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STUDY OF MULTI-AGENT-BASED COAL MINE ENVIRONMENTAL MONITORING SYSTEM PREDICTION BASED ON AZURE MACHINE LEARNING

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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.

INTRODUCTION

In case of accidents, localization of events and miners is of key importance. Activity monitoring of miners can also provide useful information at times. The most important thing is the seamless integration of all the subsystems into a complete monitoring system. This paper presents a unique and comprehensive monitoring and control system for harsh environments. It is based on an application-specific communication protocol, utilizing known network topology to design energy-efficient routing and collision-avoidance (CA) mechanism. RF modeling is used for optimum node placement and reliable connectivity. The system has integrated an intelligent anomaly detection mechanism that not only has the capability to detect and identify events in real time but also has the memory to cater for the spatio-temporal dynamics of the environment. The solution is distributed (takes care of the spatial dynamics) where individual nodes have the capability to detect local events but also carry out periodic reporting so that the central server has the global picture. In addition, localization of miners and events and roof falls, etc., has been integrated in the system.

Safety is one of the main aspects related to industries specially the mining industry. In the underground coal mines, human safety is most important thing which need to look. To avoid any types of unwanted phenomena all mining industry follows some basic precaution and rules. Communication is the main key factor for any industry today to monitor different parameters and take necessary actions accordingly to avoid any types of hazards. In recent years, disasters in coal mine occur frequently, which lead to great loss of possession and life. The accidents happening in coal mine are due to the

complexity of mine environment and the variety of work condition of coal mine, so it is necessary to monitor mine working environment.

To avoid loss of material and damaging of human health, protection system as well as faithful communication system is necessary inside the underground mines. To increase both safety and productivity in mines, a reliable communication must be established between workers, moving in the mine, and a fixed base station or control room. Inside mines, the wired communication system is not so effective. The reliability and long life of conventional communications systems in harsh mining environments has always been a problem. Inside mines due to uncomfortable situation the installation cost as well as maintenance cost is high for wired communication networks. It is very difficult to reinstall the wired communication system inside mines, after a landslide or damage due to any reason. Due to roof fall, if by any means some workers trapped inside mines, to maintain the continuity of the communication system is very much important to know the actual position and condition of the trapped workers. To monitor other parameters during this condition it is very much necessary to maintain the communication system as usual. Accordingly, development of mine monitoring system to accurately detect temperature, pressure, flammable and poisonous gas and to track underground miners and vehicles on real-time has significant meaning to safety production and rescue of coal mine disaster

To cater for challenging environments such as underground mines, wireless sensor networks (WSNs) are increasingly being used in a range of similar applications such as underwater sensing [3], structural health monitoring [4], and event reporting applications [5] as they are scalable and can be easily deployed and maintained. They are also more resilient to failure in case of accidents such as fire, roof falls, and tunnel disruptions as compared to wired networks that are prone to damage and breakage [6]. However, effective monitoring of underground mines even using WSNs is intrinsically difficult to achieve because of several design challenges such as unfavorable, time-varying and frequency-selective channel environment, difficult terrain for installation and maintenance of nodes, etc. A review of challenges associated with harsh environment communication that hinder applicability of ordinary communication protocols has been presented in [6] along with ongoing practices of mine monitoring and their problems. The authors propose the use of WSNs based on an empirical study in an actual mine. Detailed analysis of communication systems for underground mines has also been presented in [7]. Authors conclude that of all the considered communication means, wireless communication can offer solutions to some of the fundamental challenges in the underground mines.

LITERATURE REVIEW

The literature review has been categorized into two categories: the first one summarizes the features and the second one summarizes the underlying methodology and scheme for control and monitoring system incorporated by existing works.

A. Comparison of Features: Key existing works are compared in Table I for features that are essential for a widely effective mine monitoring. They all support a basic monitoring and event reporting system; however, they lack an integrated perspective considering range of features and constraints posed by each. For example, some designs

propose fixed nodes solution, which cannot support miner localization. Some works present a centralized approach where a server initiates query and nodes reply with instantaneous values of the requested parameter. This approach can be energy efficient but does not consider temporal correlation and is not suitable for ever changing mine environment. For intelligent decision making, algorithms need to be integrated at the core hardware and protocol level to be effective at the global level.

B. Prior Art on Methodology: A comprehensive review of existing approaches for mine monitoring has been presented. For the base protocol, most works have relied on ZigBee for its ease of deployment, low data rate (250 kb/s), substantial range and most importantly low power consumption when compared to other technologies such as Wi-Fi, Bluetooth and ultra wideband communication. However, this paper targets an even lower data rate and lower frequency protocol, DASH-7. Due to the simple direct energy-bandwidth relationship; lower data rate projects better energy efficiency and lower frequency promises higher range. Also, ZigBee is a general purpose protocol. Although nodes can be configured to some extent, the nodes are randomly deployed and the network is formed and operates dynamically. This means that it does not benefit from known characteristics such as signal attenuation, network topology, and routing. Connection is established using carrier sense mechanism which increases delays, uncertainty, and power usage [10]. Nodes are set to specific roles such as cluster heads and sensor nodes, which reduce flexibility [10]. Even dynamic routing between randomly distributed nodes in a big network can be complex and energy-consuming and may lead to areas with redundant or weak coverages (especially without signal attenuation consideration). An application-specific approach can benefit from known facts and answer all these challenges. The review in [10] also points out that some works have focused on simulations while not giving enough consideration to power requirements for long term operations [4] and did not present experimental results [11]. Finally, although existing works emphasize reliability, not a lot has been researched on run time intelligent decision making capability for reliable event detection. Authors in [4] and [5] emphasize the need for data collaboration between nodes and intelligent processing for efficient decision making but their scope is limited to energy saving and gas concentration detection, respectively. Unlike previous works targeting a single aspect of system, this paper takes an integrated approach, improving separate subsystems and taking advantage of dependability of various subsystems.

C. A wireless surveillance and safety system for mine workers based on zigbee designed by Tanmoy Maity and Partha Sarth Das .The design proposed a cost effective, flexible solution of underground mine workers safety. A module of MEMS based sensors are used for underground environment monitoring and automatic progression of measurement data through digital wireless communication technique is proposed with high accuracy, smooth control and reliability [3].

D. In one of studies related to wireless communication in mines , A new decision making approach to coal and gas outburst prediction with multisensory information fusion is proposed. Two of the multisensory information fusion method- neural network and the dempster-shafter evidence theory were taken into account and the improved combination rules in fuzzy sets was given for decision fusion. But, those communication methods having specific technology lacks in

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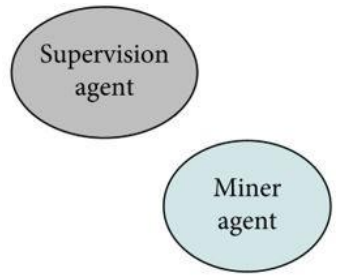
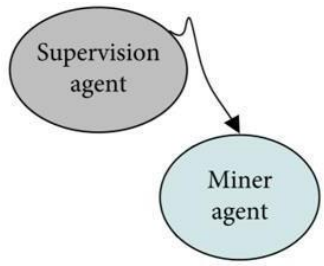
practical application in underground mines [4].

METHODOLOGY

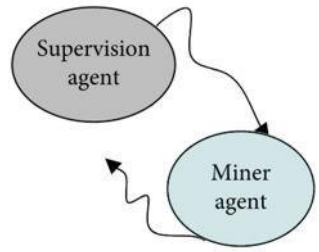
Unsafe behavior propagation model



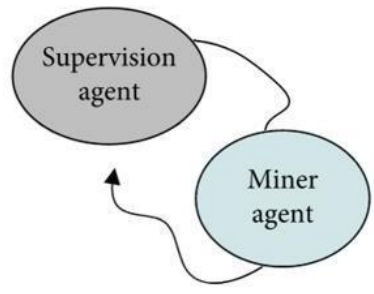
Mutual independence



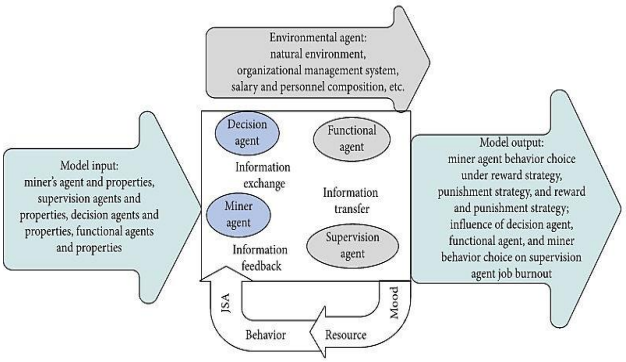
Information transfer



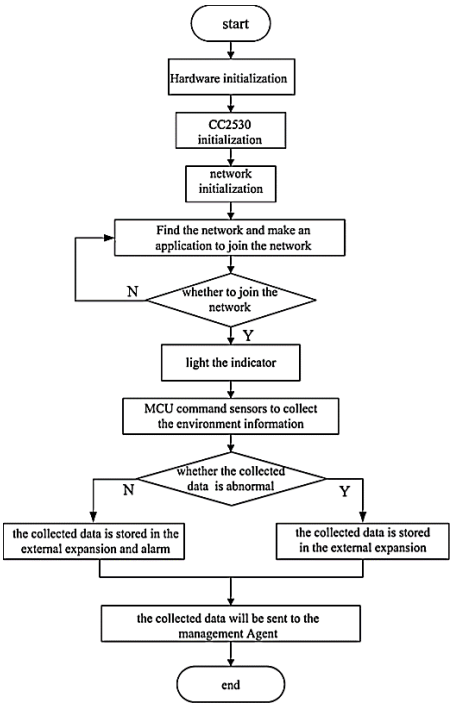
Information feedback



Information interaction



FLOWCHART



RESULTS

We can see that the average delay during the data transmission in both two systems increases along with the increase of number of nodes. That is because when the number of nodes increase, the transmitted data size will increase as well, which leads to the transmission jam and increase of average delay. Transmission delay in this newly presented system is shorter than that in the not-MAS-based system, because the monitoring agent has the local processing function, which reduces the transmitted data size and the effects of transmission jam during the data transmission process. Packet loss

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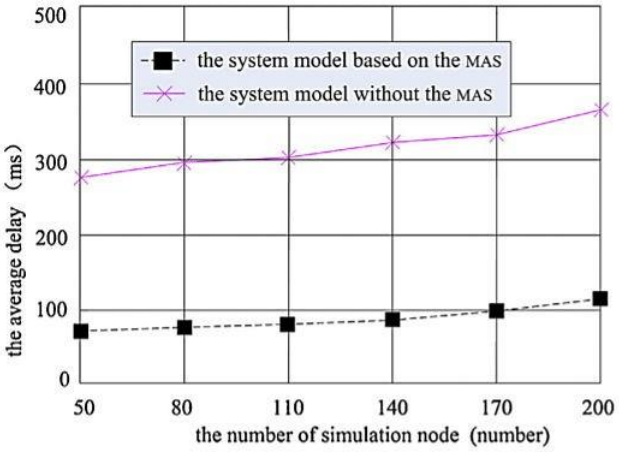
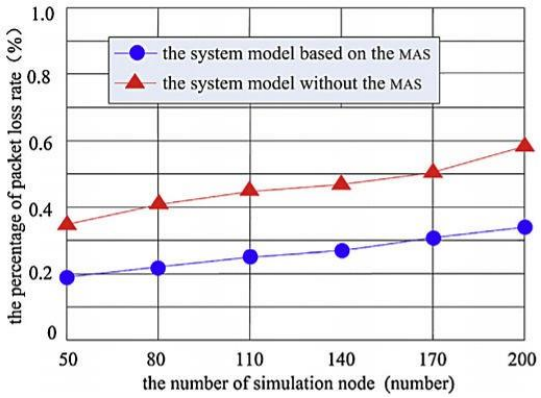
probability means the ratio of quantity of lost data packets to the total number of transmitted data packets.



Average delay comparison chart



Packet loss probability comparison chart

CONCLUSION

In this paper, based on multi-agent system technology, a coal mine environmental monitor system model based on MAS technology was built, and a coal mine environmental monitor system based on multi-agent was also developed and the system implementation with hardware and software was designed. The system adopts modular design, which can effectively improve the real-time performance and reliability of data transmission, so as to improve the timeliness and accuracy of coal mine environmental monitoring system. Simulation experiments prove that the coal mine environmental monitoring system based on multi-agent technology has stronger application prospect in the field of coal mine environmental monitoring.

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