The Research on ZigBee-Based Mine Safety Monitoring System

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Abstract—In this paper the research method of Mine Safety Monitoring System based on ZigBee is elaborated, and the hardware design of ZigBee sensor node and system software design are discussed. The self-organizing routing algorithm for ZigBee networks and the gateway design and systems integration are also studied. ZigBee-based Mine Safety Monitoring System can achieve a variety of safety factors of production, and underground environment (such as gas, temperature, humidity and other environmental indicators) for monitoring, controlling mine production, safety management to provide a good basis for decision making.

Keywords—ZigBee; Mine Safety Monitoring System; AODV; GPRS; VC++

I. INTRODUCTION

The various environmental parameters of mine safety monitoring and controlling system, such as methane, carbon monoxide, temperature, oxygen and so on, are currently using the traditional cable transmission. Thus truly mine methane, carbon monoxide gas accumulation area mechanized mining face, such as the dead gob cable security parameters can not be monitored, so they can not predict the alarm. A variety of products for the current diversity of coal mine safety and underground coal mining process variability space, mine safety wireless network should be compatible with existing mine safety system with data transmission functions, has good flexibility, scalability, self-set of network capabilities. As the mine has its own special applications require a simple sensor network protocols, network easy, self-organization, self-healing ability.

ZigBee is a wireless communications technology, with a short distance, safe and reliable, you can use ZigBee technology to collect the various parameters of the terminal transmitted to the sensor on the tunnel gateway, and then use a wired data transmission to the gateway on the ground central control computer, by computer analysis and comparison of the data in order to assess the security situation in the Mine. To achieve the target location underground, environmental and other parameters of the

remote collection, can provide scientific basis for relief. Underground mine environment, the complexity of the power consumption, interference immunity and so have more stringent requirements. Therefore, based on ZigBee technology, mine safety monitoring system has a very important significance.

II. SYSTEM METHOD

Firstly, extensively collect all kinds of mine parameters such as target location data, deeply study the key technologies of ZigBee in the application of mine safety monitoring system, based on this, design the total structure of the system including hardware and software structure, and communication interfaces. Achieve the design of intelligent sensors hardware (including the RF transceiver module, temperature and humidity sensing module, the gas sensor module, the power management module), mobile intelligent sensor (including the information display module, the power management module), and intelligent sensor software (including configuration ZigBee protocol stack, the initial of peripheral devices, the user task to achieve, the system security mechanism) design; using mobile ad hoc networks and clustering algorithm to complete the design and implementation of group agreement, use the NS2 (Network Simulator 2) network simulation tools to propose experiments, through analyzing the algorithm of proposed experiments to improve arithmetic; then, build the hardware and software platforms for the mine safety monitoring system, complete the hardware design of embedded nodes, the development of protocol stack and implementation of application software.

III. THE HARDWARE DESIGN OF ZIGBEE SENSOR NODES

A. ZigBee Sensor Node Structure

ZigBee wireless sensor nodes mainly consist the sensor unit, signal conditioning circuitry, microcontroller (MCU), RF modules MC13193, timers, memory and power management module and other components shown in Figure 1.

Micro-controller is responsible for collecting environmental information (such as temperature, carbon
monoxide, methane, wind speed, etc.) and do some data conversion, responsible for controlling and managing the entire nodes; RF module MC13193 is responsible for the communication between nodes by a certain protocol; the power module provides the necessary power for the nodes separately to run the various parts.

B. Interface Design For MCU And MC13193

MCU (MC9S08GT60) and MC13193 apply SPI to implement the wireless exchange of information, the interface circuit shown in Figure 2.

In the communicating of both sides, MCU firstly initialize all of the SPI register. In the data transferring process, MCU's SPI data register is sent from MOSI1 to client MOSI1 of MC13193 then into the SPI registers of MC13193, while the SPI register of MC13193 sends data to the MISO1 side of the MCU via MISO1, then into the MCU's SPI registers. So, complete the wireless data transmission between MCU and MC13193. SPSC1K1 is for the asynchronous clock signal, the signal is generated by the MCU clock generator, controls the SPI registers of MCU and MC13193. SS1 is for the controlling signal, only the MCU output low level to MC13193's SS1 pin, can the two communicate. IRQ is the interrupt signals of the MCU to connect to MC13193's R IQ pin. Connecting MC13193's ATTN with a GPIO of the MCU could better controlling MC13193’s operating mode. MCU is connected with the RXTXEN of the MC13193 via a GPIO port. It’s used to transceive operation for initialize the chip. RST is the reset terminal, the MCU can reset MC13193 when necessary. MC13193 side can output clock signal to the MCU by CLKO. The clock is controlled through the SPI interface programming.

IV. SYSTEM SOFTWARE DESIGN

A. ZigBee Communication Flow Between Modules

In software design, communication protocol layers have the energy conservation for the center. Take the communication between the sensor nodes and the network coordinator as an example to introduce the flow of communication between the ZigBee modules.

Before making communication, ZigBee module need effective initialization. The initialization process between ZigBee sensor nodes and the network coordinator shown in Figure 3. During initialization, the network coordinator issues a active signaling request to connect the sensor nodes. After the sensor nodes successfully receive and verify a data frame and MAC command frames. Return Acknowledgment frame to the sink node, the sensor node’s ZigBee module is in sleep mode.

After initialization, ZigBee module information processing as shown in Figure 4, the network coordinator is from the working mode to waiting for connection request signaling for the response of the sensor node, and on the regular time, the sensor nodes take the initiative request to connect the network coordinator and report the detected security information inside the mine to the network coordinator. The communication between sensor nodes and sink nodes, and exchange between sink nodes and networks coordination are similar.

B. Server And Terminal Software Structure Design

Ground controlling center server software is designed by developing VC++ language, server software structure, software structure monitoring terminals are shown in Figure 5, Figure 6. Advantages of using this structure: By bridge (or proxy) technology, make the implementation of core business logic independent from the database
implementation; by pooling technology, allows implementation of core business logic independent from the communication technology to achieve; by callbacks (or events) mechanism makes the implementation of the interface independent from the business logic, communication technology and database implementation.

Of which:

Service: service components, core services of the system;
Connection Pool: is responsible for establishing and maintaining client information online;
DB Service: data components, centralizedly process database-related requests;
DB Bridge: is a component agent model;

V. GATEWAY DESIGN AND ROUTING ALGORITHM

This system is a conversion gateway based on the GPRS’s TCP / IP protocol and ZigBee protocol. Gateway module structure is shown in Figure 7. It is divided into three modules. Using the connection of UART to connect GPRS wireless module with the ZigBee junctions in addition, considering the memory of ZigBee junctions is little, and GPRS wireless module memory is also limited, through the SPI (Serial Peripheral Interface, Serial Peripheral Interface) join an external FLASH as the cache block.

Mine safety monitoring system uses AODV (Ad Hoc On-Demand Distance Vector Routing) routing algorithm and the cluster tree routing algorithm (Cluster-Tree algorithm). Self-organizing network is a reconstructed self-organizing multi-hop wireless network without the support from reserved infrastructure. In the network, network topology, channel environment, and the business model is dynamic with the movement of the node. AODV makes routing protocol simple and easy to implement. In the network node failure case or poor transmission conditions case, AODV have strong resilience. If there are several optional path to the destination node, then the ZigBee routers will select the appropriate routing path to avoid packet loss as much as possible, with the applications of a variety of indicators including LQI records. Cluster tree is a network topology tree generated by the network coordinator, in the cluster tree routing algorithm, the data will do the transmission strictly from the "tree" shaped source device to "tree" shaped target device, in accordance with the route from parent to child or from child to parent path.

VI. SYSTEM INTEGRATION

Wireless sensor network system including the sensor node, sink node, the external network and the user interface. A large number of sensor nodes are randomly deployed in or near the Sensor field, they’re able to form self-organized network, sensor nodes transmit the monitored data to other sensor nodes along the phase-jump, during transmission, the data are processed by more than one node, then through multi-hop routing to the sink node. Finally, through serial communications, the data are transmitted to the ground control center for processing. Wireless sensor network architecture is shown in Figure 8.

Sensor nodes are usually formed by Zigbee sensor module, Processor module, wireless transceiver module, and...
power supply modules, which can accurately capture the value of environmental parameters and do the initial treatment, alarm in the danger, receive the data request command from monitoring center, and send the collected data to the monitoring center.

VII. CONCLUSION

As a recently new communication technology, ZigBee technology provides a direction for scientists who commit to solve the safety monitoring problems of coal mine. The purpose of this study is to propose a solution suitable to mine wireless communication, safety monitoring, give a proof to the further study, which including two sides, the first one is a key technological theoretical research methods based on the important support from ZigBee technology and "mine awareness" concept, the second one is about the technique problems in The Internet of Things of Mine.

REFERENCES

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