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The Design and Optimization of Underground Scraper Wireless Monitoring Networks Based on Zigbee

GuoFu Yin *

Weinan, Shaanxi, P.R. China

Abstract

A wireless monitoring network for underground scrapers on the basis of Zigbee is designed. According to the RSSI value in ZigBee networks, scrapers' coarse positioning is calculated, which is transmitted to mounted computers' main control unit, and with mounted sensor's data, scrapers' position and state is evaluated. By means of WLAN, scrapers' video monitoring data, telecontrolling data and scrapers' position and state data are transferred between ground-based computers and mounted computers, so as to achieve the function of scrapers' BVR telecontrol/unmanned autonomous walking, which is effective in simulation experiments.

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Key words: scraper, WLAN, video monitoring, mounted devices

* E-mail address: yinguofu@126.com.

Introduction

Network communication is one of the focuses in researching BVR telecontrol mining and unmanned mining. Wire transmission has deficiencies in minute and complicated wiring, high cost and line-dependent, being hard to be applied in underground mining; wireless transmission is characteristics of being randomly placed, self-organized and adjusting to the environment, being widely used in underground gas monitor [1, 2], shaft drilling's well field monitoring [3] and the monitoring of spontaneous combustion fire source of coal [4] and other underground systems. A wireless network communication program combining WLAN and ZigBee is put forward, so as to transfer scrapers' video monitoring data, telecontrolling data and the data of scrapers' accurate position and state between ground-based computers and mounted computers.

The setup of wireless networks

WLAN and ZigBee

Wireless Local Area Networks (WLAN) is derived from modern wireless communication technology and computer networks, which can function like traditional wire local area networks. The infrastructure needed by networks is no more necessary to be covered underground or hidden in walls, but can be moved or changed according to practical requirements [5,6]. Current IEEE802.11 series is the most popular WLAN protocol standard. Therefore, in a narrow sense, WLAN refers to the network of wireless local area abiding by IEEE802.11 series protocol. The carrier frequency of IEEE 802.11b is 2.4 GHz and transmission speed is 11 Mbps, while the communication distance can be as far as several hundred meters. IEEE 802.11g standard IEEE802.11b is compatible, the transmission speed increases from 11 Mbps to 54 Mbps.

ZigBee is a new type of wireless communication technology with short distance and low power consumption based on IEEE 802.15.4 protocol. ZigBee technology is low power consumption, small delay, large network capacity and safe, owing unique technological advantages in wireless communication which is short distance and low power consumption [8].

The wireless networks grounded on the combination of WLAN and ZigBee

Relative to ZigBee technology, WLAN possesses higher transmission speed and longer communication distance. The video monitoring needed by BVR telecontrol requires more bandwidth. Generally, a video, of which 1 road resolution is CIF (352×288), after being H.264 coded and compressed, needs a bandwidth of 100Kbps, so as to keep the pictures clear and smooth. Besides, every scraper should carry two web cameras, while one is in forward direction and the other backward, enabling remote manipulators to observe the running of underground scrapers. On contrary to video data, the bandwidth requirement of telecontrol data as well as the data of scrapers' position and state can be omitted. At present, the WLAN data throughout based on 802.11g or 11a is between 18~22 Mbps, which can carry dozens of scrapers' video data transmission. However, as wireless AP of WLAN possesses rather long communication distance and is high cost, the distribution distance of WLAN's wireless AP is often long (over 100m). As a result, the precision of positioning by wireless AP is not exact (the positioning error is around 10m).

Grounded on the analysis above, the wireless network communication program with the combination of WLAN and ZigBee is proposed. On the networks of ZigBee, the RSSI that is based on ZigBee anchor node, scrapers' coarse positioning data is calculated and transferred to mounted computers' control unit. In line with this coarse positioning data and mounted sensor data, the control unit evaluates scrapers' position and state; WLAN is used to send scrapers' video monitoring data, telecontrol data as well as scrapers' position and state data between ground-based and mounted computers.

System architecture

The wireless communication system of scrapers is consist of BVR control module, WLAN apparatus, ZigBee apparatus and mounted apparatus integrated module, while the system architecture is shown in figure 1.

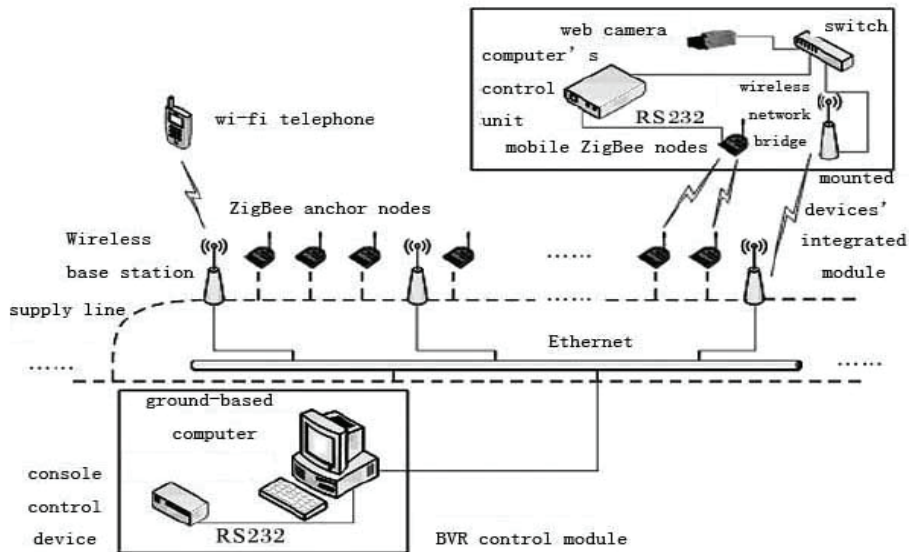


Fig 1 Architecture of the wireless network communication system for the underground scrapers

In the integrated module of mounted device, mounted computer takes EPC-8900 master control board of Zhou Ligong Company as main control unit, with which the communication architecture of mounted data acquisition unit and dynamic system control unit is shown in figure 2. Laser ranging sensors are LMS-400 and LMS-221 laser scanners, while laser scanning data is transferred via Ethernet. Data collector TTC10 takes charge of collecting angular displacement sensor and other signals, and horizon telecontrol receiver utilizes Hyde Industrial's report controller command receiver, and dynamic system control unit is developed on the base of TI-DSP2812. All of them communicate with control unit through CAN bus line.

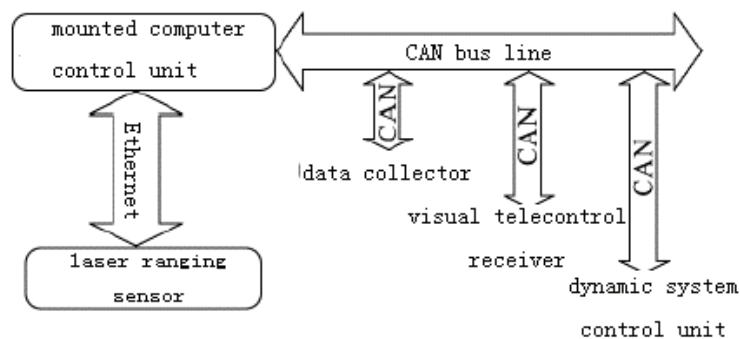


Fig 2 Communication structure of the equipments mounted on scrapers

SENAO ECB-3220 wireless AP is adopted in wireless station and wireless bridge. The AP of wireless station works in the mode of access point, while that of wireless bridge works in the mode of bridging. XBee-PRO module is used in ZigBee anchor nodes and mobile ZigBee nodes, and the communication of mobile ZigBee nodes and mounted computer control unit is via RS232.

Software platform

Scraper's data collection and control system is the application program based on Linux operating system, whose circuit is as figure 3. In Windows, BVR telecontrol and monitoring system is developed on the basis of Visual C++ and ArcEngine. The system interface offers human-computer interaction

interface to remote manipulators, supporting map import, zooming and roaming; the command from console controller is displayed in state area and sent to data collection and controlling system; figure display area can real time show scrapers' dynamic position and state.

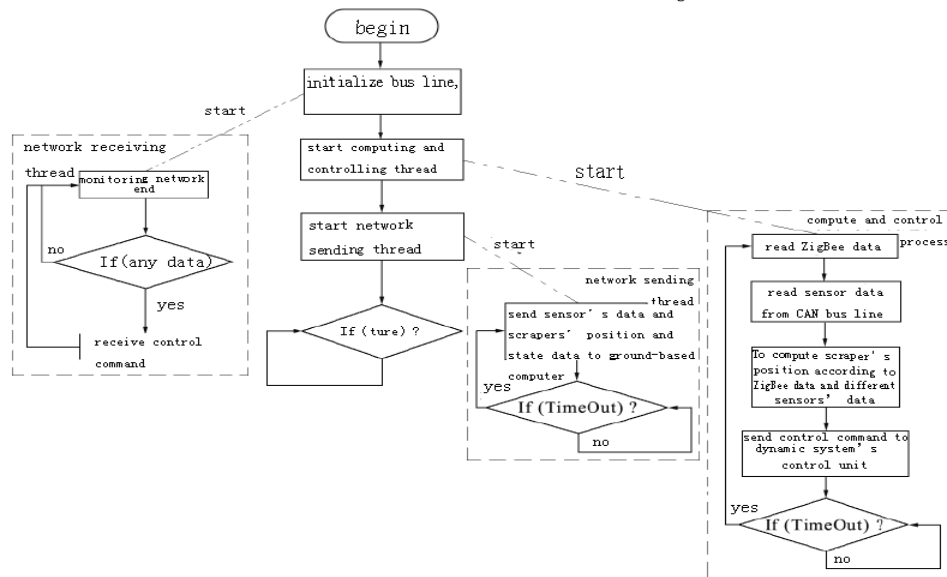


Fig3 Working flow of the data acquisition and control system for scrapers

Conclusion

The data collection and control system developed in mounted computers of simulating sample car can precisely calculate sample car's position in accordance with the collected mounted sensor's data, and then the position information is sent to ground-base computers and displayed in the monitoring system of telecontrol console; operators can send control instructions to the sample cars in simulating roadway via buttons, hand grips and treadles and other controlling units. Sample car could accurately move following the instructions given by operators. In addition, simulating sample car can also unmanned and autonomous walk in specific simulating roadway. It is expected that in future experiments, this program can be applied to actual scrapers, acquiring satisfying results in practical production environment after debugging and testing.

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