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The Gas Detection Application of Deep Well Production Based on Wireless Sensor Network

Lejiang Guo, Fangxin Chen, Lei Xiao and Yahui Hu

The Department of Early Warning surveillance intelligent ,Air Force Early Warning Academy,430019, Hubei,China
Email:radar_boss@163.com, Fangxin@163.com, Shaoxiong@263.com, Yahui @263.com

Abstract. Based on wireless sensor network, a system-level solution of wireless sensor network for oil well safety information collection is constructed, including hardware and software design of data acquisition, data transmission and data analysis and processing. The system has the characteristics of low cost, wide range and flexible layout, which solves the problems of cable networking, such as wiring, location and slow troubleshooting problem. The experiment shows that the system meets the actual requirement and runs stability.

1. Introduction

Wireless sensor network (WSN) is a new technology which integrates sensor technology, embedded computing technology, network and wireless communication technology, distributed information processing technology. It has a wide range of application scenarios. The distribution of oil drilling is relatively scattered. It is difficult to establish a wired safety production monitoring network, and it requires a lot of manpower and material resources to maintain the monitoring network. Safety production is restricted by objective conditions. In the process of oil drilling and gas production. There are many factors affecting the environment and safety. Safety production has become an important issue. The gas is easily produced in oil drilling and development, such as Hydrogen sulphide, carbon monoxide and other toxic or flammable explosive gases which threaten the personal health and safety of field workers. Therefore, the monitoring and protection of these flammable and explosive toxic gases are very important in the process of oil drilling and production.

2. The Design of the Gas Detection Application Based on WSN

2.1. Characteristics and Applications of Wireless Sensor Networks

Wireless sensor networks (WSNs) are composed of self-organizing nodes, which have independent functions of data acquisition, forwarding and transmission. The nodes form a multi-hop network topology through interconnection. There is a data receiving node in the network which is responsible for fusing all collected data and then transferring it to the local server for subsequent processing and analysis. There are many data transmission paths on each node. According to the energy consumption of the path and the interference signal on the path, users can specify the superior path of data transmission on some indicators to improve the efficiency of network utilization. At the same time, the characteristics of multi-hop and multi-path transmission make the network stronger anti-jamming and anti-destructive which is superior to wired network to a large extent in Fig.1.

Sensor technology is the most widely used technology in data acquisition. At present, the application of wireless sensor networks is just emerging. Compared with traditional sensor networks, it has the following characteristics:

The scale of the network includes two meanings: one is the size of the detection area of the network, the other is the size of the network node density. Generally, the network size can be chosen freely according to the needs of users and actual conditions. If the detection conditions are single, such as measuring only a certain quantity, the network size can be reduced appropriately. If the network size can be increased appropriately in order to ensure the reliability and accuracy of the measurement.

Self-organization nodes in the network are randomly distributed in a region. Nodes have the ability of self-organization to communicate with the surrounding nodes and build the network topology. If the nodes in the network fail or communication is blocked, the new topology can be built automatically after a period of delay between the nodes.

The reliability of network topology and the accuracy of measured data can be greatly improved by self-organization of nodes and multidimensional measurement of the same variable using multiple nodes to measure variables at a certain location.

The network data is data-centric. IP address is used as the basis of access in traditional Internet. But in wireless sensor networks, users only need to submit a query command to the network to obtain data from the network.

Resource saving and adaptability of traditional data acquisition networks are wired networks, such as optical fibber sensor networks. Cable networks are not only expensive, but also taken up a lot of resources and space when the network is huge. At the same time, when a transmission line goes wrong, it will cause a point or even an area to be unable to read data. However, wireless sensor networks do not need any wires which greatly saves wiring resources and production costs. The network has the ability of self-organization and self-adaptation. When a transmission link in the network fails, the network can reconstitute new data links to ensure the normal operation of the network.

The advanced power management technology is used to effectively manage and optimize the node power supply according to the response time of the network, so as to achieve the technical target of low power consumption.

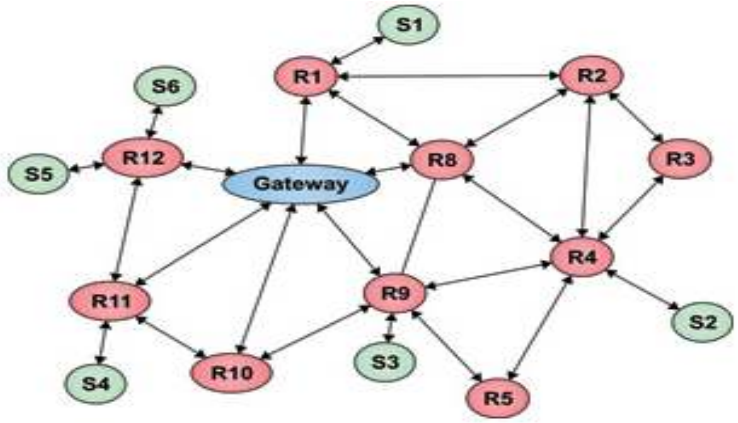

Figure 1. The structure of wireless sensor network

At present, wireless sensor networks have been applied in military detection, agricultural production, security monitoring and other fields. In the process of oil drilling and production, it is often outdoor operations, and the distribution of oil drilling is relatively scattered. It is difficult to establish a wired safety production monitoring network and require a lot of manpower and material resources to maintain the monitoring network. Safety production is restricted by objective conditions. Wireless sensor network technology can effectively solve the objective environmental constraints faced by outdoor monitoring. It provides a safe and effective monitoring network for outdoor operations and ensure the safety of personnel and equipment.

2.2. Detection Technology of Hydrogen Sulfide and Carbon Monoxide

In oil drilling and production sites, real-time detection of hydrogen sulfide and carbon monoxide produced in oil wells is needed to ensure the personal health and safety of operators. Therefore, the detection of hydrogen sulphide and carbon monoxide is the key technology affecting the efficient operation of the whole system.

According to the previous analysis, trace hydrogen sulphide and carbon monoxide will cause harm to human health in a short time. Therefore, the sensor designed is required to have high sensitivity, fast response and be able to detect the presence of toxic gases in time. Secondly, wireless monitoring network is established to detect toxic gases such as hydrogen sulphide and carbon monoxide in oil drilling and production sites. It requires sensor nodes to be small in size. It is easy to install and carry with low-power consumption, long-term continuous operation, strong selectivity. It can accurately detect a variety of gases with anti-jamming performance to work normally in complex environments. Based on the above analysis, electrochemical sensors are selected to detect hydrogen sulphide and carbon monoxide.

The electrochemical sensor has a small detection volume which is easy to install and carry. It has high sensitivity to gases and detect the presence of trace gases quickly and accurately.

3. The Realization of the Gas Detection Application based on WSN

The oil well safety production monitoring network system based on wireless sensor network is mainly divided into the following three parts, data acquisition, data transmission and data analysis. Combining with the schematic diagram of the system in Figure 2.

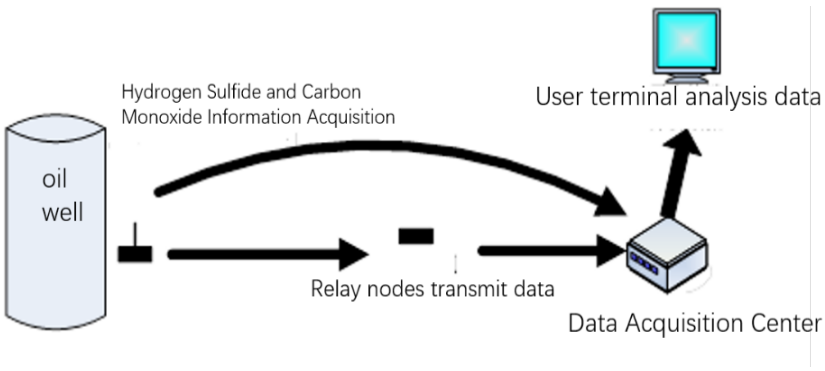

Figure 2. The System Operation Workflow

Data acquisition nodes arranged in oil wells are equipped with electrochemical sensor probes to detect the real-time concentration of hydrogen sulphide and carbon monoxide in oil wells. The detected information is transmitted to relay nodes in real time through wireless transceiver.

Data transmission refers to the process of transferring data collected by sensors from oil wells to remote user terminals. The sensor node collects data, and the data acquisition center collects the data transmitted by each sensor node, and uploads the data for the user terminal to analyse the data. If the sensor node transmits the data directly to the data acquisition canter within the effective communication distance. Otherwise, the data can be transmitted through the relay node.

Data analysis module is to analyse the collected data and display the concentration of hydrogen sulphide and carbon monoxide through the transmitted data value, and then it gives corresponding prompts with concentration value of gas.

3.1. Node Deployment

According to the need of hydrogen sulphide, carbon monoxide sensor sampling data and oil well field monitoring area. Firstly, the number of sensor nodes needed in target area and oil well, the specific location of sensor nodes is analysed. In target area, each sensor node has its own unique. According to the location of sensor nodes oil wells and sensor nodes are corresponded so that the user terminal can monitor the concentration of hydrogen sulphide and carbon monoxide in specific oil wells with the

sensor data. At the same time, according to the different installation location and communication distance of different sensor nodes, relay nodes are reasonably arranged to forward data. Reasonable arrangement of nodes can not only optimize the network system, but also save the energy consumption of nodes by using the smallest number of nodes to achieve the maximum monitoring range.

The system collects the concentration of hydrogen sulphide and carbon monoxide in oil wells through sensor nodes. As shown in Figure 3, sensor nodes include gas detection, signal and data processing, data reception and transmission.

In the gas detection part, hydrogen sulphide and carbon monoxide are detected by high precision electrochemical gas sensors. The output signal of the electrochemical sensor is sent to the signal and data processing part. The signal and data processing part includes signal processing circuit and MCU module. The signal processing circuit filters and amplifies the output signal of the sensor, and then transmits the signal to MCU and converts it into digital signal. In the data receiving and transmitting part, the wireless transceiver circuit transmits the data signal to the network for the analysis and processing of the user terminal.

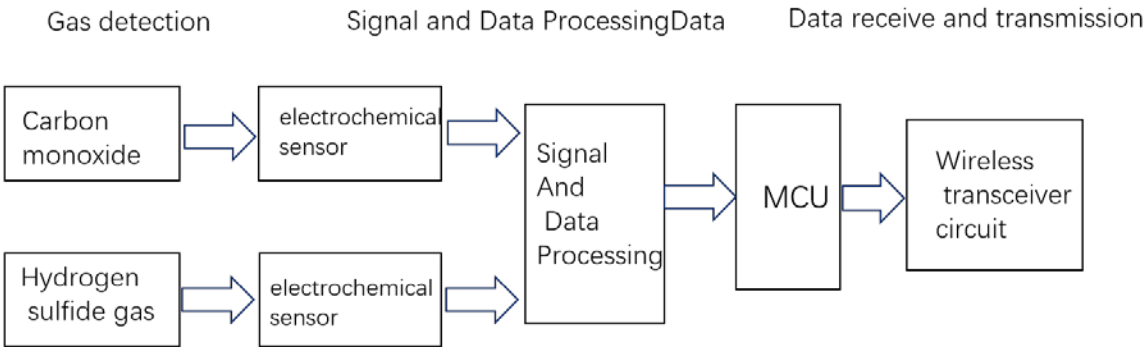

Figure 3. The Sensor Node Structure Block Diagram

3.2. Data Transfer

Data transmission refers to the process of transferring data from sensor nodes to user terminal database through network. In the process of data transmission, network topology and routing strategy are the key to high-speed and accurate data transmission.

After the nodes are deployed, the network topology can be basically confirmed according to the transmission distance of the nodes and the deployment structure of the nodes in the monitoring area. Because of the self-adaptive characteristics of the network, the nodes will automatically find the neighbouring nodes, so that they can connect with the neighbouring nodes. When all the nodes are connected with the neighbouring nodes, the topological structure diagram of all the nodes is the most original network topological structure diagram. The data of nodes can generally reach the user terminal, but with the increase of the number of nodes, data transmission between nodes will inevitably produce conflicts, affecting the real-time performance of the network. Therefore, the deployment of nodes and the construction of network topology and redundant multi-channel transmission is adopted. By applying the data forwarding function of relay nodes, the real-time performance of the network is effectively improved. The data can be sent back to the user terminal in time and accurately.

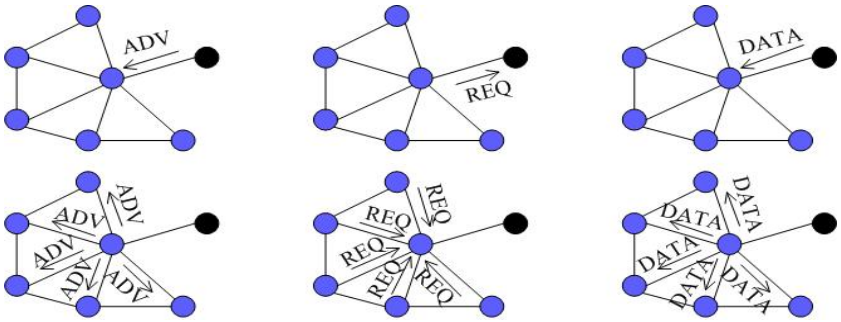

Figure 4. Data transmission

From Fig. 4,it is a schematic diagram of data transmission from node A to data sink center, where node E is a redundant relay node. Normally, the data of node A will be transmitted to the neighbor node D, node D forwards the data of node A to the data sink center, and node B and node C will also transmit the data to the data sink center through node D. when node A and node C send data to node D at the same time, data transmission conflicts will occur, resulting in transmission delay. The application of redundant multi-channel technology of relay nodes solves this problem well.

3.3. Data Analysis and Processing

When the base station receives the data from all the nodes, it stores the data in the database. Terminal application software extracts data from the database, analyses the data and extracts the concentration values of hydrogen sulphide and carbon monoxide. In the terminal software, the well number and the corresponding sensor node data are combined, so the concentration of hydrogen sulphide and carbon monoxide in each well can be dynamically displayed.

As an expert system, the user terminal can analyse the data collected according to prior knowledge, and then monitor the working environment of each oil well in real time according to the concentration of hydrogen sulphide and carbon monoxide in the oil well. The safety factor in the oil well can be judged by the staff according to the prompt information of the system.

3.4. Customer Service Software

Customer service software is the window through which the whole system interacts with users. It mainly provides users with the functions. The server software can display the concentration data of hydrogen sulphide and carbon monoxide in each oil well and store the historical data according to user needs or query. Network operation monitoring can display the network topology and data communication link status as well as the operation of each node. It is convenient for users to monitor the operation and eliminate the possible operation failure. The expert system analyses the sensor data, obtains corresponding operation tips and alarm information, and provides reference for oil well workers.

4. Conclusion

With the combination of wireless sensor technology and gas detection technology, the oil well safety monitoring system based on wireless sensor network has the following characteristics:

Wireless communication technology is used to realize the wireless transmission between data, which is convenient to work in outdoor and hard environment. Each sensor node forms a complete sensor network to facilitate users to monitor the target area comprehensively.

According to the requirements of users, the concentration of hydrogen sulfide and carbon monoxide in oil wells can be monitored in real time all day, so that users can grasp the gas situation in oil wells in time.

Wireless sensor networks have self-organizing and self-adapting functions. When a node in the network fails, new communication links can be reconstructed in time to ensure the normal flow of data in the network. Secondly, through the client software, we can real-time monitor the operation of the

network, accurately find the specific location of the fault node, so as to facilitate timely troubleshooting.

The whole network is powered by advanced power management technology, single sensor node is powered by ordinary batteries, which can work continuously outdoors for a long time, and the maintenance cost of the network is greatly reduced.

According to the collected data, the client software can display the concentration of hydrogen sulfide and carbon monoxide in each oil well in real time. The expert system synthetically analyses the data and gives the corresponding prompt and alarm information.

Sensor nodes are small in size, powered by ordinary batteries, and do not need special power supply lines and communication transmission lines. It is easy to install and build networks, and easy to maintain. Compared with the traditional wired monitoring network, the cost is significantly reduced.

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