

Study of multi-agent-based coal mine environmental monitoring system



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ABSTRACT

Existing wireless coal mine environmental monitoring system has large transmissions of redundancy data. Monitoring and treatment of multiple environmental parameters are mutually independent, with low instantaneity and reliability. To solve the above problems, this paper designs the coal mine environmental monitoring system based on multi-agent, taking advantages of the harmony and intelligence of the multi-agent technology. This system designs the environmental monitoring agent from both hardware and software aspects which can cooperate mutually and work harmoniously between each other. Thus, the quantity of transmission of data can be reduced, which optimizes the structure of the coal mine environmental monitoring system. Results of simulation experiments prove that the multi-agent-based coal mine environmental monitoring system can reduce the transmission delay and packet loss probability of data and enhance the instantaneity and reliability of data transmission in the system. Therefore, the new system is more applicable and advanced in the field of coal mine environmental monitoring.

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1. Introduction

Coal industry is the pillar energy industry in China. Safety of coal production relates to not only the personal security of workers but also the local economy and social stability (Zhang et al., 2014). Coal mines in China are mostly with complicated geological conditions and many workers operating underground, which lead to high accident occurrence rate (Zhu and Zhang, 2012; Li and Liu, 2009). For these reasons, it is really urgent to build scientific and perfect coal mine environmental monitoring system to effectively prevent and reduce the occurrence of any kind of accident (Hu et al., 2013).

Existing wired coal mine safety monitoring system (Wang et al., 2011) has many shortcomings such as wiring is hard, communication cables are easy to damage, fault rate is high and system maintenance is inconvenient. Whereas, the application of wireless communication in coal mine environmental monitoring field (Jiang et al., 2009; Li and Liu, 2007) has made up these shortcomings of the wired system, with advantages of low power consumption, low cost, and flexibility of wiring. Even though it has many merits, the wireless communication system is still deficient

in the instantaneity and reliability because of large quantity of transmissions of invalid data. The monitoring of each agent in the multi-agent wireless environmental monitoring system mentioned in literature (Gong et al., 2013) is mutually independent, which occupies large room of the narrow ground pit and increases the complexity of network structure. Besides, because of the complicated and harsh conditions in the pit, single sensor may be invalid or works inaccurately under the effects of temperature, humidity, and dust. In that case, the system is not able to react to the real environment and even result in disasters.

Agent refers to a kind of entity or program which can percept the changes of components or conditions in environment and react flexibly and spontaneously and can calculate under preset design objectives. Agent is not only spontaneous and intelligent itself but also able to communicate between each other (Liu et al., 2000). The interactivity and coordination of multi-agent technology can be applied to monitor multi-factors and multi-variables in the same environment (Gawali and Meshram, 2009).

In this paper, the multi-agent technology is used to monitor the environment in the pit and the coal mine environmental monitoring system based on the multi-agent technology is put forward. Because, the environmental monitoring agent has simple ability to handle data and there is coordination mechanism inside the environmental monitoring agent, quantity of transmission of data and packet loss probability during the transmission process of

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monitored data can be effectively reduced, which is helpful to improve the instantaneity and reliability of the system (Tang et al., 2014).

2. Design of multi-agent-based coal mine environmental monitoring system

2.1. Design of environmental monitoring system model

Level of designed environmental monitoring system can be divided into human-machine interface agent, master agent, management agent and monitoring agent on the basis of depth study on multi-agent. Fig. 1 is the system diagrammatic figure. The coal mine environmental monitoring system based on multi-agent matches the existing coal mine environmental monitoring system. Each agent accomplishes the demand from the environmental monitoring system through mutual collaboration.

Specific functions of each agent are as follows.

Human-machine interface agent is the interface that user interacting with coal mine environmental monitoring system to provide users with the interface for monitoring and management of environmental monitoring system and to assist the user's interaction with the whole environmental monitoring system. Users release tasks to the multi-agent-based mine environmental monitoring system through the human-machine interface agent which receives the user's requests and send the tasks to master agent. Finally, the master agent feeds back the result of the execution to human-machine interface agent which is used to enter and display various types of information and collect the command that issued by the operator to the system. According to operating personnel demand, it performs monitor task according to the predetermined route, and delivers the task to master agent. In this platform, the human-machine interface agent should be able to let users querying coal mine environmental danger information, print out the danger information sheet, make statistical analysis and handle the danger information.

Master agent is actually a PC, which is responsible for monitoring and controlling all agents in the whole coal mine environmental monitoring area and in the meanwhile establishing database. Master agent is mainly used for remote environmental monitoring of the environmental information in the pit (such as

gas, CO, temperature, and pressure) to realize the sharing between network transmission and network resources. It mainly has two functions: on the one hand, receive task from the system and on the other hand analyze the information from each management agent. The processed results will be fed back to the human-machine interface agent and to the users finally. Once there is any danger, danger information will be sent to corresponding management personnel in time to complete the real time monitoring of coal mine environment.

Management agent is located between each terminal agent and monitor master agent, and its role in the whole system is to organize and coordinate control functions. Besides, it is also the transmission hub between safety monitoring in the pit and the monitoring center on the ground. On the one hand, it completes the formation, operation, and maintenance of the wireless network to control the monitoring agent within the region and finish the information acquisition and processing underground. On the other hand, it communicates with the host agent by ethernet technology to pass the processed information to the master agent. Weather the coal mine safety monitoring system can achieve real-time coal mine environmental information acquisition or not depends on the ability of manage agent. Hence, management agent has played a decisive role in mine safety monitoring.

After receiving the request from management agent, monitoring agent will perform accordingly and send the collected information of the coal mine to management agent to complete the real-time monitoring of gas concentration, CO content, temperature, humidity, and wind speed, and other environmental information. Monitoring agents can be divided into gas agent, CO agent, temperature agent, and wind agent. Their functions are to real-time monitor the danger information in the mine pit. On the one hand, monitoring agent acquires, detects, and processes the hazard information in the coal mine production process in real time. On the other hand, it conducts preliminary analysis and forecasts and judge the possible risk during production process and then report to the management agent.

2.2. The working flow of the system

Fig. 2 shows the flow chart of the system. Operation of the system can be described in details as follows.

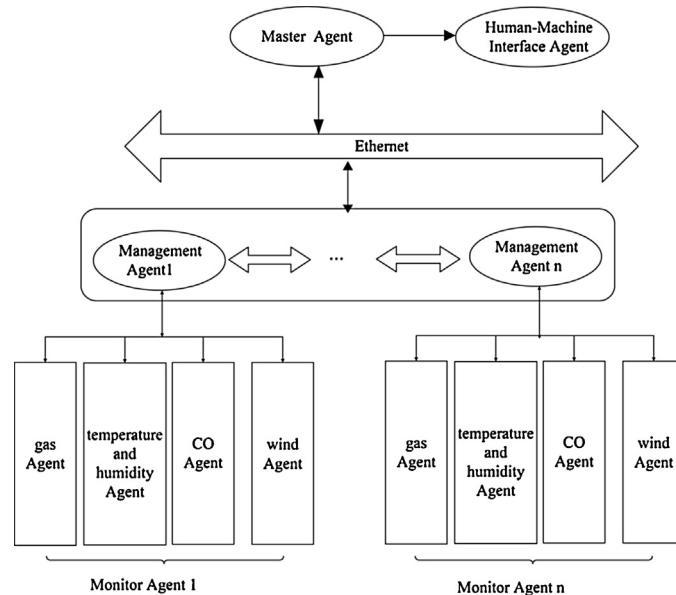


Fig. 1. Multi-agent coal mine environmental monitoring system model.

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