphics, image process and computer vision. The volume visualization technique, as the method and means for data expressing, can help people to understand data and to find the nature law behind abundance data. Volume visualization mainly studies the express, process, analysis, operation, rebuild and display of the volume data that contains the inner information of the object. The main differences between the 3D volume visualization and the traditional computer graphics is that the former is represented by limited scatter sampling, while the latter is represented by continuous geometry description. Thus the processing, operation, transform, analysis and display methods of them are much different.

Traditional computer graphics uses the boundary element of the surface and side to describe the object, which doesn't contain any inner information; while the 3D volume visualization uses 3D element (voxel) to describe the whole object, which contains the integral information of the 3D object. With the aid of 3D volume visualization, we can rebuild the structure of underground objects, describe the resource distribution, simulate the dynamic diversification trend of Geo-parameters, analysis the geometry configuration, interrelation and distribution of the Geo-body and Geo-phenomena, and greatly improve the efficiency and quality of computer processing. Fig.3 illustrates the general frame scheme of volume visualization of 3DGM and MGIS.

As a newly synthetic integrated technique, VR is another hot issue in computer field. Its basis is scientific visualization technique. VR has now got some applications in mine, including planning and management of mining project, dynamic simulation of mining activity, optimization of mining operation, determination of rational mining scheme, forecasting and monitoring of mining safety, prediction of ground deformation and mine workers training etc. These provide powerful theory and practice foundation of DM. Network gives VR a large developing space, and they intersect each other and co-develop, become the foundation and fundamental technique of DM.

Virtual GIS (VGIS) is an integration of visualization technique and GIS. It introduces VR technique to GIS and realizes 3D simulation of practical scene, and then provides interactive, dynamic and vivid perception of the real 3D world. VGIS is future of the directions of practical GIS techniques, and will be an important function of DMTitan-MGIS

5. Networking Architecture for DM

The network technique impels the generation and development of Internet/Intranet GIS. Internet GIS can reach the requirement of networked distributed

computing and social application. Based on the network technique, Open GIS can have the opportunity of realization. The union of Internet, Browser, Java and other relative techniques convert the current model to C/S architecture. The perfect union of C/S architecture and Open GIS provides the basis to realize DM. Without Open GIS, the information cannot realize effectively share and distributed interoperation. The C/S architecture based on Intranet/Internet is the fundamental technique to realize information distributed transacting and interoperation. Fig.4 illustrates the distributed 3-layers C/S architecture and its networking data stream of the Internet MGIS. Fig.5 illustrates the interoperation scheme with the conventional dual-component structure Internet MGIS system.

6.The Scheme of Development of DM

Associated with the mine development and other factors, the scheme of the development of DM is suggested: 1) Firstly, to realize LAN working informatization by the end of 2000. The goal is to provide spatial analysis, assistant evaluation and decision-making services to partly mine engineering and relative engineering geology technique problems, such as shaft layout, mine ventilation, terrain movement, subsidence, etc. 2) Secondly, to realize Intranet working informatization by the end of 2002. The goal is to provide sustainable development evaluations, multi-objects dynamical layout and assistant decision-making services for multiple mines even the whole mine bureau. 3) Thirdly, to realize Internet working informatization by the end of 2005. The goal is to provide fundamental data management, statistic, analysis and macroeconomic control services to several mine bureaus or whole mines of the province or the whole country.

7. Conclusions

The present of DE gives mine an opportunity to promote its informatization construction and to realize modern production and management. The development of DM is realistic and possible within 10 years. However, as a most comprehensive and sophistic technique, the DM is sure to face some challenges. But, we believe that the development of DM is a long–term development strategy and a science & technology policy. It will no doubt promote the development of Geoscience, informatics and informatization of the mine, make full use of the market chance. In a word, the DM is sure to come true some day no more than 10 years.

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