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Sensors and Simulation Cooperative Module Based Information Management Command System in Mine Dynamic Disaster Prevention

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Abstract. Mineral resources are a kind of important material foundation for economic and social development. With the depth of mine increasing, the mine dynamic disaster occurs more frequently and even more seriously. In addition, it results in huge economic losses and casualties and thus poses a great threat to the mine production and safety. It is therefore necessary to establish an efficient information management command system in order to prevent the rock burst and mine dynamic disaster effectively. Based on the modular modeling technology with characteristics efficiency, flexibility and dynamics sensor equipment, control equipment, simulation equipment and combination can cooperate with each over and be achieved to recombination after the partial dismantling. It draws the conclusion that it is significant for mine dynamic disaster monitoring and prediction to build an efficient information platform which combines simulation technology with sensor technology.

Keywords. Mining Engineering, Mine dynamic disaster prevention, Simulation, Module based architecture, Command System.

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Introduction

Mining industry can be seen as a big factory which has standardized uniforms and processes. Over here a large number of data is collected by different kinds of sensors, such as temperature pressure, stress, electromagnetic radiation, displacement and acoustic emission sensors. With analysis, integration and mining processes, the collected data will be further generated into effective information with its surroundings. In the end, the miners and other production workers receive the useful information from the Visual Aided Mining System as well as the Decision Support System to make them work more efficiently.

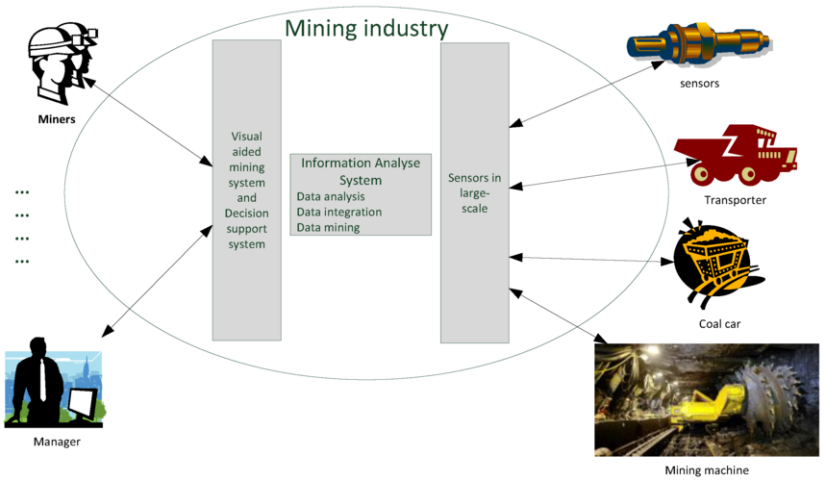

Figure 1. The information management in mining industry.

However, unlike the conventional factory, mining industry evolves continually:

- Geological environment is too complex and volatile to be well-defined and estimate accurately. With the help of multidimensional, polyphase and multiscale descriptive tools, such as geological maps, 3D simulation software, people will be able to distinguish the variety of geological environment.
- An adit, which is used for getting into the mine, draining away the water, ventilation, keeps changing its length and trends frequently.
- The onset of geological disaster is very difficult to anticipate, so that the miners cannot be given a warning early. For instance, coal and gas outburst, rock burst and mine tremor are collectively referred to as mine dynamic disaster, is the main dynamic disaster in coal mine. Scientific and accurate rescue operation is a great test to the staff in the process of dynamic disaster accident of mine. With the development of the coal mining and reduction of shallow recoverable reserves year by year, dynamic disaster during deep mining excavation become a problem to be faced with a lot of coal mines.
- Furthermore, mining involves mineral prospection and exploration, ore dressing, deep procession, etc. The mining objects, tools and production workers usually divert with the change of mining location. The transformation

of working conditions and complexity of geological conditions make mining to be a high risk industry (Ortlepp, 2005). However, the destructive mechanism of dynamic disaster has not been yet put forward.

In order to reduce or even avoid the risk, many measures have been applying in mining industry. The real time information from complex and changeable environment is extremely significant for all people in mining. Particularly for some tough tasks, the information is requested to be visual and accurately identified. The passage navigation information can be used to fix the position. Under the guidance of this information miners will be able to work safety in the underground mine with low visibility. For an early warning system and emergency preparedness the current information is also absolutely necessary. Without it the manager or commander will be very hard to get going miner's safety supervision and emergency rescues.

A sensors and simulation cooperative module based information management command system with ultra large scale integration and decision support has very important science value and engineering significance for the mine dynamic disaster prevention.

1. Scenario

This scenario is a concrete, focused, informal description of features of the system from the viewpoint of miners and company managers. The emphasis for readers during scenario identification is to understand the application domain.

Over the mining interface, sensors, transporters, mining machine and so on can be connected with Simulation System through Information Collection System and Information Analyse System, and then the Simulation images can be transmitted to miners with visual aided tools in order to achieve real time "transparency" and low visibility video surveillance technology. Miners can use gesture of wireless sender to operate sensors, transporters and mining machine with the help of Control Information System. The real time information, which has been collected by sensors, will be sent back to analyse, simulate and visualise again. Furthermore, the integrated underground mobile equipment enables automatic fault diagnosis, optimal control and intelligent function.

For the managers above the ground the information is collected and analyzed into effective information. Moreover managers can apply the virtual and real information by definition of the logical relationship between the different components on the Simulation System, and all possible eventualities of mine dynamic disaster will be simulated. In the Decision Support System an early warning as well as prediction with the simulated result and real time information will be given to managers. Before a mine dynamic disaster the managers above the ground can warn the miners underground early and command evacuation. Consequently, forecasting and monitoring of mine dynamic disaster is capable to be optimized. The rescue and evacuation would be better commanded.

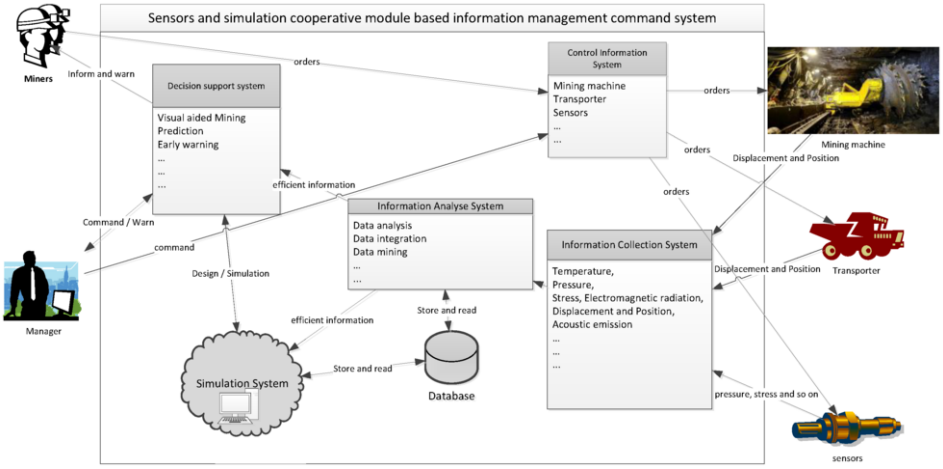

Figure 2. Scenario of sensors and simulation cooperative module based information management command system in mine dynamic disaster prevention.

2. Module based mining information architecture

How to build an efficient information platform has become the most important problem of the study, and the architecture based on module makes it possible.

Note that the concept of modules proposed here is not restricted to software modules. A module is with well-defined interfaces and is the basic entity of any model. Reusability of modules is an inherent property of the proposed architecture modeling approach. So a module can module a reusable software module, a specific sensor measuring gas flow or an automation control system.

A module based platform can be accomplished in a variety of ways to develop high quality integrated systems. According to unified form of the interface of modular information platform, a wide range of effective exchange of information between the different modules is able to be carried out. Each module integrated in the platform through a specific interface (adapter) with a platform for information exchange, the exchange of data is converted into a unified data type (for example: XML description language or C-Code). By the information management platform the managers can define the connecting logical relationship between modules on the platform, and the coordinated operations between modules will come true. Owing to the definition of logical relationship different modules can be flexible selected for a variety of different functions. Moreover, the logical relationships between modules also need to follow certain rules in order to avoid the damage to the equipment and personal injury (Christian, 2013). This helps information sharing between people, encouraging cooperation over technical disciplines such as, mining engineering, electrical engineering and software engineering.

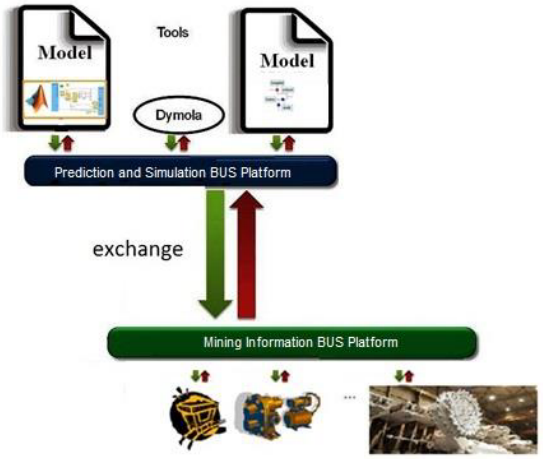

Figure 3. The sensors and simulation cooperative information management command system architecture.

As figure 3 shows, the whole sensors and simulation cooperative information management command system architecture consists of two parts: predication and simulation BUS platform and mining information BUS platform. Between them there is a kind of bridge for exchanging information.

3. Mining Information BUS

In recent years, sensor technology is developing rapidly. According to the input characterization, sensors can be divided into displacement, velocity, angular velocity, force, torque, pressure, flow rate, temperature, light, heat, electric current, voltage, gas components, concentration sensors, etc. Sensors that are widely used in mine stress are displacement, gas, temperature, thermal sensors, and wireless transmission technology plays an important role in collection of sensor information. Automatic monitoring system for gas, temperature, pressure and displacement of mine came into being, which provides a powerful protection for high production, efficiency and safety exploitation of mine.

We always focus on the research of development of high precise, interactive and visualized measurement platform, especially in the prevention and treatment of mine dynamic disaster. At the same time, the wireless remote control technology plays also an important role in fault diagnosis and centralized monitoring. For example, staff can by wireless sender/acceptor operate the monitoring equipment in the mine, and by way of illustration only with some simple gestures the previous collected information can be sent back to the information management platform in order to achieve efficient online detection function. Staff can also with same simple gesture control other machinery and equipment wirelessly.

By establishing the Mining Information BUS, it is possible to combine the gas pressure monitoring equipment, gas density monitoring equipment, temperature testing equipment, stress monitoring equipment, displacement monitoring equipment, electromagnetic radiation testing equipment, the gravity testing equipment, as well as other sensors and wireless remote control equipment.

Mining Information BUS is not only able to achieve the collaboration between multiple sensors, but also enables the information platform of 3D Simulation exchanges information with the actual sensors and controllers, which achieves the combination of virtual and reality.

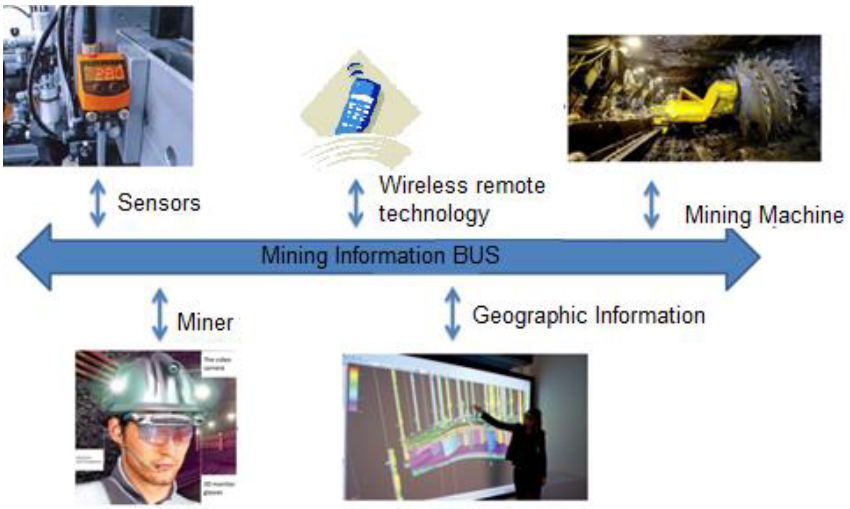

Figure 4. Mining information BUS platform.

Comparing to the 2D simulation, 3D simulation technology is significantly effective in the mine dynamic disaster monitoring, prevention and emergency rescue. Establishing of GIS system, which is based on 3D simulation technology, enables the geological structure and mine tunnel transparent. When mine dynamic disaster occurs, the specific location of the disaster and the situation of the disaster can be as quickly as possible determined, in order to achieve the most accurate and most efficient relief and rescue measures.

The 3D simulation technology based Geographic Information Systems, which is involved in the full range of information system of geological structure and road way structure; provide people the image data with different dimension and different resolution. Additionally, it achieves a real sense of "transparency". This project is developed by the Energy Research Centre of Lower Saxony, Germany (EFZN) (Leonhard, 2011).

A design concept for future miners, which combines 3D simulation, GIS, Video Camera and Telephone Technology, was presented by Walter in 2004 (cf. Walter, A. 2004).

4. Prediction and Simulation BUS

As mentioned above, mining Information BUS combines sensors, visual complex and changeable geologic environment, wireless remote technology and field staffs together, and realizes a integration system. On the other hand, prediction and Simulation BUS devotes itself to dynamic disaster prediction and early warning. To join these two BUS

platform together is of great importance to digital mine information management system and disaster relief.

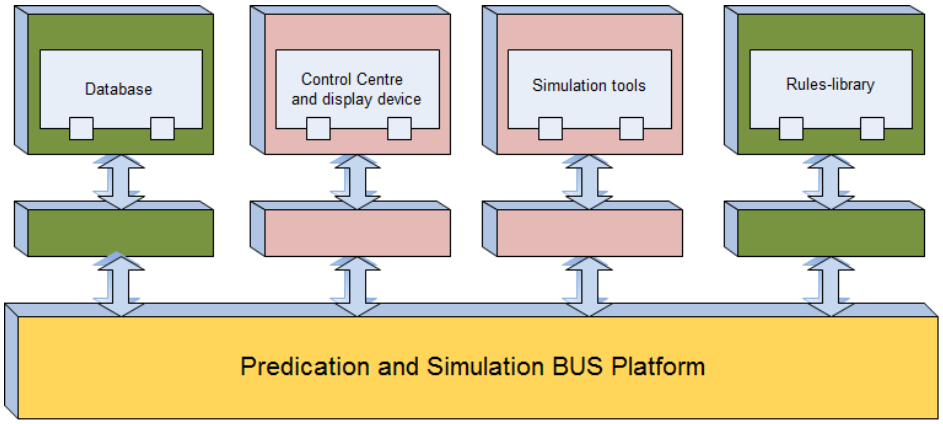

Figure 5. Predication and Simulation BUS platform

Prediction and early warning technology of has a vital significance to dynamic disaster management. The most important basic work of early warning technology is layout and data collection of sensors, which includes pressure, stress and displacement sensor for surrounding rock, pressure, concentration, temperature sensors for gas, and temperature, electromagnetic radiation, acoustic emission sensors. In the aspect of digital mine, it mainly focuses on the virtual reality of mine geology, terrain and roadway and as well as production management.

Predication and Simulation BUS integrates the Simulation tolls, Database, Rules-library, Control Centre and display device. All possible eventualities of mine dynamic disaster will be simulated with the virtual and real time information by definition of the logical relationship between the different components. The rules based on safety and efficiency will be used for simulation, prediction and early warning. Through the use of Control Centre and display device will the managers command for the rescue and evacuation.

This can make designers understand the entire structure of products, the characteristics of parts (such as the simulation of structure movement and interference inspection), and the static or dynamic analysis of the entire structure or parts. Especially in the structural dynamic analysis and simulation, designers can find and modify structure flaws promptly, and ensure that the structure has excellent dynamic performance.

5. Conclusions

The sensors and simulation cooperative module based information management command system can realize effective information exchange between different modules. By application of sensors and like wireless remote technology, multidimensional data fusion could be achieved and multidimensional and interactive information platform of coordinated operation, management and command is able to be established. Based Geographic Information Systems, mine 3D virtual realization of

geological structure and mine tunnel is to be completed to achieve real time "transparency" and low visibility video surveillance technology. Staffs can use gesture of wireless sender to operate the controller and send the real time information, which have been collected by sensors, selectively back to the information platform. Then, effectively forecasting, monitoring and rescuing of mine dynamic disaster can be achieved, which is of great significance to improve the level of mine safety production and management.

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